
UTRECHT ROADMAP TO A THIRD INDUSTRIAL REVOLUTION



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A LETTER FROM THE PRESIDENT

The Second Industrial Revolution, which created the biggest economic boom in history, is dying. The fossil fuel energies that make up the industrial way of life are sunsetting, and the technologies made from and propelled by these energies are antiquated, with diminishing productive potential. The entire industrial infrastructure, made of carbon composites, is aging and in disrepair. Unemployment is rising to dangerous levels all over the world. Governments, businesses and consumers are awash in debt and living standards are plummeting everywhere. A record one billion human beings — nearly one seventh of the human race — face hunger and starvation. Worse, catastrophic climate change looms on the horizon. In short, the Second Industrial Revolution is on life support and will never rebound to its former glory. And everyone is asking the question, “What do we do?”

The Province of Utrecht is one of the fastest growing regions in the European Union. Unemployment is low, the standard of living is relatively high and the region boasts a world class university which makes it one of the critical hubs in the European knowledge economy.

Still Utrecht is not unmindful of the dangers that lie ahead in a world facing evermore volatile energy prices and shortfalls and the potentially devastating ecological and social dislocations brought on by human induced climate change.

With this in mind, the Province has set an ambitious agenda: to lead the regions of the EU into a Third Industrial Revolution and to become the first region in the world to become carbon neutral by 2040. To help achieve its goals the Province and The Third Industrial Revolution Global CEO Business Roundtable have entered into a collaborative partnership to rethink economic development in the 21st Century. The mission is to prepare Utrecht to make the transition to a post-carbon Third Industrial Revolution economy and become the first province of the biosphere era.

The plan we have outlined would remake Utrecht, embedding it within the larger biosphere, providing its inhabitants with a locally sustainable economic existence far into the future. The biosphere envelope is less than forty miles from ocean floor to outer space. Within this narrow band, living creatures and the Earth’s geochemical processes interact to sustain each other. Scientists are beginning to view the planet more like a living creature, a self-regulating entity that maintains itself in a steady state conducive to the continuance of life. According to this new way of thinking, the

adaptation and evolution of individual creatures become part of a larger process; the adaptation and evolution of the planet itself.

Our dawning awareness that the Earth functions like an indivisible organism requires us to rethink our notions of the meaning of the human journey. If every human life, the species as a whole and all other life forms are entwined with one another and with the geochemistry of the planet in a rich and complex choreography which sustains life itself, then we are all dependent on and responsible for the health of the whole organism. Carrying out that responsibility means living out our individual lives in our neighborhoods and communities in empathic ways to promote the general well-being of the larger biosphere within which we dwell.

By reconstituting itself as a biosphere community, Utrecht is taking a leap into a new era and creating the foundation for a truly sustainable society. It is our hope that the Province of Utrecht will be the first node in a Third Industrial Revolution network that will connect the regions of Europe and serve as a lighthouse for communities around the world.

INTRODUCTION:

The global economy has shattered. The fossil fuel energies that propelled an industrial revolution are sunsetting, and the infrastructure built off these energies is barely clinging to life. Making matters worse, we now face catastrophic climate change from spewing industrial induced CO₂ into the atmosphere for more than two centuries. The entropy bill for the industrial age has come due, with ominous and far-reaching consequences for the continuation of life on Earth.

What is happening to our world? The human race finds itself groping in a kind of twilight zone between a dying civilization on life support and an emerging civilization trying to find its legs. Meanwhile, old identities are deconstructing, while new identities are still too fragile to grasp. To understand our current plight and future prospects we need to step back and ask: what constitutes a fundamental change in the nature of civilization?

The great changes in civilization occur when new energy regimes converge with new communication revolutions, creating new economic eras. The new forms of communication become the command and control mechanisms for structuring, organizing and managing the more complex civilizations made possible by these new energy regimes. For example, in the early modern age, print communication became the means to organize and manage the technologies, organizations and infrastructure of the coal, steam and rail revolution. It would have been impossible to administer the First Industrial Revolution using script and codex.

Communication revolutions not only manage new, more complex energy regimes, but also change human consciousness in the process. Forager/hunter societies relied on oral communications and their consciousness was mythologically constructed. The great hydraulic agricultural civilizations were, for the most part, organized around script communication and steeped in theological consciousness. The First Industrial Revolution of the 19th century was managed by print communication and ushered in ideological consciousness. Electronic communication became the command and control mechanism for arranging the Second Industrial Revolution in the 20th century and spawned psychological consciousness.

Today, we are on the verge of another seismic shift in communication technology and energy regimes. Distributed information and communication technologies are converging with distributed renewable energies, creating the infrastructure for a Third Industrial Revolution. In the 21st century, hundreds of millions of human beings will

transform their buildings into power plants to harvest renewable energies on-site, store those energies in the form of hydrogen and share electricity with each other across continental inter-grids that act much like the Internet. The open source sharing of energy will give rise to collaborative energy spaces—not unlike the collaborative social spaces on the Internet.

In 2007, the European Parliament passed a written declaration committing itself to the Third Industrial Revolution economic game plan. That same year, the European Union committed its 27 member states to a 20-20-20 by 2020 initiative: a 20% increase in energy efficiency, a 20% reduction in global warming gas emissions, and the generation of 20% of its energy needs with renewable forms of energy, all by the year 2020 (based on 1990 levels).

The new communication revolution not only organizes renewable energies, but also changes human consciousness. We are in the early stages of a transformation to biosphere consciousness. When each of us is responsible for harnessing the Earth's renewable energy in the small swath of the biosphere where we dwell, but also realize that our survival and well-being depends on sharing our energy with each other across continental land masses, we come to see our inseparable ecological relationship to one another. We are beginning to understand that we are as deeply connected with one another in the ecosystems that make up the biosphere as we are in the social networks of the Internet.

This new understanding coincides with cutting edge discoveries in evolutionary biology, neuro-cognitive science and child development, revealing that human beings are biologically predisposed to be empathic and that our core nature is *not* rational, detached, acquisitive, aggressive, and narcissistic, but affectionate, highly social, cooperative and interdependent. *Homo sapien* is giving way to *homo empathicus*. Historians tell us empathy is the social glue that allows increasingly individualized and diverse populations to forge bonds of solidarity across broader domains so that society can cohere as a whole. To empathize is to civilize.

Empathy has evolved over history. In forager hunter societies, empathy rarely extended beyond tribal blood ties. In the great hydraulic agricultural age, empathy extended beyond blood ties to associational ties based on religious identification. Jews began to empathize with fellow Jews as a fictional extended family, Christians began empathizing with fellow Christians, Muslims with Muslims, etc. In the Industrial Age, with the emergence of the modern nation state, empathy extended once again, this time to people of like-minded national identities. Dutch people began to empathize with other Dutch people, Americans with Americans, Japanese with Japanese, etc. Today, on the

culmination of the Third Industrial Revolution, empathy is beginning to stretch beyond national boundaries to biosphere boundaries. We are coming to see the biosphere as our indivisible community and our fellow creatures as our extended evolutionary family.

The realization that we are an empathic species, that empathy has evolved over history, and that we are as deeply interconnected in the biosphere as we are in the blogosphere, has profound implications for rethinking the future of the human journey.

What is required now is a leap in human empathy, beyond national boundaries to biosphere boundaries. We need to create social trust on a global scale if we are to establish a seamless, integrated, just and sustainable planetary economy.

That's beginning to happen. Classrooms around the world are fast becoming laboratories for preparing young people for biosphere consciousness. Children are becoming aware that everything they do—the very way they live—leaves a carbon footprint, affecting the lives of every other human being, our fellow creatures, and the biosphere we cohabit. Students are beginning to take their empathic sensibilities to the biosphere itself, creating social trust on a global scale.

We can no longer afford to limit our notion of extended family to national boundaries, with Europeans empathizing with fellow Europeans, Chinese with Chinese, and the like. A truly global biosphere economy will require a global empathic embrace. We will need to think as a species—as *homo empathicus*—and prepare the groundwork for an empathic civilization.

When communities around the world take responsibility for stewarding their part of the biosphere and sharing the energy they generate with millions of others across continental land masses, we begin to extend the notion of family to all of the human race and our fellow creatures on Earth; we create biosphere consciousness. Utrecht, as one of the fastest growing regions in Europe, has an essential role in the Third Industrial Revolution: to serve as a lighthouse for The European Union, facilitate the transition from geopolitics to biosphere politics, and help replenish the earth for future generations.

THE THIRD INDUSTRIAL REVOLUTION

The Third Industrial Revolution is built upon a foundation of increased energy efficiency – using less energy to provide the same level of goods and services, while maximizing utility from increasingly scarce resources. From this foundation the four pillars of the Third Industrial Revolution can be constructed:

The expanded generation and use of **renewable energy** resources — gathering the abundant energy available across our planet wherever the sun shines, the wind blows, the tides wax and wane, or geothermal or power exists beneath our feet.

The use of **buildings as power plants** — recognizing that homes, offices, schools and factories, which today consume vast quantities of carbon producing fossil fuels, could tomorrow become renewable energy power plants.

The development of **hydrogen and other storage technologies** — husbanding surplus energy to be released in the times when the sun isn't shining or the wind isn't blowing.

A shift to **smart-grids and plug-in vehicles** — the development of a new energy infrastructure and transport system that is both smart and agile.

The creation of a renewable energy regime, loaded by buildings, partially stored in the form of hydrogen, and distributed via smart intergrids opens the door to a Third Industrial Revolution. It should have as powerful an economic impact in the twenty-first century as the convergence of print technology with coal and steam power in the nineteenth century, and the coming together of electrical forms of communication with oil and the internal combustion engine in the twentieth century.

It needs to be emphasized that what we've outlined is a "system." All four pillars of the Third Industrial Revolution infrastructure have to be laid down simultaneously over time or the foundation will not hold. That's because each pillar can only function in relationship to the others. The entire system is interactive, integrated and seamless.

The road ahead also requires a "systems approach" that adequately addresses the economic, energy, and environmental challenges, and simultaneously, the human and social dimensions. The successful realization of this vision is not simply a function of innovative engineering, new technologies and physical infrastructure. New social, cultural and behavioral mechanisms will be needed in order to empower individuals and communities, and ensure equitable participation in the transformation to a post-carbon

world.

UTRECHT

The Province of Utrecht is comprised of 29 municipalities, and is one of the fastest growing regions in the European Union, with both GDP and population growth outpacing national averages. With nearly 1.2 million inhabitants, Utrecht boasts the lowest unemployment rate in the country.¹ Provincial GDP is near 48 Billion Euros — which is currently the second in the Netherlands and 16th in European regions.

Located in the center of the Netherlands on the eastern end of the Randstad, Utrecht is the smallest of the twelve Dutch provinces, resting between Gelderland, Eemmeer, North and South Holland, and the Rhine River. This close proximity makes it a prime transportation hub for the rest of the Netherlands, as it is conveniently located less than an hour away from Schiphol International Airport in Amsterdam, and an even shorter distance from the port of Rotterdam.

Utrecht's capital city, Utrecht, is home to Utrecht University, the nation's largest and most prestigious university. With more than 65,000 students currently pursuing degrees of higher education, Utrecht (the city) has the nation's most highly-educated workforce.² Utrecht also boasts the largest number of cultural treasures per square kilometer, including "The Dom" — the nation's tallest church tower. Outside of the economic and cultural arena, 59% of Utrecht's surface is used for agricultural purposes. This includes more than 30,000 hectares set aside for nature reserves.³

Overall, Utrecht could be categorized as a region of balance. It is the balance between people, planet and profit (the 3 P's) that has allowed Utrecht to grow thus far, while maintaining its rich cultural heritage and preserving the biosphere. In a recent survey comparing the quality of life, current conditions and economic potential of 214 European cities and regions, The Province of Utrecht was ranked #2.

This balance, however, has not been the result of natural progression. It has been the outcome of strong, decisive political leadership. The Provincial authorities of Utrecht have long been concerned with sustainable planning efforts. In 2008, the region produced its *State of Utrecht* results and, consequently, hosted a conference entitled "Together on the Road to 2040!" From the results of the monitoring report and the

1 http://investinutrecht.com/page/downloads/Utrecht_in_top_20_money_making_countries.pdf

2 Utrecht, city of knowledge and culture, November 2009, May 4, 2010,
<http://www.oebielicious.com/home/files/vertaling_position_paper_gemeente_utrecht.pdf>

3 <http://www.provincie-utrecht.nl>

collaborative conference, the region then published its working strategy document: *Utrecht 2040: joint effort for an attractive and sustainable region* and its mission:

We want good quality of life for all inhabitants of our province. We strive for a sustainable Utrecht and the preservation of the attraction of the region. We enhance the things we are good at: a meeting point of knowledge and creativity, with a rich culture and an attractive landscape.

Utrecht is unique in this combination of qualities. That is why we want a coherent further development of the economy and the social relationships and the quality of the environment. We agree that as of this moment, in taking important decisions for this region, we will maintain the balance between people, planet and profit. We are working on decreasing and compensating and ultimately preventing the negative impacts of our choices on other stocks, on following generations and on other areas on earth.

Utrecht then released its ambitious climate objective: to be climate neutral by the year 2040 — climate neutral, of course, refers to zero greenhouse gas emissions. Although this goal is laudable, there are two remaining questions: “Is it possible?” and “How can Utrecht capitalize on its geographical advantage as a transportation hub in a carbon constrained economy? How can Utrecht meet the energy needs for today and in the future, while simultaneously drastically reducing its greenhouse gas emissions?”

In February 2010, Dr. Wouter De Jong invited international renowned economist, Jeremy Rifkin, along with global sustainability experts from the Third Industrial Revolution Global CEO Business Roundtable, to Utrecht for a collaborative three day session. On February 4th, 5th, and 6th, these experts met with political and business leaders from Utrecht to discuss the way forward. Governor De Jong made his vision clear: to

decrease Utrecht’s Greenhouse Gas footprint and refashion the region into a dynamic, Third Industrial Revolution Region; one that is economically productive, socially progressive, and ecologically sustainable.

Achieving this goal requires a careful assessment of Utrecht’s current situation, an ambitious plan for moving forward, and the political and social will to carry out these objectives. This report presents a Third Industrial Revolution vision for the Utrecht biosphere, with key recommendations for the challenges ahead.

BIOSPHERE CONSCIOUSNESS

Meeting the environmental, economic, and energy needs of the future will require the active participation of all Utrecht's citizens. This brings to light the question: "What does every citizen of Utrecht hold in common? More importantly, is there something that every Citizen of Utrecht shares with the entire human race?" At this critical juncture in history, in a world increasingly characterized by individualization and singularity, everyone shares one thing: a common biosphere.

The biosphere is the thin layer, less than forty miles, that extends from the ocean's depths to the uppermost stratosphere. Within this narrow band, living creatures and the Earth's geochemical processes are in a constant, synergistic relationship, interacting to sustain one another. The constant interaction and feedback between living creatures and the geochemical processes act as a unified system, maintaining the Earth's climate and environment, and sustaining all of life on earth.

Ironically, although we all share in a common biosphere and intimately affect one another in our choices, most of us are completely separated from the very systems that support our lives. Our food is shipped from hundreds of kilometres away, after being grown in synthetic chemicals and transported in petrochemical packaging. Our energy is likewise created through an equally mysterious process. Although this is partly a result of our educational value system, it is also the result of our social and organizational patterns.

Today, most people live in cities far removed from where their food is grown and the people growing it. At some critical point, however, we will realize that we share a common planet, we are equally affected by one another, and separation from the systems that support our lives is directly contributing to our civilization's degradation.

Utrecht is a region of diverse culture, home to a ballooning knowledge-based economy, but also deeply whetted to a long agricultural tradition. The citizens and their lives, then, must also be integrated.

In Utrecht, the commercial, residential and rural spaces are interspersed. Together these three areas make up the Utrecht biosphere. The Third Industrial Revolution economic development plan transforms the region of Utrecht into an integrated social, economic and political space, embedded in a shared biosphere community. Unlike previous concentric city models, the Third Industrial Revolution model emphasizes zonal

interconnectivity—bringing together the agricultural region with the commercial zone, residential areas, and the historic core, in an integrated relationship, connected by locally generated renewable energies, and shared across a smart distributed electricity power grid.

The Third Industrial Revolution vision for Utrecht is intended to show how the areas surrounding the city centre can be reconnected and work together to support each other in an integrated and holistic way.

RESIDENTIAL

The current trend for urban centers is de-population, due to a lack of housing to meet modern needs, along with severe traffic congestion and air pollution. The Third Industrial Revolution vision for Utrecht, however, positions the inner core as an attractive, connected and lively place, with accessible open space and traffic-free roads, allowing pedestrians to reclaim the streets and enjoy the historical surroundings. Improved public transport, cycle paths and pedestrian routes are needed to encourage this transition. High quality sustainable housing and energy efficient apartment-living will also be needed to increase inner-city population density and to help maintain a vibrant sense of community. These housing initiatives will also result in more opportunities for public transport, a critical element in achieving high levels of urban sustainability. Maintaining inner-city population density, with its opportunities for facilitating viable public transport and energy efficient living, is also critical to achieving these high levels of urban sustainability.

While central Utrecht has a shortage of housing, like many other cities, it has a surplus of office space. Currently, the province is seeking to rectify the situation through its “From Workspace to Housing” initiative, complete with a taskforce, a “quicksan guide” and sample projects available on the Province’s website.⁴

The Third Industrial Masterplan envisions transforming now defunct commercial buildings into new residential blocks without damaging the architectural heritage. The idea is to maintain the historical facades of the office buildings, while excavating the central cores and turning them into communal gardens. The goal is to preserve the aesthetic value of Utrecht’s rich architectural history, and at the same time, prepare the new infrastructure for a Third Industrial Revolution region.

⁴ <http://www.provincie-utrecht.nl/prvutr/internet/wonen.nsf>



EXCAVATING AND REMODELING RESIDENTIAL BLOCKS IN THE CITY CENTER

INDUSTRIAL

Surrounding a newly revitalized urban centre will be the green industrial/commercial circle—the hub of Utrecht’s economy. The industrial/commercial space should become a vast laboratory for developing the technologies and services that will transform Utrecht into a model low-carbon economy that can provide a high quality of life. There is tremendous opportunity for a new generation of entrepreneurs to develop a range of Third Industrial Revolution industries and services which will grow on the back of local demand and then, from there, grow to compete successfully across Europe.

The Third Industrial Revolution Plan envisions the creation of biosphere science and technology parks scattered across the industrial/commercial space. These science and technology campuses will house university extension centers, high-tech start up companies and other businesses engaged in the pursuit of Third Industrial Revolution technologies and services. Spain already boasts one such science and technology park. The Walqa Technology Park in Huesca, Spain is among a new genre of technology parks that produce their own renewable energy on- site to power virtually all of their own operations. There are currently a dozen office buildings in operation at the Walqa Park, with another forty already slated for construction. The facility is run almost entirely by renewable forms of energy, including wind power, hydropower, and solar power. The park also houses leading high-tech companies, including Microsoft and other ICT and renewable energy companies.

The potential of local demand and smart regulation to create whole new sectors of the economy can be clearly seen in the recent experience of the German economy, which has rapidly become a global market leader in the production and installation of photovoltaics. In 2000, renewable energy contributed just 6% to Germany’s national electricity mix. In order to increase this total, Parliament set a target of 12% by 2010 and

created a 'Feed-in Tariff.' This legislation ensured that homeowners and commercial building owners who installed photovoltaics were paid a premium price for all electricity generated and sold back to the grid. In only eight years, Germany not only increased its renewable energy in the grid mix to 14%, but also created 200,000 jobs and established itself as the world's leading photovoltaic manufacturer.

The industrial/commercial space will be an attractive working environment, with significant green space, populated with self-sufficient buildings and factories, powered by renewable energies and connected to distributed, "agile energy systems."⁵

AGRICULTURAL

In the twentieth century model of urban development, cities became increasingly divorced from the production of the food they consumed. The production and transportation of food has also become an increasingly large source of greenhouse gas emissions. This problem is frequently underestimated as urban carbon models tend to focus mostly on emissions generated by processes within the city boundaries, and focus less on emissions embedded in the products consumed, but produced elsewhere. Ecological footprint data suggests that food consumption forms a large, possibly the largest, proportion of a city's Ecological footprint.⁶

More than 85,000 of Utrecht's 144,915 hectares are designated as green space. Although this is a step in the right direction, the agricultural resource is still underutilized. It could not only be made more agriculturally productive, but act as a site for large scale renewable energy generation and be used for leisure activities.

By investing in locally grown produce and becoming more self-sufficient in food production, Utrecht will be able to enjoy greater food security and a reduced carbon footprint. The Third Industrial Revolution Vision will transform the agricultural community into a modern biosphere community: a place that can provide food for the industrial, residential and historic sectors, while preserving the local flora and fauna of the region for future generations. The agricultural region will be a living showcase of the Slow Food Movement, combining state-of-the-art agricultural ecology and biodiversity practices. Open air country markets and country inns and restaurants will feature local cuisine and promote the ecological and health benefits of a "small footprint" diet.

⁵ Clark, Woodrow, W, "Agile Energy Systems: Global lessons from the California Energy Crisis" Elsevier Press, 2004

⁶ The Ecological Footprint (EF) is a measure of the consumption of natural resources by a human population. A country's EF is the total area of productive land or sea required to produce all the crops, seafood, wood and fiber it consumes, to sustain its energy consumption and to give space for its infrastructure.

Agricultural research centers, animal sanctuaries, wildlife rehabilitation clinics, plant germ plasm preservation banks and arboretums will be established in the rural region to revitalize the biosphere.

Utrecht's green outer space also offers tremendous opportunities for large scale renewable energy projects, which utilize wind, solar and biomass energies. Renewable energy parks will be situated throughout the agricultural region and integrated seamlessly into the rural landscape.

All of these far-reaching innovations are designed to rejuvenate the biosphere and transform the region into a relatively self sufficient ecosystem that can provide much of the basic energy, food and fiber to maintain the growing population. With imaginative planning and marketing, this biosphere park could be turned into a highly visible sign of Utrecht's exemplary embrace of the Third Industrial Revolution vision.

One institution in the Netherlands has recognized this need, and is a working example of a growing realization of biosphere consciousness. The Eemlandhoeve, or what has been called a green oasis is more than a farm; it's a place creating connections and encounters between farmers and citizens, between city and countryside, between the Creator and creation; with an eye to sustainable living.

EMISSIONS REDUCTION FRAMEWORK

The 2007 20, 20, 20 by 2020 initiative is a bold political target set forth by the European Council that communicates the urgency of global climate change and, perhaps more importantly, global leadership. EU Heads of State have also offered to move to a 30% reduction under a Global Climate Agreement if other countries committed to similar targets. Unfortunately, a global climate accord has not yet been reached. However, a few member states have taken it upon themselves to take the initiative.

The Netherlands is one of the five member states to announce its support for a 30% reduction by 2020.⁷ Clearly on Target to meet its Kyoto target of a 6% by 2012, The Netherlands announced its new energy and climate change program “Clean and Efficient.” The plan calls for: 1). Cutting emissions by 30% in 2020 compared to 1990 levels; doubling the rate of yearly energy efficiency improvement from 1% to 2% in the coming years; and reaching a 20% share of renewable energy by 2020.⁸

The Province of Utrecht, however, has retained its ambition to be “climate neutral” by 2040. The first question to be answered, then, is “What is the quantity of the required reduction? Or, in other words, “Just how much is a 30% reduction?” Once we know the answer to the question, the next becomes “How much will it cost?”

INTRODUCTION:

Building on the national 2020 target, using 1990 emission levels, we extended this trajectory to evaluate the potential emissions reductions that might be attainable for the year 2040. The scenario projections below can inform the Province of Utrecht about the potential scale of investments necessary in order to reduce the Province’s total greenhouse gas emissions — to what we hope will be around an 84% reduction by 2040.

In effect, we have completed a three step process: (1) built a reference case for emission projections through the year 2040; (2) identified a potential path that would provide at least a 30 percent reduction from 1990 levels by 2020 and evaluated the implied reductions (somewhere near 84%) for 2040; and then, (3) estimated the potential investment needed to move onto a cost-effective emissions reduction path through 2040.

⁷ Germany, France, Ireland, and UK are the others.

⁸ A full description of the program to be announced in September 2010
<http://international.vrom.nl/pagina.html?id=37556>

The methodology employed here builds on feedback received regarding population projections and current estimates for the level of provincial Gross Domestic Product (GDP) (estimated in constant 2008 Euros). It is important to note, however, that this methodology again only provides a broad estimate of the investment magnitude that may be required. As provincial officials begin to secure specific proposals that relate to the costs associated with the anticipated goods and services necessary to implement a transition to a Third Industrial Revolution Economy, these estimates will be refined, revised, and reconsidered.

TOTAL GREENHOUSE GAS EMISSIONS PROJECTION

To come up with a starting point for total greenhouse gas (GHG) emissions (including both energy and non-energy related emissions), we used a variety of data. In general, we grew the 2008 level to 2030 by relying on the IEA World Energy Outlook 2009 (we also reviewed a variety of data from the European Union over the period 2007 to 2030).⁹ Based on the Province's own population forecast and by extending the IEA World Energy Outlook assumptions from 2030 to 2040, we extended our projections to 2040. Finally, we made an assumption about the "normal rate" of reduction in provincial emission intensity (measured as the level of GHG emissions per real Euro of GDP). This assumption refers to the advances and improvements that would occur naturally in the technology or marketplace, without policy initiatives or significant changes in energy prices. As shown in the table below, however, the decreasing energy intensity and emissions occur at a smaller rate than growth in the economy (This is why there is a slight increase in provincial emissions in the reference case projections).

As suggested in the table below, the "normal rate of reduction" in carbon dioxide emissions tracks the estimates as projected by the IEA through 2030, and then, what this might look like if extended out to 2040 (IEA 2009). To illustrate the methodology and encourage further ongoing discussion, we have created the following table of key illustrative values for the years 2010 and 2030 and 2040:

9 [IEA 2009] World Energy Outlook. 2009. Paris, France: International Energy Agency.

Key Utrecht Data	2010 (est)	2030 (est)	2040 (est)	Annual Growth
Population (1,000s)	1,205	1,350	1,413	0.5%
GDP (millions of 2008 Euros)	46,800	63,000	73,100	1.5%
Estimated Primary Energy (PJ)	212	220	225	0.2%
Estimated GHG Emissions MMTCO ₂	11.4	11.9	12.1	0.2%

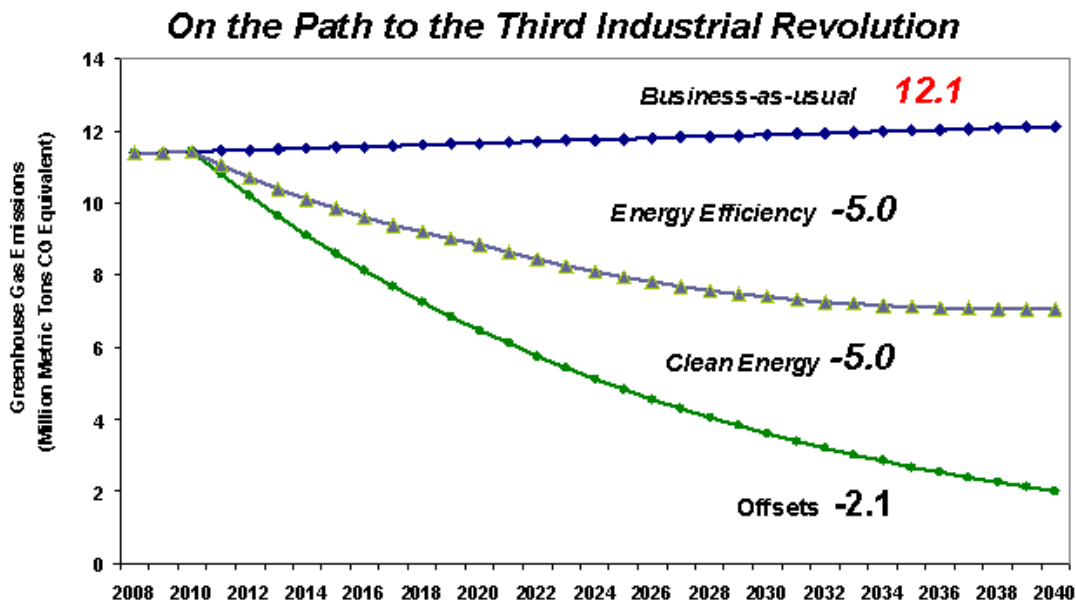
THE ENERGY REDUCTION PATH

The estimate of the 30 percent energy and related emissions reductions by 1990 levels was a straightforward calculation. It generally followed a number of previous estimates of what might be possible economy-wide (see Elliot et al 2007, Laitner et al 2007, AEF 2009, McKinsey 2009, and IEA 2009).^{10&11} This resulted in the following values for the years 2010, 2030 and 2040.

Utrecht Energy/GHG Data	2010 (est)	2030 (est)	2040 (est)	Annual Growth*
Baseline Energy (PJ)	212	220	225	0.2%
TIR Energy (PJ)	212	150	131	-1.6%
Baseline GHG Emissions (MMTCO ₂)	11.4	11.9	12.1	0.2%
TIR Emissions (MMTCO ₂)	11.4	3.6	2.0	-5.6%

10 [AEF 2009] Committee on America's Energy Future. 2009. America's Energy Future: Technology and Transformation: Summary Edition. Washington, DC: National Academy of Sciences; National Academy of Engineering; and National Research Council.

11 [EIA 2009a] Energy Information Administration. 2009. International Energy Outlook 2009 with Projections to 2030. Washington, DC: U.S. Department of Energy.



UTRECHT GREENHOUSE GAS EMISSIONS TRAJECTORIES 2008-2040

As illustrated above, if the current trajectory for the Third Industrial Revolution is followed, then total primary energy demand for Utrecht (in petajoules, including transportation and all non-electricity fuels) in 2040 would be reduced by about 42 percent from the business-as-usual or reference case projection, and total greenhouse gas emissions would be reduced by about 84 percent in 2040. That's moving from a projected 12.1 million metric tons of CO₂ equivalent in 2040, to around two million metric tons. Or, if you think about it on an individual basis, each resident in Utrecht currently releases somewhere around nine metric tons of CO₂ per year; to reach the 2040 Third Industrial Revolution goal will require each person reducing their emissions to approximately two metric tons.

But what does this really mean? How much is one metric ton of CO₂ and how much of an effect can one person have? As CO₂ is an odorless, colorless gas, this can be quite difficult to imagine. In 2007, the Danish Climate Campaign shed light on this mystery, and simultaneously involved its citizenry in the fight against climate change through its "1tonmindre" campaign.



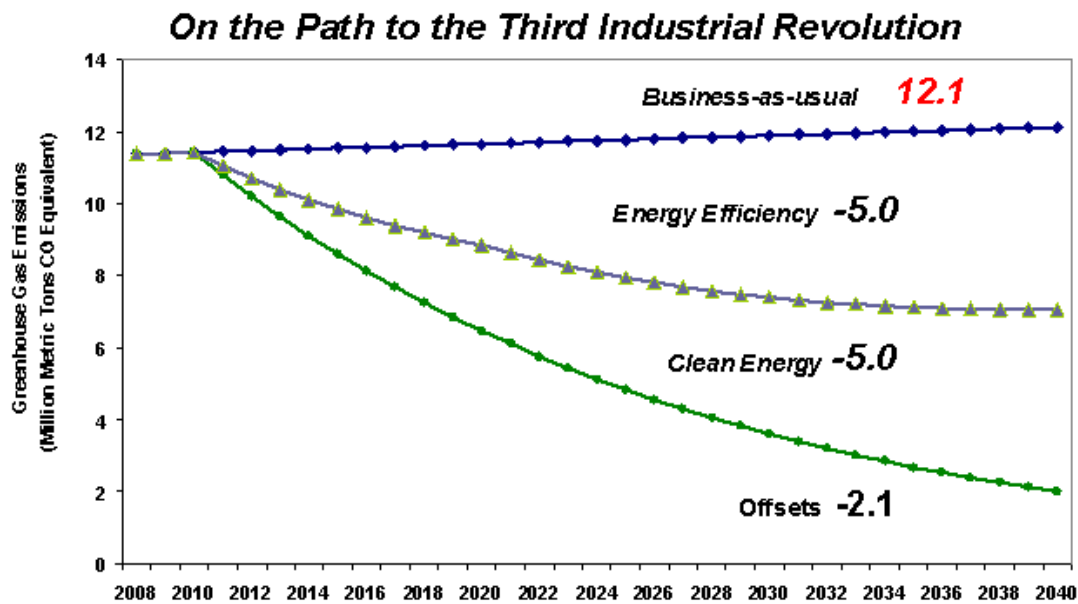
PHOTO OF 1TONMINDRE "CARBON GLOBE"¹²

The One ton mindre (one ton less) campaign is a robust public relations strategy complete with a website featuring an emissions calculator, suggestions and advice on individual reduction methods, and even free downloads of "The Climate Song." The real public communications tool, however, is its giant 10 meter "planet balloon" that represents the enormous size of one ton of CO₂. Although the initial goal was ambitious — obtaining 50,000 Danish climate pledges — by the end of August 2009, more than 84,000 people had made commitments. Moreover, as each promise usually amounts to more than one ton, if all of these promises are kept, an estimated 163,000 tons of CO₂ will be saved.

Even in an ecologically utopian society, one in which every person in Utrecht thought first about the impact that his/her actions would have on the earth, reaching the climate neutrality would still require an accompanying policy infrastructure and the full support of business and industry. Trying to reach this milestone without the full support of politicians or industry will be impossible. In much the same way, a single technology or one new policy will not be enough.

We have divided the "reduction opportunities" into three areas: Energy Efficiency (5,000,000 tons), Clean Energy (5,000,000 tons), and Offsets (2,100,000 tons).¹³ (See image below)

¹²Image Courtesy of <http://international-club-copenhagen.blogspot.com/2007/04/new-campaign-1-ton-co2-less-every.html>



As will be explored further in the following section, we chose to use carbon dioxide offsets to provide the equivalent of the last two million metric tons of emissions reductions rather than explore the costs of zero actual emissions. The reason is the existence of many long-lived assets within the province. Many buildings, roads and other infrastructures have useful lives that extend well beyond 40 years. Hence, it likely would be prohibitively costly to completely transform all of the capital stock within the regional economy in just three decades. This is not taking into account the fact that a complete transformation by 2040 will require significant new labor skills and an expansive system of supporting technologies. To achieve this scale in less than one generation with the existing labor force is likely more difficult than might be justified by the economic cost. GHG offsets, however, allows us to balance the costs of transformation within the spirit of a “carbon neutral” economy.

ESTIMATING THE INVESTMENT

From published sources within the publications of the European Union and the OECD, we estimate that annual investments throughout the Netherlands are now about 21 percent of regional GDP.¹⁴ By applying that ratio to the projected GDP for Utrecht, we estimated that normal investments to maintain ongoing economic activity within the Province would rise from about 11 billion Euros in 2010 (around 23% of GDP), to about

¹³ These are rounded figures and in the scenario generated, offsets do not begin until 2020.

¹⁴ [OECD 2009]. Organisation for Economic Co-operation and Development. Input-Output economic accounts and other economic statistical data for Italy. Accessed at various times in December 2009 through February 2010.

20 billion Euros in 2040 (around 27% of GDP).¹⁵ This, of course, includes a huge number of uncertainties, but it allows a benchmark against which to compare or understand the magnitude of the investment that might otherwise be required to achieve the necessary reductions in total greenhouse gas emissions.

The total investment required to reduce total greenhouse gas emissions is assumed to be a function of changes in energy use, the GHG intensity of the remaining energy that is consumed, and the non-energy related GHG intensity of the provincial economy. The basic calculation depends on the starting average price for all primary energy used in 2010, multiplied by an estimated payback period needed to reduce either energy use or the GHG intensities that might be associated with energy and non-energy uses. From preliminary data, and comparing it to other IEA data published in 2009, we are now assuming an average price of all energy in Utrecht as 27 Euros per gigajoule.¹⁶ If the equivalent starting payback value for an investment in emissions reduction is three years in 2010, then the investment to reduce GHG (either through reduced energy use or reduced CO₂ intensity for the energy that is used) is 81 Euros per GJ (also in constant values). If that average payback eventually grows to 11 years by 2040 as we assume here, then the investment required also grows to 300 Euros per MJ (again in constant Euros).

