
GlobalFOCUS
12
Climate Entrepreneurs
REVOLUTIONARY INNOVATIONS
FOR A CARBON-FREE FUTURE
Jakob Rutqvist

At GlobalFOCUS we concentrate on the possibilities that come with the transformation to a climate friendly world, and we are guided by the vision of sustainable development as a source of inspiration rather than problems. During the coming years we will work intensively to put climate change on top of the agenda and to spread knowledge about new solutions and ideas that can help form a non-fossil future. We will also work hard to create new interesting alliances in the subject of climate change solutions, and make sure that the perspective is global.

THANKS TO:
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Preface

Zhengrong Shi, the richest person in mainland China, has a private fortune of more than two billion dollars. He amassed this fortune in six years, by selling solar cells. Zhengrong founded Suntech Power in 2001; by 2004 it was one of the top ten manufacturers in the world. The following year, Suntech became the world's third largest solar cell manufacturer, with a total production capacity of 300MW. This growth has resulted in a market capitalization of seven billion dollars and, of course, global distribution of Suntech Power's climate technology.

Tulsi Tanti is one of India's most successful businessmen. He earned his fortune with Suzlon Energy, the wind turbine manufacturer and complete wind energy solutions company that he founded in 1995. He started out with 20 employees; today Suzlon is one of the top five wind turbine suppliers in the world, with almost 3GW installed capacity and 13,000 employees.

Zhengrong Shi and Tulsi Tanti represent a new type of entrepreneur whose importance will only increase in the coming years. These entrepreneurs develop and deploy innovations that offer solutions to the world's greatest challenges. These solutions will carry our world into a new, low-carbon era – we call these amazing people climate entrepreneurs.

This report focuses on climate and energy challenges from a solutions perspective. Following a long period of discussion and debate, researchers, politicians, and businesses now agree on the need for action – but very little is happening in terms of concrete implementation. The next step is to move from science to solutions. Naturally, research on climate change needs to continue; however, politicians, business leaders, government officials, and entrepreneurs must realise that the time has come to develop and deploy solutions in large scale.

The world needs leadership – and we should all ask ourselves how we can contribute to solving these problems on a global scale, as individual citizens as well as in our professional lives. We need to develop strategies to fundamentally change our policies and our economy.

Mahatma Gandhi urged us to be the change we want to see in the world. When it comes to the climate crisis, this will not suffice – we must also mass-produce and spread globally the change we want to see.

"I say the debate is over. We know the science, we see the threat, and the time for action is now."

Arnold Schwarzenegger (Governor of California)

Executive summary

The purpose of the GlobalFOCUS climate entrepreneurs project is to accelerate the transition from a fossil-fuel based economy to a low-carbon economy. The project highlights winners in this transition, the climate entrepreneurs who make the low-carbon future possible, and discusses how these entrepreneurs can be supported by the surrounding society. The objectives with this report has been:

- to identify and present twelve world-leading climate entrepreneurs and their low-carbon innovations
- to map out ideas and proposals for faster development, diffusion, and deployment of climate technology globally

The companies presented in this report were selected by a panel of technology, innovation, and market experts in China, India, and Sweden. The twelve companies was selected based on their climate innovations, in particular based upon the potential of those innovations to reduce greenhouse gas emissions on a global scale.

The twelve companies can be divided into five different sectors: Energy Production, Energy Efficiency, Construction, Transportation, and System Innovations. The collective potential greenhouse gas emission reductions (given a set of assumptions on market penetration and share) are 600 million tons of carbon dioxide annually. This is equal to the total combined annual emissions of Australia, Argentina, and Belgium.[1]

全球聚焦(GlobalFOCUS)气候企业精英项目旨在通过寻找和支持气候产业未来的改革者和创新者，为将世界转变为低碳经济的努力做出贡献。为了达到这个目标，在下面的报告中，我们的工作包括以下几个方面：

a) 通过全球视角 项目，找到瑞典 12 个最有潜力的气候企业精英。
b) 归纳相关建议，制订计划，帮助加速全球低碳经济的发展、扩散和应用。

通过由瑞典、中国和印度三国的技术、创新，以及市场运营方面的专家组成的裁判团评价论文建议的实施潜力，我们挑选出了报告中的 12 个优胜创新者。如果，这 12 个优胜者的建议都得到实施，全球每年可以减排至少 6.0 亿吨二氧化碳。优胜的 12 个报告的中文版将会在 2008 年下半年度推出。