The average payback over the entire 2010-2040 time horizon is about seven years. This assumes efficiency would deliver about half of the reductions by 2040. Clean energy technologies – primarily renewable energy and the other low carbon technologies responsible for the remaining 50 percent reductions – would cost an average of 2,100 Euros per kilowatt of electricity capacity equivalent (less in the early years and more in the later years). The purchase of offsets are assumed to cost 15 Euros in 2020 (the first year we suggest they might contribute to a climate neutral Utrecht), rising to about 50 Euros by 2040. All of these values are integral to our estimates of the spending and investments necessary to achieve a 30 percent reduction by 2020 and a “climate-neutral” economy by 2040. We triangulated around these values relying on a variety of

¹⁵ Both figures are measured in constant Euros

¹⁶ There is a wide range of uncertainty about the average cost of purchased energy as we are not aware of data that are published at the provincial level. Hence, we have used a variety of OECD and IEA data sources to converge around the estimate of 27 Euros per gigajoule (Euros/GJ), expressed as 2008 constant monetary values. It could be as low as 24 or as high as 29 Euros. We hope to refine this value as we move to a final work product. Please note that to maintain a conservative estimate, we use this same price through 2040 to generate estimates of potential energy bill savings and required investments. But, in fact, the real price of energy is likely to rise significantly over time. However, absent other projections of future increases under either a reference case or an alternative policy case, our use of an estimated value based on 2008 data is generally reasonable.

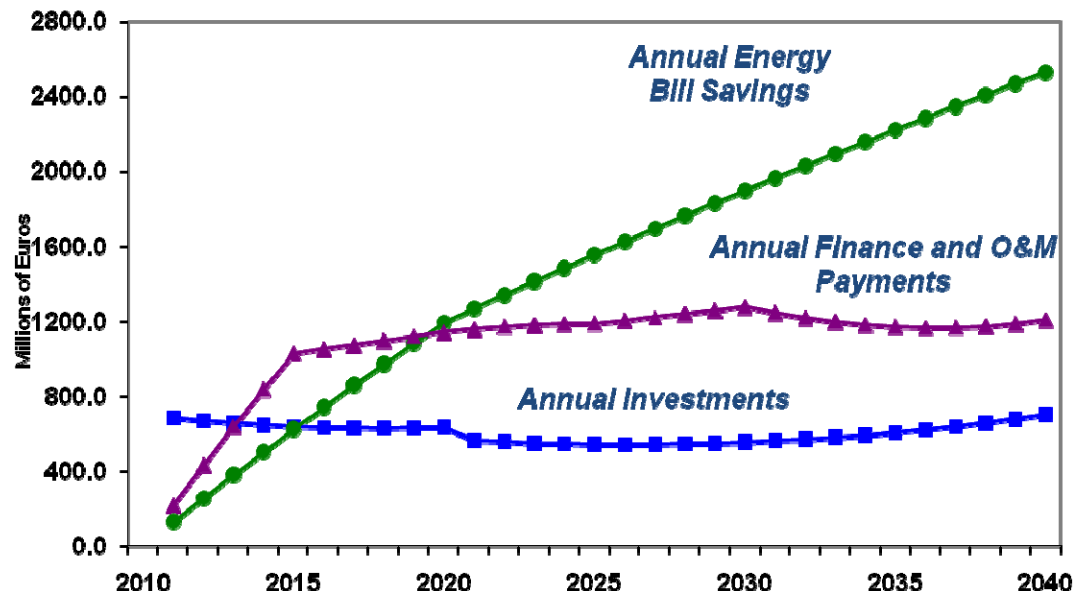
sources to inform our estimate (including Lazard 2008, Elliott et al. 2007, AEF 2009, McKinsey 2009, and IEA 2009).¹⁷

From the data that we are now using, we estimate that the annual investment would have to average 600 million Euros (also in constant terms) over the period 2010 through 2040. That is an investment level that represents about four percent of total required on-going annual investment in Utrecht over the period 2010 through 2040, and about one percent of the provincial GDP. The good news here is that the energy bill savings continues to build over time. As the graph below illustrates, even when we account for interest payments on money that might be borrowed to make the efficiency improvements, assume a 40 percent operating cost above the annual cost of capital for renewable energy technologies, and add in the cost of emissions offsets, the benefit cost ratio for the transition to a Third Industrial Economy appears to hover to just over one.¹⁸ This implies that the Province of Utrecht can achieve carbon neutrality, and do so in ways that pays for itself over time.

17 This was a technique we adapted for the Semiconductor Industry Association in May 2009, for example (see Laitner et al. 2009) as well as for the City of San Antonio (Rifkin et al 2009).

18 For purposes of calculating a benefit cost ratio, this analysis assumes a 7 percent cost of borrowing money for 5 years to cover the cost energy efficiency investments and 20 years to pay for renewable energy technologies. Also assuming a 7 percent discount rate over the period 2010 through 2040 for the investment, operating and offset costs as well as the energy bill savings, the calculations suggest a roughly 1.14 benefit-cost ratio. That is, for every Euro paid to reduce greenhouse gas emissions (whether borrowing the money or paying any operating expenses associated with the renewable energy technologies), approximately one 1.14 Euros are saved over this 2010 through 2040 time horizon.

Investments, Costs and Savings to Transition to The Thrd Industrial Revolution

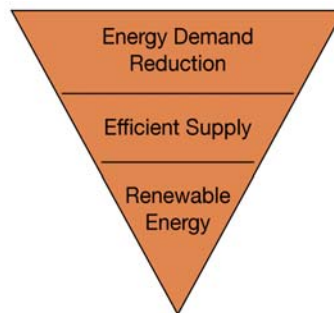


It is again important to highlight several caveats. First, this estimate does not include the program or policy costs necessary to administer this transition. It also does not account for any “learning,” where investments and operating costs might decline because of improved processes; nor does it include economies of scale, with expanded ramp up of program efforts. Finally, the model does not take into account innovations in technology and/or any dynamic market response that may result (see Knight and Laitner 2009, for example). As these and other assumptions are modified, this would, of course, change these values.

It is also important to note that these figures do not begin to describe the unquantifiable benefits and economic multipliers that result from building a new economy: the innumerable new business models and commercial opportunities, the new manufacturing and service clusters, and the hundreds of thousands of new jobs. The economic development roadmap laid out herein describes these benefits and sets out key recommendations for how Utrecht can balance people, planet and profit based upon the Four Pillars of the Third Industrial Revolution. But while we cannot provide a precise estimate of any future values, we believe that these results reasonably describe the magnitude of potential emission reductions and the magnitude of investments required to achieve the reductions.

ENERGY EFFICIENCY

Constructing the Four Pillars of the Third Industrial Revolution will necessitate large technological and infrastructural innovations. Although increasing renewable energy production will require significant short-term capital costs, the long-term dividends will provide a handsome return on investment for the region. To ease this financial burden, however, and to help smooth the capital shortfalls, the first steps in transitioning the economy into to a Third Industrial Revolution is to 1) improve the efficiency with which consumers and businesses currently use energy, and 2) reduce wasted energy in order to cut the scale of demand for renewable generation. Methodologically this can be expressed in the following hierarchy:



In the Climate Change Action Plan for the city of London, for example, it was calculated that a 60 percent reduction in carbon emissions by 2025 could be most efficiently achieved through roughly equal efforts in each of these areas.¹⁹ Since 1990, across the European Union, two thirds of new energy demand has been met by energy efficiency—only one third by new supply.²⁰

In most cities, there are a handful of principle opportunities for energy efficiency which are cost-effective; that is, opportunities which pay for themselves over time. Some of the most popular include:

- improving the thermal performance of buildings
- optimizing energy demand in buildings

¹⁹ http://www.london.gov.uk/mayor/environment/climate-change/docs/ccap_fullreport.pdf

²⁰ John Skip Laitner, presentation at the Third Industrial Revolution workshop in Rome, 5 December 2009.

- achieving transport modal shift
- reducing water usage/waste

Reducing demand for energy doesn't have to mean large sacrifices, but it does require the participation of a significant proportion of citizens. As the former Mayor of London Ken Livingstone said when launching London's climate change plan, "We don't have to reduce our quality of life to tackle climate change. But we do have to change the way we live."

In most developed countries, fossil fuel prices have remained sufficiently low to encourage a high degree of wastefulness in energy use, both at a commercial level and by individual citizens. In London, more than 20 percent of energy consumption is entirely unnecessary.²¹ This waste is attributable to large scale commercial problems, such as a lack of building management systems that control energy use, and smaller scale domestic actions, such as excessive heating/cooling or leaving lights on in unoccupied rooms. Even when the marginal cost of fuel is low and if one excludes the long-term environmental and societal consequences, the wasteful use of energy is always economically irrational.

Reducing demand for energy through behavioral changes can be partially achieved through the use of technology. One can imagine the role of Internet technology in particular, to significantly improve energy efficiency in the future. For example, consider the production and sale of shoes. Currently shops have to stock a wide range of sizes and styles to accommodate its customers. However, if the shop took a digital imprint of a customer's foot, this could be fed back to a central production house where the shoe would be made to measure and sent directly to the customer. This technology would reduce transportation costs and carbon emissions, free up space the shop is using to stock shoes in all shapes and sizes, and, ultimately, produce a better shoe.

Undoubtedly, changing established behavior will require either a strong price mechanism, such as road pricing in Stockholm and London, or a significant change in mindset. A salient example is provided by the iconic Bed Zed development in the UK. Energy use in this low carbon community has been monitored since it was first occupied in 2002. Despite identical building fabrics, however, there is as much as a 40 percent difference in per capita energy use—even between adjacent apartments—as a direct result of the different lifestyles of the inhabitants.

²¹ That is, it does not deliver any benefit to the individual consumer or to society at large. London Climate Change Action Plan, Greater London Authority, 2007.

The full benefits of energy efficiency are likely to be even larger than what is immediately apparent. As Dr. Ernst Worrell of Utrecht University commented at the Third Industrial Revolution Workshop, every unit of electricity saved in the home or office translates into perhaps 2.5 to three units saved at the power plant due to the inefficiencies of generation, transmission and distribution.

Another largely unexplored area of behavior is that of food consumption. Although not a popular position, it is clear that carbon emission reductions could also be achieved by reducing the emissions from meat production, particularly beef. The United Nations FAO study reports that livestock generate 18 percent of the greenhouse gas emissions. This is more than transport. While livestock—mostly cattle—produce 9 percent of the carbon dioxide derived from human-related activity, they produce a much larger share of more harmful greenhouse gases. Livestock account for 65 percent of human-related nitrous oxide emissions – nitrous oxide has nearly 300 times the global warming effect of carbon dioxide. Most of the nitrous oxide emissions come from manure. Livestock also emit 37 percent of all human-induced methane – a gas that has 23 times more impact than carbon dioxide in warming the planet.

The high caloric diet in the West has a significant impact on the climate. In addition, the petrochemicals used in fertilizers, pesticides, and packaging materials, along with the energy used to transport the meat and the farmland required to carry out this process—all to breed animals for human consumption—provides a significant portion of greenhouse gas emissions. Obviously, then, another significant way to reduce individual carbon emissions is to alter consumption patterns so that meat is eaten less often.

BUILDING EFFICIENCY

Reducing energy demand through building retrofits is now a significant focus of cities around the world. At least twenty of the C40 Cities (a grouping of 40 of the world's most prominent cities) have programs to retrofit municipally owned buildings. The city of Berlin has, through its Berlin Energy Saving Partnership, retrofitted over 1,300 buildings and has reduced CO₂ emission by an average of 27 percent per building (the equivalent of avoiding 64,000 tonnes of CO₂ emissions and over 10 million Euros in annual energy costs). This is consistent with the average pay-back for building retrofits of 8-12 years.²²

Typically, the largest energy savings through building retrofits come from improving thermal efficiency to cope with hot summers, cold winters or both. How well the building is insulated and sealed also determines the size and output of air conditioning

²² www.c40cities.org/bestpractices/buildings/berlin_efficiency.jsp

and heating units. To improve upon thermal performance, cavity walls can be filled and solid walls lined to improve thermal mass, double glazing and high performance windows that reflect heat can be installed, as can doors with good thermal performance.

Another increasingly popular and effective way to improve thermal mass is through the use of green roofs. Green roofs not only provide a moderate insulation value and even a small cooling effect (through evapotranspiration), but can also help reduce the impact of flooding, through absorbing and slowly releasing rain water. Large green-roof programs are already underway in North American cities such as Chicago and Toronto.



CHICAGO CITY HALL GREEN ROOF

Retaining hot and cool air within a building is critical. However, natural measures which allow for ventilation can be equally as important. Although these 'systems' can be as simple as opening a window, most natural ventilation systems in commercial buildings are carefully designed to adjust to outside conditions. Once the building envelope has been sufficiently insulated and thermal mass considerations have been accounted for, other technical efficiency measures can then be considered. Building management systems, utilizing motion sensors and other devices can control various systems- such as lighting, air conditioning, heating or ventilation- to maximize efficiency in response to activity within buildings, and can also optimize heating and cooling generation. There are various commercially available tools that enable building owners to assess the potential of retrofitting their own buildings, such as Arup's DECODE product, developed for the UK's Carbon Trust.²³

²³ Decode is a software tool that identifies the impact of various interventions within new and existing buildings. This enables the user to understand what low carbon non-domestic building stock could entail and the actions that should be taken. The tool uses data from an evidence base of existing work and

EFFICIENT LIGHTING

Perhaps the most easily achievable energy efficiency improvement is in lighting. Lighting accounts for 19 percent of global electricity consumption, but around 80 percent of lighting is aging and inefficient. In commercial buildings, the largest contribution to greenhouse gas emissions (after space heating and cooling) comes from the electricity consumed by lighting and computing.

Urban areas are responsible for 75 percent of energy consumed by lighting, 15 percent of which is from street lighting. Despite this, the switch-over rate to modern efficient lighting for streets is 3 percent per year, and 7 percent for offices. There is only a 7-year pay-back period in switching to energy efficient lighting.

In Europe, improved lighting could result in an average of 40 percent electricity savings (which amounts to 99 million tonnes of CO₂ per year). As the other examples below illustrate, the energy savings alone can be significant enough to make LED lighting cost-free over a relatively short investment horizon. There are likely to be additional benefits as well, such as better quality light for a safe, enjoyable environment.

The Mayor of Los Angeles recently started a program to replace all 209,000 streetlights in the city with more efficient LED lights. It is expected that the scheme will save 40,000 tonnes of carbon emissions per year and that the €38.5 million in capital costs will be offset by a savings of over €6.7million per year. Part of the cost savings emanates from the fact that LED bulbs have an eleven year life-span and, thus, maintenance and replacement costs are greatly reduced when compared to conventional tungsten bulbs.

Ultimately, the most successful strategy for energy efficiency, consistent with the overall strategy for the Third Industrial Revolution, is likely to be that which combines communication and energy solutions. For example, installing a building management system will deliver efficiencies on its own, but these can be maximized with the use of state of the art communication technologies to provide information to consumers and energy operators, encouraging both reduction in energy demand and improvements in supply efficiency.

PUBLIC /PRIVATE SOLUTIONS

Although energy efficiency and retrofit solutions are often deployed on a single private contract basis, it is also possible for a municipality to oversee a city-wide

assumptions based on our extensive experience in low and zero carbon development. Output includes the level of carbon abatement achievable at sector, national and end-use level, the economic cost of the interventions and the consequences of various demolition and build rates.

implementation. Queensland, Australia for example, has developed a Home Service as a part of the Government's ClimateSmart Living initiative. It was designed to help Queenslanders contribute to addressing climate change by reducing their carbon footprint in their own homes. For around €33 per household, residents can sign up online to receive a one hour energy appointment. Following this assessment, an energy service company (ESCo) can be appointed to install energy efficiency measures in a building and to guarantee a set level of energy savings, out of which the ESCo receives its fee. This offers a financial savings over a period of years to the consumer and transfers capital costs to the ESCo, rather than the owner or occupier of the building.

Unlike traditional public building improvement programmes, a whole group of buildings being retrofitted at once allows energy services companies to achieve economies of scale. This also allows for more long-term infrastructure improvements to be made, not only small, less-intrusive measures.

Performance contracting can be one of the most cost effective investments for government entities as it often requires no direct cash outlays. Established energy companies, such as Philips and Schneider, provide energy efficient installations and retrofits and guarantee a minimum level of energy efficiency gain. In other words, these companies are paid back through the energy savings; the customer is not actually spending any more money than it previously would have.

In Rouen, France, Philips is moving beyond providing lighting products in its performance contract to now offer a public safety service. Not only has Philips found a financial partner to help capitalize the project, but the project includes a closed network electronic system which provides traffic management, video surveillance, and, of course, lighting. Improving upon lighting can also improve upon the overall quality of life: the LED lighting scheme that Phillips installed in the London Borough of Redbridge, for instance, not only had energy savings of 50 percent, but also decreased crime rates and raised property values.

OPPORTUNITIES AND CHALLENGES IN UTRECHT

As in all major changes within the economy, it takes money to drive the desired result. A new study of the costs of climate mitigation within Europe suggests that moving to the equivalent of a Third Industrial Revolution might require an investment of 0.6 percent of GDP by 2010-2012, and slowly rising to perhaps just under one percent by

2040.²⁴ As noted earlier in this report, given its aggressive set of efficiency improvements and emissions reductions goals, we estimate an average one percent of GDP over the period 2010 through 2040, or an average €600 million of investment per year to transform the economy.²⁵ At the same time, improving energy efficiency has the potential to reduce the cost of living in Utrecht and, thus, release significant resources back into the local economy for other productive investment. At current energy prices, if Utrecht were to achieve its target of a 30 percent reduction in greenhouse gas emissions, the Province would enjoy an average net energy bill savings of about 1,195 million Euros per year.²⁶ Assuming that these savings were consumed or invested in line with current economic patterns, the energy savings could be expected to generate 250 million Euros of economic growth per year.²⁷ And these savings would be expected to grow over time to as much as 2.5 billion Euros by 2040. In addition, the steady investment in new technologies and regional infrastructure would significantly increase the economic benefits for the Province.

The large volume of buildings in the Province of Utrecht, and the economic and cultural importance attached to maintaining its architectural heritage means that the most significant and the most difficult demand-side carbon savings will come from retrofitting existing buildings. There is technical and economic potential for a large-scale building retrofit within the entire region. But in order to exploit this potential, the Province needs to coordinate action and build capacity. This is also critical as building retrofits can be disruptive—varying from minimal disturbances for minor work, to having to vacate the building for two years during a complete refurbishment. While there are many generic building retrofit measures, each building requires a unique combination of such interventions. Again there are tools available to enable building owners to determine what level of refurbishment is needed and what will be the financial impact.²⁸ (This topic will be further explored in the Buildings as Power Plants section and Decarbonization Planning).

In terms of lighting, the initial cost of investment in new LED technology will inevitably be higher than maintaining the existing infrastructure, but, as can be seen in the Philips

24 Eskeland, Gunnar S., et al. "Transforming the European Energy System," in Mike Hulme and Henry Neufeldt, editors, *Making Climate Change Work for Us: European Perspectives on Adaptation and Mitigation Strategies*, Cambridge, UK: Cambridge University Press, 2010.

25 In constant 2008 Euros

26 John Skip Laitner

27 John Skip Laitner, *ibid*, using economic data for the Netherlands published by the Organisation for Economic Co-operation and Development.

28 See Arup's 'Existing Buildings Survival Strategy' toolkit and associated FIT costing tool.

proposal below, total lifetime cost is less; there is a reduction in both energy consumption and maintenance costs.

PROJECT 1: PHILIPS: CHRISTELIJK COLLEGE (ZEIST)

Philips suggests the Province of Utrecht upgrade its inefficient indoor lighting systems in schools to new lighting solution (T5 28W) with lighting controls. For an example, we will use the Christelijk College Zeist in the province of Utrecht.

Details of the project

The current situation:

Current office luminaire:	2x36W TL-D conventional gear
Lighting specifications:	500 lux (acc EN 12464-1)
Number of square metres classes:	22 classes x 52 m ² = 1.140m ²
Number of installed luminaires:	132 luminaires
Installed power current lighting system:	12kW
Burning hours:	1500 hrs per year

Solution 1:

Change current TL-D 36W with a TL-D Eco 32W. This means a saving of 4W per lamp.

Energy Saving: 10%

CO₂ reduction (0,52 kg/kWh): 0.8 ton of CO₂ per year

Solution 2:

Make use of presence detection with current lighting installation

Energy Saving: 30%

CO₂ reduction (0,52 kg/kWh): 2.5 ton of CO₂ per year

Solution 3:

Change current school luminaire 2x36W/830 TL-D conv. gear into TBS 460 2x28W/830 HFP D8 with presence detection

Energy Saving: 50%

CO₂ reduction (0,52 kg/kWh): 4.1 ton of CO₂ per year

Solution 4:

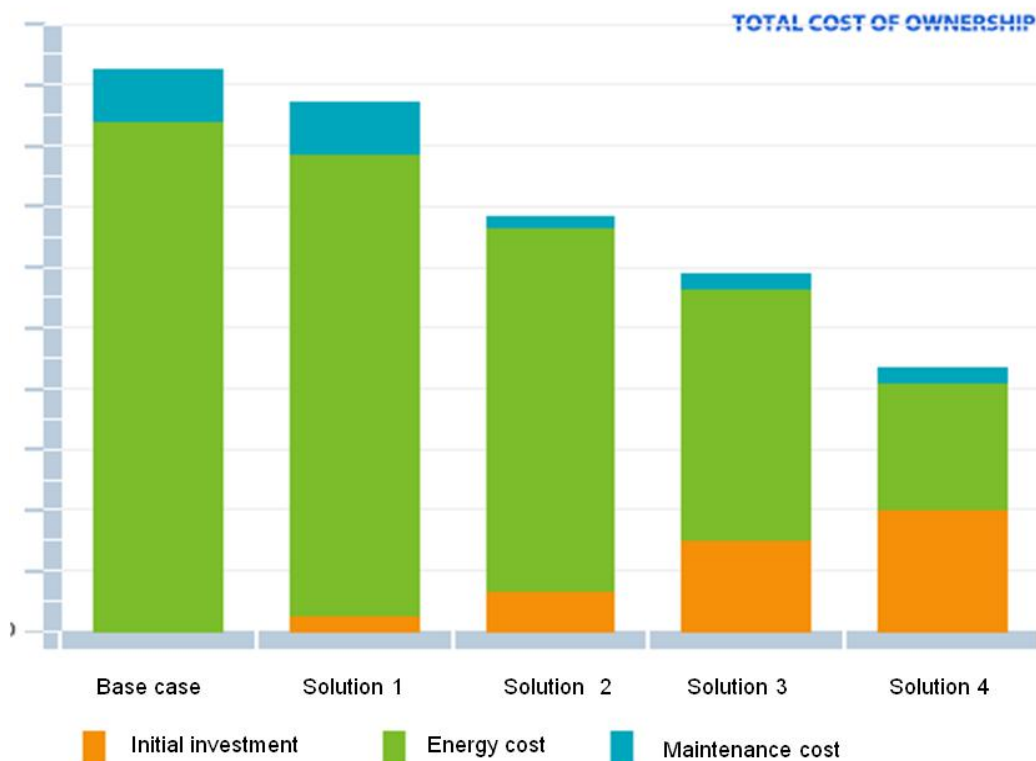
Change current school luminaire 2x36W/830 TL-D conv. gear into TBS 460 2x28W/830 HFD D8 including presence detection and daylight control.

Total burning hours will reduce by 30% due to presence detection, which also has an effect on the maintenance cost. And this means less consumed materials per year.

Daylight control will have an extra 50% energy savings.

Energy Saving: 75%

CO₂ reduction (0,52 kg/kWh): 6.2 ton of CO₂ per year



Opportunities at Scale

This energy savings opportunity is not only applicable for the Christelijk College Zeist, but most of the schools in Utrecht. Several studies in the Netherlands have shown that 70% of all schools have inefficient and outdated lighting. By extrapolating the energy savings opportunity from the Christelijk College Zeist to all schools in the province of Utrecht, the energy savings are enormous.

The 613 elementary schools have approximately 6.130 classrooms, while the high schools have approximately 2.240 classrooms.

In total there are 8.370 classrooms in the province of Utrecht, of which 70% are outdated with inefficient lighting. The energy saving opportunities, then, would be applicable for 5900 classrooms.

Solution 1:

Change current TL-D with a TL-D Eco. This means a savings between 8 and 4W per lamp.

Energy Saving: 10%

CO₂ reduction (0,52 kg/kWh): 219 ton of CO₂ per year

Solution 2:

Make use of presence detection with current lighting installation

Energy Saving: 30%

CO₂ reduction (0,52 kg/kWh): 658 ton of CO₂ per year

Solution 3:

Change current school luminaire with TL-D conv. gear into T5 HFP with presence detection

Energy Saving: 50%

CO₂ reduction (0,52 kg/kWh): 1.097 ton of CO₂ per year

Solution 4:

Change current school luminaire with TL-D conv. gear into T5 HFD including presence detection and daylight control. Total burning hours will reduce by 30% due to presence detection, which also has an effect on the maintenance cost. And this means less consumed materials per year.

Daylight control will have an extra 50% energy savings.

Energy Savings: 75%

CO₂ reduction (0,52 kg/kWh): 1.645 ton of CO₂ per year

Conclusion for the schools in the province Utrecht

An energy savings of 75% can be reached in almost 5900 classes, meaning **1.645 ton of CO₂** per year, by simply changing the lighting installation.

Outside of schools, energy saving with lighting could be applied in the following areas:

Governmental and Provincial office buildings

Hospitals

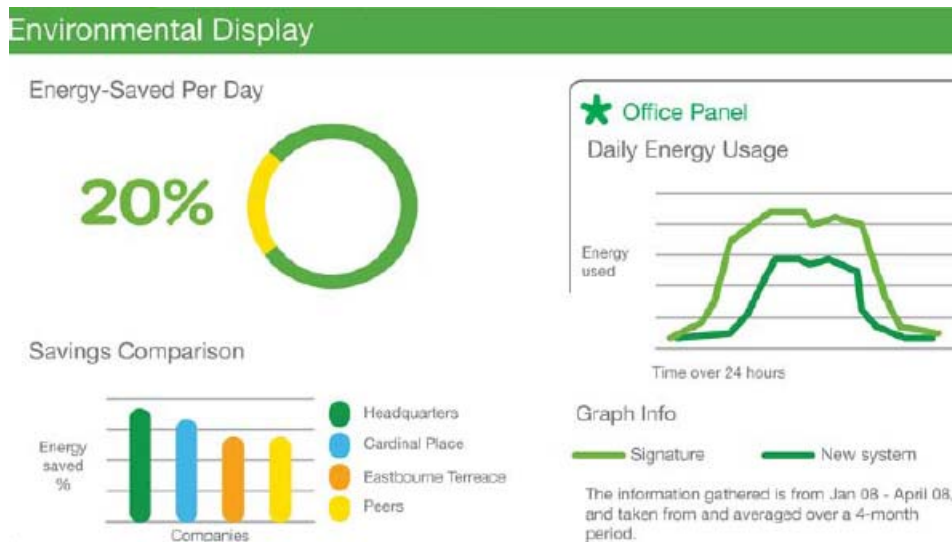
Street Lighting (Provincial and Urban)

PROJECT 2: SCHNEIDER ELECTRIC

Communication:

People must understand that *Energy Efficiency is not something that simply happens ("Save Energy"). It requires action ("Reduce Energy Waste"). In addition, the connection between actions and results must constantly be visible. We recommend using the daily newspaper and the Province's website to show **energy use** vs. **availability** or **emissions** vs. **needed reductions**.* The Province might consider using an energy dashboard (like the one below) to communicate the **need for CO₂ savings** and the **progress** thus far.

Every building's "Energy Signature" should be benchmarked as a quality indicator. The signature should be visible to all and open to bid by companies. This information would also provide the customer with the information on how to improve and by how much.



Example of a dashboard:

Understanding "Why & How"

Kids today understand why the polar bear is suffering. But how many can explain the carbon cycle? How much is one Ton of CO₂?

Schneider Electric has launched the e-learning website Energy University (www.myenergyuniversity.com) to provide the latest information and professional training in Energy Efficiency concepts and best practices. In addition to learning new energy conservation ideas that contribute to the overall well-being of the earth, people

will also become more valuable employees by contributing to the bottom line of their company. Utrecht can start using the Energy University at the Hogeschool van Utrecht and even other academic learning paths to make students more aware and more knowledgeable on this important subject.

The Schneider Electric Energy Edge service helps companies realize the benefits of energy efficiency with minimal risk and a large potential payback. Our proven process, combined with a holistic view of facilities and ongoing proactive measures, gives companies the ability to invest in energy efficiency with a predictable rate of return. Energy Edge addresses all energy consumption in a facility, from the building “envelope” to the internal controls and systems, including lighting, heating, air conditioning, electricity, and water.

By leveraging energy and facilities as investments, companies can gain control of energy use and achieve high rates of return in the form of energy savings. The Internal Rate of Return (IRR) on these projects can be sizeable. In fact, they can be even greater than other corporate investments. When considering the cost of capital, the Modified Internal Rate of Return (MIRR) can be as high as 29 percent. Companies are also eligible for rebates from utility and government programs.

Benefits from this investment approach include double digit energy reductions, as well as improved building performance, worker productivity, and environmental responsibility.

The comprehensive, step-by-step approach of Energy Edge allows executives to make informed decisions about their facilities and energy use. The result converts sunk energy costs into competitive agile assets.

Residential Buildings: Project “Kill a watt”

In 1975 a home used 100 GJ/y; now that number is 50 GJ/y.

Utilities face a growing demand, while managing Production CAPEX to meet the needs. Reduce and shape the demand becomes crucial!

Schneider Electric Home Energy Management solution will be a combination of

- An Active Energy Management solution
 - Providing to consumers a monitoring and on line audit of their energy consumption (Energy cockpit)
 - Giving consumers the means to reduce their consumption by behavior change and active decisions and/or automation

- A Demand/response management
 - With bonus / malus on tariff, hourly energy price to incentivize customers to move a % of his consumption to accurate time frame
 - To allow utilities to adapt the demand in order to
 - Avoid peaks, better use the renewable and distributed energy capacities and reduce the usage of High CO₂ emission production plant
- In-Home Management of distributed power generation

A partnership between Schneider Electric and the utilities will bring the possibility to benchmark, get more awareness and implement active energy efficiency in the homes in the province of Utrecht.

Demonstration project:

Use IKEA to promote energy efficiency, energy savings, and CO₂ conservation as part of a larger program.

People are not aware of the possibilities of energy savings; some are too complex, others are not sufficiently known by the public. To change this, a demonstration project could be placed next to the IKEA. In this house several possible solutions can be shown at the two known directives: passive measures, and active measures.

PILLAR I: RENEWABLE ENERGY

Renewable forms of energy—technologies that draw on solar heat and light, wind resources, hydropower, geothermal energy, ocean waves and biomass fuels—anchor the first of the four pillars of the Third Industrial Revolution.

While these sunrise energies currently account for a small percentage of the global energy mix, they are growing rapidly as governments mandate targets and benchmarks for their widespread introduction into the market and their falling costs make them increasingly competitive. With businesses and homeowners seeking to reduce their carbon footprint and become more energy efficient and independent, billions of Euros of public and private capital are pouring into research, development and market penetration. As these incentives take hold and the market expands, costs of renewable energy technologies will become increasingly competitive.

Pillar One of the Third Industrial Revolution rests upon the concept of distributed renewable energy—using energy as a highly-dispersed and locally-managed resource in contrast to former centralized power sources. Larger systems are managed by large firms and typically are encumbered by complicated regulations. Distributed renewable energy systems provide a broad range of new civic-based market and investment opportunities.

The fact that these systems are dynamic, progressive and cost-effective, as well as readily adapted to a wide variety of economic circumstances, are reasons why more and more business and community leaders are moving towards a Third Industrial Revolution renewable-based economy.

RENEWABLE ENERGY POLICY AND LEGISLATION IN UTRECHT

Before making proposals about the future direction of energy policy in Utrecht, it is important to understand the existing regulatory and legislative landscape. Historically, there have been two main policies that have supported renewable electricity generation in the Netherlands: the Wet Milieukwaliteit Electricityproductie premium (MEP) and The Stimuleringsregeling Duurzame Energie (SDE). In 2003, MEP premium was introduced, awarding a bonus tariff to renewable energy generation on top of the standard retail value of electricity. However, in 2006, when it was apparent that the Netherlands was on course to meet its Kyoto CO₂ targets (a 9% reduction by 2010), the scheme was discontinued.

The SDE regulation was introduced in 2008 and is similar to the MEP—in that it provides an extra premium over the standard export tariff—but it is a fixed contribution, with a

maximum value per year. In addition, projects are awarded on a “first come first served” basis.

Category	Base	Correction	Subsidy period	Full load hours	Subsidy ceiling	Expected capacity
	€/kWh or €/Nm ³		yr	h/yr	Mln €	MW
Wind on-shore	0.118	0.049	15	1,760	1,512	830
Biomass to power (joint ceiling)					550	43-55
Combustion (10-50 MW)	0.115 - 0.156 (0.123) ¹	0.044	12	8,000		
Organic waste digestion	0.129 - 0.149 (0.134) ¹	0.044	12	8,000		
Co-digestion and small-scale combustion	0.152 - 0.177 (0.158) ¹	0.044	12	8,000		
Other digestion	0.158	0.044	12	8,000		
Biomass to bio-methane (joint ceiling)					180	16-22
Organic waste digestion	0.465	0.147	12	8,000		
All other digestion	0.583	0.147	12	8,000		
Solar PV						
0.6 - 15 kWp	0.526	0.202	15	850	62	15
15 kWp - 100 kWp	0.459	0.053	15	850	26	5
Power from wastewater treatment and landfill gas						
	0.059	0.044	12	8,000	7	5
Bio-methane from waste water treatm. and landfill gas						
	0.218	0.147	12	8,000	15	8
Power from waste incinerators						
	0.117 - 0.140 (0.131) ¹	0.092	15	3,840	158	57
Hydro power						
Hight diff. <5 meter	0.125	0.044	15	3,800	60	13
Hight diff. > 5 meter	0.073	0.044	15	3,800	12	7
Wind off-shore ²						
	0.186	0.077	15	2,897	2,645	450

¹: Specific level of support depends on the amount of co-generated heat applied usefully. The number within brackets is a weighed average.

FIGURE 1.2 – SDE PREMIUMS FOR RENEWABLE ELECTRICITY GENERATION

The Province of Utrecht has three levels of targets from which it must adapt its behavior: EU targets, the Netherlands targets, and the Province of Utrecht. The goals of these policies can be summarized in the table below.

REGIONAL TARGETS AND POLICIES

Level of Government	CO ₂ Target (1990 Levels)	Energy Efficiency Target	Renewable Energy Target
Provincial	Climate Neutral	Climate Neutral	Climate Neutral
National	30%	Double	20%
EU	20%	20%	20%

Research undertaken to support this study indicates that the focus for climate change policy in Utrecht has historically been, and remains, solely energy efficiency. This is consistent with prevailing thinking, in that energy efficiency is the most pertinent place to begin reducing the impact of energy use on the environment. London's 2007 Climate Change Action Plan for instance, and all subsequent climate change policies in London, utilize an energy hierarchy of "lean, clean and green" to achieve its CO₂ emission reductions. That is, first reducing energy use through energy efficiency, then supplying energy with more efficient systems, and then, where possible, employing renewable energy technologies.

CURRENT RENEWABLE ENERGY DEPLOYMENT

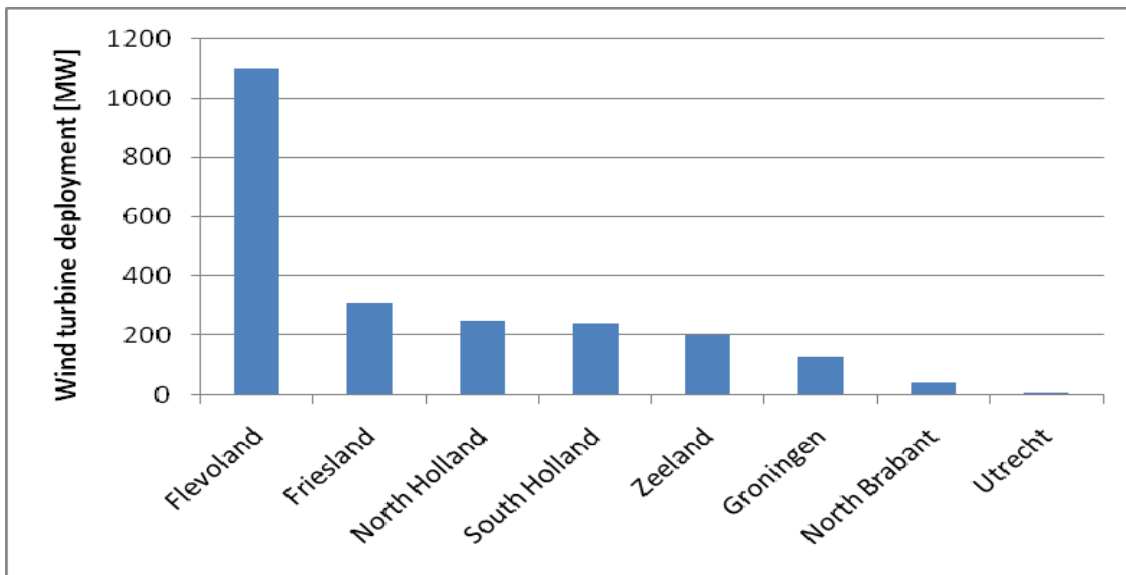
As part of the Third Industrial Revolution Master Plan, we have assessed the current level of renewable energy deployment in Utrecht (as far as the information is available). The aim has been to consider which technologies are prevalent, in what contexts and at what scale. Also, where possible, historic data has been obtained to allow estimation of recent trends, and hence, the current rate of growth.

WIND POWER

As one might imagine, due to the higher wind speeds, the regions in the Netherlands with the highest deployments of wind energy are those on the coast. Utrecht, largely due to its small size and being land-locked, has one of the lowest wind energy deployments in any of the Dutch provinces.²⁹ Existing wind energy generation in Utrecht is 12.12 GWh/yr, which equates to around 5.5MW of generation capacity.³⁰ In 2008, the provinces of Utrecht, Drenthe, Overijssel and Gelderland had a combined deployment of 55MW (or 33 turbines). As low as this may sound, even this was an increase from 2007 (41MW). To give an idea of the necessary magnitude required in order to reach Utrecht's reduction targets, even if this rate of growth were sustained to 2020, the three provinces combined would only generate 200MW of wind power.

²⁹ Renewable Energy in the Netherlands 2008, Statistics Netherlands, The Hague, 2009

³⁰ Information supplied directly by the Province of Utrecht



COMPARISON OF WIND ENERGY CAPACITY IN SELECTION OF DUTCH PROVINCES ³¹

Flevoland, on the other hand, which has limited available coastline, nevertheless enjoys nearly 600 MW of on shore wind capacity – almost 12 times that of Utrecht, Drenthe, and Overijssel combined. Although other provinces have higher wind speeds due to their proximity to the ocean, public opposition to wind turbines may be a large barrier to wind power generation in some provinces.³²

STAND ALONE SOLAR PV

Data has not been located on the current solar PV capacity for the Province of Utrecht. It can be assumed, however, that solar PV in The Netherlands, in general, is largely dominated by building integrated systems. Of those systems not building integrated, 8.7 MW was generated in 2008. It can be inferred that these were mainly stand alone installations—not connected to the national electricity distribution or transmission grids. Given Utrecht's small size and overall energy consumption in proportion to the rest of The Netherlands, it can be assumed that the majority of this energy is generated outside of the Province.

WOODY BIOMASS

Biomass energy use data has not been available for the province of Utrecht. The Netherlands consumed 12,825 TJ of biomass in 2008. However, it is uncertain how much of this was used in Utrecht. Biomass co-firing in fossil fuel plants (wood chip in coal-fired power stations, bio-fuel in gas-fired power plants) have, like most other renewables, followed a growth profile in line with the introduction and removal of MEP,

³¹ Renewable Energy in the Netherlands 2008, Statistics Netherlands, The Hague, 2009

³² Ibid.

and with the introduction of SDE (see Section 1.2.1 for more information). In 2009 co-firing accounted for one sixth of all renewable electricity production in the Netherlands.

HYDRO POWER

There are three hydro power plants in the Netherlands, with a collective power generation capacity of 37 MW. None of these plants are in Utrecht, however, which currently has no hydro power capacity.

LANDFILL BIOGAS

Currently around 670,000 m³ of biogas is generated per year, which would equate to around 4.3 GWh of energy, or around 1.3 GWh of electricity per year. This figure will decrease going forward as the remaining biological material in the landfills is decomposed.

REMAINING TECHNOLOGIES

For the remaining technologies considered in this study, no specific data indicating the level of deployment was found (municipal waste to energy, farm biogas and sewage treatment biogas). Geothermal power is confirmed to have no existing capacity within the province.

METHODOLOGY

This chapter addresses the question of how renewable energy will contribute to the carbon savings targets set by the Province of Utrecht. The methodology for developing scenarios for the future rollout of renewable energy is based on supply constraints rather than demand. In other words, if there is biomass available, it is assumed there is a suitable use for it. It should be noted, however, that the potential for rolling out heat networks to capture the waste heat from biomass Combined Heating and Power (CHP) has not been addressed because of the level of detail required.

This study is aimed at exploring the types of options available to Utrecht in meeting its long term CO₂ emissions reductions targets. In doing so, the approach that has been taken is to identify the maximum resource availability for each of the relevant renewable energy technologies. From this maximum resource, high level assumptions have been made as to the feasible extent to which the resource may be captured. The impact this may have on emissions reductions has then been compared with the targets, allowing a picture to be developed of the technological options available on the scale required. High level indication of the impact such deployments will have, include, for instance, the number of wind turbines required throughout Utrecht or the number of lorries of imported biomass required.

The predicted trajectory for total emissions in the business as usual case and the expected reductions from energy efficiency and renewable energy are included in Figure 1.4. As indicated, of the 4.2 million tCO₂/yr savings required by 2020, 2.2 million are to be delivered through renewable energy. Of the 12.1 million tCO₂/yr reduction required by 2050, close to 6.3 million are assumed to be provided by renewable energy.

Emission reductions associated with transport, hydrogen and smart grids are not in this figure. This is because, in a business as usual scenario, CO₂ emissions savings from transport are set to increase. These can be curtailed through some modal shift and remain constant until 2020, but in reality, have no impact on emissions (see transport section for more information). After 2020, it can be assumed the vehicle fleet will be electrified and shifted to hydrogen (ultimately with all internal combustion engine based vehicles removed from the road by 2050). From this point on, it is largely by virtue of these vehicles being powered by low carbon electricity and hydrogen (fuel generated from renewable energy) that they achieve carbon emission reductions. In essence, then, these reductions only contribute insofar as they make use of renewable energy.

In a similar way, hydrogen and smart grids contribute to carbon savings in as much as they improve energy efficiency or enable greater renewable energy deployment. Therefore, they have not been shown separately in Figure 1.4.

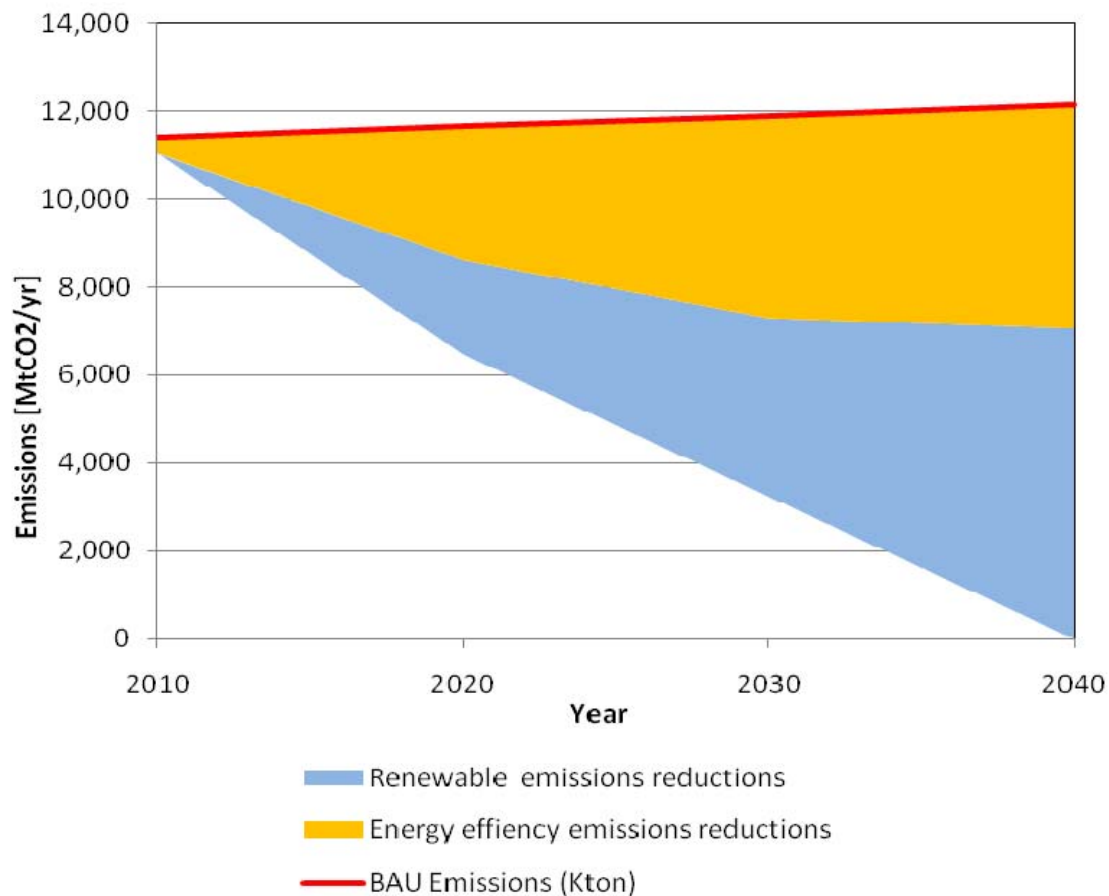


FIGURE 1.4 CARBON EMISSIONS SAVINGS TO BE DELIVERED THROUGH ROLLOUT OF RENEWABLE ENERGY IN UTRECHT.

OPPORTUNITIES IN UTRECHT

This Pillar explores the possibilities for achieving CO₂ emission reductions and driving the transition toward the Third Industrial Revolution through the development of renewable energy. Therefore, only those systems other than BIPV will be considered here. These include:

MEDIUM AND LARGE SCALE WIND POWER (on-shore only as the Province of Utrecht is land locked), typically of at least 10 kW_e generating capacity. This includes smaller scale community-owned wind projects (perhaps single 250kW_e wind turbines) to large scale commercial wind farms (tens of larger turbines in excess of 2.5 MW capacity).

STAND-ALONE PHOTO-VOLTAIC INSTALLATIONS are typically of at least 10 kW_e generating capacity. PV panels generate electricity directly from sunlight via the photoelectric properties of semi conductor materials. It is a well-established, but expensive technology in capital terms.

SOLAR PHOTOVOLTAIC PANEL FARM



BUILDING INTEGRATED PHOTO-VOLTAIC INSTALLATIONS: PV panels can be installed on the roof of buildings, where the conditions are favorable (i.e. orientation, shadowing, etc.)

BIOMASS: CHP/boilers supporting district heat networks supplying multiple buildings. Although such systems supply buildings directly, they are not building integrated due to the need for separate distribution infrastructure.

MUNICIPAL WASTE TO ENERGY, UTILIZING THERMAL PROCESSES: Incineration and advanced technologies such as gasification allow generation of heat and electricity directly from domestic and commercial wastes.

BIOGAS: Waste to energy technologies such as anaerobic digestion.

FARM BIOGAS: Biological waste, such as animal slurry, when combined with bacteria in an oxygen-deprived environment—known as anaerobic digestion—can be used to process green waste and kitchen waste, among others. Bacteria break down waste under conditions of low oxygen. Biogas, a mixture of around 60% methane and 40% carbon dioxide is generated and can be subsequently used in a gas engine to generate electricity.

SEWAGE WORKS BIOGAS: The same process as farm biogas, but using sewage sludge as the fuel source.

LANDFILL BIOGAS: When in the anaerobic environments found within landfill sites, bacteria decompose biological material, releasing methane just as in an anaerobic digestion plant. If captured, this can be combusted to generate heat and electricity. As the biological material degrades, the methane volume vented by the site decreases, until eventually, it will stop all together. This process can last in excess of ten or fifteen years.

HYDRO POWER: The gravitational potential energy contained within water as it drops altitude can be harnessed to generate electricity. This is a very well-established

technology, yet usually requires a varied topology, which is often not present in the Netherlands.

GEOTHERMAL POWER: This refers to the use of high temperature stone heated by the earth's core to raise steam and generate electricity. It is to be distinguished from ground energy storage, which uses the fact that the first 100m or so into the earth's crust remains at a regular temperature throughout the year.

Technologies that have not been included in this Pillar are:

- 1) Gas fired CHP supporting a district heating network. Although low carbon and not building integrated, gas CHP is not a renewable resource. Gas CHP, however, could play a crucial role in preparing for the transition to a renewable energy regime since it allows for the growth of district heating infrastructure, which could then be converted into a renewable (biomass for instance) system at a later date.
- 2) Solar thermal collectors are almost exclusively a building integrated system
- 3) Ground source heat/cooling storage (heat pumps) is almost exclusively a building integrated system.
- 4) Air source heating/cooling (heat pumps) is almost exclusively a building integrated system

DRIVERS OF CHANGE

The key to developing a strategy for renewable energy deployment in Utrecht is an understanding of the drivers for doing so. The key drivers then formulate the criteria against which the proposed strategy can be assessed. This study has identified and described the key drivers. These include:

Environmental	As a member state of the European Union, the Netherlands formally recognises the danger of anthropogenic climate change to this and future generations. Renewable energy generation technologies do not contribute to atmospheric greenhouse gas levels when generating energy. Their deployment will, therefore, lessen the effect energy use has on global warming, and so help avoid the dangers highlighted by the Intergovernmental Panel on Climate Change (IPCC) and the Stern Report.
Commercial	Job creation through growth in green industries. This will increase the attraction to Utrecht, both in terms of businesses looking to be seen as ecologically minded and in terms of

	environmentally conscious tourism.
Security	Over-exposure to energy security risks through dependence on imported fossil fuels is an issue faced by many European countries. The Netherlands has large domestic off-shore natural gas reserves, which have contributed significantly to national revenue and have allowed the Netherlands to avoid the high level of dependence on gas imports seen in countries like Germany. It is therefore expected that there are no urgent problems related to energy security in the short term. However, in the medium to long term, as these reserves are depleted, "the Netherlands recognises the need to stay alert, improve monitoring and to create the necessary instruments to deal with future problems." ³³ Risk arises from over dependence on imports from a small number of fossil fuel producing states. This future risk can be mitigated by diversifying the range of primary energy sources available. Renewable energy, particularly when relying on indigenous sources like wind, waste and domestically sourced biomass, is an ideal alternative to such fossil fuels.
Social	Social factors can include reducing energy poverty, improving awareness of impact on the environment and improving community cohesion through collaborative endeavours. Renewable energy can reduce energy poverty in low income homes by supplying energy at a lower cost than conventional energy sources. Of the 20,000 low income households in Utrecht, most live in rented houses and so do not benefit from national incentives for renewable energy and energy efficiency. It is understood that there is a concern regarding the levels of energy poverty, which is driving projects like the Energy Profit – Action against Fuel Poverty project undertaken in Utrecht in 2008.

RENEWABLE ENERGY ENABLERS

A renewable energy strategy is a plan for taking advantage of enabling influences and removing inhibiting influences to effectively harness renewable energy resources. The potential rate of deployment of renewable energy is governed by a number of key factors. These are to be distinguished from the drivers listed above as they serve to directly enable or inhibit individual projects, whereas the following drivers are what make the deployment of renewable energy in general attractive. Some of these factors

³³ International Energy Agency, In Depth Review: Netherlands, 2008, http://www.iea.org/publications/free_new_Desc.asp?PUBS_ID=2071

are difficult to appraise within the given time frame, and some are technology, location and application specific. For this reason, our appraisals are high-level, particularly for social factors and associated risks.

POLITICAL WILL TO DELIVER RENEWABLE ENERGY AT THE LOCAL AND NATIONAL LEVEL

As set out in the Province of Utrecht's Strategy Working Document, Utrecht2040, it is recognized that "towards 2040 we will be facing the depletion of fossil fuels, climate change and a decrease in biodiversity. This forces us to come up with solutions that are sustainable in the long term."³⁴ Options to help deliver on this include:

- Integrating climate proof spatial planning in development processes
- Developing geothermal power stations
- Putting maximum focus on decentralised energy
- Promoting energy farming, for instance, by CO₂ reduction, CO₂ absorption and energy production

SOCIAL FACTORS

Utrecht 2040 also notes that there may be "decreasing involvement on the part of the community" in Utrecht, as indicated by the "red card" rating given for confidence in politics amongst the population.³⁵ This means that it is considered an area which needs significant improvement to come in line with the Province's desired level. When asked, 31.8% of Utrecht's citizens disagree, to varying levels, that they have a "vast preference for green energy." This was awarded an orange card (below green and gold), and indicates an average level of public support for renewable energy projects, which suggests that while there is still a lot of work to be done in encouraging a more sympathetic view of low carbon energy, there is clearly already some acceptance.

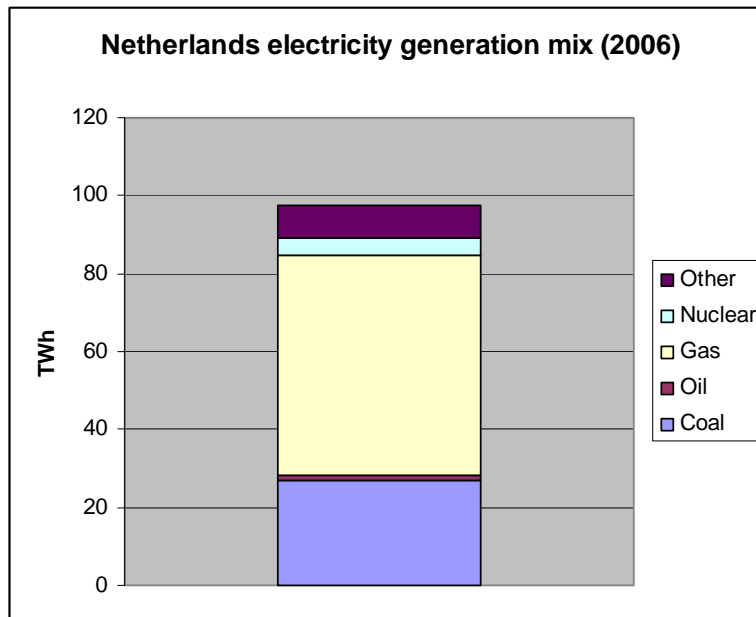
It is important to be conscious of these factors since public opposition to development of renewable energy projects can be one of the main obstacles to deployment. In particular, wind farms and energy from waste plants can receive significant resistance from local residents.

³⁴ Utrecht2040, Joint effort for a sustainable and attractive region, Strategy Working Document, 2009

³⁵ Utrecht2040, Joint effort for a sustainable and attractive region, Strategy Working Document, 2009

EXISTING CONVENTIONAL ENERGY SUPPLY SYSTEMS IN UTRECHT

Electricity generation in the Netherlands is mainly reliant on fossil fuels, with only 4% being produced by nuclear power plants and another 7% produced from “other fuels” (pre-dominantly renewable wind energy). This high dependence on fossil fuels, particularly on coal, results in a grid emission factor of 394 grams of CO₂ per kWh of electricity produced and annual carbon emissions of 10.91 tonnes of CO₂ per capita. Both figures are slightly above the European Union’s average of 354gCO₂/kWh and 8.07 tonnes CO₂/capita respectively.



EXISTING (2006) ELECTRICITY GENERATION MIX OF THE NETHERLANDS (SOURCE: IEA STATISTICS, 2008)

INDICATIVE RENEWABLE ENERGY POTENTIAL

Through consultation with Province of Utrecht authorities, it has been ascertained that work characterizing renewable energy potential is still largely underdeveloped. This is with the exception of biomass, for which an extensive report was undertaken in 2004 by Ecofys.

To give some context to discussions around renewable energy in Utrecht, an assessment has been made of the renewable energy potential for each of the technologies discussed in this chapter. Information has been included in the relevant technology, with estimates as to the maximum feasible resource developed where other data is not available.

WIND POWER

Utrecht is a land-locked province and, therefore, cannot access the considerable off-shore wind resource available in the Netherlands.

The primary factor on which the viability of wind energy depends is the local annual average wind speed. In northern Europe, a commercially viable wind installation must have a minimum wind speed of around 5 m/s (although local regulation and subsidies can affect this broad rule). The average annual wind speed in the Province of Utrecht is 6.1 m/s at 50m above the ground.^{36 & 37}

Within Utrecht, 99,919 hectares of land space is either: not urbanized, in an area of existing nature, a new nature area or a bird habitat and, thus, could theoretically be available for wind turbines. As a very high level first-pass analysis, assuming a wind turbine occupies an area of 10 hectares (2 MW turbines of 80m blade diameter), this indicates a 10 GWe generating capacity. At a wind speed of 6m/s this would result in 20 TWh of electricity generation (or 13 MtonCO₂/yr savings). In reality, this scenario is unachievable, as it would require several thousand turbines. However it does set the context for what is possible.

WOODY BIOMASS

Woody biomass resources can be sourced in one of a number of ways and can be used in a range of different technologies.

The key sources of biomass fuel are:

FORESTRY MAINTENANCE: Managed woodlands abate a greater level of CO₂ than unmanaged woodlands as the rate of wood growth increases if the woods are properly managed. Woodland management can provide wood chips using the whole stem of the tree as well as the branches. A typical yield would be 2.9 oven dried tonnes per hectare. There are 20,214 hectares in the Province of Utrecht.³⁸ It is therefore estimated that there are around 58,600 oven dried tonnes of wood biomass available through forestry residues that would arise from natural forestry maintenance. It is unknown at this stage to what extent this resource is already exploited.

ARBORICULTURAL ARISING: wood waste resulting from tree surgery involves the trimming and cutting of trees not in forests (trees lining streets, in gardens, parks etc). This

36 <http://eosweb.larc.nasa.gov/>

37 (It is important to note that this is a very generic figure, with local topologies having a large impact on wind speeds at specific sites).

38 Koen Rutten, Specialist Informatievoorziening (Geo-informatie), Provincie Utrecht

resource is found in urban locations and is highly variable depending on the density of trees and the different species planted. Arboricultural arisings are difficult to quantify as urban tree density varies significantly from area to area, and to do so would require a specific on-site study.

ENERGY CROPS A very wide range of plant types can be used as energy crops, and, indeed, almost any plant is suitable for energy extraction in some form. A much smaller range of plants, however, can specifically generate *wood* fuel. Most others, especially crops with high sugar content, such as sugar cane, beat, corn and other food crops, can support the production of liquid bio-fuels. Based on data provided by the Utrecht authorities, around 83,550 hectares of land is available for agricultural use. If 10% of this were converted to growing energy crops, at a yield of 12.9 oven dried tonnes per hectare per year³⁹ (assuming willow trees grown with a method called short rotation coppice), this would result in an available resource of 107,800 oven dried tonnes of woody biomass.

The report undertaken by Ecofys in 2004 looked at the available biomass resource in the Province. The results of this study are much more conservative than those indicated in the analysis above. This is largely due to the shorter time frames covered in the study, wider list of constraints considered and a focus on what is achievable in the short term. On the other hand, estimations in this study are designed to calculate a sensible, physical upper limit in order to frame a wider strategic policy debate.

Table 4.1 and Figure 4.3 summarize these findings. It is evident from this work that there is a plentiful biomass supply, as the initial analysis above would also suggest. The report indicates that around 85 ktonCO₂/yr can be saved via the use of biomass sourced within Utrecht for energy generation purposes. While this may sound immense, this is only 2% of the CO₂ reduction required to meet Utrecht's targets in 2020.

39 <http://www.biomassenergycentre.org.uk/portal>

Biomassaastroom	Bio-energie met concurrerende toepassing	Conversie-techniek	Investeringskosten conversie	Huidige verwerkingskosten	CO ₂ reductie	Kansen/belemmeringen
Eenheid	(PJ _{primaire} /jaar)		€/kWe	€/ton	ton CO ₂ /jaar	
Multifunctioneel bos	0.05	Verbranden	€ 3.700/kWe ¹	€34-40/ton ⁵	3,310	Groot potentieel. Barrières: relatief hoge kosten voor transport en verwerking, verondersteld nadelig effect op biodiversiteit en nutriëntenbalans
Landschapselementen	0.03	Verbranden	€ 3.700/kWe ¹	€34-40/ton ⁵	1,655	Aanzienlijk potentieel waarvoor LNV subsidies voorhanden zijn. Relatief hoge kosten voor oogst (handmatig), verwerking en transport.
Groenafval	0.09	Verbranden	€ 3.700/kWe ¹	€20-40/ton ⁶	6,090	Groot potentieel. Gedeeltelijk nodig voor composteringsproces. 26.000 ton direct beschikbaar voor DE doeleinden.
Bouw- en sloophout	0.16	Verbranden	€ 4.000/kWe ¹	€15-25/ton ⁷	10,261	Groot potentieel, maar draagvlak voor verbrandingsinstallatie op bouw- en sloophout is klein. Hoge kosten voor rookgasreiniging.
GFT	0.03	Vergisten	€ 6.000/ kWe ²	€20-40/ton ⁸	1,655	Contracten lopen af dus nu kijken wat kansrijke DE opties zijn.
Biobrandstoffen	0.03	Extractie/fermentatie	n.b.	n.b.	2,251	Kansrijk vanwege technologie push vanuit EU. Barrière: relatief hoge grondprijzen in de provincie.
Mest	0.17	Vergisten	€ 11.000/ kWe ³ € 5.000/ kWe ⁴	€5-15/ton	11,254	Kansrijk in combinatie met co-vergisting.
Roof- en snoeihout fruitteilers	0.09	Verbranden	€ 3.700/kWe ¹	€20-40/ton ⁶	5,627	Kansrijk voor DE opwekking in landbouwsector bijvoorbeeld koudevraag koeling fruitteiler, warmtevraag kassen.
Totaal	0.64				42,103	

¹ Op basis van 1MW_e, voor bouw- en sloophout additionele rookgasreiniging

² Op basis van GFT vergister Lelystad

³ Op basis van ontmantelde mestvergister Denekamp

⁴ Op basis van mestvergister Nij Bosma Zathe

⁵ vergoeding beheerder, inzamelen, chippen, transport [Caron et al., 2003]

⁶ composteren bij een groencomposteerder

⁷ gemiddelde marktprijs voor ontdoeners

⁸ composteren bij een GFT-composteerder

TABLE 4.1 – BIOMASS RESOURCES IN UTRECHT⁴⁰

STAND ALONE SOLAR PV

As with most northern European countries, the solar resource in the Netherlands is moderate. Due to high levels of cloud cover for much of the year and since concentrating solar energy generation systems require direct sunlight, Utrecht is not suitable for the this type of technology deployment. Solar PV panels, however, can make use of diffused light, which is present on a cloudy day.

TABLE 4.3 – AVERAGE DAILY SOLAR INSOLATION PER MONTH FOR UTRECHT (22 YEAR AVERAGE)⁴¹

Monthly Averaged Insolation Incident On A Horizontal Surface (kWh/m ² /day)												
Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ave
0.82	1.48	2.52	3.73	4.91	4.96	4.84	4.3	2.89	1.72	0.95	0.61	2.811

Given the 99,919 hectares of unconstrained land in Utrecht, if 0.1% of this were covered with solar PV panels, this would generate 111 GWh/yr, which would save around 72,000 tCO₂/yr (or 2% of the reductions required to meet Utrecht's 2020 CO₂ reduction target). At today's prices, this would cost somewhere near €700 million, or more than twice the total estimated investment for 2010. (We will further explore the option of using Building Integrated PV in Pillar II).

HYDRO POWER

40 Ecofys, Kansen Voor Bio-Energie in de Province Utrecht, December 2004

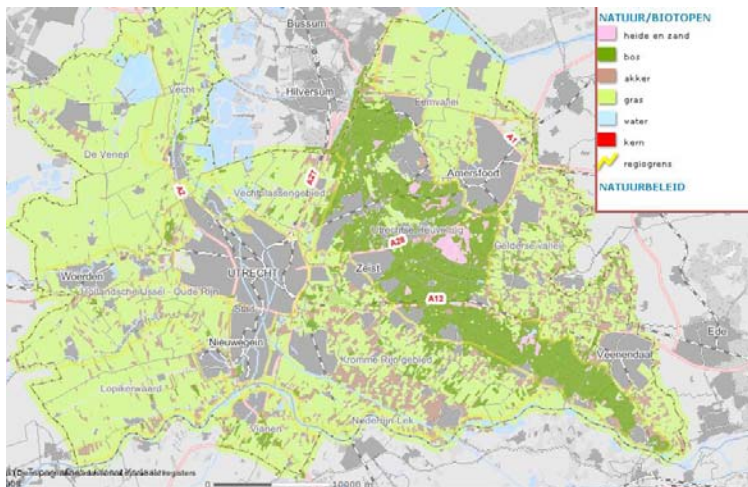
41 <http://eosweb.larc.nasa.gov>

Currently the Netherlands has around 37MW_e of hydro power generation capacity. This contribution originates from century old watermills in Limburg and Twente, to the modern hydroplants in the rivers Rhine and Maas. In particular, the significant plants are:⁴²

- Alphen (14 MW)
- Hagestein (1.8 MW)
- Linne (11.5 MW)
- Maurik (10 MW)

A feasibility study for hydro power in Utrecht is beyond the scope of this study. Hydro power plants can only be applied in specific circumstances, where there is sufficient head in a water course, over a sufficiently short distance and a sufficiently large water flow rate. These parameters can vary significantly, even along a short stretch of river. However, given the presence of hydro in other provinces of the Netherlands, and the presence of a number of rivers and water bodies as indicated in Figure 4.3, there may well be potential for such a scheme in the region. This possibility should be explored further.

FIGURE 4.3 – LAND USE IN THE PROVINCE OF UTRECHT

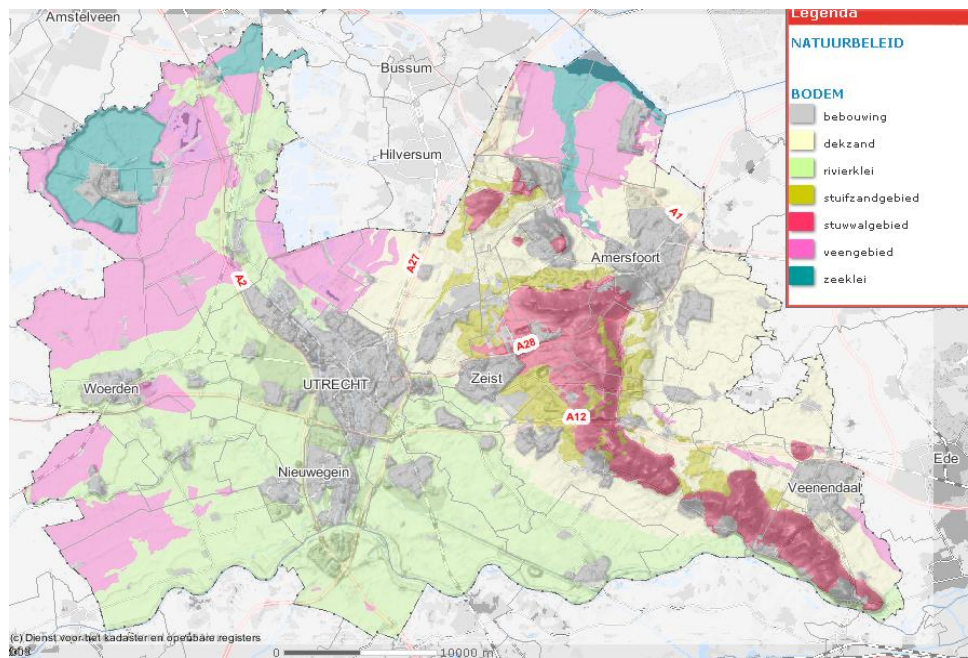


“HOT ROCK” GEOTHERMAL

⁴² http://www.microhydropower.net/nl/index_uk.php

There is no potential for conventional geothermal power generation due to the fact that there are not the required geothermal conditions in Utrecht, as indicated in Figure 4.4. However, it is known that geothermal energy at greater depth (3-4 km) is used in various locations across the Netherlands and could potentially be deployed in the Province of Utrecht too. As deep drilling advances, geothermal technology would become commercially available. Further studies will need to be carried out to assess the viability of this technology.

FIGURE 4.4 - GEOLOGICAL MAP OF UTRECHT



MUNICIPAL WASTE TO ENERGY

The province has a population of 1,180,000, with an average waste generation per person in the Netherlands of around 630 kg/yr. The Netherlands currently has a very high rate of recycling (32%), and only 3% of the waste generated goes into landfills.⁴³ It is therefore assumed that all suitable waste is used for energy generation. This results in 282,000 tonnes of waste available for energy generation per year in Utrecht, which at a calorific value of 9 GJ/tonne, amounts to 190 GWh/yr of electricity. If this electricity were counted as zero carbon, it would achieve a savings of 124 KtonCO₂/yr. This would be an unfair assumption, given the wide-ranging emissions associated with waste incineration, but it is beyond the scope of this study to estimate the specific carbon intensity associated with Utrecht's waste stream.

⁴³ Eurostat news release, Environmental Data Centre on Waste, Municipal Waste, 9th March 2009

LANDFILL BIOGAS

Research undertaken for this study indicates that the landfill biogas resource is already well exploited. Given that this resource is one that is regularly depleting, it is not likely to be a significant contributor to carbon emissions savings in Utrecht. In London, for instance, the Mayor's 2010 Climate Change Mitigation and Energy Strategy estimated that land fill biogas would contribute significantly less than 1% to overall energy consumption.⁴⁴

SEWAGE TREATMENT BIOGAS

DHV studies for the Province of Zuid Holland show a potential for the production of sewage treatment biogas of ca. 40M m³/year. This could be burnt to produce heat and electricity, contributing to carbon emissions reduction. However, given the scarcity and low calorific value of the resource, it has been estimated that the contribution would only be in the order of 53ktonCO₂/year, which represents less than 1% of the current carbon emissions for the Province of Utrecht.

FARM BIOGAS

As discussed above, there is an estimated 83,550 hectares of agricultural land in the province of Utrecht. Accounting for all the animals present in the Netherlands, as reported in "Statistical Yearbook 2009"⁴⁵, the overall electricity that can be generated from this source would only grant a carbon saving of the order of 20ktonCO₂/year. Once this number is reduced to only account for the Province of Utrecht, it is clear that the carbon saving will not represent a major contributor towards the Province's carbon emissions reduction target.

RENEWABLE ENERGY OPTIONS FOR UTRECHT

The objective of this study is to explore the options for how available renewable energy resources can help achieve the carbon emissions reduction targets set by the Province of Utrecht. These scenarios explore the scale of renewable energy deployment required to meet the targets, based on those technologies and applications which may be most suitable for Utrecht. At this stage the scenarios do not in any way constitute recommendations. Developing full proposals for large scale deployment of renewable energy in the province would require further investigative work.

It is clear from the outset that the only two technology options capable of delivering carbon emissions reduction on the scale required to meet Utrecht's medium and long

44 London Climate Change Mitigation and Energy

45 By Statistics Netherlands

term targets are the production of heat and electricity from woody biomass and large scale wind generation. However, this does not mean that other technologies cannot make a valuable contribution.⁴⁶

The key driver for renewable energy in Utrecht is perceived to be CO₂ emissions reduction, but also, in alignment with the Utrecht 2040 mission statement, these reductions must be delivered in a way consistent with the other drivers, so that any new deployment brings economic and social prosperity to the province.

As indicated in the energy efficiency section of this report, 3.04 million tonnes of the required reductions by 2020 will be affected through energy efficiency measures. The remaining 2.1 million tonnes must be delivered through renewable and low carbon energy. Note that energy storage and smart grids, two of the other Pillars of the Third Industrial Revolution model, do not deliver carbon savings in and of themselves, but they enable a greater deployment of renewable energy and energy efficiency measures, as well as prepare for their rapid commercialization. Therefore, these measures have not been directly included in this calculation.

An upper limit for deployment of wind turbines has been specified at 50 MW by the authorities in Utrecht, at least in the short term. This will deliver a CO₂ reduction of around 180 ktonCO₂/yr. It is understood that the main reason for this upper limit is due to political concern around public perception of wind turbines. The remaining savings, then, would have to be met by biomass energy, likely developed along those lines set out in the Ecofys report.

Ground mounted solar energy is not expected to be able to make a significant contribution to Utrecht's long-term carbon savings, although the available opportunities are discussed below.

The following scenarios explore some of the main options available across the medium and long-term for Utrecht. They are not recommendations, but have been formulated to frame the discussion around how Utrecht may need to shift its energy production methods in order to supply its growing population in the coming decades.