1 WRI (2008)

The Companies

Air to Air

Climate benefit: -28 $MtCO_2/yr$
Business: Energy efficiency
Summary: ReHydrator – technology that reduces energy consumption in new and existing HVAC systems

Absolicon

Climate benefit: -9 $MtCO_2/yr$
Business: Energy production
Summary: Solar8 – solar energy system that, for the same level of energy production, uses only 1/10 solar cells compared to conventional solutions

Capital Cooling

Climate benefit: -36 $MtCO_2/yr$
Business: System innovation
Summary: Systems for large-scale production and distribution of district cooling, up to ten times more efficient than conventional cooling technology – and which can also deliver district heating

Ecoera

Climate benefit: -169 $MtCO_2/yr$
Business: Energy production
Summary: BIOAGRO – a system that enables conversion of agricultural residues into Agropellet, a cheap and carbon-neutral source of energy

Morphic

Climate benefit: -12 $MtCO_2/yr$
Business: Energy production and system innovation
Summary: Cost effective production of flow plates for fuel cells and an innovative system for decentralized renewable energy production

NordIQ

Climate benefit: -89 $MtCO_2/yr$
Business: Energy efficiency
Summary: A control system for real-time energy-balanced heating for buildings that through intelligent control makes energy consumption more efficient

Parans Solar Lightning

Climate benefit: -59 $MtCO_2/yr$
Business: Construction
Summary: Products that can lead natural light into buildings and reduce the energy needed for lighting and cooling

Picoterm

Climate benefit: Impossible to estimate
Business: Transport and system innovation
Summary: Stack-free thermoacoustics; technology that in the future might replace the combustion engine and radically reduce global demand for fossil fuels

REHACT

Climate benefit: -95 $MtCO_2/yr$
Business: Construction and energy efficiency
Summary: IVS – an intelligent heating system, based on new heat exchanger technology, which in an energy efficient manner take care of heating, cooling and ventilation in buildings

SkyCab

Climate benefit: Climate friendly travels
Business: Transportation
Summary: Personal Rapid Transit – a new way to travel, independent of fossil fuels and ready to meet the transportation needs of the future