46 Please see “methodology” section for a discussion of carbon accounting in this chapter.

SCENARIO 1: WIND EXPANSION MINIMIZED, MAXIMUM BIOMASS DEPLOYMENT

As discussed above, there has been a commitment in Utrecht to develop wind capacity to around 50 MW, which is understood to be a suitable cap on wind deployment for the region. This scenario explores these implications for achieving Utrecht's CO₂ targets. As discussed above, even with a very ambitious solar energy rollout, biomass would be the only significant option remaining. Figure 5.1 indicates the contribution to savings from the different technologies.

There is physically not a large enough biomass resource available within Utrecht to supply the volumes required to meet Utrecht's CO₂ reduction scenario. In fact, even if all agricultural land was converted to grow high yield energy crops by 2020, Utrecht would still need to import 2.9 million tonnes of woody biomass per year. This equates to roughly 120,000 lorries deliveries per year from outside the province (and obviously this would then increase the emissions from transportation).

This raises significant questions around energy security and the sustainability of fuel stock, in that it may be difficult to guarantee both in the long-term. Energy security may be particularly important, given the large dependence that the Province would have on external suppliers of woody biomass.

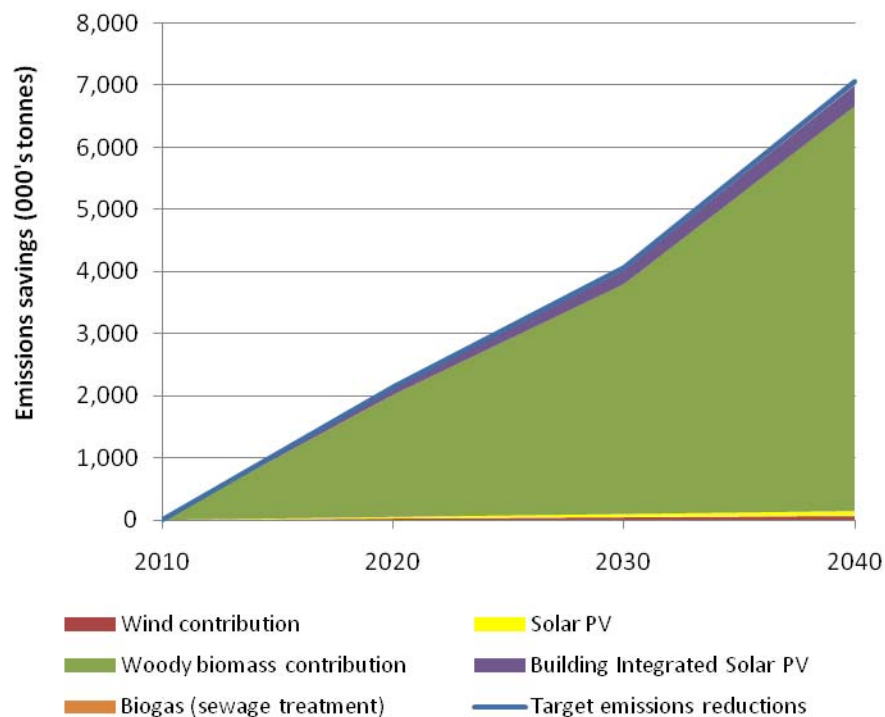
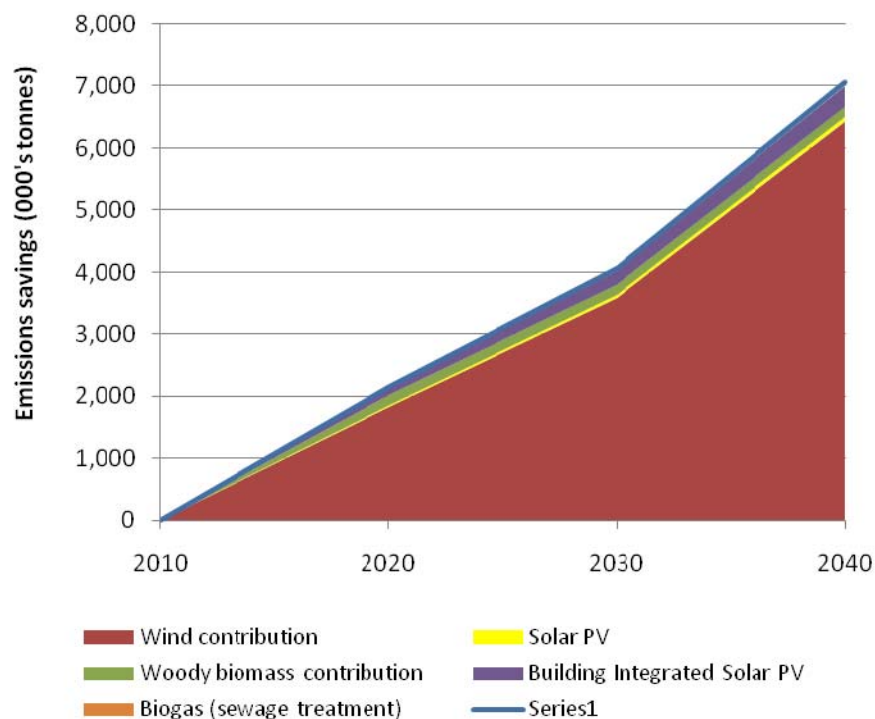


FIGURE 5.1 SCENARIO 1 EMISSIONS REDUCTIONS IN UTRECHT

Scenario 2: 25% of arable land converted to energy crop production, wind supplies the remainder

This scenario explores the possibility of an ambitious program to develop biomass resources internally within the province, combined with a commitment to not rely on external imports. In this case, if all residue from the management of Utrecht's forests was collected and 25% of agricultural land was converted to the production of energy crops by 2020, it still would only contribute 3% towards the 2020 reduction requirements, or 1% toward ensuring a zero carbon Utrecht in 2040.

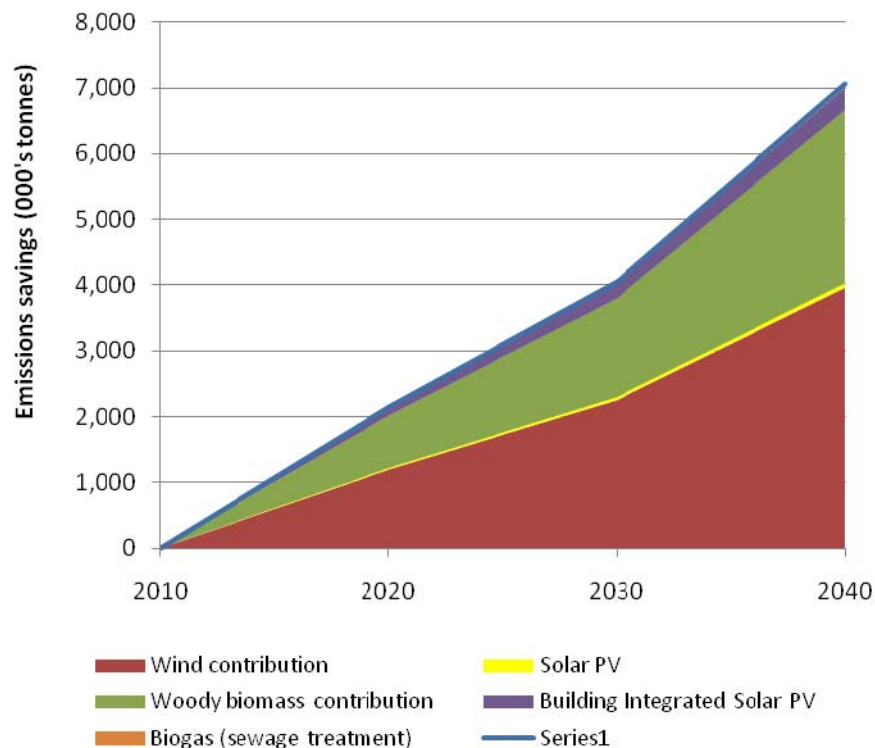
The remaining emissions savings would have to be delivered by solar power and wind. Making the same assumptions regarding solar power as in Scenario 1, this would result in a need for 1,600 large utility scale turbines at 2.5 MW each. Such systems would be up to 80m high. This level of deployment would require around 16,000 hectares of land to include wind farms, which would occupy 11% of all the land in Utrecht.



SCENARIO 2 EMISSIONS REDUCTIONS IN UTRECHT

SCENARIO 3 – 60% WIND AND 40% BIOMASS

In this option, ambitious programs for increased deployment of both wind and biomass are assumed. All forestry residue is collected and 25% of agricultural land is converted to energy crops. This would still require importing around 1.3 million tonnes of biomass per year in 2020, and 4 million by 2040. In addition to this, around 350 wind turbines (900 MW) in 2020 and 1,000 wind turbines (2,500 MW) in 2040 would still be required. This still does not eliminate the energy security risk, but does reduce it relative to Scenario 1.



SCENARIO 3 EMISSIONS REDUCTIONS IN UTRECHT

POTENTIAL DELIVERY OPTIONS

Examples set in other cities looking to reduce their carbon emissions through deployment of renewable energy generation would indicate that there is a wide scope for different programs, policies, legislative mechanisms and other initiatives that would be beneficial to investigate at the regional level. The primary policies, however, such as financial support mechanisms like feed-in tariffs, are usually implemented at the national level. There is, therefore, a constraint on the level of impact local policy can

have in the absence of supportive national measures. Fortunately, some of these measures are already in place in the Netherlands. The key to success will be taking advantage of these and ensuring their benefits are captured for Utrecht.

Planning policy

Discussion with the Province of Utrecht indicates that there are currently no planning policy requirements focused specifically on the rollout of renewable energy. There are three main ways in which such legislation would impact building integrated systems:

New business parks and other developments with large land areas may well be able to accommodate large scale generation systems such as a utility scale wind turbines. It may be beneficial, therefore, to require the exploration of such generation possibilities as a prerequisite for planning and approval of new development. The new developments at Rijnenburg and Soesterberg (7,000 and 400 new homes respectively) may allow for the integration of new renewable energy capacity systems if required by the planning authorities. Given that these developments will represent new demand, it is even more important to offset the CO₂ associated with their energy consumption.

In addition, new buildings also could enable the development and growth of district heat networks (and hence, any associated biomass heat provision) by requiring that all buildings commit to connect to the local heat network now and in the future. This will give investors the confidence that the demand exists and therefore a business case for installing a larger system.

The third option is to require that new developments contribute to a fund for commitment to some renewable energy or carbon savings infrastructure. This would allow for new developments outside the Province to offset carbon emissions when there is no potential for local renewables to contribute to Utrecht's 2020 goals.

Support local green businesses

Supporting local business by offering free or low cost training in renewable energy related skills can encourage business to move into this area. The Province of Utrecht is largely a white collar, service orientated, knowledge-based economy.

Hearts and minds

To encourage support amongst the local population for renewable energy, it may be beneficial to embark on a PR campaign to highlight their benefits. Barcelona, Spain and Freiburg, Germany have implemented such a scheme. It is generally understood that neither of these programs began from a position of mass opposition, but this is not

perceived to be the case in Utrecht either, where, as detailed in Section 4.1.2, around 62% of the population are in principle, in support of sustainable energy.

Renewable energy project funding assistance

The economic and business cases developed around renewable energy projects are often the main determinants of whether investment in renewable energy grows. The high capital costs and wide ranging risk associated with such projects (risks such as uncertain energy prices for competing fossil fuels, uncertain customer bases, uncertain technologies, uncertain renewable fuel prices, etc.) can make investment unattractive. To help reduce this, local government can offer support in the way of financial assistance and partnerships; for instance, by offering initial investment funding for the first high risk stages of a project. For example, London has been awarded money from the European Union JESSICA initiative, to help renewable energy projects get off the ground.

Lobby central government to make required changes

As attempts to promote renewable energy deployment in Utrecht continue, there may be points within national policy that are identified as not supporting Utrecht as desired. If this is the case, the province of Utrecht may need to lobby at the national level in order to influence such policies and legislation.

PROJECTS AND PROGRAMS

The London Plan

In October 2009, the Mayor of London produced a planning strategy for London, which replaced the previous strategic planning guidance for London, issued by the Secretary of State. The London Plan is the name given to the Mayor's spatial development strategy.

Through the London Plan the Mayor will require that local councils and boroughs enforce a presumption that new developments achieve a reduction in carbon dioxide emissions of 20% through onsite renewable energy generation (which can include sources of decentralized renewable energy) unless it can be demonstrated that such a provision is not feasible. This will support the Mayor's Climate Change Mitigation and Energy Strategy and its objectives to increase the proportion of energy generated from renewable sources by:

- requiring the inclusion of renewable energy technology and design, including: biomass fuelled heating, cooling and electricity generating plants, biomass heating, combined heat, power and cooling, communal heating, cooling and

- facilitating and encouraging the use of all forms of renewable energy where appropriate, and giving consideration to the impact of new development on existing renewable energy schemes.

Gigha Renewable Energy

In north Scotland, 150 people who live on the island have formed a limited company with charitable status called Isle of Gigha Charitable Trust (IGHT), a subsidiary of which is Gigha Renewable Energy Ltd (GRE). In 2004, Gigha Renewable Energy managed the installation of three pre-commissioned 225 kilowatt Vestas wind turbines (known locally as the 'Dancing Ladies') and now manages the turbines for the benefit of the whole community. The project has been hailed as Scotland's first community owned, grid-connected wind farm.

The main drivers were to ensure "long-term economic, social and environmental sustainability of community." Many local homes were cold and damp, with no gas mains, so the project aims to improve the cost of heating homes. The project has been a resounding success. £80k of profit is generated per annum, part of which is invested into energy saving measures in homes, thus reducing energy bills.

The project was largely possible due to support from local business and public sector organizations, such as:

- The Highland and Island Enterprise (HIE), which holds shares in the project (£80k equity).
- IGHT also holds shares in the project (£40k equity) and provided £40k loan.
- National Lottery's "fresh futures" scheme provided £50k grant.

Stratford City

Stratford City is the largest retail led, mixed-use urban regeneration project in the UK. Adjacent to the site of the 2012 Olympics, the £4 billion development will provide 1.25 million m² of retail, leisure and entertainment facilities, offices, hotels, housing, community facilities and landscaped public spaces. The utilities and energy sectors have provided technical and commercial advice on the procurement of a 40 year energy services concession agreement for the site with a private sector partner. The ESCo will

partially finance, design, construct and operate an energy center and extensive district heating & cooling networks to supply the entire site. Carbon savings will be achieved through the use of CHP plant and absorption chillers.



THE DOM: IMAGE COURTESY OF PICSDIGGER ⁴⁷

CONCLUSIONS

Utrecht has a clear and immediate opportunity to plant the foundations of Pillar One of the Third Industrial Revolution: renewable energy. There is significant untapped renewable energy potential in Utrecht. In particular, wind power, biomass fired electricity and heat generation represent large potential resources; the only realistic renewable technologies which will allow Utrecht to deliver on its CO₂ emissions reduction targets.

It is clear, however, that these technologies will need to be deployed on a scale much larger than anything currently envisaged by the Province of Utrecht. Also clear is that there are benefits and drawbacks to the large scale deployment of each technology.

Currently, renewable energy deployment in the province is low, much lower than in other areas of the Netherlands. This is potentially due to the fact that there is only moderate support for renewable energy amongst the population, and because most local policy has been focused on energy efficiency improvements. This is the logical way to approach delivering carbon emission reductions and has been adopted in many cities

⁴⁷ <http://picsdigger.com/image/98d31af4/>

around the world, as this report will continually stress. However, meeting the needs of today will not prepare Utrecht for tomorrow. It is common for strong energy efficiency policies to be accompanied by parallel policies encouraging the growth of low and zero carbon power generation.

The question for Utrecht is one of economic competitiveness. Lacking these essential policies may encourage developers to focus on other provinces. This is especially true due to the existing “first come first served” nature of the SDE feed in tariff system. It is clear that there is great potential for growth in renewable energy generation in Utrecht, but also that significant changes are required in order to encourage and facilitate the realization of this potential.

PROJECT 3: NORDEX (PLEASE SEE COMPANY RECOMMENDATIONS)

PROJECT 4: WEKA DAKSYSTEMEN BV (PLEASE SEE COMPANY
RECOMMENDATIONS)

PILLAR II: BUILDINGS AS POWER PLANTS

While renewable energy is found everywhere and new technologies are allowing us to harness it more cheaply and efficiently, we still need infrastructure to load it. This is where the building industry steps to the fore, to lay down the Second Pillar of the Third Industrial Revolution. Within the European Union, buildings account for 40 percent of all the energy produced and are responsible for equal percentages of CO₂ emissions.⁴⁸

For the first time, new technological breakthroughs make it possible to renovate existing buildings and design and construct new buildings that create some, or even all, of their own energy from locally available renewable energy sources, allowing us to reconceptualize buildings as “power plants.” The economic implications are vast and far reaching for the real estate industry and, for that matter, the world.

Over the next 25 years, thousands of buildings — homes, offices, shopping malls, and industrial and technology parks — across Europe will be converted or constructed to serve as both “power plants” and habitats. These buildings will collect and generate energy locally from the sun, wind, waste, and geothermal heat to provide for their own power needs and even surplus energy that can be shared on the grid.

A new generation of commercial and residential “buildings as power plants” is going up now. In the United States, Frito-Lay is retooling its Casa Grande plant, running it primarily on renewable energy and recycled water. The concept is called “net-zero.” The factory will generate virtually all of its energy on-site by installing solar roofs and by recycling the waste from its production processes and converting it into energy. In France, Bouygues is taking the process a step further, putting up a state of the art commercial office complex this year in the Paris suburbs that collects enough solar energy to provide for all of its own needs, while also generating surplus energy.

The creation of a network of distributed power plants made up of buildings could also help maintain a stable and reliable electricity grid. If these buildings are energy efficient and can create more energy than is consumed at certain times of the day or week, then the excess energy can be stored or transmitted to nearby neighbors.

Due to the inefficiencies of centrally generated electricity, the energy used in a home or business today is only a fraction of the energy that has been used to deliver the electricity to the consumer. One particular benefit to locally sited renewable energy

⁴⁸ Presentation by Acciona to Third Industrial Age workshop, Monaco

infrastructure and low-carbon forms of energy generation is that these heat and transmission losses are virtually eradicated.

A DECARBONIZATION PLAN FOR UTRECHT

For the first time in human history, more of the world's population lives in urban centers than rural areas, a trend showing no sign of diminishing. This urban migration represents a tremendous global opportunity; yet, existing models of urban design are proving to be an anachronism. Energy, water, waste, social and other essential infrastructures are struggling to keep pace with the rate and magnitude of this change. A new approach to urban design is required to address these issues that features unprecedented speed with access to vast stores of information, and that is both adaptable and accountable through continual monitoring.



ENERGY DEMAND OF EUROPEAN CITIES

The city is a living organism, constantly evolving with the repositioning of existing buildings and land use alterations and growing as new development is brought online.

Demographic indicators such as immigration and birth rates suggest that over the next several decades, Utrecht will play an even greater role on the demand side of the nation's energy equation. It is therefore critical that legislation governing land use and urban development be reviewed within the context of a future carbon-constrained economy.

Population	2010	2015	% groei 2010-15	2030	% groei 2015-30	2040	% groei 2030-40	% groei 2010-40
Nederland	16.536.250	16.779.067	1.5%	17.380.280	3.6%	17.473.817	0.5%	5.7%
POU	1.225.712	1.261.824	2.9%	1.350.254	7.0%	1.413.142	4.7%	15.3%
SG Utrecht	611.547	639.885	4.6%	707.748	10.6%	752.335	6.3%	23.0%
SG A'foort	278.642	287.161	3.1%	301.176	4.9%	312.908	3.9%	12.3%
CR G&V	242.574	243.936	0.6%	249.137	2.1%	252.992	1.5%	4.3%
NV Utrecht	1.132.763	1.170.982	3.4%	1.258.061	7.4%	1.318.235	4.8%	16.4%
SG A'dam	1.507.600	1.570.134	4,1%	1.695.190	8,0%	1.721.569	1,6%	14,2%
SG DH	1.015.923	1.070.870	5,4%	1.108.803	3,5%	1.151.474	3,8%	13,3%
SG R'dam	1.172.467	1.193.001	1,8%	1.239.246	3,9%	1.242.771	0,3%	6,0%

In contrast to a traditional approach to planning, which culminates in the delivery of a static document, fixed in time, a carbon conscious approach to planning is dynamic and flexible in light of an ever evolving urban context. Utilizing a parametric data model, a decarbonization plan for Utrecht would provide value by:

- Aggregating carbon emissions from a comprehensive set of end uses and readily allowing for benchmarking and statistical comparison of similar consumers, such as buildings, to rank opportunities for carbon abatement
- Tracking the success of carbon emission reduction initiatives and projecting the efficacy of possible future approaches to reduce aggregate carbon emissions

- Reducing carbon abatement costs through multi-objective optimization of specific strategies and policy instruments
- Educating the populace on the decarbonization planning initiatives and communicating progress



DECARBONIZATION PARAMETRIC MODEL OF CHICAGO DEVELOPED BY AS+GG AND PEPRACTICE

DECARBONIZATION PLANNING ELEMENTS:

The Utrecht Decarbonization planning effort is a novel approach for the design and planning of districts, institutions, cities and entire regions. By quantifying and monetizing the relationship between how we build things and total energy costs, decarbonization modeling allows leaders and key stakeholders to prioritize initiatives, project future environmental and economic costs, and strategically increase the livability of the study region.

The Utrecht Decarbonization plan also seeks to bridge the divide between centralized planning and a more organic, democratic approach to urban growth. Disregard for the finite supply of traditional energy sources, the associated external environmental costs from consumption of that energy, and dramatically escalating demand from emerging markets poses significant risk to the global economic system: a systemic risk, for which we are all stakeholders. Through the lens of climate change and energy security, Decarbonization planning utilizes an open source information and collaboration platform that enables citizens and business to visualize the collective results of their actions. Just as cities provide a framework of services to improve the quality of life for residents and businesses; this urban operating system is a framework for behavior change marketing and public consensus building for planned development.

DECARBONIZATION PLAN VALUE TO UTRECHT:

The province of Utrecht is committed to reducing their total regional greenhouse gas emissions by 20% from 1990 levels by the year 2020. This reduction will be accomplished by a number of strategies including energy efficiency improvements, renewable energy and other clean energy technologies. Based upon data provided by the province and coordination with the other supporting pillars of the Third Industrial Revolution, it is anticipated that approximately 1100 kTon CO₂e, or approximately 28% of the total necessary reduction can be accomplished through building retrofit. Building retrofit includes envelope improvements, heating and cooling system upgrades, lighting upgrades, high efficiency appliance and equipment replacement, and enhanced building energy management systems. Energy efficiency is critical to enabling buildings to serve as power plants, allowing a greater proportion of energy to be fed into the grid rather than meeting the demands of the building.

An additional 700 kTon CO₂e (16%) or more may be accomplished through distributed combined heat and power generation, including integrated wind and photovoltaic energy. Roof mounted photovoltaic systems provide the greatest opportunity for carbon reduction for the city of Utrecht. Easily mounted discretely on roof tops, the electrical system can be easily integrated with the existing building infrastructure allowing buildings to become distributed power sources supporting the city. Combining this renewable energy integration strategy with roof insulation improvements can allow the city to quickly and dramatically reduce carbon emissions.

Utrecht has approximately 56,000,000 m² of total roof area, half of which is low rise housing. If 25% of the low rise housing roof area was dedicated to PV it would save approximately 210 kTons of CO₂. If 50% of the Utility-building roof area (30% of the total roof area) was dedicated to PV it would save approximately 252 kTons of CO₂. Assuming 25% of the remaining roof area on the rest of the buildings was integrated with PV, 74 kTons of CO₂ would be reduced. The total CO₂ savings associated with BIPV is therefore estimated at 536 kTons or 14% of the target CO₂ savings.

The remaining carbon savings associated with renewables are a result of waste heat from onsite power generation from natural gas, biogas or hydrogen that can be reclaimed to provide heat, domestic hot water or even cooling through an absorption process. Finally, for a total reduction of 48% from the buildings pillar, a 7% reduction is anticipated from behavioral adjustment through smart metering and intelligent controls.

The contribution of these various strategies is based on previous assessments for other cities such as Chicago and university campuses. Undoubtedly there will be some exchange between these categories as well as with the renewable energy and hydrogen pillars with respect to their overall contribution. The value of the decarbonization plan will be to prioritize investment, identify the specific projects for which this investment should be directed and actively track how this distribution changes through time.

DECARBONIZATION PLANNING SCOPE:

The Utrecht Decarbonization plan directly links land use and essential infrastructure planning through a climate change thematic integrator. Based upon the goals of the city, it is possible to concurrently evaluate the reduction of carbon emissions and cost savings realized by the plan with traditional planning metrics, considering nine areas of scope from the perspective of the second pillar of the Third Industrial Revolution: Buildings as Positive Power Plants.

Building Performance:

Responsible for the largest fraction of energy consumption and associated carbon emissions in the developed world, upgrading standards for new and existing buildings is an appreciably cost effective way of reducing carbon emissions. Establishing a localized framework for calculation and monitoring integrated performance of buildings is essential. A decarbonization plan establishes minimum energy standards for new and existing buildings, an energy certification process and a platform for accountability and adaptability.



Land Use: Seeking to minimize the aggregate environmental cost of buildings, transit oriented land use patterns which support density can reduce redundancy in programs such as retail and other amenities. Moreover, unrestrained development can inhibit the effectiveness of policy and investment in public transportation. Proper planning can prevent extensive road investment associated with urban sprawl and decentralization.

The Utrecht decarbonization plan considers the feedback between planning, buildings and mobility.



Mobility: Having a direct impact on local air quality and carbon emissions, development of a clean mobility framework is a critical aspect to decarbonization planning. The Utrecht decarbonization plan takes a building centric approach to mobility, associating commuter emissions with the corresponding structure or development. Energy storage and generation capabilities for future vehicles and mobility vectors and the interface of this motive infrastructure with buildings as a power plants, is also considered.



Smart Infrastructure: Computing has become ubiquitous, as scheduled interactions with programmed databases via desktop machines have given way to continually connected mobile devices for dynamic sharing and collaboration through social networks. The city is therefore emerging as a bifurcation of its previous self, the historic physical layer now joined by a new virtual layer. Beyond Twitter and Facebook, this virtual layer would allow the city to reach unprecedented levels of environmental efficiency: optimizing energy performance of building systems, identifying routes and modes of transportation and tracking resource flows such as water and waste. The decarbonization plan

establishes a framework for the development of the necessary physical and virtual infrastructure.



Energy: The virtual city layer is also an enabler of distributed clean energy generation, as a multitude of decentralized energy sources can be effectively managed and balanced against demand. Buildings are an excellent platform for distributed power through micro-generation and renewable energy. Buildings can provide the necessary electrical, communications and physical infrastructure for deployment. Development of an Energy framework within the Utrecht decarbonization plan must consider future planning, as energy, water and waste characteristics of the city continually evolve.



Water: Water quality, while essential to all cities is of particular significance to Utrecht considering its canal system and its potential impact on local environmental quality. Water treatment and distribution methods also play a role in aggregate carbon emissions for the city. Decentralized water treatment at the building or district level is an emerging trend throughout the world; in many ways, it is analogous to developments in distributed energy. The Utrecht decarbonization plan considers the implications of this trend on infrastructure costs and environmental impact.



Waste: Inefficient management of resources leads to waste, something that can be reduced through good design. On the supply-side of production, a framework for building design standards that reduce waste in construction can also significantly reduce upfront cost to the developer. The majority of waste for a city such as Chicago comes from construction, as the city is continually renewing itself. Strategies used by firms such as 2012 Architekten to track and minimize these flows are essential to future building design, increasing the economic viability of buildings as power plants. With the potential for waste minimized, appropriate measures are proposed to establish demand for reused and recycled products through legislation and marketing.



Ecosystem Services: The natural infrastructure inherent to healthy ecosystems can provide a full suite of services that may offset engineered infrastructure at little to no cost, while benefiting human livelihood. Services can include water treatment, decomposition of wastes and natural carbon sequestration through vegetative growth while benefits include natural habitat, scenic beauty and increased property value. A decarbonization plan seeks harmony between the built and natural environment, through a pragmatic approach of market-based conservation and stewardship.



Community Engagement: Participation in the activities of the community enhances shared feelings of citizenship, pride and can build consensus for future development plans. The expansion of social networks with new technologies enhances both the identification and interaction of citizens on multiple levels, including energy and environmental management. A decarbonization plan establishes an approach for community engagement to initiate and continue the plan into the future.



PLANNING AND FIRST STEPS:

As Decarbonization planning is a new approach for the design and planning of cities, it is recommended that a pilot area be identified prior to a city or regional rollout for value demonstration. Performance improvements to the city core would requisitely be low intrusion, high impact, such as those associated with smart infrastructure; while, new developments could feature elements from all nine areas of scope. It is therefore recommended that a new development be considered, with an assessment of the expandability of specific strategies generated throughout the exercise to the existing built environment. Two specific developments have been highlighted through discussions with city officials: Rijnenburg, a development of around 7,000 homes with a

specific interest towards sustainable development; and Soesterberg, a development of around 400 homes, equally interested in sustainability.

		2010-2015	2015-2020	2020-2030	2010-2020	2010-2030	2015-2030
1	Regio Utrecht	20000 **)	16400	20600	36400	57000	37000
2	Regio Amersfoort	7500 **)	7000	5200	14500	19700	12200
3	Utrecht-Zuidoost en -West	7000	7500	7500	14500	22000	15000
4	Provincie Utrecht	34500	30900	33300	65400	98700	64200
6	Gewest Gooi en Vecht		3000	1500			4500
6	Almere						15000
	Noordvleugel Utrecht (rijen 1, 2, 5, 6)		26400	27300			68700

HOUSING GROWTH PROJECTIONS: PROVINCE OF UTRECHT

Perhaps in coordination with the KIC CarboCount project, which aims to “develop instruments and devices to measure and verify CO₂ emissions at as low as the individual business level, the municipal level and ultimately the global level,” we propose an even more inclusive team consisting of representatives from the local government, Utrecht University, private development and industry and firms such as PostivEnergy Practice LLC and Adrian Smith + Gordon Gill Architecture to lead a community-wide effort to establish appropriate metrics for performance measurement, assess baseline conditions and appropriate targets, simulate projected development scenarios with respect to those targets, and, ultimately to implement and monitor performance.

INTEGRATION OF SPECIFIC PROJECT PROPOSALS:

Design is the seamless integration of utility and significance. Integrating the relevant Third Industrial Revolution CEO Roundtable participants, a Decarbonization plan synthesizes a multitude of individual schemes into a strategic framework. Specific technologies put forth by experts ranging from the American Council for Energy Efficient Economy, Schneider Electric, Philips Lighting, Q-Cells, Hydrogenics, CISCO Systems and Utrecht University will be considered in concert with strategies by 2012 Architecten, Cloud-9 and other consultancies.

With a Decarbonization plan, the region can maximize the positive return from investment by aligning resources, project type and location so that they may reinforce

each other. The plan also considers appropriate phasing of proposals, as Utrecht transitions into a vibrant low-carbon economic future.

Step 1:

Technology is only as effective as its implementation and thus community engagement is essential to the success of the Utrecht Decarbonization Plan. It is proposed that an energy framework be established which would specifically define an approach to analyzing a new development, such as those mentioned previously. This framework would include an approach to establishing the baseline conditions, environmental targets and a mechanism for continual monitoring and feedback. The development of this framework would be done in collaboration with professors and graduate students from Utrecht University.

Step 2:

Energy audits could be carried out by students, and the data could be entered into a web-enabled portal. The portal could include a virtual representation of the city, where users can visualize alternate low-carbon realities for Utrecht through simulation of strategy and policy. Information would be kept anonymous and confidential unless otherwise granted. Comparison of specific individual's performance with the distribution of their larger "energy peer group" could enable savings from behavioral change and help develop a large retrofit market in Utrecht.

Companies could also connect with consumers, giving rise to an online marketplace where companies bid on projects posted by individual residents, business, or associations. Not only would this help address a currently complicated regulatory process, but it might also help overcome communication problems and economies of scale- often associated with the unexploited retrofit market. Consequently, this tool could also be applied to renewable energy, hydrogen or smart grid technologies.

Just as cities provide a framework of services to improve the quality of life for residents and businesses, the region must come up with a comprehensive plan to serve as a virtual framework or urban operating system to improve efficiency and performance. By tracking and aggregating the environmental impact of the city, leaders and the greater populace are enabled by information to make the right decisions and to reduce cost while minimizing harmful impact on the planet.

PROJECT 5: ADRIAN SMITH GORDON GILL ARCHITECTURE (PLEASE SEE
COMPANY RECOMMENDATIONS)

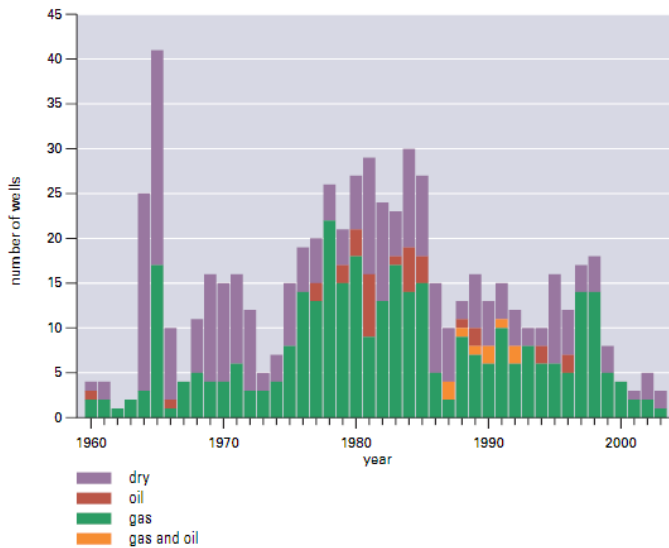
PROJECT 6: 2012 ARCHITECTEN (PLEASE SEE COMPANY
RECOMMENDATIONS)

PILLAR III: HYDROGEN AND ENERGY STORAGE

The introduction of the first two pillars of the Third Industrial Revolution – renewable energy and “buildings as power plants” – requires the simultaneous introduction of the third pillar, storage capacity. After all, what happens if the sun is not shining, the wind is not blowing, and water is not flowing for days, weeks, or even months? When energy is not available, electricity cannot be generated and economic activity grinds to a halt.

To maximize renewable energy and minimize cost, it will be necessary to develop storage methods that facilitate the conversion of intermittent supplies of energy sources into reliable assets. In addition, when significant amounts of renewable energy are present on the grid, an increased number of power generators are needed on standby to handle large power fluctuations. At penetration levels greater than 20-25%, most grids start to hit the limits of their ability to handle these fluctuations. To move beyond those limits, energy storage is a necessity.

On the other hand, if one could store large quantities of energy and provide a means to balance load and power, the need for grid stabilization services would be better met and there would be greater capacity to take on more renewable energy. The graph below depicts peak oil and gas in the Netherlands, or what is otherwise known as the “simultaneity problem,” since electricity generated must be simultaneously dispatched to customers. Storage, when paired with renewable energy, not only adds value to the generation source, but could potentially even eliminate the need for expensive, GHG emitting standby generation.



PEAK OIL AND GAS IN THE NETHERLANDS (PROVIDED BY HYDROGENICS)

There are many storage options to consider, including: pumped hydro storage, compressed air energy storage (CAES), lead-acid batteries, lithium-ion batteries, and hydrogen. Today the most popular form of energy storage for utility companies is pumped hydro. This simple storage method involves pumping water to a high elevation. When it is released, it flows downhill and drives a hydroelectric turbine.

If the topography is available, pumped hydro can be a relatively efficient method of storage with short discharge times. On the other hand, this storage form is limited by stringent requirements for excess energy, a plentiful water supply, and variable topography. In addition, storage plants are characterized by long construction times.

Another technology for utility-scale energy storage is Compressed Air Energy Storage (CAES). Such a system pumps air where it is stored until needed. Upon release, the system mixes the high velocity air with natural gas and it co-fires this as a clean fuel in a regular natural gas combustion turbine—using 30 to 40% of the natural gas compared to a regular turbine.

At present, there are only two CAES plants worldwide, one in Germany and the other operated by the PowerSouth Energy Cooperative in McIntosh, Alabama. PowerSouth pumps the compressed air into a 19 million-cubic-foot underground cavern. While CAES energy storage is not reliant on water and nearby high elevations like pumped hydro, it does require the presence of a hydrocarbon-based fuel in order to be co-fired, and therefore, has a somewhat higher level of greenhouse gas emissions. Both CAES and pumped hydro energy storage technologies are large and expensive systems, and thus, are mostly restricted to centralized utility-scale applications.

Another energy storage option is using batteries. Commercially available from manufacturers all over the world, there have been recent experiments with large-scale (10kW to 50 MW) battery systems. As battery technologies have been around for years and since people are generally much more familiar with these technologies, batteries are currently considered the “low cost” storage solution.

However, battery storage systems are not without their limits. Although batteries are commercially viable, the large, stationary applications are usually not. This is due, in part to the fact that batteries of one cell type or those with certain chemical combinations are not produced in fully automated production lines, and thus, cannot reach economies of scale. In addition, batteries have relatively short life spans. Ultimately, the goal of sustainable planning is to reduce waste and increase efficiency. Batteries, on the other hand, are largely composed of nonrenewable materials, and thus, also face the problem of disposal.

There is one storage medium, however, that is widely available, capable of a vast number of uses, and is environmentally friendly. Hydrogen is a universal medium that “stores” all forms of renewable energy to assure that a stable and reliable energy supply is available for power generation and transport. Our spaceships have been powered by high-tech hydrogen fuel cells for more than 40 years. It is the lightest and most abundant element in the universe and, when used as an energy source, the only by-products are pure water and heat.

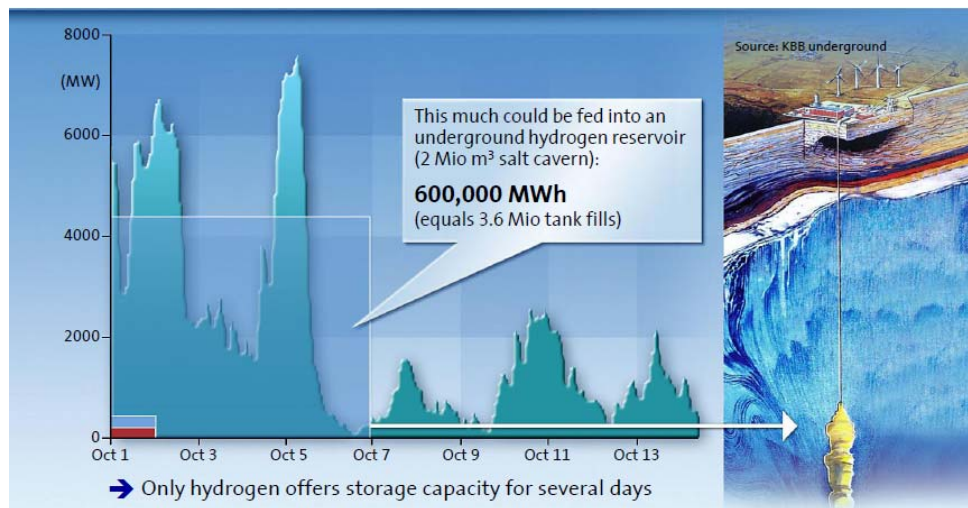
Here is how hydrogen works: Renewable sources of energy — solar, wind power, hydropower, geothermal power, and ocean waves —are used to produce electricity. That electricity, in turn, can be used through a process called electrolysis, to split water into hydrogen and oxygen. Hydrogen can also be extracted directly from energy crops, animal and forestry waste, and organic garbage —biomass—without going through the electrolysis process.

There are a large number of options to store hydrogen gas at a variety of pressures for very low incremental cost compared to more traditional electrical energy storage devices such as batteries. Hydrogen’s real value, however, is its ubiquitous, universal nature. Hydrogen can easily be obtained and used in a number of industrial processes, and it can be used in a variety of applications—including compression and storage like those in CAES systems.

The diagram below depicts comparisons for energy storage systems. The small blue rectangle in the lower left hand corner is the amount of energy produced from one of the largest and most advanced pumped hydro systems in the world. The total capacity,

however, is somewhere near 8,000 MWh (the equivalent of providing enough energy to power 1,000 electric drive vehicles). The smaller red square within the light blue rectangle shows the potential of a two million cubic meter CAES system within a salt cavern (4,000 MWh, or the equivalent of providing enough energy for 500 electric drive vehicles). These can both be compared to a hydrogen reservoir, the large light blue translucent square engulfing both smaller rectangles. Although the space requirements are the same as the CAES system (2 million cubic meters), the hydrogen solution delivers 150 times the power.

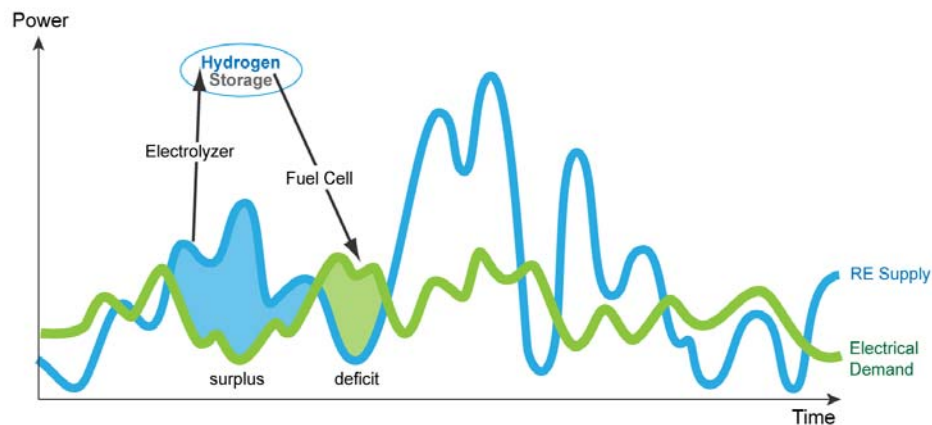
DARYL WILSON HYDROGENICS PRESENTATION (ORIGINAL SLIDE GENERAL MOTORS)



Combining renewable energy potential with hydrogen also unveils new market opportunities through ancillary services or demand response and load control (as opposed to the more expensive option of ramping up power generation from standby mode). Renewable energy can produce electricity to split water into hydrogen and oxygen via a process called electrolysis. In addition, a machine known as an electrolyzer can be turned on and off very rapidly, or be used to follow a power signal; thus, allowing it to be used for grid stabilization. In this scenario, hydrogen generation is the by-product of grid stabilization.

Using hydrogen as an energy storage and transmission media in this way has an additional economic benefit. Combining wind or solar generation assets with hydrogen

provides a more efficient way of developing electricity than more conventional forms of power generation. Many generation methods operate in a steady state fashion, often referred to as “baseload power.” The drawback to these assets is that they don’t respond to load demand very well. In other words, they continue to produce the same amount of power whether the grid demands it or not. But, as can be seen from the diagram below, by coupling renewable energy with hydrogen storage, one cannot only handle the intermittency of the renewable power source, but also provide a means to match the load demand moving up and down over the course of the day. This can prove to be a more effective use of power generation since there is no wasted power. A renewable energy/hydrogen plant, sized to meet a typical load profile may actually be less expensive, on a capital cost basis, than some large-scale conventional baseload power plants.



SUPPLY AND DEMAND- HYDROGEN SOLUTION (HYDROGENICS)

Additionally, plug in hybrids and battery electric vehicles are the first step in the electrification of transportation. These vehicles will place more demand, constraint, and variability on an already antiquated, overloaded electricity grid system. Hydrogen, however, offers far greater potential than batteries in transport applications as it has larger onboard energy storage capacity. For this reason, hydrogen fuel cell vehicles are expected to become the dominant solution for full purpose automobiles and light trucks.

In September 2009, Daimler, Ford, GM/Opel, Renault, Nissan, Hyundai-Kia, Honda and Toyota, signed a global Memorandum of Understanding (MOU) to enable Fuel Cell Vehicles to become commercially available by 2015— and perhaps even as early as 2012. One day later, energy companies including EnBW, Shell and Total, combined with

car companies to sign another MOU in Germany's "H2 Mobility" initiative, committing to laying the foundation for Germany's Hydrogen Fuel Cell infrastructure.

But hydrogen is not a new technology waiting to be tested. As early as 1997, the German state of Bavaria partnered with 14 companies to develop hydrogen buses, generation systems, and refueling infrastructure at the Munich Airport. Hydrogen gas—as used in buses—is obtained from the waste of a local petroleum refinery and is used in a pressurized electrolyzer. Meanwhile, the airport uses liquefied hydrogen in an automated refueling station (with robot dispensers) for small tanks in passenger cars. The first five years of the project costs about €14 million, but has resulted in over 13 thousand visitors, and is set to be expanded upon in subsequent stages.

The price of hydrogen and the associated infrastructure has, to date, been one of the biggest barriers to hydrogen being widely used. Nevertheless, Hydrogenics, the world's leading producer of electrolyzers, notes that the cost of fuel cells has decreased five-fold in the last five years and the durability has risen ten-fold in the last three years. Another misconception about hydrogen is its safety when stored and used in vehicles. However, this problem of perception can be overcome as more people have contact with hydrogen technologies.⁴⁹



6MWH OF HYDROGEN ENERGY STORAGE

As one kilogram of hydrogen contains roughly the same amount of energy as one gallon of gasoline, and given present-day prices at the pump, producing hydrogen can be competitive with gas. Hydrogen has storage capacity costs of €68 KWh.⁵⁰ The US National Renewable Energy Laboratory (2006) found that wind turbines could generate

49 http://www.ieahia.org/pdfs/bavarian_proj.pdf

50 Presentation by Daryl Wilson - Hydrogenics

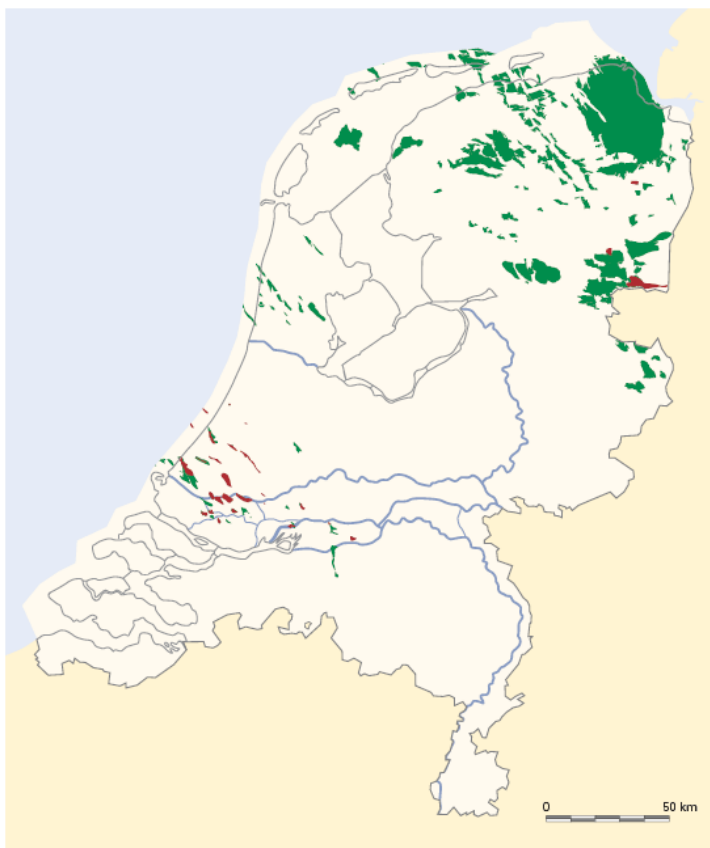
hydrogen through on-site electrolysis for a near term price of €3.80 per kilogram and a long term price of €1.56 per kilogram.⁵¹ Transmitting wind electricity to distributed fueling stations where it would be converted to hydrogen—at next generation “gas stations” for instance—is even cheaper, at €2.76 per kilogram in the near-term and €1.60 per kilogram in the long-term.

Researchers are currently experimenting with new methods of hydrogen synthesis that can produce gas even more cheaply and cleanly. Electrolysis can produce hydrogen, and if the electricity is from a clean energy source, this process emits no greenhouse gases. In the future, “bio-hydrogen” may even be produced using food, sewage, or crops as a substrate. But today, it is already possible and profitable to create an integrated system for the production, distribution, and consumption of hydrogen at a local level, as the Munich Airport has demonstrated.

Implementing hydrogen technology for utility and storage will require a coordinated effort. Only such a coordinated approach will lead to the realization of the full potential of hydrogen technology. Optimizing an overall hydrogen energy system on a broader basis will take some insightful planning across several agencies in the community. As noted in the Utrecht Master Plan Workshop, it is extremely important to keep in mind the four “Ds” of commercialization (discovery, development, demonstration, deployment) as Utrecht constructs its own hydrogen strategy.

THE HYDROGEN OPPORTUNITY: RESOURCES AND COLLABORATION.

(DISCOVERY)



From a geographical standpoint, as the map to the left shows, the Netherlands’ Northeast region has a significant opportunity to explore the potential for storing energy in oil and natural gas fields. Although none of these opportunities are specifically within Utrecht,

the Netherlands is the second largest producer of natural gas in the EU. And Utrecht's current grid mix is almost 97% natural gas. Since hydrogen can be generated from natural gas with approximately 80% efficiency, Utrecht would be well-positioned for a Dutch transition to hydrogen infrastructure.

COLLABORATION (*DEVELOPMENT*)

Outside of the opportunities in landscape, Utrecht's strong knowledge-based economy holds significant potential for collaboration with other regions and associations. The province has taken the first step in identifying its local capacity by hosting the Third Industrial Revolution Master Plan Executive Conference. The key to a successful strategy, however, will include coordination and collaboration, including alliances with companies and organizations interested in realizing a Hydrogen future. The relationships will help with all barriers that impede full implementation: financial, political, and communication barriers.

DutchHy

DutchHy is a national coalition of three cities: Rotterdam, Arnhem, and Amsterdam. DutchHy's mission is to promote the use of hydrogen and fuel cell technology in the Netherlands in the broadest sense. DutchHy hopes to: advise on; strengthen competitiveness for; assist in the development of; and spread a cohesive Dutch vision in the areas of hydrogen and fuel cell technology. As can be seen from the diagram below, DutchHy is Utrecht's "point of contact" to connect with the existing political, governmental, and commercial bodies. DutchHy is currently planning to set up a "Steering Road Show," which will travel around the Netherlands demonstrating the future of hydrogen fueling stations and gaining support for hydrogen fueled transportation.

Knowledge Innovation Community (KIC)

KIC is an initiative through the European Institute of Innovation and Technology that seeks to address Europe's innovation gap. KIC's are innovative 'webs of excellence': highly integrated partnerships that bring together education, technology, research, business and entrepreneurship. Over the next four years, the Climate KIC, of which the University of Utrecht is the coordinating body, will have more than €750 million at its disposal for the development of four areas: climate change monitoring, transition to cities with low CO₂ emissions, water management, and CO₂ free production regimes.

The climate KIC aims to “develop a generation of commercial specialists who are aware of climate change issues and who have the necessary expertise to develop economically, environmentally and socially sustainable products and services to facilitate the adaption to the impact of climate change.” Working with this established body, with access to European wide finding and knowledge, Utrecht would significantly strengthen its knowledge based economy.

New Projects (Demonstration)

As has been previously mentioned, Rijnenburg and Soesterberg are two planned, ecologically sustainable housing developments. Rijnenburg will be a mixed use residential development with somewhere near 7,000 homes. Soesterberg will be a much smaller (400-500 homes) development.

With regards to hydrogen, Utrecht should probably act as a “first follower” by benefitting from other case studies’ knowledge and lessons learned. In this way, it will allow others to absorb most of the risk and costs that are associated with all new technology development. On the other hand, there is plenty of experience and case studies available for existing hydrogen solutions such as public transit busses, industrial cooling, forklifts, etc.

The success of these developments will lie in the creation of customized solutions that can serve as both a test case and showcase for technology whose product timeline intersects with the rollout of these two housing and commercial developments. As hydrogen technology develops and the solution matures, the region then also reaps the rewards.

THE FUTURE OF HYDROGEN: THE ECONOMIC OUTLOOK (DEPLOYMENT)

The switch to a hydrogen infrastructure may start off slow, with the initial changes in transport and cogeneration applications. Today, however, while local hydrogen production units can make use of the reforming natural gas units, petrol stations could be converted to hydrogen fuelling stations. The hydrogen can also be invoked in tube trailers or as liquid hydrogen from the refinery. Adaptations of larger stationary hydrogen storage infrastructures will take large investment. However, when the switch to a hydrogen fueled economy occurs, the dividends of this investment will be well worth it. The ultimate question, however, will be where does Utrecht fit into the mix. As Utrecht’s economy is largely run off the service industry (including consulting services), we suggest the commissioning of a long-term economic analysis, assessing where hydrogen would fit into the local economic development plans of Utrecht.

PROJECT 7: HYDROGENICS

HYDROGEN VEHICLES AND FUELING INFRASTRUCTURE

HYDROGEN FUELING STATIONS

Hydrogen is already being used as a transportation fuel with over 150 fueling stations around the world supporting demonstration programs for buses, cars and off road vehicles such as forklifts. A fleet of 100 municipal buses would consume about 3.8 tonnes of hydrogen per day given typical bus routes. If supplied with electrolysis, this would represent about 10 MW of continuous load. In addition, the fueling stations and the load could be in several locations allowing control of load to address transmission constraints as well as load balance and ancillary services. With the appropriate amount of extra hydrogen storage, there would be no impact on the station's bus users for potentially many hours or even days.

ELECTROLYSIS SYSTEMS

Electrolysis systems have the ability to ramp up and down very quickly without any adverse effects. The Hydrogenics HySTAT electrolyzer systems can operate over a wide range of capacities from 10%-100% of rated load for large, multi-stack systems. If the system has storage, as is the case with fuelling stations, the electrolysis can be operated at different times from the fuelling of the vehicles.

Hydrogenics current HySTAT electrolysis product line is highly modular with building blocks of 365 kW (60 Nm³/h hydrogen output). Multiple systems are often delivered to a single site achieving 1-5 MW and very large-scale system concepts could achieve 10-100 MW.



**FIGURE 1: HYSTAT 60 PRODUCT (350 KW LOAD)
FAST RAMP RATE**

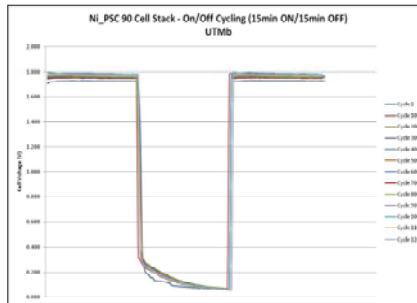


FIGURE 2: IMET ELECTROLYSIS ON-OFF CYCLING SHOWING

Hydrogen fueling stations have hydrogen storage allowing the electrolysis system to ramp up and down independently from the hydrogen load requirements.

SMART GRID RENEWABLE HYDROGEN IN UTRECHT

PROJECT DETAILS

The proposal for Utrecht is to install 300 municipal buses supported by 10 fueling stations. These fleets and fueling stations will be distributed across the region of Utrecht to maximize the positive impact on the grid. The total load represented by these stations is approximately 30 MW of highly controllable load that can help the grid operator manage renewable energy intermittency and transmission constraints on the grid.

Bus Details	
Bus capacity:	~35 seats
Typical distance travelled:	250 km
Fuel consumption:	15 kg/100 km
Station Details	
Number of municipal buses:	30
Fueling station maximum hydrogen capacity:	480 Nm ³ /h (1000 kg/d)
Fueling station power draw:	3 MW
HySTAT 60 modules:	8 units

BENEFITS OF RENEWABLE HYDROGEN FUELING

The ability to use an electrolysis load to provide ancillary services gives the grid operator an additional tool to manage grid intermittency. Using a controllable load can offer significant advantages over using controllable power sources for ancillary services and demand response.

- **Zero Emission Link:** Hydrogen electrolysis produces no incremental emissions and provides a totally clean and green connection between renewable energy sources and zero-emission transportation using hydrogen fuel
- **Additional Income Stream:** By delivering ancillary services, the electrolysis system is able to generate an additional income stream, effectively lowering the cost of delivered hydrogen for either industrial or transportation hydrogen applications
- **Frees Power Resources:** Using load for ancillary services frees the power generation systems to focus on only providing power
- **Better Response Rates:** Using loads also provides a better response to the control centre requests. Loads can typically respond more quickly as opposed to large systems that have slower response rates
- **Alleviate Transmission Problems:** The modular nature of electrolysis loads also allows it to be distributed broadly across a particular grid. This provides the additional opportunity to balance load, provide ancillary services as well as allow transmission constraints to be addressed. For instance, if an area had five large electrolysis fuelling stations and a transmission problem occurred in a location with one of the fuelling stations, then that station could be temporarily turned-off until the problem was resolved
- **Modularity and Redundancy:** The modularity makes the overall system less prone to large-scale failure, decreasing the need for redundancy in overall ancillary services contracted

Efforts to promote the adoption of renewable energy sources on our grids and hydrogen vehicles for our transportation do not need to be independent efforts. They can be linked with hydrogen electrolysis in a way that is highly complementary. Hydrogen vehicles and fuelling can provide the important controllable load that renewable power sources critically need to allow high penetration into the modern grid. We have the opportunity to simultaneously change the way we generate, store and use energy on both our grids and in our transportation.

PILLAR IV: SMART GRIDS AND TRANSPORTATION

By benchmarking a shift to renewable energy, advancing the notion of buildings as power plants and funding, supporting and integrating an aggressive hydrogen fuel cell technology R&D program, Utrecht will have erected the first three pillars of the Third Industrial Revolution.

The fourth pillar is the smart reconfiguration of Utrecht's infrastructure. This includes reconfiguring the transportation system, the communications network and the power grid along the lines of the Internet—what some are beginning to call the Smart Web. This “intelligent utility network” will enable the community to produce and share more forms of their own energy in more cost-effective ways. The smart grid will also provide energy companies and utility systems with the means to increase system reliability, enhance market robustness and reduce overall energy system costs. Finally, an intelligent utility network will allow businesses and homeowners to provide, move and ship goods and services in new and different ways.

A smart intergrid that allows producers and consumers to tap into multiple resource options by way of several different energy providers will not only give end users more power over their energy choices, but will create significant new efficiencies and business opportunities in the distribution of electricity. The intergrid is a stark contrast from today's centralized distribution of energy resources.

The smart intergrid is made up of three critical components. Minigrids allow homeowners, small- and medium-size enterprises (SMEs), and large-scale economic enterprises to produce renewable energy locally –through solar cells, wind power, small hydropower, animal and agricultural waste, and garbage- and use it off-grid for their own electricity needs. Smart metering technologies allows local producers to more

effectively sale their energy back to the main power grid, as well as accept electricity from the grid, making the flow of electricity bidirectional.

The next phase in smart grid technology is embedding devices and chips throughout the grid system, connecting every electrical appliance. Software allows the entire power grid to know how much energy is being used, at any time, anywhere on the grid. This interconnectivity can be used to redirect energy uses and flows during peaks and lulls, and even to adjust to the price changes from moment to moment.

In the future, intelligent utility networks will also be increasingly connected to moment-to-moment weather changes –recording wind changes, solar flux, and ambient temperature—giving the power network the ability to adjust electricity flow continuously, to both external weather conditions and consumer demand. For example, if the power grid is experiencing peak energy use and possible overload because of too much demand, the software can direct a homeowner’s washing machine to go down to one cycle per load or reduce the air conditioning by one degree. Consumers who agree to slight adjustments in their electricity use receive credits on their bills. Since the true price of electricity in the grid varies during any twenty-four-hour period, moment-to-moment energy information opens the door to “dynamic pricing,” allowing consumers to increase or drop their energy use automatically, depending upon the price of electricity on the grid. Up-to-the-moment pricing also allows local minigrid producers of energy to either sell energy back to the grid or go off the grid altogether. The smart intergrid will not only give end users more power over their energy voices, but it also creates new energy efficiencies in the distribution of electricity.

The intergrid makes possible a broad redistribution of power. Today’s centralized, top-down flow of energy becomes increasingly obsolete. In the new era, businesses, municipalities, and homeowners become the producers as well as the consumers of their own energy — what is referred to as “distributed generation.”

The distributed smart grid also provides the essential infrastructure for making the transition from the oil-powered internal combustion engine to electric and hydrogen fuel-cell plug-in vehicles. Electric plug-in and hydrogen-powered fuel-cell vehicles are also “power stations on wheels” with a generating capacity of twenty or more kilowatts. Since the average car, bus and truck is parked much of the time, it can be plugged in during nonuse hours to the home, office or main interactive electricity network, providing premium electricity back to the grid.,

SMART GRID CHARACTERISTICS AND BENEFITS FOR THE PROVINCE

According to KEMA, "smart grids" is the grid integration of different energy sources, tools and mechanisms used in an efficient, effective and flexible way. Some characteristics include:

- Grid integration of both centralized plus de-centralized electricity (or even energy) generation;
- Minimization or – if possible – elimination of bottlenecks and loop of energy flows;
- Two- way distribution of network energy flows and, to a certain extent, additional transmission functions to distribution networks;
- Customer interaction & participation;
- Adaptation of variability & intermittency of generation energy sources;
- Demand side response to minimize peak loads and adapt to intermittent energy sources;
- "Internet-like" architecture: dispersed intelligence and power flows.

The final pillar can be one of the key drivers for the Province of Utrecht to realize the optimal "Quality of Life" for all stakeholders of the province for several reasons.

- Implementing the smart grid concept in the energy chain will result in an optimum balance between the production of renewable energy, distributed energy resources and smart appliances. Smart grid is regarded as the enabler of renewables by seamless integration in the new energy value chain;
- Development and implementation of the smart grid concept requires many innovative ideas and highly skilled workers. This offers the province of Utrecht the opportunity to create an innovative and attractive environment to work in when it comes to Energy, ICT, etc.;
- The smart grid allows for the integration of electric-transport without substantial investments in extension of the grid capacity. This will connect the energy chain with the mobility chain. Utrecht, which is already in the center of the Netherlands when it comes to public transport (train and electricity based), is perfectly suited to create new mobility concepts which are almost without emissions and very efficient. Here too a lot of innovation is necessary, adding

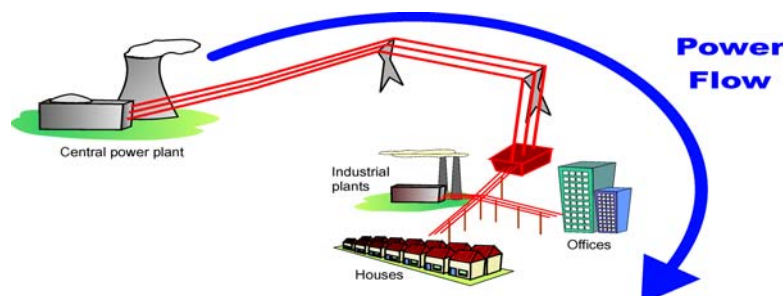
- Because of the abovementioned characteristics, a lot of new social, economic, political and technical challenges are emerging. Political leadership and private entrepreneurship will meet these challenges, creating new business opportunities, especially in the liberalized energy market of the Netherlands. Many new jobs will be created and a lot of new research and development activities will be started, both in existing organizations and by new market entrants;

When implemented in a smart way, the concept can provide the province of Utrecht the opportunity to become the first area in Europe which is fossil fuel independent and, thus, less dependent on (international politics). Besides, it eases meeting the energy and environmental targets for 2020. Perhaps most important, Utrecht will achieve its mission and continue to be a European leader in the area of “Standard of living.”

SMART CONCEPTS

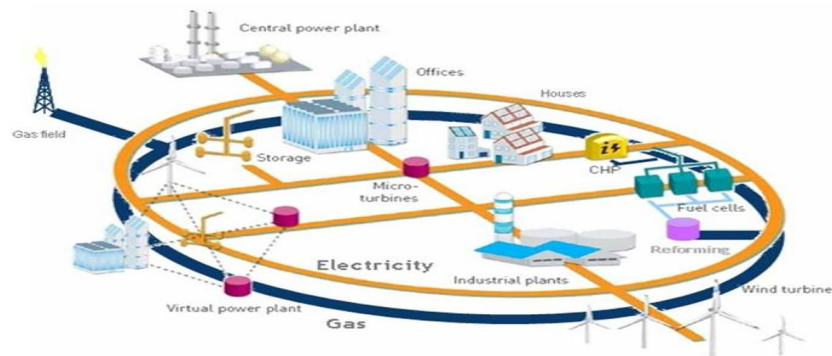
Having described the definition of the smart grid, what characteristics it has, and the “high level” benefits it brings to the province, we will further describe “what a smart grids does,” both technically and its overall contribution to the energy system. In table 1, we describe several topics, and the differences between the current energy system and the future energy system (the smart grid system).

In the current power system, the transmission and distribution networks are, in organizational terms, a serial process, having the sources and co-ordination at one end and the demand /users at the other. The diagram that follows is a simplified representation of classical grids.



If we compare the classical energy system with the smart grid system, there are several differences with more than technical implications. There are implications in relation to the roles within the system, the processes and the information that comes available. As described in the other pillars, the distributed generation (DG) and Renewable Energy

Resources (RES), including wind, solar, biomass and gas-based micro technologies are expected to supply more and more of the energy in the coming years. Small to medium sized conversion technologies, including high speed micro and mini power turbines, reciprocal machines, fuel cells, power electronics and energy storage, will soon be installed on the electrical network. As a consequence, we envision a future power system (a smart grid) that looks like an energy web, like the one depicted below (a much less hierarchical electricity system).



The difference between our current energy system and its relation to stakeholders is contrasted below with a distributed energy system of the future. All of these areas we have included are potential items from which the Province of Utrecht can profit.

Topics	Classical energy system	Future energy system (Smart grid)
Direction of energy	One way	Two ways
Customers	Reactive, passive users Few players involved No incentives	Pro-active, contribution with own production Many players involved Incentives for participation and energy awareness
Production of energy and it's integration within the grid	Central production, no decentralized production Demand at end users Investments at production locations at energy company	Central production, and also decentral production at end user Demand at end users (prosumers) Investments at local level

Information and awareness of end users	Not a lot of technical monitoring and feedback systems for end users -- not much information, so awareness is still low	A lot of technical monitoring, feedback systems for end users - much information, so more possibilities to let end users be aware of their energy usage
Energy storage	No substantial energy storage in the system	Energy storage possible in different levels of the system
Electrical vehicles + infrastructure	Very limited	Charge points at home, charge points in district, fast charging in certain area's

DIFFERENCES BETWEEN THE CURRENT ENERGY SYSTEM AND THE FUTURE ENERGY SYSTEM

Hereafter the topics of importance in relation to the future energy system are described in more detail.

Direction:

The classical grid design is robust, reliable and cost effective. The flow of energy goes from a few big energy production companies towards the end users (in one direction). More and more distributed generation and renewable energy sources are becoming part of today's power system. Distributed generation and renewable energy sources are currently connected to the network. On the other hand, end users are not responsible for overall power system management. This "fit and forget" policy is only possible since the share of these energy sources is low and sufficient headroom exists so that operational limits for the network are not encroached. However, if a "fit and forget" policy continues, the system will reach a point where it becomes increasingly difficult to manage, with high associated connection costs and inefficiencies. Besides these inefficiencies, there will be increased unreliability and more outages. Therefore, the future of smart grid will require some new technological solutions such as: fault level limitation, voltage control, and automatic protection systems; these will get introduced to intercept the new power system faults.

Customers:

As described before, customers are now passive users. When smart grids evolve, customers become active, even pro-active users. They produce their own energy and, therefore, have more choices: either satisfy their personal demand; or sell the electricity back to the grid when electricity prices have peaked. When these opportunities arise and users become active, and even commercial, "prosumers," more participants

become involved in the processes. This, of course, will not be possible without more intelligent appliances and a smarter distribution grid (the smart grid).

Energy Production

As described before, the production of energy will also be produced by the end-user. This end-user is not only a single household but could also be a school, a shopping mall or an industrial area. All locally produced energy must be integrated with the grid. In the past, the energy production companies were the only ones investing in large power plants (worth millions of Euros), or in their connection to the grid. With local energy production, the investment, for both the installation and the connection to the grid, are also local. In this case, new commercial opportunities for local businesses arise.

Information

In the classic system, the only information that customers received was via their energy bill. Even here, they only received the total amount of energy they consumed per month or per year. But this situation is changing. New possibilities are coming on the market, not only the smart meter, but many other monitoring and feedback systems. This, coupled with appliances connected to the internet, will, in the near future, give end-users additional information about their energy use. Consumers will have information regarding: real-time production, real-time demand, advice on energy savings, and, for very active prosumers, real-time market information for use in commercial transactions.

Energy Storage

In the classic energy system, not much storage is incorporated, simply because it's too expensive as a result of technical restraints. As more and more options for storage come on the market, the future grid will expand to encompass new products and services. For example, the battery of the electrical vehicle can act as an energy carrier for the car, and also, deliver electricity to the end user. This gives the end user the possibility to buy electricity at a low price, store it in their car's battery, and sell the electricity at a higher price later in the day.

Electrical vehicles and Mobile infrastructure

Transport revolutions are always embedded in larger infrastructure revolutions. The coal-powered steam engine revolution required vast changes in infrastructure including a shift in transport from waterways to railbeds, and the ceding of public land for the development of new towns and cities along critical rail links and jurisdictions. Similarly, the introduction of the gasoline-powered internal combustion engine required the

building of a national road system, the laying down of oil pipelines, and the construction new suburban commercial and residential corridors along the interstate highway system. The shift from the internal combustion engine to electric and hydrogen fuel-cell plug-in vehicles requires a comparable new commitment to a Third Revolution infrastructure.

In 2008, Daimler and RWE, Germany's second-largest power and utility company, launched a project in Berlin to establish recharging points for electric Smart and Mercedes cars around the German capital. Renault-Nissan is readying a similar plan to provide a network of battery-charging points in Israel, Denmark, and Portugal. The distributed electric power-charging stations will be used to service Renault's all-electric Megane car. By 2030, charging points for plug-in electric vehicles and hydrogen fuel-cell vehicles will be installed virtually everywhere-along roads and in homes, commercial buildings, factories, parking lots, and garages, providing a seamless distributed infrastructure for sending electricity to the main electricity grid as well as receiving electricity from it. IBM, General Electric, Siemens, and other global IT companies are just now entering the smart power market, working with utility companies to transform the power grid to intergrids, so that building owners can produce their own energy and share it with each other. CPS Energy in San Antonio, Texas; CenterPoint Utility in Houston, Texas; Xcel Energy in Boulder, Colorado; and Sempra Energy and Southern Cal Edison in California are beginning to lay down parts of the smart grid, connecting thousands of residential and commercial buildings.

The question is often asked as to whether renewable energy, in the long run can provide enough power to run a national or global economy. Just as second-generation information-systems grid technologies allow businesses to connect thousands of desktop computers, creating far more distributed computing power than even the most powerful centralized supercomputers, millions of local producers of renewable energy, with access to intelligent utility networks, can potentially produce and share far more distributed power than the older centralized forms of energy oil, coal, natural gas, and nuclear- that we currently rely on.

Today we use all kinds of fuels for transportation. The energy chain and the mobility chain are separate. But what will happen if the electric car completely replaces the internal combustion engine? Then the two chains will come together, giving rise to many new commercial opportunities, and not only those related to CO₂ reduction. One opportunity is related to the battery of the car, since it can be used for storage.

For this to happen, two major developments must take place. First, the price of the electric car must be dramatically reduced. Additionally, we must develop the

infrastructure to charge the cars' batteries. This new infrastructure will be integrated in to the total architecture of the smart grid. The smart grid that enables the driver of the electrical vehicle to drive wherever he/she wants. But more important, is that the driver can charge his/her car, or sell this electricity back to the grid.

As described above, the energy system will change. This will ultimately change the role and relationship of key players in the energy system. The next paragraph will describe these roles.

Role of province/municipality: initiator, facilitator, and policy maker

The province and municipalities can be the initiator for all kinds of sustainable projects. The policies on a local or provincial level can be aligned with the province's goals, even if they differ from national targets. The province and the municipality also play an important role in communication with end-users: schools, shopping centres, offices and households. With the new developments in electrical vehicles, the province and municipality also play an important role in facilitating public charge points and establishing regulations and guidelines.

Role of the project developer: designer and builder of the project

The project developer will accept the order of the municipality or province for designing and building the district according to specific requirements. This includes the sustainability requirements and energy demand. The project developer will have communication lines with the local grid owner and several suppliers of sustainable products and appliances.

Role of housing corporations: initiate new projects and renovations

The housing corporation has access to a lot of the building environment. They can play an important role in initiating new plans and finding creative solutions for people who rent the houses. These individuals have direct and indirect influence both on new buildings and on existing buildings.

Role of grid owner: facilitator and co-designer of the local grid

The choice of the local grid structure is the responsibility of the grid owner. Having different energy carrier and communication options is essential to make the right choice for the smart grid design. The grid owner may also invest in several components of the energy system in order to optimize the local grid. The grid owner will work in close

cooperation with the project developer, especially with regards to designing an intelligent energy distribution station.