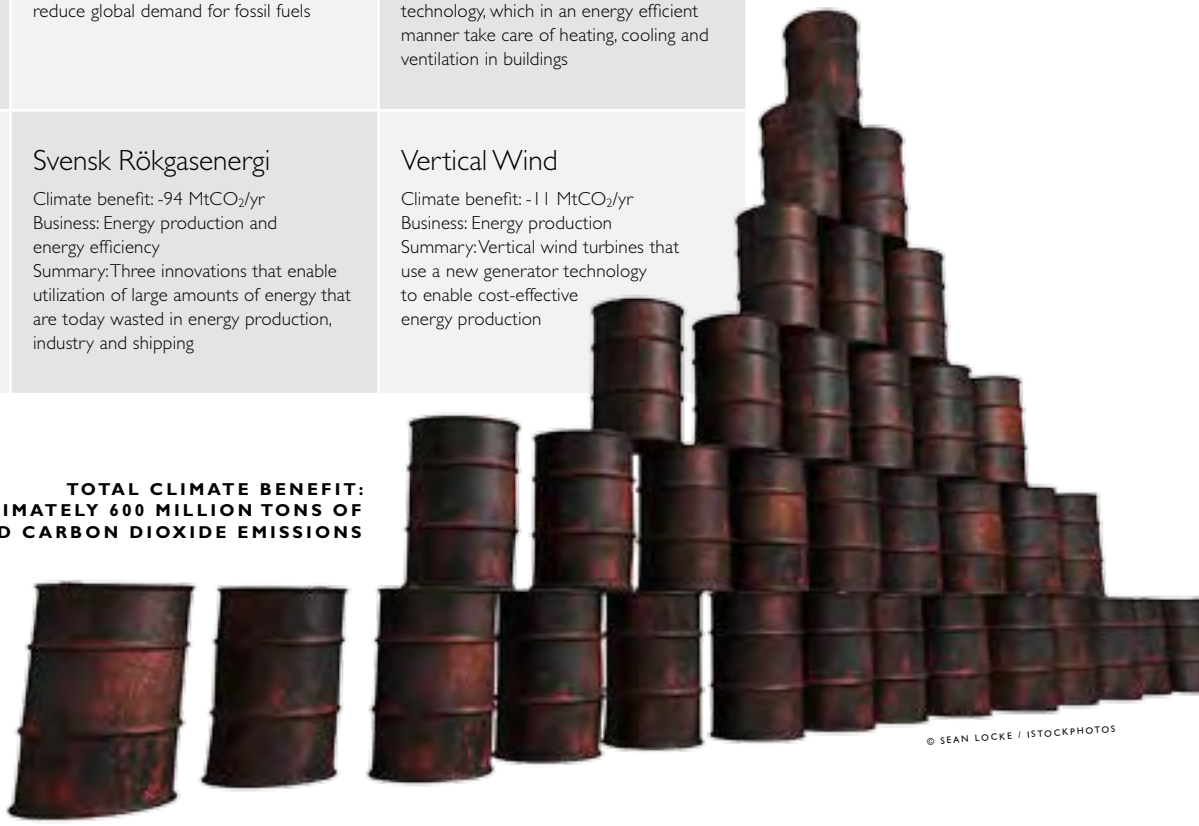
Svensk Rökgasenergi

Climate benefit: -94 $MtCO_2/yr$
Business: Energy production and energy efficiency
Summary: Three innovations that enable utilization of large amounts of energy that are today wasted in energy production, industry and shipping

Vertical Wind

Climate benefit: -11 $MtCO_2/yr$
Business: Energy production
Summary: Vertical wind turbines that use a new generator technology to enable cost-effective energy production

TOTAL CLIMATE BENEFIT: APPROXIMATELY 600 MILLION TONS OF REDUCED CARBON DIOXIDE EMISSIONS



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The path forward for...

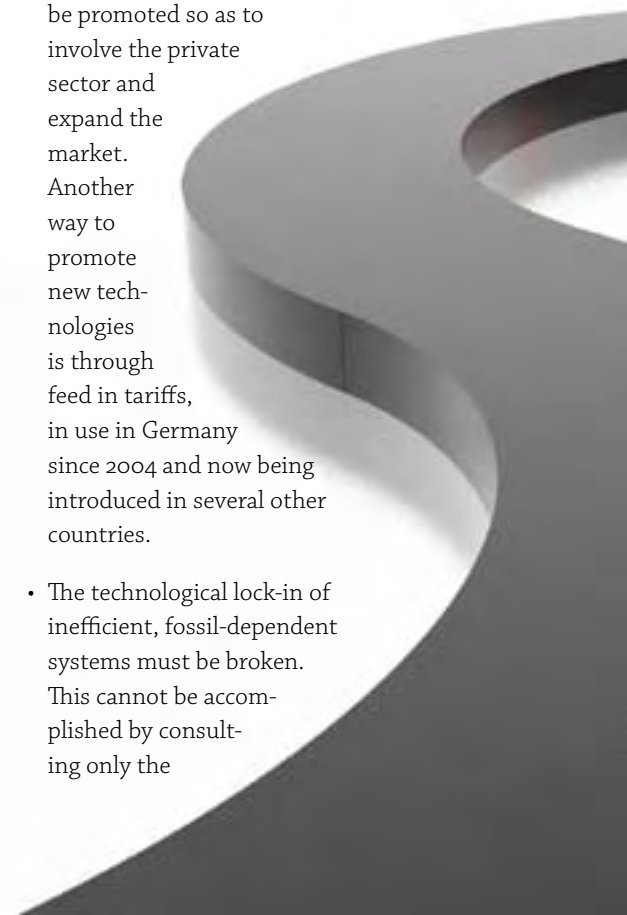
In collaboration with a large number of relevant parties, our working group has considered innovation systems, export, and institutional frameworks that matter to the everyday activities of climate entrepreneurs. We did this in order to identify barriers and opportunities for innovators and to formulate proposals for how policy makers can move ahead toward a new low-carbon economy and climate-friendly society.