The new role of a “prosumer”

The end consumer will buy appliances (electrical vehicles, solar cells, fuel cells, and heat pumps), for their own benefit (increase comfort levels, lower energy bills, etc.), while also impacting the grid. When it’s possible in the future, the end user will also be participating in the energy market.

The proposed smart grid

The following initiatives set out the key tasks to be undertaken in developing a high level strategy for the development of a smart grid for the province of Utrecht. KEMA will report the findings per key task, which is outlined in the following sections.

The approach of KEMA is focused on two lines:

- Envisage the future end state situation including the process to that end state segmented in different steps;
- Learning by doing in a controlled environment by execution of well defined demonstration projects.

Prior to envisaging the future end state, we must properly assess the current state and the key drivers for the Province of Utrecht.

IDENTIFY THE KEY DRIVERS FOR UTRECHT IN RELATION TO SMART GRIDS

Key to developing a strategy for deployment of smart grids in the province of Utrecht is an understanding of the drivers for doing so. There are also external drivers and trends in our society, which directly impact the province.

The strategy and working principles of the province will be crucial for a successful transition into a “more sustainable” province that has an even “higher quality of living.”

The study will identify and describe the key drivers in relation to smart grids when it comes to:

- Politics and regulations;
- Economics;

- Social issues;
- Technological issues.

Current (smart) grids deployment in Utrecht

The study will include an assessment of the current level of deployment in Utrecht, as far as the information is available. This will consider how the current energy system in the province is working, how the responsibilities and processes are implemented, which technologies are prevalent, and in what contexts and at what scale. A high-level feasibility analysis will estimate the potential for further deployment of particular stand-alone and fully integrated “smart grid concepts.” KEMA will use, where possible, simulation models to estimate the impact of different solutions on different system layers (household, street, quarter, local area, etc.). By doing this, several critical performance issues can be identified and, in interaction with the different stakeholders in the system, the optimum solution can be implemented and monitored.

Develop high-level smart grid strategy for Utrecht (Future End State)

The key output of the study will be a strategy for how to fully implement integrated smart grids for the province of Utrecht and recommendations for how to use the smart grid as a flywheel to stimulate new energy efficient appliances and renewable energy sources. In addition, we will explore new products and services that support reduction of energy consumption, preferentially using renewable energy and providing new business opportunities to incumbents and energy service providers.

The strategy will identify which concepts are suitable for Utrecht and how the implementation of these concepts in a particular situation can be best organized. In the first stage, it’s very important to address critical performance issues, potential hurdles, and to make a thorough analysis of the key values in the system.

Identify impacts of recommendations

The deployment of smart grid concepts will have a number of implications for Utrecht, particularly in relation to the drivers identified above. Economic, social, public and environmental impacts, both positive and negative, will be considered. At this stage, given the available data and level of analysis possible, the impacts will be mostly qualitative and high level.

Identify obstacles to delivery of recommendations

There may be specific barriers to the deployment of stand-alone renewable energy capacity as outlined in the recommendations. To move towards delivering the recommendations, these barriers must be clearly identified. The study will list those obstacles specifically for Utrecht and clarify what they mean. These are expected to include, but not be limited to: economic obstacles, legislative and regulatory obstacles, social obstacles and technological obstacles.

Delivery recommendations

Based on experience in other cities, recommendations will be made as to the types of programs, policies, legislative mechanisms and other initiatives that would be beneficial to investigate to enable delivery of those recommendations made above.

LEARNING BY DOING IN A CONTROLLED ENVIRONMENT: DEMONSTRATION PROJECTS

Besides the above mentioned approach, which is focused on the transition from the current situation towards the future end state and what is needed; we also recommend the province implement demonstration initiatives for the very short term. Especially in relation to smart grids, a lot of innovation is necessary, which can only be achieved if companies of various markets successfully collaborate. An ideal way to stimulate the required innovation is by the creation of controlled demonstration projects. Because of the level of local knowledge required to identify individual potential projects, consultation and discussion with the Utrecht authorities will be crucial in the first stage.

Implementing smart grid projects can be within a new build environment as well as in the industrial areas. KEMA thinks that the smart grid concepts can make a significant contribution to the plans that the province has with Rijnenburg and Soesterberg. KEMA suggests that the Province of Utrecht investigate the possibilities of implementing smart grid options in both areas.

Rijnenburg:

Rijnenburg is envisioned to be “climate proof and sustainable.” Therefore, the approach should consist of five important aspects (Safety, Living environment, CO₂ reduction, Economy & Infrastructure and Nature & Landscape). KEMA believes that - especially with regards to “CO₂ reduction” and “Economy & Infrastructure” -(and to almost all the icons of the climate studio) the smart grid concept can contribute to the goals of Rijnenburg.

From a smart grid perspective, a direct contribution can be made: starting with the discussions with project developers and other key players and then, with interactive sessions with municipalities and provincial officials.

KEMA works with many smart grid technology suppliers on several different projects. In the demonstration projects of Rijnenburg and Soesterberg, the different suppliers can bring new, innovative products/solutions and, during this process, try to realize a win-win solution for all involved stakeholders. KEMA sees a lot of opportunity in both Rijnenburg and Soesterberg to bring in smart grid suppliers.

Soesterberg:

Soesterberg Airbase is an ideal situation to start with the implementation of a smart grid project. As the Master Plans for the redevelopment of Soesterberg are being formulated now, both the province and the municipalities have an opportunity to start assuming their role of initiator and facilitator of smart grids. The only question is “to what level is it possible”. There are opportunities to demonstrate strong leadership here by facilitating the different roles: by the people and the province.

Interaction with other Pillars

The smart grid is the network that integrates the other pillars into a seamless Third Industrial Revolution infrastructure. It's the backbone where everything comes together and can be optimized. Several activities can be taken on a high level, which don't have any impact on other activities in other pillars. However, a close cooperation with the other pillars is crucial to achieve the highest effectiveness. Specifically, the study will include a high-level list of “interaction effects” between pillars, each with an accompanying description of how to take advantage of the opportunity to optimize, ensure a flexible approach, and allow for future integration of developments and investments.

A living Smart Grid demonstration project in the Netherlands

KEMA has created a living lab smart grid environment. “This Power Matching City” consists of 25 interconnected households equipped with micro cogeneration units, hybrid heat pumps, PV solar panels, smart appliances and electric vehicles. A wind farm and a gas turbine produce additional power. The aim of the project is to develop a market model for a smart grid under normal operating conditions. The underlying coordination mechanism is based on the Power Matcher, a software tool used to balance energy demand and use. The aim is to extend this coordination mechanism in

such a way that it can support simultaneous optimization of the goals of different stakeholders:

- In home optimization for the prosumer;
- Reduced network load for the distribution system operator;
- Reduced imbalance for program responsible utilities

In the end, the goal of this project is to build and demonstrate an industry-quality reference solution for aggregation, control and coordination of distributed energy resources, renewable energy and smart appliances, based on cost effective, commonly available ICT components, standards and platforms.

From Power Matching City and other projects, KEMA has established the business case calculations and helpful information for the different roles in the process.

PROJECT 9: CISCO

To make the Third Industrial Revolution a reality requires real-time monitoring, measurement and optimization. Utrecht cannot optimize what it cannot see. Therefore, Cisco proposes leveraging Information and Communication Technologies to make the most of future investments.

Each pillar of the 3rd Industrial Revolution requires baseline system measurements, improvement targets and results reporting in order for users to know whether changes are required.

Not only can Cisco help provide the communication infrastructure necessary to rollout Pillars I through IV, but Cisco can also provide technologies and solutions necessary to help the Provence to reach its goals.

The transformation of Utrecht is filled with opportunities for citizens, businesses and public leaders. Upon examining the requirements for Utrecht, there are many positive approaches that could work to start the Provence's transformation.

Cisco proposes to focus efforts on the communication connections within and among buildings. Buildings represent the largest users of energy—and it's where community members can engage directly in the transformation. It is here that users will learn to save money, reduce generation emissions, improve system reliability and bench mark with peers. As Utrecht works toward a sustainable community, buildings must be reimaged and reconfigured as power plants. In addition to any physical changes that

might be required, this transformation requires additional insight into energy consumption measurement, reporting and optimization.

The communication networks required to provide this increased insight and control can also provide additional building information services for tenants and home owners. ICT can be leveraged to make living and working environments personalized, efficient, functional, and profitable.

As the community rolls out pilot projects, it is important to convert energy consumption information into actionable information. This means that buildings must be inversed to collect and report real-time energy use information. Practically speaking, initial pilot projects should include simple shadow meters that enable users to see real-time energy load profiles. This information also needs to be normalized with respect to weather (these data standards are currently in development). But that won't prevent some basic steps that lead to large savings. For example, energy use profiles are often used to see where equipment is running—but malfunctioning. It's also a good way to spot poor performing buildings (by bench marking).

Projects should be undertaken that provide immediate benefits and value to end users.

End users need to see when and where power is used; they must have the ability to set flexible conservation policies that match the needs of the home or business. In many cases, conservation policies can be automated—making it is easy to conserve on a daily basis. ICT leveraged as an energy control plane will make it possible to measure current power consumption, engage policies to automate and take actions by controlling the power levels of attached devices; and change the amount of power being consumed. Energy consumed can easily be found with ICT by allowing a realistic view of power consumed per apartment, home, office building floor or campus. After power consumption is understood optimization is made possible.

The ICT energy control plane must be able to monitor and control power not only during periods of electric grid instability and peak power events but also 24/7 to ensure grid reliability while providing users with maximum energy at the lowest possible cost. The framework must enable users to convert energy consuming devices from “Always on” to “Always Available”.

Building planners must take steps to transform the physical spaces of today into the more efficient and cost-effective buildings of tomorrow. This transformation can be accomplished primarily by converting existing building systems into one unified and intelligent structure that monitors, maintains, and automates such complicated and disparate systems as:

Data connectivity (including wired and wireless LANs)

Voice communications (including IP-based telephony services)

Building and site security (including video surveillance and building access)

Digital signage (including passive displays and active touch-screens)

Heating, ventilation, and air conditioning (HVAC) controls

Building management systems (BMS)

Electrical energy systems and utility monitoring and management

However, before this transformation can occur, building planners need to assess ways to connect various systems and applications together. Cisco, along with other Rifkin team members, can help Utrecht realize the monetary, cultural, and procedural benefits of converging data, voice, video, security, HVAC, lighting and other building controls on a single IP-based platform. This strategy can integrate existing disparate systems as well as new IP based systems.

The Cisco Connected Real Estate solution begins with an intelligent IP network infrastructure that integrates building control and management with Cisco next-generation technologies such as Cisco® Unified Communications, Cisco® TelePresence, and Cisco® Video Surveillance. The solution can enable the Province of Utrecht to:

Enhance productivity by improving access to services through unified communications, mobile solutions, and biomedical device engineering, all running on Cisco's Medical Grade Network.

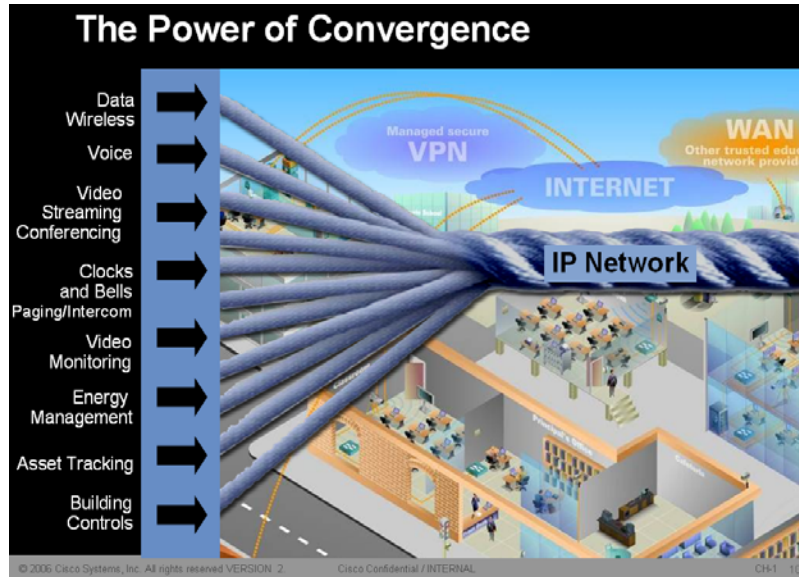
Improve building performance by centralizing the operation of lights, heating, ventilation, air conditioning, and elevators to save energy and cut costs.

Provide a safe, flexible, customized environment that promotes patient and staff security.

Manage costs and preserve natural resources, by using technology to manage new environmental capabilities, such as solar power and energy management.

Provide better security and building management, by integrating alerts from Fire/Life/Safety systems with building enunciation systems such as Digital Signage, IP Telephony, overhead speakers, alarms, lighting, access control systems, and event coordination solutions.

Cisco Real Estate converges critical functions into one network



The Cisco Connected Real Estate solution provides a “building information network” that uses the Cisco IP network as the foundation for communications systems, building systems, and personal devices. With Cisco Connected Real Estate, a converged IP network is built into the fabric of every building and acts as the platform supporting all other real estate requirements. Each part of the solution can support additional solutions, each a building block to create and support the next layer of solutions.

Specific Recommendations

Start with simple plans. Develop residential and commercial pilot projects that engage end users in energy conservation and control.

Ensure that pilot projects provide building occupants with real-time energy use. Normalize the data to weather (to ensure accurate bench marking).

Leverage Information and Communication Technology. Use standards based communication protocols like IP/Ethernet.

Support innovation. New technologies and processes require flexibility and experimentation.

PROJECT 8: KEMA (PLEASE SEE COMPANY RECOMMENDATIONS)

CONCLUSION

The Third Industrial Revolution journey that the Province of Utrecht has set out on is a difficult one. Its destination is a post-carbon era. Skeptics will argue that Utrecht's vision is unattainable and its mission impossible. But it is the visionaries, not the skeptics, that chart new frontiers and discover new worlds. Utrecht is on what might be the most important mission ever undertaken by our species — discovering our place in the communities of life that make up the living biosphere of the Earth. We look forward to being part of the journey.

**COMPANY RECOMMENDATIONS FROM MEMBERS OF THE THIRD
INDUSTRIAL REVOLUTION GLOBAL CEO BUSINESS ROUNDTABLE**

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Lighting Improvements

I. Overview

Philips is a global company which delivers meaningful innovations that improve people's health and well-being.

Our health and well-being focus extends beyond our products and services to include the way we work: engaging our employees; focusing our social investment in communities on education in energy efficiency and healthy lifestyles; reducing the environmental impact of our products and processes; and driving sustainability throughout our supply chain.

Our health and well-being offering is powered by our three sectors: Healthcare, Consumer Lifestyle and Lighting.

Meeting people's needs with "sense and simplicity"

People's needs form the starting point for everything we do. By tracking trends in society and obtaining fundamental insights into the issues people face in their daily lives, we are able to identify opportunities for innovative solutions that meet their needs and aspirations.

Our "sense and simplicity" brand promise expresses a commitment to put people at the center of our thinking, to eliminate unnecessary complexity and to deliver the meaningful benefits of technology. Our adoption of Net Promoter Score (NPS), which measures people's willingness to recommend a company/product to a friend or colleague, shows how we are doing in this respect.

Capturing value in mature and emerging markets

We see enormous potential in both mature and emerging markets, and we apply our competence in marketing, design and innovation to capture value from major economic, social and demographic trends. These include the need of a growing and longer-living population for more and affordable healthcare, the demand for energy-efficient solutions to help combat climate change and promote sustainable development, the emergence of empowered consumers with high health and well-being aspirations, and, last but not least, the growing importance of emerging markets in the world economy.

We have a long-established presence, strong brand equity and large workforce in the emerging economies. This gives us the home-grown insights needed to produce sustainable solutions that meet the needs of local people. We already realize one-third of our sales in the emerging markets, and this figure could conceivably rise to around 50% by the middle of this decade. In order to capture the growth opportunities that are available, we continue to invest in building our local organizations, competencies and resources in these markets. The current economic crisis is likely to have the effect of accelerating the fundamental trends outlined above, increasing demand for healthcare (especially outside the hospital), a healthy lifestyle and energy-efficient high-quality lighting.

Building the leading company in Health and Well-being

Delivering on our promise of "sense and simplicity", we deliver solutions that create value for our customers – healthcare and lighting professionals and end users.

People-focused, healthcare simplified

In Healthcare, we are building businesses with strong leadership positions in both professional and home healthcare, as well as a growing presence in emerging markets. We simplify healthcare by focusing on the people in the care cycle –patients and care providers – rather than technologies or products. By combining human insights and clinical expertise, we deliver innovative solutions that help improve patient outcomes while lowering the financial burden on the healthcare system.

Enabling people to enjoy a healthy lifestyle

The pursuit of personal well-being is a universal trend, equally relevant in mature and emerging markets. With a strong market-driven, insight-led culture, coupled with technological expertise and excellent design, Consumer Lifestyle focuses on innovative lifestyle solutions that enhance consumers' sense of personal well-being. With simplicity providing our competitive edge, we continue to build upon existing market-leading positions based on differentiation and profitability rather than scale, as well as entering new value spaces.

Simply enhancing life with light

Supported by the growing demand for energy-saving solutions and the structural shift toward solid-state lighting, our Lighting sector is strengthening its global leadership in fast-growing areas, such as LEDs and energy-efficient lighting, by driving the transition from products and components to life-enhancing applications and solutions. Our strong IP position across the LED value chain will further reinforce this leadership.



Calling for immediate action

To combat climate change, Philips calls upon mayors and municipal leaders to accelerate sustainability in infrastructure projects and building renovation.

We believe there is opportunity for a robust and comprehensive follow-up agreement to the Kyoto Treaty, with existing technology solutions offering an achievable path to reducing harmful emissions.

At the UN climate conference in New York, Philips CEO Gerard Kleisterlee said: “If an ambitious and effective global climate change program can be agreed, it will create the conditions for transformational change of our world economy and deliver the signals that companies need to speed up investment of billions of dollars in energy-efficient products, services, technologies and infrastructure such as LED lighting technology.”

We put weight behind this appeal by partnering with the World Green Building Council, committing to improving the energy efficiency of cities by 40% in the next 10 years.

Transforming the global market

Philips is participating in a global initiative to accelerate the uptake of low-energy light bulbs and efficient lighting systems by the Global Environment Facility and the United Nations Environment Programme. The aim is to reduce the bills of electricity consumers in developing economies while delivering cuts in emissions of greenhouse gases. The goal is also to replace fuel-based lighting systems, such as kerosene, which are linked with health-hazardous indoor air pollution.

Breakthrough idea

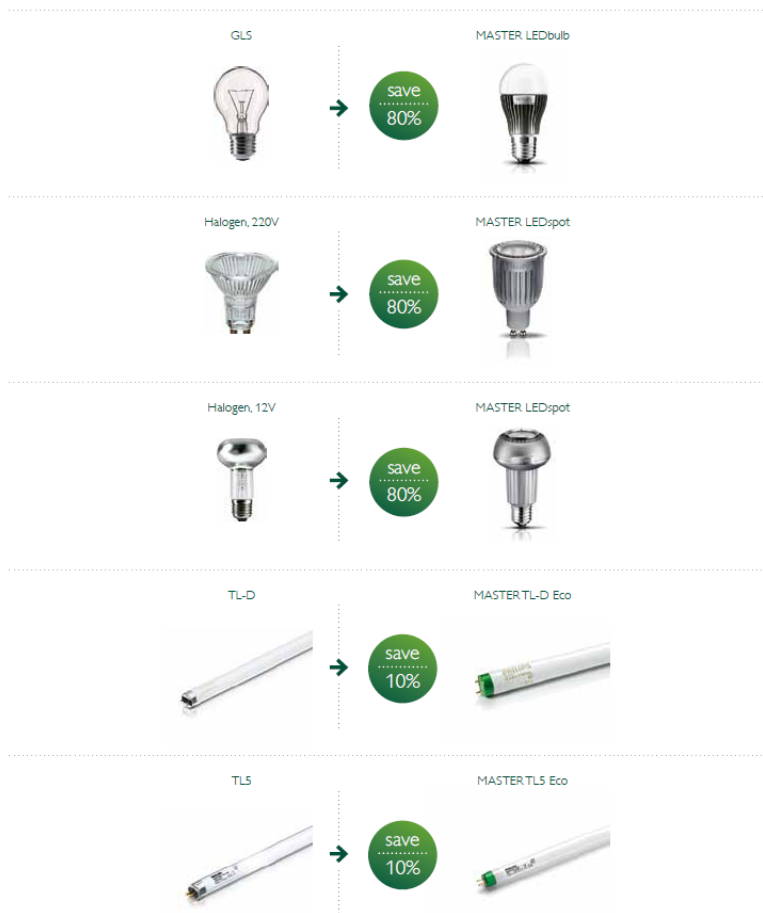
We submitted the first entry in the US Department of Energy's L Prize competition, which seeks high-quality, high-efficiency solid-state lighting products to replace the 60W incandescent light bulb. Named one of the “best inventions of 2009” by TIME Magazine, our LED bulb emits the same amount of light as its incandescent equivalent but uses less than 10W and lasts for 25,000 hours – or 25 times as long.

2. General Opportunities in Utrecht

There is a huge saving potential in Outdoor & Indoor Lighting. By switching to the new energy efficient solutions, and using additional dimming solution the energy saving can be further enhanced up to

Lamp replacement is a simple switch solution

In the rest of this brochure we'll show you how you can achieve even more significant savings through more substantial renovations.



80%.

Outdoor Lighting

Making cities safer to live in and more enjoyable to experience

- **Offering the highest energy saving and reduction of CO₂ emission**
- **Assure operation through monitoring and control maintenance cost**

We believe that making outdoor spaces more sound, secure and engaging enhances people's lives. An effective image-builder for any city, our innovative outdoor lighting solutions are designed to beautify and inspire, while making people feel safer and more comfortable.

Office/School & Healthcare Lighting

Beautify and distinguish, while increasing productivity and energy efficiency

- **People-centric office spaces that offer a pleasant working environment and stimulate productivity with maximum energy efficiency**

Our work in offices revolves around three areas of focus. First, we're focused on helping offices transition to more energy-efficient and environmentally sustainable solutions. We also want to show your company in its best possible light, to help inspire customers and employees alike. And we want to help create healthier workplaces. Because it's the right thing to do for the company's workforce – and the bottom line!



* percentage energiebesparing per stap

Industry Lighting

Reduce environmental impact, while increasing quality and productivity

- **Factories where lighting solutions increase productivity and at the same time reduce energy consumption**

Industry lighting can help people see clearly and so work better, and also improve safety and security, while creating flexible workspaces that can be adapted to the task at hand. And it can help companies achieve sustainability goals that communicate corporate responsibility.

Our energy-efficient lighting solutions for industry reduce environmental impact and save cost, while increasing quality and productivity.

Home Lighting

Helping people express who they are and how they feel

- **Help people to save energy and the environment: Philips Ecomoods, Led retrofit bulbs**

Our innovative home lighting solutions beautify and inspire while empowering people to define the ambience in their personal environments. Lighting can provide form and function, increase safety and security, and improve well-being, while allowing people to tailor their home spaces to their desires.

We believe that making homes more beautiful and more functional – and doing so in an environmentally responsible way – enhances people's lives.

Hospitality Lighting

Promoting guest comfort and building brand differentiation

The hospitality industry is focused on transforming guest experiences in the most sustainable way possible.

Our Hospitality business provides flexible, energy-efficient lighting and infotainment solutions that empower guests to personalize their spaces, adjust environments according to their mood or activity and create a unique experience at the touch of a button. In turn, this helps hotels to differentiate their brand.

Retail Lighting

Enabling a distinct brand and shopping experience

retail lighting is a source of empowerment: when used to its fullest potential, it makes merchandise, brands and business shine. It enables retailers to drive sales and minimize costs. All vital in such a highly competitive marketplace.

Flexible, efficient, high-quality lighting helps retailers communicate their identities in a way that is healthy for business, relevant to consumers and maximizes the shopping experience.

3. Specific Opportunities in Zeist, province Utrecht



To start reducing the carbon target we suggest Utrecht to change inefficient indoor lighting systems in schools with a new lighting solution T5 28W with lighting controls. For example the Christelijk College Zeist in the province of Utrecht.

Details of the project

Facts of the current situation:

Current office luminaire:	2x36W TL-D conventional gear
Lighting specifications:	500 lux (acc EN 12464-1)
Number of square metres classes:	22 classes x 52 m ² = 1.140m ²
Number of installed luminaires:	132 luminaires
Installed power current lighting system:	12kW
Burning hours:	1500 hrs per year

Solution 1:

Change current TL-D 36W with a TL-D Eco 32W. This means a saving of 4W per lamp.

Energy Saving: 10%

CO₂ reduction (0,52 kg/kWh): 0.8 ton of CO₂ per year

Solution 2:

Make use of presence detection with current lighting installation

Energy Saving: 30%

CO₂ reduction (0,52 kg/kWh): 2.5 ton of CO₂ per year

Solution 3:

Change current school luminaire 2x36W/830 TL-D conv. gear into TBS 460 2x28W/830 HFP D8 with presence detection

Energy Saving: 50%

CO₂ reduction (0,52 kg/kWh): 4.1 ton of CO₂ per year

Solution 4:

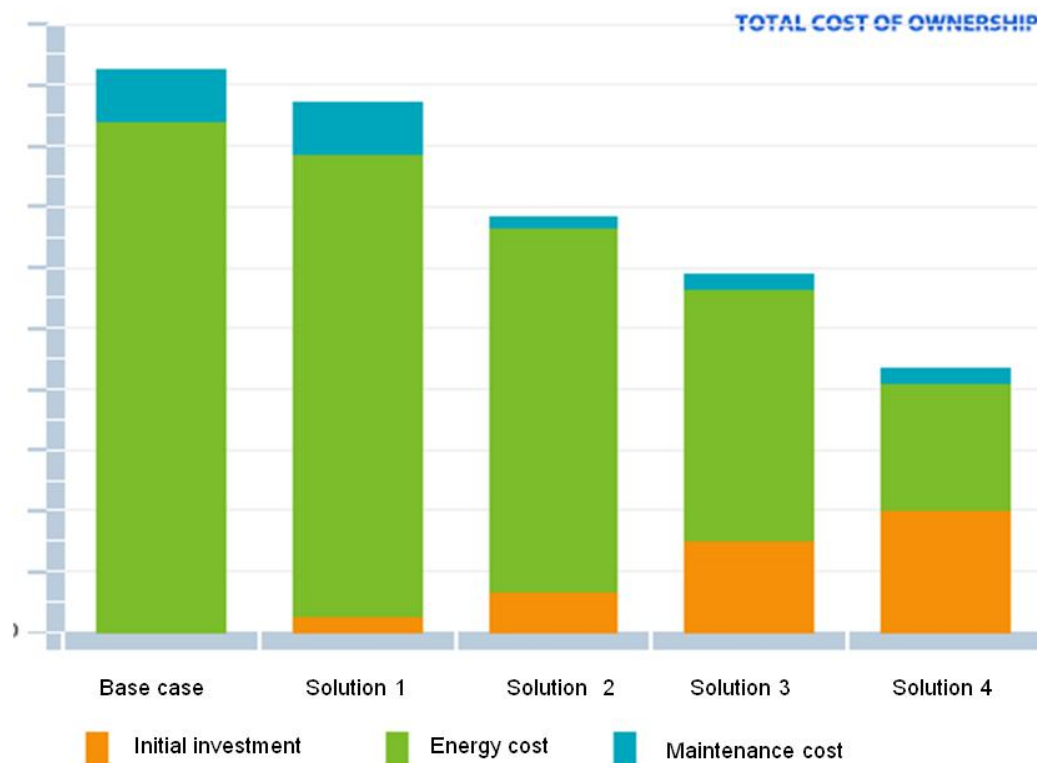
Change current school luminaire 2x36W/830 TL-D conv. gear into TBS 460 2x28W/830 HFD D8 including presence detection and daylight control.

Total burning hours will reduce by 30% due to presence detection, which also has an effect on the maintenance cost. And this means less consumed materials per year.

Daylight control will have an extra 50% energy savings.

Energy Saving: 75%

CO₂ reduction (0,52 kg/kWh): 6.2 ton of CO₂ per year



4. Specific Opportunities in the province Utrecht

The energy saving opportunity is not only applicable for the Christelijk College Zeist, but most of the schools in Utrecht. Several studies in the Netherlands have showed that 70% of all schools have inefficient and outdated lighting. By extrapolating the energy saving opportunity of the Christelijk College Zeist to all schools in the province of Utrecht, the energy savings are enormous.

The 613 elementary schools have approximately 6.130 classrooms, while the high schools have approximately 2.240 classrooms.

In total there are 8.370 classrooms in the province of Utrecht, of which 70% are outdated with inefficient lighting. The energy saving opportunities are applicable for 5900 classrooms.

Solution 1:

Change current TL-D with a TL-D Eco. This means a saving between 8 to 4W per lamp.

Energy Saving: 10%

CO₂ reduction (0,52 kg/kWh): 219 ton of CO₂ per year

Solution 2:

Make use of presence detection with current lighting installation

Energy Saving: 30%

CO₂ reduction (0,52 kg/kWh): 658 ton of CO₂ per year

Solution 3:

Change current school luminaire with TL-D conv. gear into T5 HFP with presence detection

Energy Saving: 50%

CO₂ reduction (0,52 kg/kWh): 1.097 ton of CO₂ per year

Solution 4:

Change current school luminaire with TL-D conv. gear into T5 HFD including presence detection and daylight control.

Total burning hours will reduce by 30% due to presence detection, which also has an effect on the maintenance cost. And this means less consumed materials per year.

Daylight control will have an extra 50% energy savings.

Energy Saving: 75%

CO₂ reduction (0,52 kg/kWh): 1.645 ton of CO₂ per year

5. Conclusion for the schools in the province Utrecht

An energy saving of 75% can be reached in almost 5900 classes, meaning **1.645 ton of CO₂** per year, by simply changing the lighting installation.

And next to schools, energy saving with lighting can also be reached in the following areas:

- Governmental and Provincial office buildings
- Hospitals
- Street Lighting (Provincial and Urban)

On the Path to a Clean Utrecht by 2040:

Tools will not bring results; behavior must be changed. We need a revolution.

Introduction:

Energy conservation and building maintenance costs will soon become key factors to consider when selling/buying any building. Today, focus is shifting towards how much energy a building consumes in the operational phase. Inefficient management of buildings during this phase can needlessly waste valuable energy. Intelligent energy metering provides a vital insight into the building's consumption and can help identify areas where potential savings can be made. In addition, evidence shows that operating costs typically amount to three times the capital cost of the building; and maintenance costs can be twice the building costs. Investing in systems that help reduce energy consumption naturally also reduce operational costs.

Traditionally, maintenance roles have always been reactive, but with intelligent building control systems in place, maintenance becomes intuitive and can be planned and scheduled. The advantage of this is that maintenance can be planned and budgeted, rather than considered only when the need arises. Such practice often results in maintenance works being delayed or even ignored. In addition, it is now possible for a single system to monitor gas, electricity, water, air and steam.

Apart from simplifying the roles of maintenance staff, intelligent energy management is inexpensive. In fact, a recent study by the UK's Energy Savings Trust revealed that installing the technology to meter and monitor energy consumption could have an average payback period of less than six months. A small increase in capital expenditure can reduce operational expenditure significantly. Empirical studies of metering solutions show an average of 5% reductions in utility bills in a diverse range of buildings. But the financial rewards do not stop here. Savings in the region of 2-5% can be achieved by better equipment utilization and as much as 10% savings potential can be reached by improving systems reliability.

Energy initiatives too often are one-time improvements that are not monitored and measured properly over time. As a result, the benefits of these improvements are soon lost. The key to improving and sustaining energy use is providing executives with the right information, so they can make informed decisions that balance energy use with other objectives such as building comfort and employee productivity.

Schneider Electric Energy Remote Monitoring is a proven solution that delivers a visible impact to the bottom line. Using Web-based technology, energy remote monitoring delivers information, analysis, and guidance that allow executives to understand their energy use, take appropriate action, and continually improve energy efficiency and building performance.

More political pressure for a green business world

Less than a quarter of the Dutch companies (21%) monitor their energy consumption (globally 37%) and 10% monitor their carbon footprint!

The Dutch business world is to this day not yet progressive with regard to green entrepreneurship. We therefore believe that companies should be stimulated more. Not in the form of subsidies, but in the form of political pressure.

According to the research 'EERE Building Energy Data book 2006 & EERE Manufacturing Systems Footprint' the industry & infrastructure sector is responsible for 31 percent of the use of energy worldwide. Buildings are responsible for 18 percent, residences for 21 percent and

datacenters and networks are responsible for 2 percent. The energy consumption will double in 2050. 'We already know that the use of electricity contributes for forty percent to the greenhouse effect. We cannot be blind to the drastic consequences of energy consumption, and we must, especially in the mentioned sectors, rigidly steer towards energy-efficiency'.

Until now, the Dutch trade and industry has shown too little interest in doing business in an environmentally responsible way. Stimulation has not proven to be effective enough. For successful green enterprising, obligation is required. Stimulating the consciousness-raising process is still an important motive though.

It is incomprehensible that many organizations have until now not yet appointed employees responsible for energy consumption. As long as nobody is actively focused on reducing energy costs, no one will feel responsible for enforcing energy-efficiency measures. The reason for this is that the bulk users are not often aware of the costs involved with their actions. 'By obliging an executive sponsor, such as a Chief Energy Officer in the case of bulk consumers, organizations are stimulated to implement energy-saving changes by granting inspection.'

Outsourcing tasks to external parties creates a problem too. For instance, a growing number of enterprises outsource their IT to hosting companies. Organizations receive a monthly invoice from these outsourcing parties, which does not state the energy costs. The hosting companies still do not benefit much by improving the energy efficiency, as it does not make a big difference in the invoice that they send to their customers every month. It often concerns 'only' tenfold of Euros per month, which will not result in great competitive advantages.

The government needs to stimulate the consciousness-raising process more effectively and obligate outsourcing companies, such as service providers, to inform end customers about their energy consumption. In this case, the consumption must be itemized clearly. 'The more you are confronted with your energy consumption as a user, the higher the urge becomes to introduce improvements. The consumption must be made comprehensible. It means little to users if you calculate the energy costs of certain production processes or information systems in kilowatt hours. If one knows how many cars could be driven for this amount of energy, then this will lead to action sooner.'

Communication:

People must understand that *Energy Efficiency is not something that simply happens ("Save Energy"). It requires action ("Reduce Energy Waste"). In addition, the connection between actions and results must constantly be visible. We recommend using the daily newspaper and the Province's website to show **energy use** vs. **availability** or **emissions** vs. **needed reductions***. The Province might want to consider putting an energy dashboard (like the one below) to communicate the **need for CO₂ savings** and the **progress** thus far.

Every building's "Energy Signature" should be benchmarked as a quality indicator. The signature should be visible to all and open to bid by companies. This information would also provide the customer with the information on how to improve and by how much.

Environmental Display

Energy-Saved Per Day

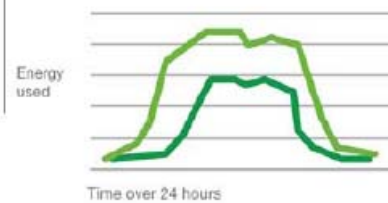


Savings Comparison



Office Panel

Daily Energy Usage



Graph Info

Signature New system

The information gathered is from Jan 08 - April 08, and taken from and averaged over a 4-month period.

Example of a dashboard:

Understanding “Why & How”

Kids today understand why the polar bear is suffering. But how many can explain the carbon cycle? How much is one Ton of CO₂?

Schneider Electric has launched the e-learning website Energy University (www.myenergyuniversity.com) to provide the latest information and professional training in Energy Efficiency concepts and best practices. In addition to learning new energy conservation, ideas that contribute to the overall well-being of the earth, people will also become more valuable employees by contributing to the bottom line of their company. Utrecht can start using the Energy University at the Hogeschool van Utrecht and even in other academic learning paths to make students more aware and more knowledgeable on this important subject.

The Schneider Electric Energy Edge service helps companies realize the benefits of energy efficiency with minimal risk and a large potential payback. Our proven process, combined with a holistic view of facilities and ongoing proactive measures, gives companies the ability to invest in energy efficiency with a predictable rate of return. Energy Edge addresses all energy consumption in a facility, from the building “envelope” to the internal controls and systems, including lighting, heating, air conditioning, electricity, and water.

By leveraging energy and facilities as investments, companies can gain control of energy use and achieve high rates of return in the form of energy savings. The Internal Rate of Return (IRR) on these projects can be sizeable. In fact, they can be even greater than other corporate investments. When considering the cost of capital, the Modified Internal Rate of Return (MIRR) can be as high as 29 percent. Companies are also eligible for rebates from utility and government programs.