Summary of recommendations to politicians:

- Goals for commercializing climate technology and for export of low-carbon innovations
- Establish a center for climate entrepreneurship with substantial financial resources
- Financial support for climate innovation zones
- Elect a minister for climate change with coordination responsibilities
- Create support for low-carbon innovations from the demand side using public procurement, public works and economical incentives
- Phase out fossil-intensive technology using laws, standards and regulations
- A big commitment to energy efficiency and energy productivity
- Make sure export policies and the framework for international investments support a sustainable development globally

... POLITICIANS

- Design strategies for transitioning to smart low-carbon solutions by phasing out fossil-based technology – in collaboration with businesses and other organisations – and with a global perspective in mind.
- These strategies call for specific, long-term climate technology goals with quantifiable and measurable annual targets for numbers of businesses created and magnitude of exported emission reductions. To reach these targets, a well-funded centre for climate entrepreneurs should be created – a public programme supporting research and development, commercialization, deployment, and export. The centre will tie together all existing forms of support and coordinate one-stop-shopping for climate entrepreneurs. Centre employees will proactively seek out climate entrepreneurs and offer them help with the innovation, commercialization, and export processes. Four funds, with considerable financial resources, will be part of the centre and give support in all four focus areas.
- Policy makers and public authorities will interact continuously with the centre, in order to determine how legislation and regulation best be developed to support the new low-carbon economy transition. The government will promote formation of similar centres in other nations, as well as promote an international network of climate entrepreneurs.
- Public funds should support construction of climate innovation zones where low-carbon innovations can be demonstrated in systems and help new technology to reach the market faster.
- The climate challenge is not just, or mainly, an environmental issue, but a matter of fundamental importance throughout the political arena. Therefore, a climate ministry is called for. The climate minister would be responsible for coordinating climate policy among all government departments and for safeguarding a coherent and effective approach.
- Climate change has to be handled as a long-term and strategic task within all political fields, but most importantly in all commitments regarding innovation, trade, enterprise, energy, research and development, export and infrastructure.
- Low-carbon innovation needs to be supported on the supply side but also on the demand side, through public procurement programmes and public construction investments with climate innovation quotas. Public-private technology procurement programmes should be promoted so as to involve the private sector and expand the market. Another way to promote new technologies is through feed in tariffs, in use in Germany since 2004 and now being introduced in several other countries.
- The technological lock-in of inefficient, fossil-dependent systems must be broken. This cannot be accomplished by consulting only the



big actors, who offer traditional solutions, when planning official investments. This means that supporting technology innovation requires financial innovation, to allow clusters of solutions to be realised as system solutions, especially within energy, construction, and transportation.

- Traditional climate-damaging technology should be phased out with the implementation of new legislation and regulation, especially where climate-friendly solutions are more cost-efficient and new investment has a quick payback. Where climate-friendly technology is not yet competitive, dynamic policy measures are needed to encourage the transition and to build up economies of scale.

- The focus will need to be system-wide, not piecemeal or marginal. New investments as well as existing solutions need to be transformed within many sectors, especially energy. Climate efficiency must be a natural part of societal and economic systems, rather than being reduced to a matter of individual consumer involvement.

- Well-functioning markets need a rational system of rules and institutions suited to handling failures within the market. External costs associated with fossil fuel technology must be internalised[1] and borne by that technology, without exceptions based on special interests. Consumers need information to make climate friendly and rational choices. Specific climate labelling should be required for all products where relevant.

- Major investments are needed to promote energy efficiency and to completely end any further funding or expansion of fossil-fuel based energy production worldwide. Increasing fossil production capacity is unacceptable; more than half of the energy produced today is wasted and is not being used to meet energy needs at the end user.[2] New technology can make the use of energy radically more effective and increase energy productivity.

- Export policies and the financial regulatory framework should be adjusted to guarantee international support for climate-smart development – not the opposite. Government-controlled pension funds, export support, and official export loan facilities should be used to support the transition to a low carbon world, not to spread and support fossil-dependent technology.

- Climate change poses one of humanity's greatest challenges. More resources are needed to meet this challenge. For nations, devoting percentages, rather than a fraction of a percent, of GDP to the transition to the low-carbon society should be obvious.

1 The price of fossil energy and technology does not reflect their true costs. External costs need to be internalised. A tax or cap and trade system serve to internalise climate impact.

2 Gardner, Prugh et al., (2008), p. 80

Summary of recommendations to businesses:

- Accept that status quo is not an option
- View climate adjustment of operations as a long-term strategic issue
- Climate adjust products and services
- Climate adjust operations
- Invest in low-carbon innovation
- Aim for vertical sustainability through the complete value chain

...BUSINESSES

- The third industrial revolution has already started and has sustainability at centre stage. Fossil-dependent technologies will be replaced by greener solutions. Infrastructure will be modernised, and our buildings and transportation systems will be improved. Linear resource flows with input, process, and waste will be replaced by cyclical flows, which are more respectful of natural resources and climate impact. For businesses, these changes will pose new challenges and present new opportunities. Businesses hoping to survive the transition to a low-carbon economy have to start preparing strategy and operations now.
- For a business, managing the transition mainly involves: 1) Minimising the emissions of greenhouse gases through the whole chain from suppliers to customers, not least to avoid future difficulties with internalized costs, legislation, and regulation. 2) Transforming or modifying own products and services, in order to maintain competitive power and ensure demand in the future market. Manufacturing and operating costs for fossil-intensive products and services will increase throughout the transition to the low-carbon economy. Fossil-dependent products will also become less and less compatible with the surrounding technological and institutional context. There are today great opportunities for lowering climate impact while at the same time increasing margins, profitability and radically reducing future risks.
- Low-carbon, climate-friendly innovations should be the strategic focus and be incorporated into all main activities and the core business. If some area of activity is not compatible with the low-carbon economy, a change must be initiated. Any number of fascinating ways of embarking on this change can be found among the climate entrepreneurs emerging all over the world today. The climate efficiency offered by the innovative companies presented in this report should serve as an indicator of what shareholders, investors, regulators, and the market will soon demand.

"Companies that persist in treating climate change solely as a corporate social responsibility issue, rather than a business problem, will risk the greatest consequences. Of course, a company's climate policies will be affected by stakeholder expectations and standards for social responsibility. But the effects of climate on companies' operations are now so tangible and certain that the issue is best addressed with the tools of the strategist, not the philantropist"

Michael E Porter, Forest L Reinhardt, Harvard Business Review, okt 07

Content

Introduction

Several nations and regions claim to want to take the lead in fighting climate change. Within Europe, Great Britain, Germany, and the Nordic countries are prominent. In the United States, California stands out. Japan has clearly shown leadership in Asia with a 40 billion dollar commitment to low-carbon innovation investments both domestically and abroad. New Zealand is at the cutting edge with a 2025 renewable energy target of 90%.[1] So far, perhaps the most ambitious nation of all is Costa Rica, which aspires to become completely climate neutral by 2021.[2]

In almost every nation, certain political parties, municipalities, cities, and leaders in private industry aspire to move ahead and lead on climate action and the transition to the low-carbon economy.[3] However, if a single nation, region, or corporation truly wishes to make a significant contribution, the effort must be measured globally. If the EU meets the target of reducing greenhouse gas emissions by 20% by 2020, this will save the equivalent of one billion tons of carbon dioxide.[4] Within the same time period, emissions from China and India are projected to increase by more than three billion tons.[5] An effective climate policy must keep a global perspective and focus on how to spread emission reduction opportunities and lessons learned, globally. The climate challenge will only be manageable if attractive visions of a low-carbon society and successful technology are developed and spread globally.

In order to meet the climate challenge while increasing the standard of living for the three billion people around the world living in poverty,[6] and offer the additional three billion the globe will need to support by 2050 an adequate standard of living,[7] we need to actively help climate entrepreneurs to a dramatically different extent than we currently do.