Benefits from this investment approach include double digit energy reductions, as well as improved building performance, worker productivity, and environmental responsibility.

The comprehensive, step-by-step approach of Energy Edge allows executives to make informed decisions about their facilities and energy use. The result converts sunk energy costs into competitive agile assets.

Residential Buildings: Project “Kill a watt”

In 1975 a home used 100 GJ/y, now the number is 50 GJ/y. In the near future, this will be need in the near future is max 10 GJ/y

Utilities face a growing demand, while managing Production CAPEX to meet the needs. Reduce and shape the demand becomes crucial!

Schneider Electric Home Energy Management solution will be a combination of

- An Active Energy Management solution
 - Providing to consumers a monitoring and on line audit of their energy consumption (Energy cockpit)
 - Giving him the means to reduce their consumption by behavior change and active decisions and/or automation
- A Demand/response management
 - With bonus / malus on tariff, hourly energy price to incentive customers to move a % of his consumption to accurate time frame
 - To allow utilities to adapt the demand in order to
 - Avoid peaks, better use the renewable and distributed energy capacities and reduce the usage of High CO₂ emission production plant
- In-Home Management of distributed power generation

A partnership between Schneider Electric and the utilities will bring the possibility to benchmark, get more awareness and implement active energy efficiency in the homes in the province of Utrecht.

Demonstration project:

Use IKEA to promote energy efficiency, energy savings, and CO₂ conservation as part of a larger program.

People are not aware of possibilities of energy savings; some are too complex, others are not sufficiently known by the public. To change this, a demonstration project could be placed next to the IKEA. In this house several possible solutions can be shown at the two known directives: passive measures, and active measures.

Schneider Partnerships: The key to Our Success

Schneider Electric, as a leading company in energy management, is transforming into a full solutions provider. Offering our solutions with the additional knowledge and support is our key added value. A perfect Dutch example of this is the new Head Quarters of TNT, the TNT Green Office, whose construction will be complete by the end of 2010. TNT is the leading mail company in the Netherlands, with locations and business all around the world. For their new HQ, TNT has partnered with OVG Projectontwikkeling and Triodos. OVG is the largest commercial property developer in the Netherlands. Triodos is the financial partner, which is founded on a sustainability strategy. OVG and Triodos were selected to build a 17,000 square meter HQ and are responsible for the realization of the building and managing its energy use for 10 years.

The building will be CO₂ neutral and will get a LEED Platinum certificate for both the building and its energy use. To reach this goal, OVG and Triodos selected an unconventional approach, but understood that they could not realize this goal on their own; they would need partners. Schneider Electric is one of these partners, connected to the project from the earliest stages.

Schneider Electric delivers the total energy distribution solution, the building management solution, energy management solution and the security solutions.

Schneider Electric has been supporting TNT in the specification and realization process and, now that all parties are involved, we are responsible for the results. This was only possible when the founding goals were made our common goals. Today we work together with all partners, from architects and builders to contractors and subcontracted partners in transparency and openness. This may sound romantic, but it is reality. As the builder says, "When you walk through the building, you do not see anything extraordinary. But when you go into the details, you know the result would never have been possible if the partners would not have worked together, from both a financial and technical standpoint.

A simple but clear example has been the energy and data distribution in the floors. TNT asked for a raised floor to ensure flexibility on the large and open floors. LEED showed this would have a negative impact on the scoring since it would add a lot of materials, not needed for the basic construction of the building. Recessed floor boxes seemed to be the answer, but with their standard height and the complexity of the very wide floors this was no option. Rather than looking for other solutions having an impact on the flexibility and again on the addition of materials the partners worked together on specifying a special floor box which has been developed and produced by Schneider Electric. Only this simple floor box today has the attention in the market for other projects for exactly the same reasons.

When the contractor sees an opportunity to improve the solution with a positive impact on the exploitation of the building there is direct communication, up to the level of the developer and in some cases with the tenant, TNT. Thus not the conventional reaction: "The contractor has a point, so it must be that he sees a place to make more money". This is covered by the agreed transparency and communication between the partners. Recent discussions with leading investors and end users underlined the point that partnership from the start of a project is the only way to reach the sustainability goals we set today.

This is the way of cooperation and partnership, and Schneider Electric would like to invest the same time, effort and philosophy, for Utrecht.

Nordex Recommendations Forthcoming

WeKa Daksystemen BV.

I. Overview

WeKa Daksystemen BV. is a Dutch roofing company which specializes in production and installation of waterproof, durable and environmentally friendly roofing products. Our company strongly believes in bringing products to the market that will make a positive change to our well being and our climate. That is why we not only offer durable photovoltaic roofing solutions, but also total solutions for complete building management; energy production, energy storage and everything in between. WeKa and her partners provide and supply solutions for energy neutral buildings in existing as well as newly constructed edifices.

WeKa products have won several prestigious awards in the Netherlands:

- The 2008 innovation award, presented by the minister of Economical Affairs, Maria van der Hoeven to our own Dick Groenenberg.
- Our client WTH, won the prize for best energy project. Minister Cramer, from the Department of Environment, presented the prize to the commercial manager of WTH, Geert Ververs.

2. General Opportunities in Utrecht

There is huge building integrated photovoltaic potential in the province of Utrecht. There is 12.000.000 m² of flat and slightly sloped roof space available, and 1.080.000 m² of roof space is either renovated or built yearly.

Using this immense potential in Utrecht, building integrated photovoltaics could produce 600.000.000 kWh, and save 1.120.000.000 kg CO₂. Integrating photovoltaics with roofs during scheduled renovation and new construction, Utrecht could capitalize on the full potential of building integrated solar in about 12 years. In cooperation with green banks, WeKa could provide capital for the installation, as well as the management expertise needed to initiate and develop the project. The warranty on the solar installations will be 20 or 25 years, depending on the product (Evalon-Solar or Solyndra).



3. PIUS X and CANISIUS COLLEGE

It was requested by the management of the college that a solar roof be installed as an educational tool for its students. It was decided that two systems be put on the roof. The roof will also be equipped with an extra monitoring system and, in the main entrances, flat screens with additional software will be installed.

Introduction

Total roof size is 350 m², of which 53 m² will be covered by Evalon-Solar (white) and 33 frames of Solyndra Solar modules.

3.1 Technical specifications Evalon-Solar and Solyndra

The roofing material is sustainable and completely environment friendly. The materials do not consist of toxic materials and are fully recyclable, fitting within the concept of cradle to cradle. The materials are resistant to chemicals, copper and iron dust. The Evalon-Solar is a membrane of EVA integrated with Alwitra Unisolar modules. These Solar membranes are certified by the TUV, and comply with the highest European standards for roofing materials and solar technology. This brand is the highest selling flat roof system in the world because of its high quality, performance and efficient installation. In addition, it's the only system that delivers an aesthetically pleasing roof surface without crinkles, lose threads or connection boxes. The photovoltaic modules are specially designed for use on flat and lightly sloping roofs with strong reflecting surfaces. Solyndra frames consist of two glass tubes, the inner tube has a layer with a CIGS Solar cell which is protected by the outer glass tube air tide press with a special silicone past.

3.2 Cost

The total cost is 99.440,00 excl. VAT for a waterproof membrane and a fully operational solar installation, including the removal of the old roof.

3.3 Warranties

- Evalon-Solar including 80% of the output - 20 years
- Solyndra including 80% of the output - 25 years
- All the other components - 20 years

3.4 Maintenance

Maintenance and quality inspections will be executed once a year. The first year is free of charge, further maintenance will be contractual agreed to after the first year.

3.5 Output

- Evalon-Solar 2.45 kWp is 2500 kWh
- Solyndra 10.01 kWp is 8700 kWh
- 1.7 CO₂ reduction
- The CO₂ reduction will be 9.480 kg per year

3.6 Details of the project

Current roof: Bitumen with mastiq underlayment

2.3 RC isolation partly filled with water, which is the result of poor maintenance.

350 m² of roof space

3.7 Proposed solution: Renovation



The existing roofing membranes (bitumen) and the insulation will be removed in order to rebuild the roof from the concrete level up. An emergency layer will be attached to the concrete (APP 460 K14 thick 3 mm), this layer also has the function of vapor barrier. Thermal isolation type PIR 2 x 50 mm (RC 4,2) will be mechanically attached to the concrete. Partial slope isolation (EPS) will connect to the PIR to create a slope of three degrees for the Evalon-Solar membranes. All membranes will be white in color, with a high reflection coefficient.

52 m² of Evalon-Solar will be mechanically attached with parkers and rings according to NEN 6702, NEN6707 and NPR 6708. 298 m² of Evalon will be mechanically attached to the roof. Evalon V thick 2.2 mm white, edging of the roof, parkers NEN6702, NEN 8707 and NPR 6708.

All the seams will be sealed with hot air at 600 degrees.



Roof edge construction:

Before assembling the steel hood of the roof edge, the membrane will be attached. A strip of Evalon SK (self adhesive) must be glued from the front of the edge to the roof (at least 100 mm). Also the seams will be sealed.

On the roof edge, the roofing membranes will be composed of foliate steel plating and designed according to wind pressure calculations and NEN 6702/6707. Drainage, emergency spitters and smoke/air connections will also be installed. All pipes have a collar of Evalon N, which will be sealed to the roofing membranes.

Assembly of the Solyndra modules:

55 frames Solyndra type SL-001-182 will be assembled according to the technical instructions of the producer and layer.

Weight is 20 kg per m², including the Evalon roofing membrane.

Installation activities:

- 1 Fronius inverter type IG Plus 100
- 1 Fronius inverter type IG 20
- 138 mounts
- 1 set cables
- 1 certified kWh meter
- 1 return kWh meter
- Two flat screens with statistical analysis software

All building activities are excluded from this proposal.

Pricing:

Total cost of a new roof and solar systems Evalon-Solar and Solyndra is 99.944,00 euro excl. VAT.

- Removal cost of the existing roof is 14.250,00 euro
- Cost of Evalon-Solar and Solyndra modules 54.000,00 euro
- Cost of Isolation, membranes and other details 31.694,00 euro
- Not including in these figures is the risk and the safety plan

Included are:

- Layers
- ROI calculation
- 20 years warranty for the Evalon-Solar
- 25 years for the Solyndra
- 20 years waterproofing of the roof
- A customer manual detailing the installation and software
- One year maintenance free of charge

Utrecht Decarbonization Plan Proposal



PositivEnergy Practice LLP
Adrian Smith + Gordon Gill Architecture LLP

A decarbonization plan is a dynamic and concurrent approach towards reinforcing the cultural vitality of the city while maximizing its ecological and economic efficiency. A decarbonization plan focuses on climate change as a thematic integrator, aggregating key performance indicators across a broad spectrum of categories: energy, water, waste, land use, health and mobility in an open source networked virtual city model, the UrbanOS©. This virtual layer of the city, living in parallel with its brick and mortar counterpart, allows for continued decision support beyond a traditional planning effort. Enabled with unprecedented access to stores of information, it is adaptive and accountable, continually mining data for new opportunities for improvement, seeking equilibrium with real estate, energy and carbon markets.



- Aggregates annual energy consumption, demand profiles and broader scope carbon emissions from a comprehensive set of end uses and readily allows for a statistical comparison of consumers, such as similar buildings, to rank opportunities for resource sharing and carbon abatement
- Maximises carbon abatement value through multi-objective optimisation of specific strategies and policy instruments identifying opportunities and incentives for new development
- Tracks and predicts the success of carbon emission reduction initiatives providing diagnostic and decision support for further measures of energy efficiency and greenhouse gas emission reductions
- Communicates with a broad spectrum of audiences the details and progress of specific initiatives to build political will and broadcast the successes of the city to the world

In Utrecht, the UrbanOS© will be utilised by a decarbonization planning effort to identify opportunities for tapping into the latent potential energy in existing buildings to bring online new planned development, such as Rijnenburg or Soesterberg, with little to no impact to the city's overall utility loads. Intelligent and interconnected, the UrbanOS© provides a platform for social marketing to develop public consensus for these planned works and to broadcast the city's achievement to the world. A combination of energy cost savings, central utility investment mitigation, clean technology marketing, carbon abatement, and real estate appreciation may also be directed towards investment in the planned development. In this capacity, the model serves not only as a vehicle for public engagement, but as a virtual market place for future resource consumption and greenhouse gas emissions reduction associated with the built environment.

2012Architects

2012Architects utilizes the contextual potential for design. A design is not considered to be the beginning of a linear process, but a phase in a continuous cycle of creation and recreation.

2012Architecten is directed by: Jan Jongert (Amsterdam, 1971), educated at TU Delft and Academy of Architecture in Rotterdam, Césaire Peeren (The Hague, 1968), educated at TU Delft department of Architecture, Jeroen Bergsma (1970), educated at TU Delft department of Architecture.

Since its start in 1997 2012Architects has developed several strategies to contribute to sustainable design, building, and urban planning.

Recyclicity

Most of our cities have grown into conglomerates of monofunctional districts that hardly relate to each other. Business districts, industrial zones, agriculture, housing and commerce are spatially restricted and hardly benefit from each others presence. The increasing flow of incoming and outgoing goods, energy, water, food, and even capital have lost connection between their place of production, consumption and disposal. They contribute to limitless transport, local clogging of traffic, loss of energy and growth of pollution.

Recyclicity creates interaction between current flows by intelligently linking them, helping to regenerate districts into dynamic ecosystems. (recyclicity.vacau.com)

Superuse

As a first step towards realizing Recyclicity, 2012Architects initiated Superuse, a trendsetting concept for reuse of material wasteflows with as little as possible added energy for adaptation and transport. Since virtually all of the products that surround us today have been designed for just a single (short) life and do not take in account the treatment after this lifespan, special effort has to be undertaken for discovering their potential in the phase after they have been discarded. Superuse explores the reappropriation of waste components and elements into functional products for design-, interior and building applications. (www.superuse.org)



the first Superuse Villa by 2012Architecten in Enschede 2009 (60% locally reclaimed materials) Photo by Erik Steekelenburg

Harvest Maps

In order to use local sources to realize superuse buildings, we have developed the technique of Harvestmaps.

A harvest map shows available sources in the proximity of a planned construction site:

- available material sources
- derelict buildings and wastelands
- potential energy sources (heat/cold and electricity)
- unused food production facilities
- derelict infrastructure

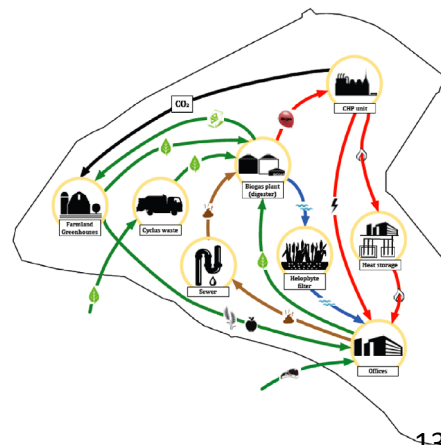
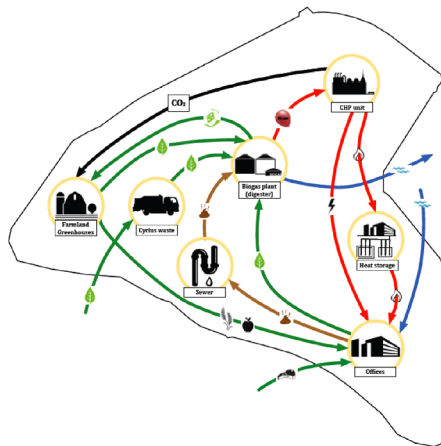
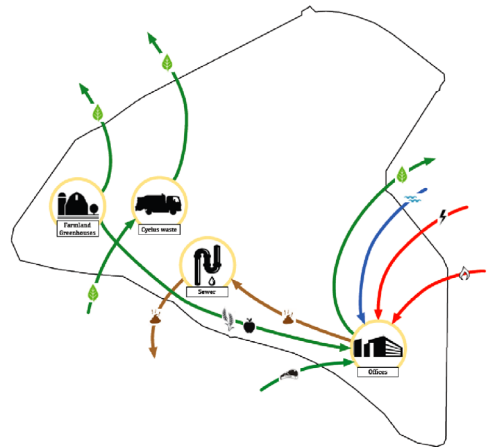
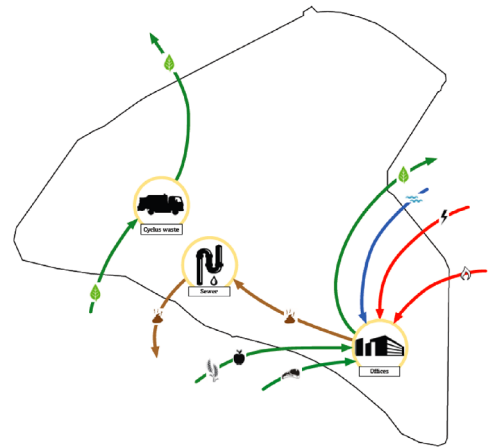
The map indicates geographical positions, amounts, dimensions, availabilities and potential for each source. In the past years, we have made harvest maps for Enschede, Apeldoorn, Dordrecht, Utrecht, Amsterdam, Rotterdam, Eindhoven, and New York.



Cyclifier

When buildings need to contribute to a cyclical organised city or region, building or spatial entity that will facilitate the exchange between different flows.

In order to re-loop urban flows, a new type of building and urban space is needed, which we call cyclifiers. They connect source and waste streams, and facilitate the exchange between flows of energy, material, water, food, transportation, skills, information, etc. This prevents useless transportation energy loss and pollution, and reactivates neglected neighbourhoods. Cyclifiers ideally are programmatic enrichments of existing urban actors.



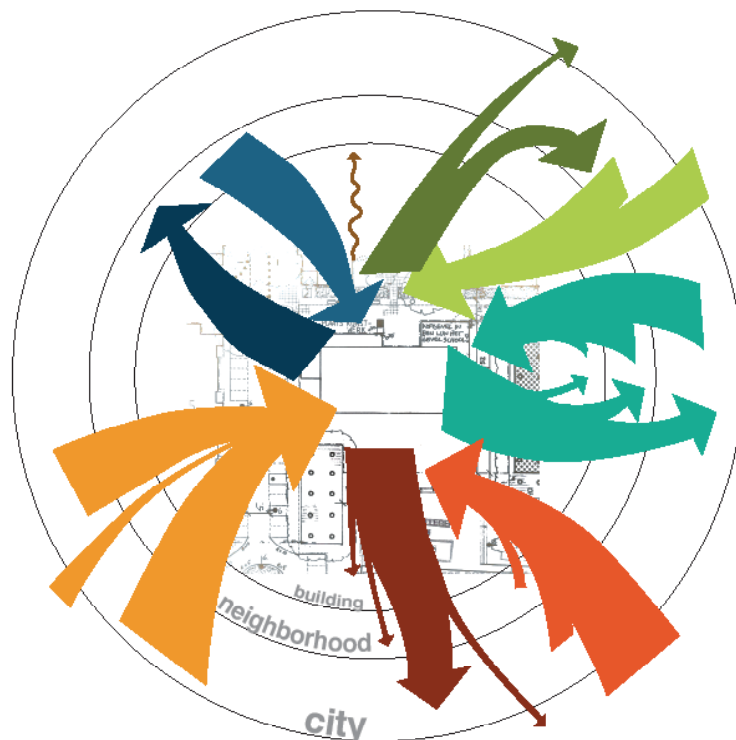
Utrecht Cyclifier

For the Utrecht Cyclifier we propose to connect four of the identified flows in a communicative manner: public(users), energy, built environment and material

Using the potential of empty offices, a transformation can take place that breathes the approach of the third industrial revolution. Empty space will now serve a new purpose, as the building is made self sufficient in energy production and is able to regulate its own heating and cooling by adding insulating layers and greenhouses.

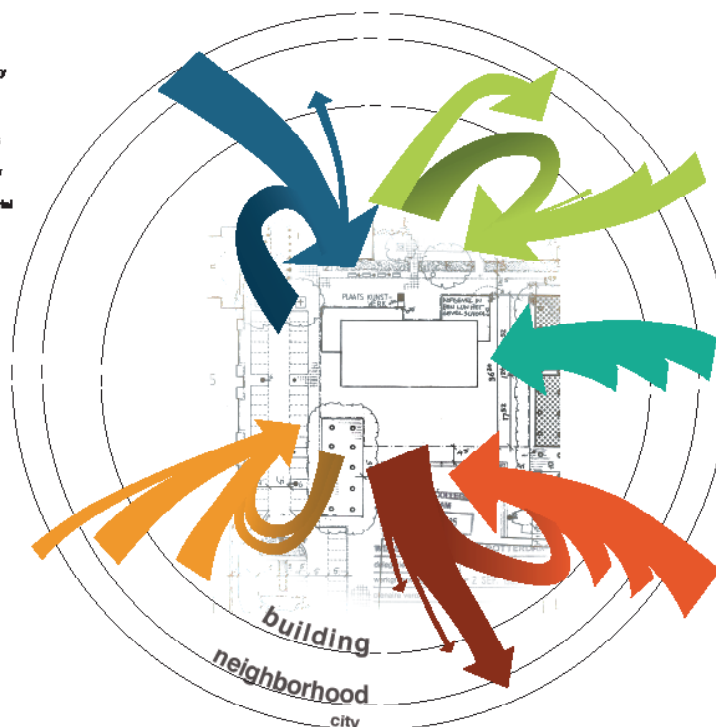
The result of this transformation would be a building that optimally fits its site, connecting active flows, and creating a balance for itself and its surroundings.

2010



traditional in- and outgoing flows for buildings

2040



in- and outgoing flows for a building as cyclifier



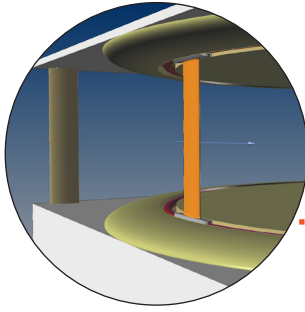
derlict office building



sketch for the cyclifier
138

Design Components

Maglev turbine
high efficiency wind energy



patented C. Kapteyn

MATERIAL SUPERUSE
reduction of waste and transport



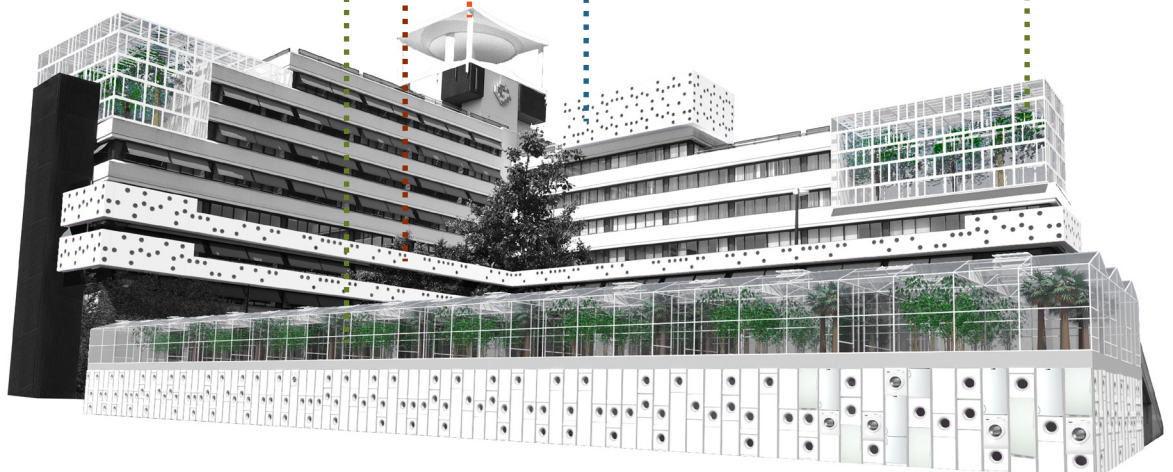
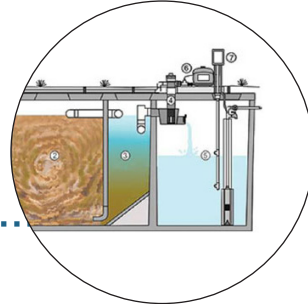
PARKING GLASSHOUSE
food and heat production
CO2 sequestration



WINTERGADEN
heat production
natural ventilation
CO2 sequestration

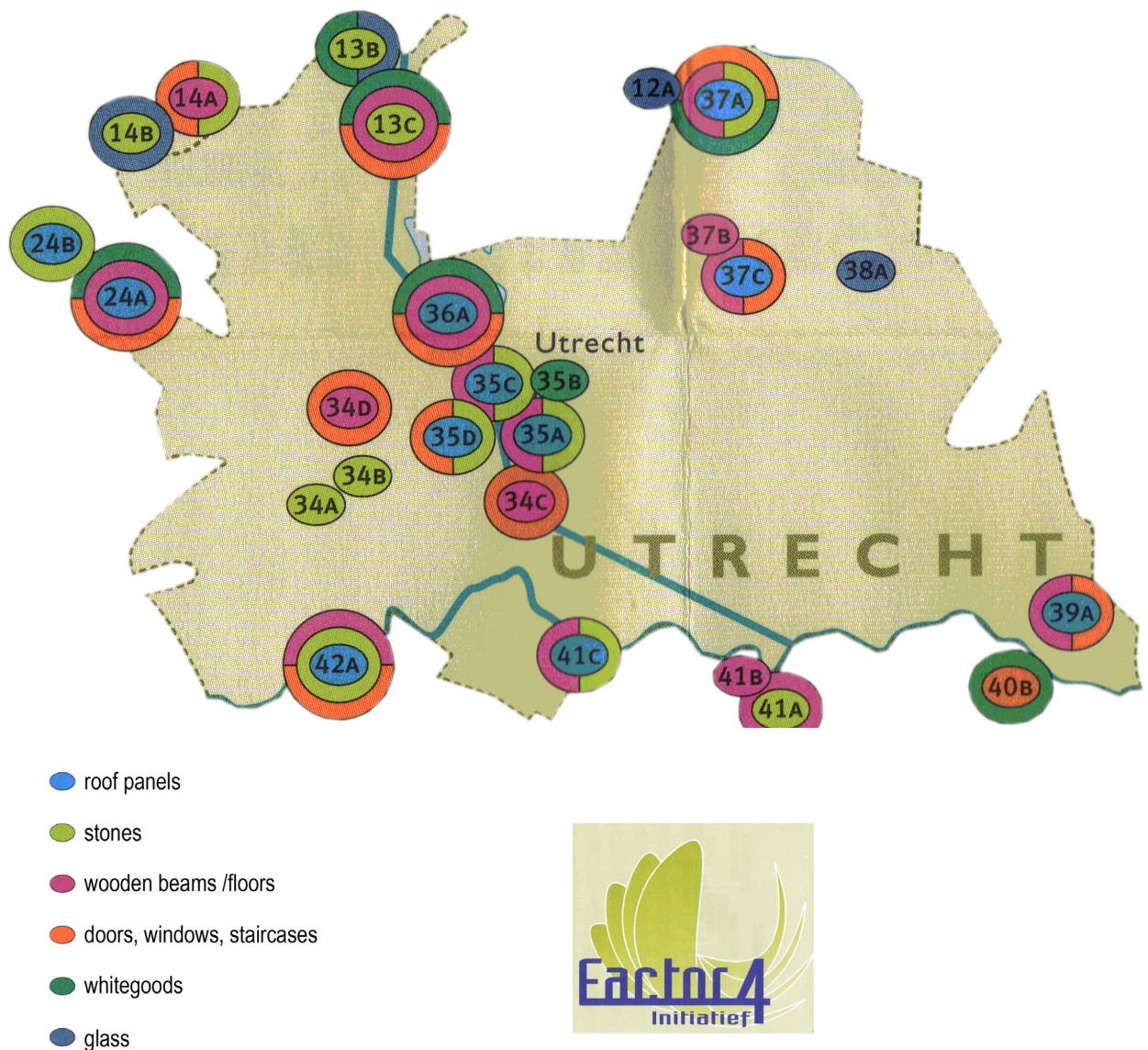


WATER REUSE
rain water collection
gray water filtration



Materialization

For the harvest map of the Utrecht Cyclifier, we propose to work with Kringloopbouwmaterialen.nl, a Utrecht funded and based initiative. We'll include information from a very well developed source plan for secondary building materials. The map shows that Utrecht has a wide variety of supply fitting the concept.



sourcemap of second hand materials within the Province of Utrecht (www.kringloopbouwmaterialen.nl)

References

2012Architecten has produced a decade of inspiring designs for interiors, buildings, and recently for urban and regional plans. Clients vary from private to commercial to local and national government. The qualities rewarded most are: the capacity to be experimental and practical, socially and environmentally conscious, innovative, esthetical, optimistic, trendsetting and humoristic.

In the past years, 2012Architects has been able to construct interiors with up to 95% locally reused materials and buildings up to 60%. At the moment, the office works on Urban design projects according to the Recyclicity strategy.



Espresso Bar Sterk Faculty of architecture Delft (material: reclaimed wash machines)



No Flat Future study for Ministry of Vrom (retrofitted postwar flats made out of reclaimed window frames)



Villa Welpeloor for private clients (materials used :cable reel wood, machine-steel, construction wood)

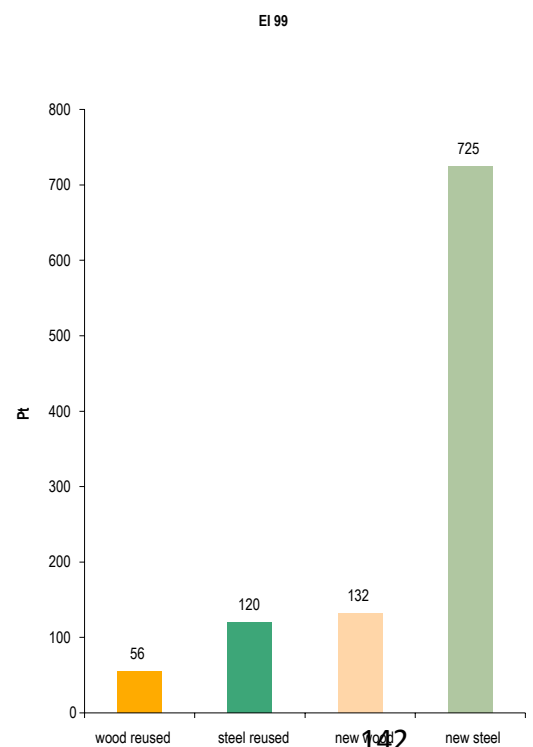
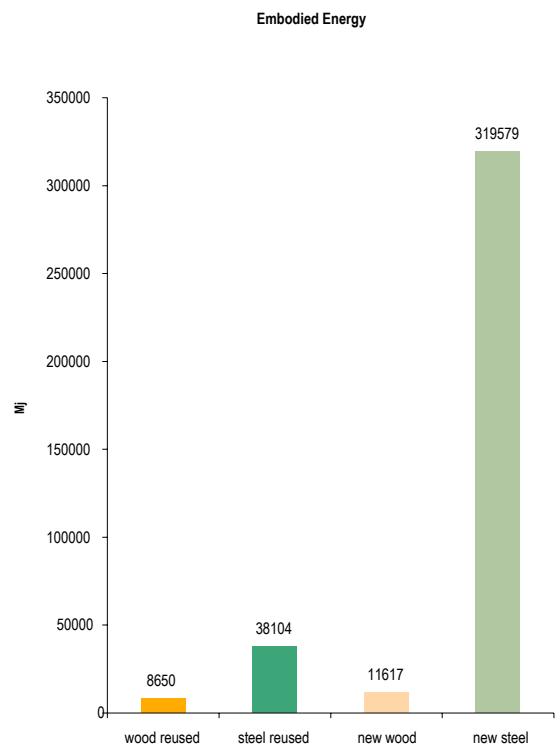
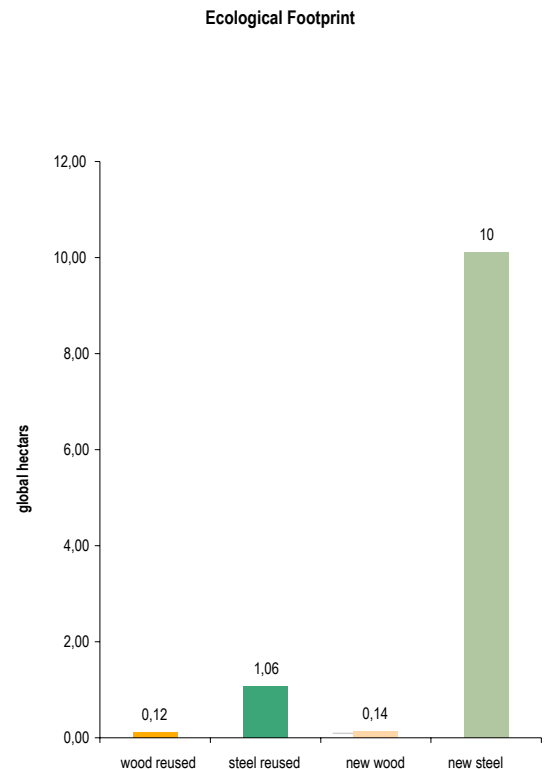
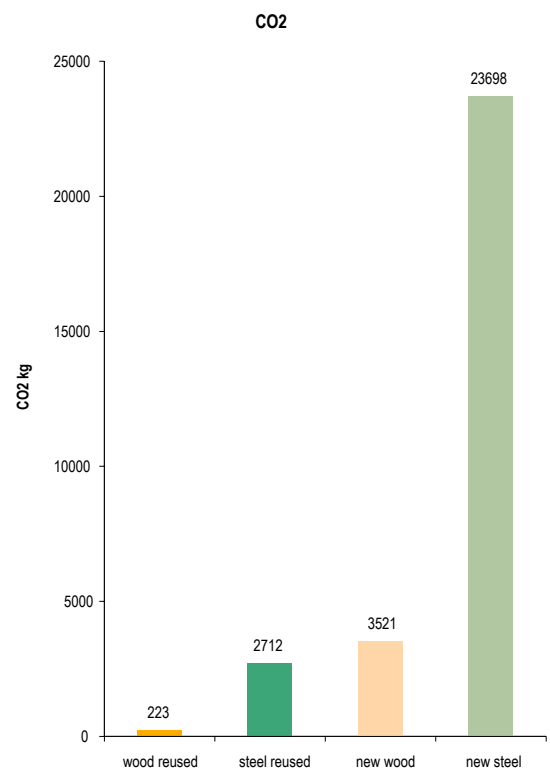


Sink Skin by 2012Architecten i.c.w. MVRDV (office building made out of reclaimed sinks)

Environmental Impact calculations

In order to measure the impact of our buildings on the environment, we have included an environmental scientist in our reserach team. Recent evaluations show that Superuse will create serious reductions in CO2 emissions for construction in its projects.

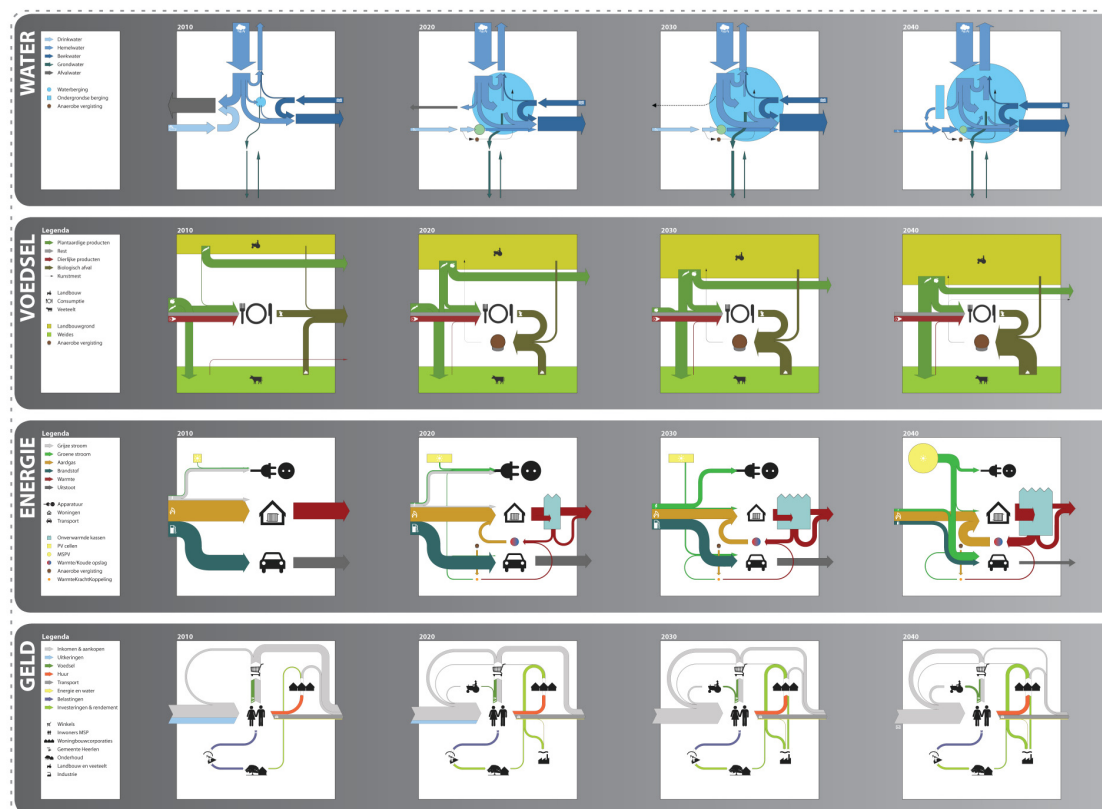
Below are four graphs showing the reduced impact for superused steel and wood in CO2 emisions, ecological footprint, embodied energy, and environmental impact..