To be able to meet the challenges of climate change while at the same time building a better, smarter, and more attractive global society, will require change. Wasteful lifestyles and technology need to undergo radical change. Unfortunately, and unnecessarily, such change is often perceived as negative rather than positive.

But meeting the climate challenge and transitioning to the low-carbon economy means creating a better – more just – society, realising visions of a society with a higher standard of living through a smarter economy. Progress requires change. It is our hope that this GlobalFOCUS report will contribute to generating hope and optimism as well as a demand for the transition to a fossil-free future. After you've read this report, please ask yourself how you – educationally, professionally, and as a member of the civil society – can contribute toward the sustainable global future we want.

The first step toward solving the climate problem lay in identifying it. This was accomplished by researchers worldwide. The average global temperature has increased by 0.8°C in the last 150 years; moreover, most of this increase has come in the last 50 years. Eleven of the past twelve years are the warmest since 1850, when reliable records began; and this is beyond doubt due to human interference with the climate.[8]

The second step will be to focus on solutions and discuss opportunities, transitioning, and breakthroughs, rather than focusing on difficulties and problems. The process leading to this report identified, not only twelve world leading climate entrepreneurs, but numerous concrete proposals for how policymakers and businesses can support the transition to the low-carbon economy. These proposals are presented throughout this report.

GlobalFOCUS selected these twelve climate entrepreneurs by studying a pool of hundreds of businesses. We compiled a short-list of fifty companies and reduced this to nineteen. Following expert evaluation of these companies' global climate potential and the possibilities for large-scale implementation of their products, we determined the final list of twelve climate entrepreneurs with the biggest potential to reduce global greenhouse gas emissions.

1 New Zealand Government (2007) & Carbon Finance (2008)
2 Reuters (2007)
3 Sources: The Climate Group (2006), ICLEI (http://www.iclei.org) & Mayors Climate Protection Center (http://www.usmayors.org/climateprotection)
4 European Environment Agency, Greenhouse gas data viewer
5 EIA Reference Case. Source: WRI (2008)
6 World Bank, PovcalNet
7 UN World Population Prospects
8 Scientific American (2007), p. 66

All twelve companies featured in this report are Swedish, but GlobalFOCUS are currently in the process of initiating similar projects in several other countries around the world. If 12 Swedish companies have the potential to reduce global carbon dioxide emissions with 600 million tons; imagine what's possible for thousands of companies globally.

Expert panel members:

STEFAN HENNINGSSON (Chair)
Programme Director Climate Change, WWF, Sweden

ANIL K GUPTA
Chair in Entrepreneurship, Indian Institute of Management, India. Co-ordinator, SRISTI (Society for Research and Initiatives for Sustainable Technologies and Institutions), India. Executive Vice Chair, National Innovations Foundation, India.

GÖRAN BROMAN
Professor, Mechanical Engineering, Blekinge Institute of Technology, Sweden.

JAMES SHI
Secretary General, Sweden China Development Council.

MATS LEIJON
Professor of Electricity, Uppsala University. President, Energy Potential Investment, Sweden.

OLA ALTERÅ
State Secretary to the Minister of Enterprise and Energy, Sweden.

PETER EKMAN
Business Development and Innovations Manager, ALMI Stockholm, Sweden.

ROLF MÖLLER
Managing Director, Senior Architect, Swedesign Connection. Visiting Professor, Architecture and Urban Planning, Beijing University of Technology, China.

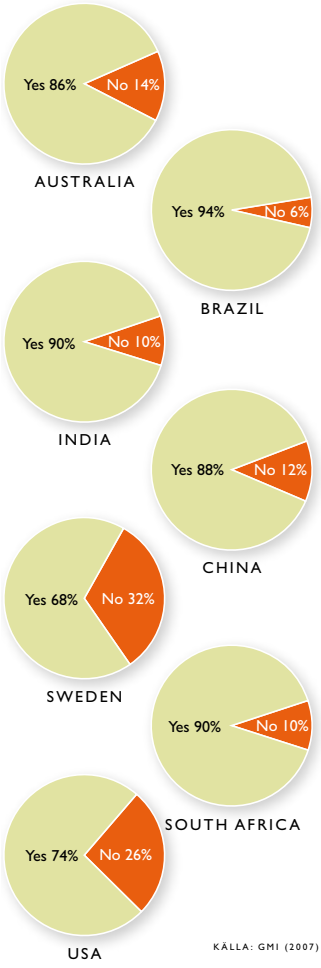
TOMAS KÅBERGER
Director General, Swedish Energy Agency. President, Svebio, Swedish Bioenergy Association. Adjunct Professor, International Institute for Industrial Environmental Economics at Lund University, Sweden.