Action plan

Based on the described strategies, we could outline a principal 7-step plan, that would follow these steps:

- site analysis and definition of system borders
- inventory (harvest maps of flows and possible partners)
- identification of possible interaction (inside and outside)
- architectural concept
- implementation
- evaluation/adaptation (including environmental impact calculations)
- repeat [a-f]



Smart Grid Renewable Hydrogen in Utrecht

1 Overview

Renewable energy sources of power, such as wind and solar, are rapidly being adopted worldwide as a means to improve our environmental footprint. However, due to their intermittency, we still heavily rely on fossil fuel power to provide stability. Thanks to the versatility of hydrogen, this problem can be put in the past.

Hydrogenics offers clean, zero emission solutions from production to consumption. Hydrogen excels in its ability to store large quantities of energy for long periods of time. It is an excellent option to smooth out the intermittency of renewable energy sources by generating 100% clean fuel as a replacement for today's fossil fuel vehicles. Hydrogen creates the pathway from renewable energy to vehicles that can eliminate the need for fossil fuels in transportation.

Hydrogenics is a leading provider of hydrogen fuel cell and infrastructure solutions. Started in 1948, we have over 60 years experience in the hydrogen business for renewable and industrial applications and an extensive 10 year experience in hydrogen fueling stations. We are committed to a better, cleaner future and have been an active player in promoting hydrogen technologies and products.

Hydrogenics' core activities consist of three business lines:

- **Hydrogen Generators** for industrial hydrogen production and energy applications,
- **Fuel Cell Power** systems for back-up power and mobility applications,
- **Renewable Energy Systems** for community energy storage and smart grids.

2 The Opportunity for Smart Grid Hydrogen

Renewable energy sources of power, such as wind and solar, are an attractive source of electrical power as they have little or no emissions, are sustainable and provide a domestic energy source rather than relying on costly energy imports. By deriving more of our power from uncontrollable renewable energy sources, we are complicating our ability to control and balance the grid, which is traditionally fed with steady electricity from coal or natural gas power plants.

One of the solutions to manage intermittent renewable power, is to create more controllable loads that offset renewable sources. A fueling station equipped with an electrolysis system uses electricity to generate hydrogen fuel from water, which can be rapidly controlled over a broad load range.

Hydrogen vehicles and fueling can provide the important controllable load that renewable power sources critically need to allow high penetration into the modern grid. We have the opportunity to simultaneously change the way we generate, store and use energy in our grids and in our transportation.

In addition, hydrogen produced from this process can be used in traditional industrial hydrogen markets by allowing utility companies to control the electrolysis plant intermittently in order to match grid requirements. The benefit to the electrolysis plant owner is a lower overall cost of hydrogen delivery to their process thanks to demand-response or ancillary services contracts.

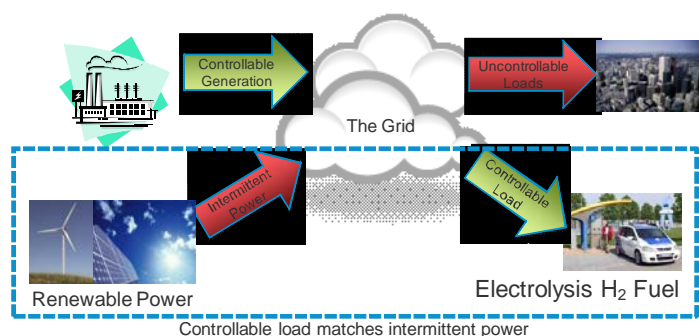


Figure 1: Electrolysis is a controllable load needed with more RE power

3 Hydrogen Vehicles and Fueling Infrastructure

Hydrogen Fueling Stations

Hydrogen can be used as a transportation fuel with over 150 fueling stations around the world supporting demonstration programs for buses, cars and off road vehicles such as forklifts. A fleet of 100 municipal buses would consume about 3.8 tonnes of hydrogen per day given typical bus routes. If supplied with electrolysis, this would represent about 10 MW of continuous load. In addition, the fueling stations and the load could be in several locations allowing control of load to address transmission constraints as well as load balance and ancillary services. With the appropriate amount of extra hydrogen storage, there would be no impact on the station's bus users for potentially many hours or even days.

Electrolysis Systems

Electrolysis systems have the ability to ramp up and down very quickly without any adverse effects. The Hydrogenics HySTAT electrolyzer systems can operate over a wide range of capacities from 10%-100% of

rated load for large, multi-stack systems. If the system has storage, as is the case with fuelling stations, the electrolysis can be operated at different times from the fuelling of the vehicles.

Hydrogenics current HySTAT electrolysis product line is highly modular with building blocks of 365 kW (60 Nm³/h hydrogen output). Multiple systems are often delivered to a single site achieving 1-5 MW and very large-scale system concepts could achieve 10-100 MW.



Figure 2: HySTAT 60 product (350 kW load)

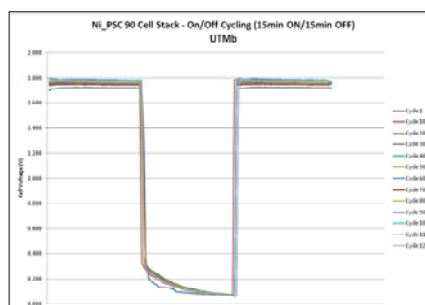


Figure 3: IMET electrolysis on-off cycling showing fast ramp rate

Hydrogen fueling stations have hydrogen storage allowing the electrolysis system to ramp up and down independently from the hydrogen load requirements.

4 Smart Grid Renewable Hydrogen in Utrecht

Project Details

The proposal for Utrecht is to install 300 municipal buses supported by 10 fueling stations. These fleets and fueling stations will be distributed across the region of Utrecht to maximize the positive impact on the grid. The total load represented by these stations is approximately 30 MW of highly controllable load that can help the grid operator manage renewable energy intermittency and transmission constraints on the grid.

Bus Details	
Bus capacity:	~35 seats
Typical distance travelled:	250 km
Fuel consumption:	15 kg/100 km
Station Details	
Number of municipal buses:	30
Fueling station maximum hydrogen capacity:	480 Nm ³ /h (1000 kg/d)
Fueling station power draw:	3 MW
HySTAT 60 modules:	8 units

Benefits of Renewable Hydrogen Fueling

The ability to use an electrolysis load to provide ancillary services gives the grid operator an additional tool to manage grid intermittency. Using a controllable load can offer significant advantages over using controllable power sources for ancillary services and demand response.

- **Zero Emission Link:** Hydrogen electrolysis produces no incremental emissions and provides a totally clean and green connection between renewable energy sources and zero-emission transportation using hydrogen fuel
- **Additional Income Stream:** By delivering ancillary services, the electrolysis system is able to generate an additional income stream, effectively lowering the cost of delivered hydrogen for either industrial or transportation hydrogen applications
- **Frees Power Resources:** Using load for ancillary services frees the power generation systems to focus on only providing power
- **Better Response Rates:** Using loads also provides a better response to the control centre requests. Loads can typically respond more quickly as opposed to large systems that have slower response rates
- **Alleviate Transmission Problems:** The modular nature of electrolysis loads also allows it to be distributed broadly across a particular grid. This provides the additional opportunity to balance load, provide ancillary services as well as allow transmission constraints to be addressed. For instance, if an area had five large electrolysis fuelling stations and a transmission problem occurred in a location with one of the fuelling stations, then that station could be temporarily turned-off until the problem was resolved
- **Modularity and Redundancy:** The modularity makes the overall system less prone to large-scale failure, decreasing the need for redundancy in overall ancillary services contracted

Efforts to promote the adoption of renewable energy sources on our grids and hydrogen vehicles for our transportation do not need to be independent efforts. They can be linked with hydrogen electrolysis in a way that is highly complementary. Hydrogen vehicles and fuelling can provide the important controllable load that renewable power sources critically need to allow high penetration into the modern grid. We have the opportunity to simultaneously change the way we generate, storage and use energy on both our grids and in our transportation.

4.1 Contact Information

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Cisco Smart Energy Consulting Engineering Team, 8-23-10

Chris Lonvick, Director of Consulting Engineering

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Introduction

Cisco thanks Jeremy Rifkin and the Province of Utrecht for inviting us to participate in your workshop on the Third Industrial Revolution in February, 2010. Despite the challenges, we believe there are many positive changes that will come from a transformation of Utrecht to a Third Industrial Revolution community. As a leading global provider of communication and information technology, Cisco is excited to be part of the Third Industrial Revolution—a revolution marked by the convergence of a new distributed energy generation and communication regime.

Though this revolution is underway and the sub parts are documented in Mr. Rifkin's 4 Pillars, not all the necessary solutions are developed. This presents some challenges, but it should not delay initiation of numerous projects that will drive change while saving money and reducing greenhouse gas emissions. In practical terms, this means that many projects can start and generate savings without the full roll-out or integration with the smart grid. While distributed renewable energy, buildings as power plants (micro grids), Hydrogen creation and storage, plug-in vehicles and other components of the Third Industrial Revolution can all be implemented as independent initiatives, when each part of the puzzle is connected to the others, their combined value grows.

Given the vast opportunity for recommendations on pilot projects, the scope of possible challenges and the enormity of the changes necessary to transition the Province of Utrecht to a Third Industrial Revolution Community, the Cisco team focused its recommendations on activities that positively affect as many community members as possible as early as possible. That dictates a focus on end users of energy in commercial and residential buildings. Though Cisco also provides numerous utility solutions, there are a number of other Rifkin associates focused on the workings of the smart grid from a utility and central plant perspective. The following document describes our recommendations for Utrecht.

Background

In order to understand the solutions needed for buildings that operate as part of the Third Industrial Revolution, it is important to review them in relation to the future smart grid.

Today's electric grid was developed over one hundred years ago. During the intervening time consumers have grown accustomed to using more electricity when they wanted, while disregarding the impact on the grid. Consumers (and businesses) assumed that if they turned on a light switch, power would flow to the light. When customers demanded more power, the utilities responded by making more. With the recent and rapid rise of energy consumption, it's becoming clear that the world's ecological limits are near. Rising energy prices, monetization of carbon and the need to reduce



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greenhouse gas emissions is prompting utilities, regulators and consumers to consider new approaches to satisfy the growing demand for clean and reliable electricity. They recognize that new electric generation capabilities are needed and that the cheapest form of electric generation comes from generation that is not used. Conservation will power growth. This represents a substantial departure from the current coupling between utilities and their customers.

In response to rising energy costs, environmental concerns and government directives, businesses are increasingly seeking ways to transition to sustainable operations. This effort demands better tools to monitor and manage energy use. Though a number of new techniques, tools and processes have emerged that provide improved energy visibility and management, the advent of the Smart Grid introduces a unique and revolutionary opportunity to modify energy consumption and control practices. The energy management changes enabled by the Smart Grid have no equal since the development of the modern electric grid.

The future Smart Grid is a grid instrumented to have full knowledge of grid generation, transmission and distribution conditions. Moreover, it is fully aware of energy users' load, reliability, emissions and quality preferences at any point in time, and at any price. The Smart Grid will be more reliable while producing fewer greenhouse gas emissions per unit of output.

The development of the smart grid inherently assumes a development of smart loads. Any pilot project with a focus on sustainable use must also support energy intelligence. This means that buildings and load consuming devices should have a real-time ability to report power consumption to users. Increasingly, users are turning to internet communication technology as the method of choice for developing energy intelligence. Building communication networks and smart end devices combine to make the network a control plane for power and thermal energy management.

The Smart Grid vision can only reach its full potential when electricity generation and consumption are perfectly paired. The grid works this way today. However, today's electric grid lacks awareness of user preference for price, time of use, reliability and sensitivity to greenhouse gas emissions—this means that energy is wasted, used when not needed and that customers spend more money than necessary while consuming electricity made from dirty energy sources.

The Smart Grid will evolve by adding large distributed and micro generation sources like wind and solar, battery storage, plug in electric vehicles, and other intelligent loads, the ability to quickly—and in real-time—balance consuming loads with available generation is critical for grid stability. No longer will electricity flow from generator to consumer in a unidirectional point to point manner. For this to work, grid regulation (the perfect balance between generation and load) will be more challenging than ever.

The next generation grid will be intelligent, interconnected with redundant supply. For this to occur, the grid control systems must communicate with smart loads. This functionality dictates much richer capabilities with respect to intelligent load shedding. To achieve maximum grid reliability, output and



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savings with the least amount of impact to users, a rich set of user defined consumption preferences and conservation policies and enforcement mechanisms will be created.

A smart grid makes it possible for businesses and consumers to time shift electric consuming processes to take advantage of more reliable and cleaner power at lower prices.

Recommendations

To make the Third Industrial Revolution a reality requires real-time monitoring, measurement and optimization. Utrecht cannot optimize what it cannot see. Therefore, Cisco proposes leveraging Information and Communication Technologies to make the most of future investments.

Each pillar of the Third Industrial Revolution requires baseline system measurements, improvement targets and results reporting in order for users to know whether changes are required.

Not only can Cisco help provide the communication infrastructure necessary to rollout Pillars I through IV, but Cisco can also provide technologies and solutions necessary to help the Province to reach its goals.

The transformation of Utrecht is filled with opportunities for citizens, businesses and public leaders. Upon examining the requirements for Utrecht, there are many positive approaches that could work to start the Province's transformation.

Cisco proposes to focus efforts on the communication connections within and among buildings. Buildings represent the largest users of energy—and it's where community members can engage directly in the transformation. It is here that users will learn to save money, reduce generation emissions, improve system reliability and benchmark with peers. As Utrecht works toward a sustainable community, buildings must be reimagined and reconfigured as power plants. In addition to any physical changes that might be required, this transformation requires additional insight into energy consumption measurement, reporting and optimization.

The communication networks required to provide this increased insight and control can also provide additional building information services for tenants and home owners. ICT can be leveraged to make living and working environments personalized, efficient, functional, and profitable.

As the community rolls out pilot projects, it is important to convert energy consumption information into actionable information. This means that buildings must be innervated to collect and report real-time energy use information. Practically speaking, initial pilot projects should include simple shadow meters that enable users to see real-time energy load profiles. This information also needs to be normalized with respect to weather (these data standards are currently in development). But that won't prevent some basic steps that lead to large savings. For example, energy use profiles are often used to see where equipment is running—but malfunctioning. It's also a good way to spot poor performing buildings (by benchmarking).

Projects should be undertaken that provide immediate benefits and value to end users.

End users need to see when and where power is used; they must have the ability to set flexible conservation policies that match the needs of the home or business. In many cases, conservation

policies can be automated—making it is easy to conserve on a daily basis. ICT leveraged as an energy control plane will make it possible to: 1) measure current power consumption 2) engage policies to automate and take actions by controlling the power levels of attached devices and 3) change the amount of power being consumed. Energy consumed can easily be found with ICT by allowing a realistic view of power consumed per apartment, home, office building floor or campus. After power consumption is understood, optimization is made possible.

The ICT energy control plane must be able to monitor and control power 24/7 to ensure grid reliability while providing users with maximum energy at the lowest possible cost, not only during periods of electric grid instability and peak power events. The framework must enable users to convert energy consuming devices from “Always on” to “Always Available”.

Building planners must take steps to transform the physical spaces of today into the more efficient and cost-effective buildings of tomorrow. This transformation can be accomplished primarily by converging existing building systems into one unified and intelligent structure that monitors, maintains, and automates these complicated and disparate systems as:

- Data connectivity (including wired and wireless LANs)
- Voice communications (including IP-based telephony services)
- Building and site security (including video surveillance and building access)
- Digital signage (including passive displays and active touch-screens)
- Heating, ventilation, and air conditioning (HVAC) controls
- Building management systems (BMS)
- Electrical energy systems and utility monitoring and management

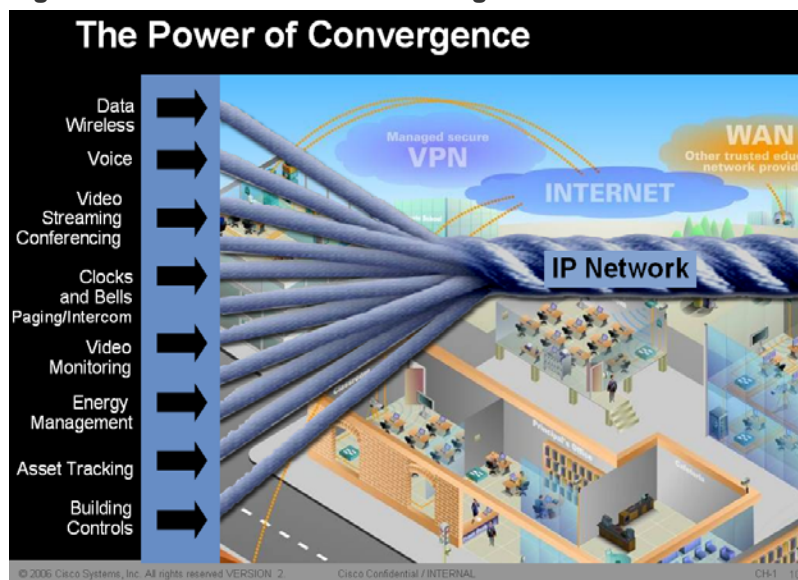
However, before this transformation can occur, building planners need to assess ways to connect various systems and applications together. Cisco, along with other Rifkin team members, can help Utrecht realize the monetary, cultural, and procedural benefits of converging data, voice, video, security, HVAC, lighting and other building controls on a single IP-based platform. This strategy can integrate existing disparate systems as well as new IP based systems.

The Cisco Connected Real Estate solution begins with an intelligent IP network infrastructure that integrates building control and management with Cisco next-generation technologies such as Cisco® Unified Communications, Cisco® TelePresence, and Cisco® Video Surveillance. The solution can enable the Province of Utrecht to:

- **Enhance productivity** by improving access to services through unified communications, mobile solutions, and biomedical device engineering, all running on Cisco's Medical Grade Network.
- **Improve building performance** by centralizing the operation of lights, heating, ventilation, air conditioning, and elevators to save energy and cut costs.

- **Provide a safe, flexible, customized environment** that promotes patient and staff security.
- **Manage costs and preserve natural resources**, by using technology to manage new environmental capabilities, such as solar power and energy management.
- **Provide better security and building management**, by integrating alerts from Fire/Life/Safety systems with building enunciation systems such as Digital Signage, IP Telephony, overhead speakers, alarms, lighting, access control systems, and event coordination solutions.

Figure 1: Cisco Real Estate converges critical functions into one network



The Cisco Connected Real Estate solution provides a “building information network” that uses the Cisco IP network as the foundation for communications systems, building systems, and personal devices. With Cisco Connected Real Estate, a converged IP network is built into the fabric of every building and acts as the platform supporting all other real estate requirements. Each part of the solution can support additional solutions, each a building block to create and support the next layer of solutions.

Specific Recommendations

1. Start with simple plans. Develop residential and commercial pilot projects that engage end users in energy conservation and control.
2. Ensure that pilot projects provide building occupants with real-time energy use. Normalize the data to weather (to ensure accurate benchmarking).
3. Leverage Information and Communication Technology. Use standards based communication protocols like IP/Ethernet.
4. Support innovation. New technologies and processes require flexibility and experimentation.



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Cisco Corporate Overview

At **Cisco (NASDAQ: CSCO)** customers come first and an integral part of our DNA is creating long-lasting customer partnerships and working with them to identify their needs and provide solutions that support their success. The concept of solutions being driven to address specific customer challenges has been with Cisco since its inception. Husband and wife Len Bosack and Sandy Lerner, both working for Stanford University, wanted to email each other from their respective offices located in different buildings but were unable to due to technological shortcomings. A technology had to be invented to deal with disparate local area protocols; and as a result of solving their challenge — the multi-protocol router was born. Since then Cisco has shaped the future of the Internet by creating unprecedented value and opportunity for our customers, employees, investors and ecosystem partners and has become the worldwide leader in networking — transforming how people connect, communicate and collaborate.

For more information about Cisco, please visit us at:

http://newsroom.cisco.com/dlls/corpinfo/corporate_overview.html

Implementing smart grids.

PowerMatching City: a living Smart Grid demonstration.



Implementing smart grids.

PowerMatching City: a living Smart Grid demonstration.

Distributed energy resources are a very promising way to solve today's climate and energy problems. To integrate distributed energy resources in the energy network on a large scale, grid operators and utilities will face new social, technical and economic challenges. As the project leader of PowerMatching City, KEMA is looking for the answers required to connect distributed generators and consumers in a smart way.



Smart grids

A sustainable energy system requires that a large proportion of our total energy be generated in the future by distributed energy resources like wind turbines, photovoltaic solar panels and micro cogeneration systems. At the same time, energy demand will change: electric vehicles will become our means of transportation, (hybrid) heat pumps will keep our houses warm during cold winter nights and washing machines will start when the wind power peaks.

The supply chain will change completely: from a classical, top down oriented structure to a full, bidirectional system. But market roles will also change — consumers will become prosumers and new market parties, like commercial aggregators, will enter the supply chain.

To connect and match the energy generators and consumers, the electricity grid is the linking pin. Without introducing smart solutions into the grid and behind the meter, the benefits of a sustainable energy supply won't be fully reached. Advancements in ICT technology make smart grids feasible. ICT will not only provide us direct insight into our energy consumption, but will also become a major controlling component throughout our entire energy system. Intelligent software will seamlessly match supply and demand of energy without human interaction, ensuring uninterrupted availability of energy whenever we need it.

Today, politicians, market parties and product suppliers recognize the potential of smart grids, but much is still unclear. As a utility, grid operator,



or manufacturer, you will have to answer many questions before implementing and connecting all of these sustainable and smart systems, including:

- How can the residual demand for energy be fulfilled without making concessions to cost-effectiveness, comfort and security of supply?
- What is the most optimal combination of technologies such as PV solar panels, wind turbines and micro-cogeneration?
- How can we give priority to sustainable energy sources?
- How can we coordinate the generation of these sources to prevent a local overload of the grid?
- What is the market potential of these integrated smart grids?
- Which standards and coordination mechanisms at the different network levels should we use?

The best way to gain answers to these questions and bring smart grids to the next level is by bringing them to life. This requires detailed engineering and testing of concepts because 'the devil is always in the details'. With our knowledge of the whole energy value chain and experiences gained in previous projects, KEMA can help you find an integrated solution.

PowerMatching City

KEMA has created a living lab smart grid environment together with Dutch research center ECN, software company ICT and utility Essent. This 'PowerMatching City' consists of 25 interconnected households equipped with micro cogeneration units, hybrid heat pumps, PV solar panels, smart appliances and electric vehicles. Additional power is produced by a wind farm and a gas turbine.

The aim of this project is to develop a market model for a smart grid under normal operating conditions. The underlying coordination mechanism is based on the PowerMatcher, a software tool used to balance energy demand and use. The aim is to extend this coordination mechanism in such a way that it can support simultaneous optimization of the goals of different stakeholders:

- In home optimization for the prosumer
- Reduce network load for the distribution system operator
- Reduce imbalance for program responsible utilities

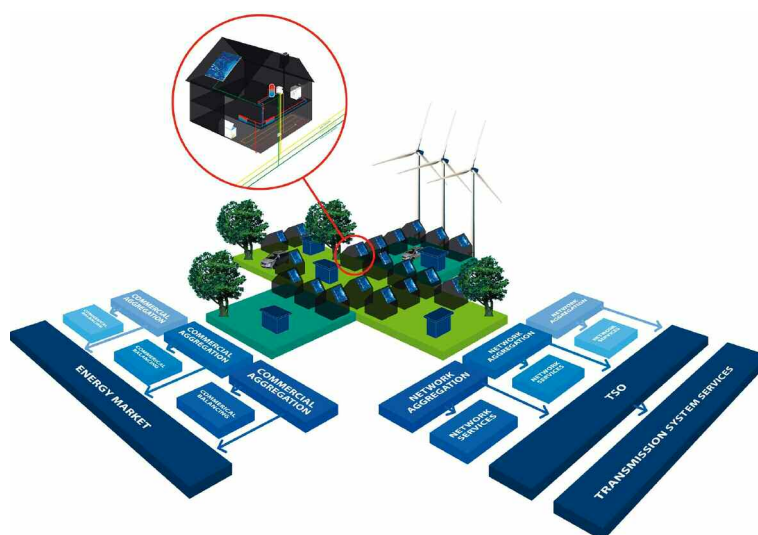
In the end, the goal of this project is to build and demonstrate an industry-quality reference solution for aggregation, control and coordination of distributed energy resources, renewable energy and smart appliances, based on cost effective, commonly available ICT components, standards and platforms.

What do prosumers expect?

Prosumers should be willing to invest in smart appliances and distributed energy resources. What do they expect from such investments, and under what conditions will they accept smart power? It's clear that they will only accept smart power as long as their comfort level is not affected. Therefore, systems have to be designed in such a way that, no matter how the flexibility is exploited by a smart grid, their life can continue as it normally would. In our laboratories we have developed installations that meet these requirements. During the field test we will research if the prosumers are willing to exchange comfort for flexibility based on financial incentives.

Furthermore, we assume prosumers will only invest in these technologies as long as they profit from it. Therefore, we strive for economic optimization as a primary goal for these prosumers. In our concept, energy can be imported and exported freely from the house to the network and vice versa, as long as the costs or benefits for the prosumer are optimized. A local PowerMatcher agent that acts on behalf of the prosumer does this optimization in the background without user interaction. From a consumer perspective, the savings in their energy bill increases further because of the energy efficiency of the installation.

Prosumers can access their energy consumption profiles in real time anywhere and at any time via



an internet portal. The necessary data is measured by smart meters connected to each individual installation and collected in a central database. Peer group comparison ranks their performance and triggers them to decrease their energy consumption. An operator portal for system maintenance is created as well. It monitors the performance of the whole system and allows maintenance personnel take action before the consumer has noticed that the performance of their system has decreased and while failure can be prevented.

imbalance reduction in their portfolio. From a supplier point of view, the cluster of PowerMatching City can be operated as a Virtual Power Plant, adding value from different perspectives:

- Control of the cluster by a Trading Objective agent that provides price incentives so that the energy demand by the cluster can be controlled. One should keep in mind that this control mechanism is in principle limited to load shifting of the whole cluster, since consumers will not

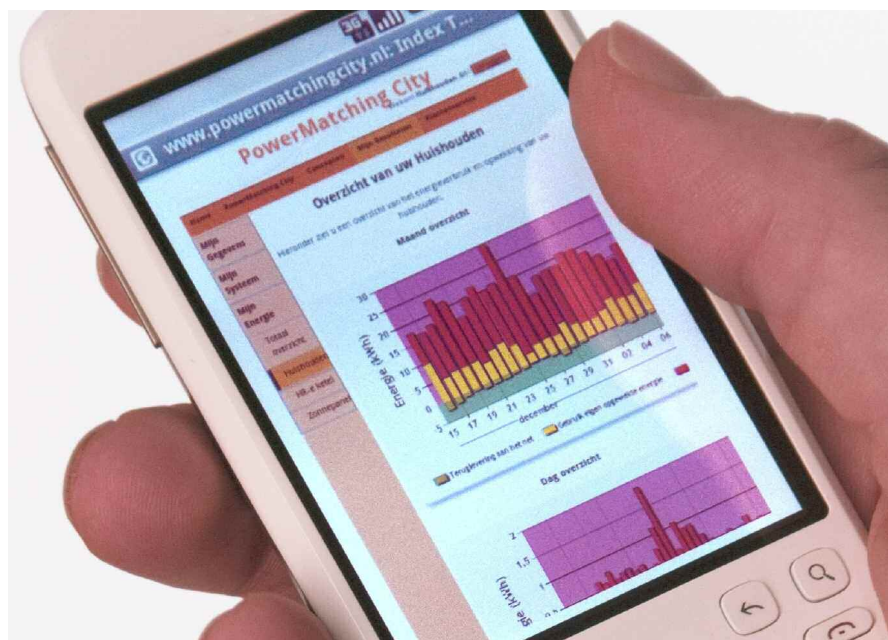
INTEGRAL

The INTEGRAL project is a European project under the 6th Framework Programme.

The goal of Integral is to build and demonstrate an industry-quality reference solution for aggregation, control and coordination of distributed energy resources, renewable energy and smart appliances based on cost effective commonly available ICT components, standards and platforms.

The building and demonstration project will take the following steps:

- Define Integrated Distributed Control as a unified and overarching concept for co-ordination and control
- Show how this can be realized with common industrial, cost-effective and standardized state-of-the-art ICT platform solutions
- Demonstrate its practical validity via three field demonstrations covering the full range of different operating conditions including:
 - normal operating conditions of DER/RES aggregations, showing their potential to reduce grid power imbalances, optimize local power and energy management, minimize cost (PowerMatching City, the Netherlands)
 - critical operating conditions, showing stability when grid-integrated (Spain)
 - emergency operating conditions, showing self-healing capabilities (France)



What do grid operators expect?

Large scale introduction of electric heat pumps and electric vehicles will create a significant increase of the peak load on the electricity grid. This will lead to (local) congestion of the network at peak times. For example at 18:00 when people get home from work and directly start loading their electric cars while there is already a 'natural' peak load. In our cluster, the grid operator can give local price incentives — for example in a network segment behind a transformer — such that the import or export from this network is reduced below a level where the aging of the transformer is limited.

What do utilities expect?

The highest costs for suppliers or program responsible parties are caused by imbalances and

produce or consume more energy but will only provide flexibility.

- Improved predictability of the cluster due to price optimization and internal balancing, allowing better day ahead forecasting.
- Smart metering will increase the readout frequency of the energy demand by the whole cluster on a near real time basis, and allows validation of the internal balancing point of the cluster itself.

To gain detailed insight into these processes, and the interaction with the regular trading and dispatching activities of a supplier, the cluster is controlled from the trading room of Essent. The cluster is dispatched near real time and various trading strategies will be tested.

Elements of PowerMatching City.

Integrating renewable energy

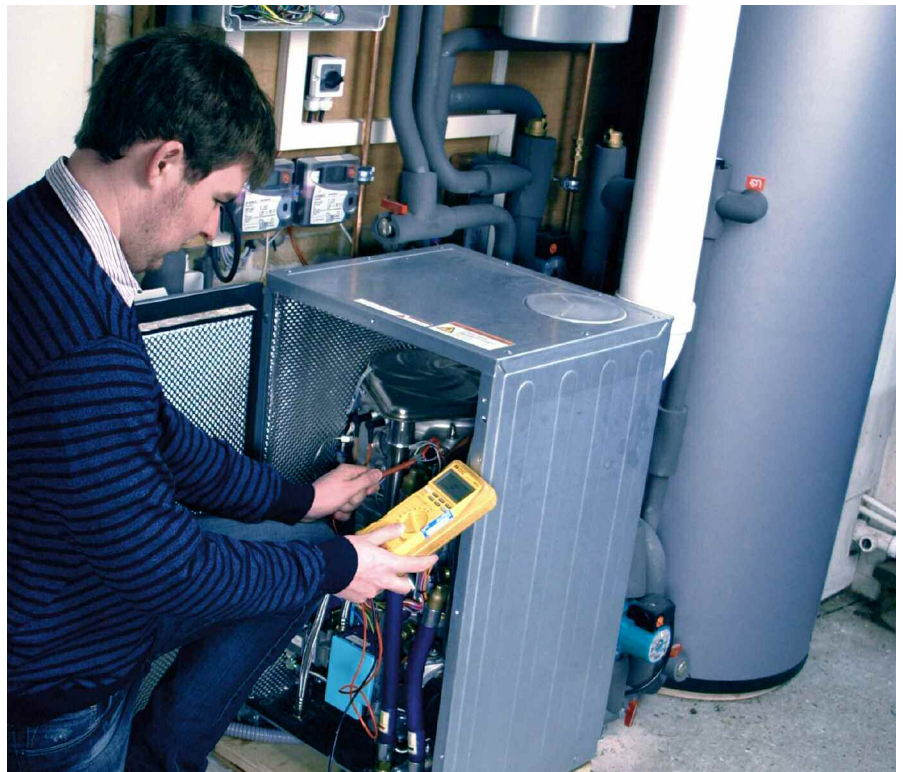
Fluctuations in power production of wind turbines or solar power caused by heavy winds, half open clouds and uncertainties in the weather forecast requires fast responding power. Smart grids can provide this flexibility by rapidly shifting energy demand from loads like electric vehicles, heat pumps and smart appliances towards peaks in the production and use of distributed energy resources, such as mCHP's, to fill in the gaps in production when the wind is fading away. In the field test of PowerMatching City these effects are demonstrated and the amount of flexibility of such a cluster is exploited.

Cogeneration on micro scale

In the coming decade, combined heat and power (CHP) technologies will be introduced into our households based on different technologies, such as Stirling engines, internal combustion engines and fuel cells. These mCHPs will be controlled on the basis of the heat demand in a household and will produce electricity as a side effect. In our laboratories, we have developed a system where the heat is stored in a heat buffer, thereby decoupling heat and power production.

Hybrid Heat Pumps

Combining an electric heat pump with a high efficiency boiler provides a way to generate highly efficient base load with network-friendly peak load demand. The efficiency of heat pumps is very high, because for every kW of electrical power, 3-5.5 kW thermal power is produced. For peak demand activities such as taking showers, or situations like extreme low outdoor temperatures, a high efficiency boiler is used to support the heat pump, thereby reducing the need for auxiliary electric heating, which would



stress the electricity net. We have decoupled the heat production from the moment the heat is produced by inserting a heat buffer to the system. This allows us to generate heat when (renewable) electricity is readily available.

Electric Mobility

Due to the high potential for primary energy savings and the corresponding CO₂ emissions, light electric vehicles like cars, scooter and bicycles might become our main means of transportation. Light vehicles are needed to minimize the energy consumption for transportation.

Without appropriate measures, people will start charging their cars when they come home after work, increasing the already high-energy peak demand in the evenings. These cars will be

equipped with a PowerMatcher agent that allows smart charging, spreading the charging process overnight, shaving the peaks in wind power production and ensuring the lowest cost for recharging the batteries. PowerMatching City will be equipped with fully electric cars as well as a plug-in hybrids.

Smart Appliances

Smart freezers or washing machines can help to reduce peak loads on the electricity net or to utilize available renewable energy. In the PowerMatching City, we create flexibility by allowing the system to decide, for example, when to start the wash. The washing machine is programmed to finish the cycle at a given time. Consequently, the PowerMatcher will try to find the optimal moment to start the cycle, for



example when electricity is cheaply available. In the smart freezer, the temperature is allowed to fluctuate between boundaries. Again here, the PowerMatcher chooses the moments when to begin cooling. In both applications it is important that comfort is ensured.

PowerMatcher

PowerMatcher technology is a distributed energy system architecture and communication protocol, which facilitates implementation of standardized, scalable smart grids that can include both conventional and renewable energy sources. Through intelligent clustering, numerous, small, electricity -producing or -consuming devices operate as a single, highly flexible generating unit, creating a significant degree of added value in electricity markets. PowerMatcher technology optimizes the potential for aggregated, individual, electricity -producing and -consuming devices to adjust their operation. This is in order to increase the overall match

between electricity production and consumption through dynamic, real-time pricing. These real-time prices provide incentives for off-peak electricity usage and on-peak electricity generation, improving the load factor of the grid.

ICT Architecture

PowerMatching City wouldn't be possible if it wasn't for a modern ICT infrastructure. Secure VPNs (Virtual Private Networks) connect all households, wind turbines, electric vehicles and devices over the public internet. Database servers collect information on a local household level as well as on the level of PowerMatching City. This enables researchers to analyze the results and create improvements. Personal data is available to the household owners via the 'User Portal' website, so they can observe their contribution to a more sustainable environment. An 'Operator Portal' offers information for daily operation of PowerMatching City from the control room.

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