The climate transition so far

"Speed is irrelevant if you are going in the wrong direction"

Mahatma Gandhi

Are you worried about climate change?



KÄLLA: GMI (2007)

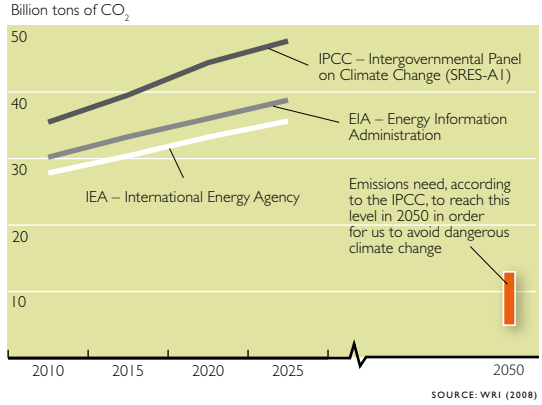
Since the mid-nineteenth century, burning fossil fuels has resulted in 1,100 billion tons of carbon dioxide emitted into the atmosphere.[1] For the past 150 years, our atmosphere has been used as a gigantic open sewer, and as if it could absorb unlimited quantities of pollution. Recently, we discovered we were wrong to assume we could not affect the climatic system. With this mistake, we have brought about the first anthropogenic global climate change in history. Scientific consensus on this is virtually unanimous, and the scientific community is calling for forceful, rapid, and global action.

The most famous scientific body in this context is the UN Intergovernmental Panel on Climate Change (IPCC), which received the 2007 Nobel Peace Prize and whose Fourth Assessment Report covers six years of research on climate change in collaboration with 130 nations. In total, 800 authors were involved, and the report was reviewed by more than 2 500 experts.[2] The conclusions reached by the IPCC are supported by all major national academies of sciences.[3] Further, a 2004 review of 928 scientific articles dealing with climate change, found no articles opposing the consensus view.[4] Those of us who are not scientists can discuss details out of curiosity regarding this or that, but when it comes to choosing strategies for action, rational individuals should let the scientific consensus inform their choice.

Given the powerful message from the scientific community, all the attention climate change has received in the last few years, and the fact that the majority of the global population is in fact worried about the effects of climate change – one might assume that the transition to the low-carbon society is already well underway. That policies, corporations, and lifestyles are changing and emissions are dropping. Unfortunately, this is not the case.

The graph below shows the projected global emissions in three different scenarios, from the International Energy Agency (IEA), the US Energy Information Administration (EIA), and the IPCC. They all show roughly what can be expected unless radical measures are taken now to transition from fossil technology to climate innovations.

Global emissions in three scenarios



SOURCE: WRI (2008)

As shown in this report, the technologies required for climate-friendly energy generation and consumption already exist. Despite this, fossil energy is still subsidised at 200-300 billion dollars per year, while renewable energy only receives a fraction, 33 billion dollars per year. If fossil subsidies were eliminated, global climate pollution would be cut by 1.8 billion tons per year, according to the United Nations Environment Programme.[5]

These financial resources could instead be used to support sustainable energy systems and new climate technology. The world needs massive support for climate entrepreneurs like the twelve presented in this report, not further exploitation of fossil structures that cannot meet global standard-of-living demands without jeopardising our environment and climate.

Obviously, the transition to the low-carbon economy needs to be considered from a global perspective. On the one hand, developed economies have the highest per capita emissions by far (although this is true for those consuming vast amounts of resources, in general, i.e., for well-to-do people in poor

1 IPCC (2007a), p. 253

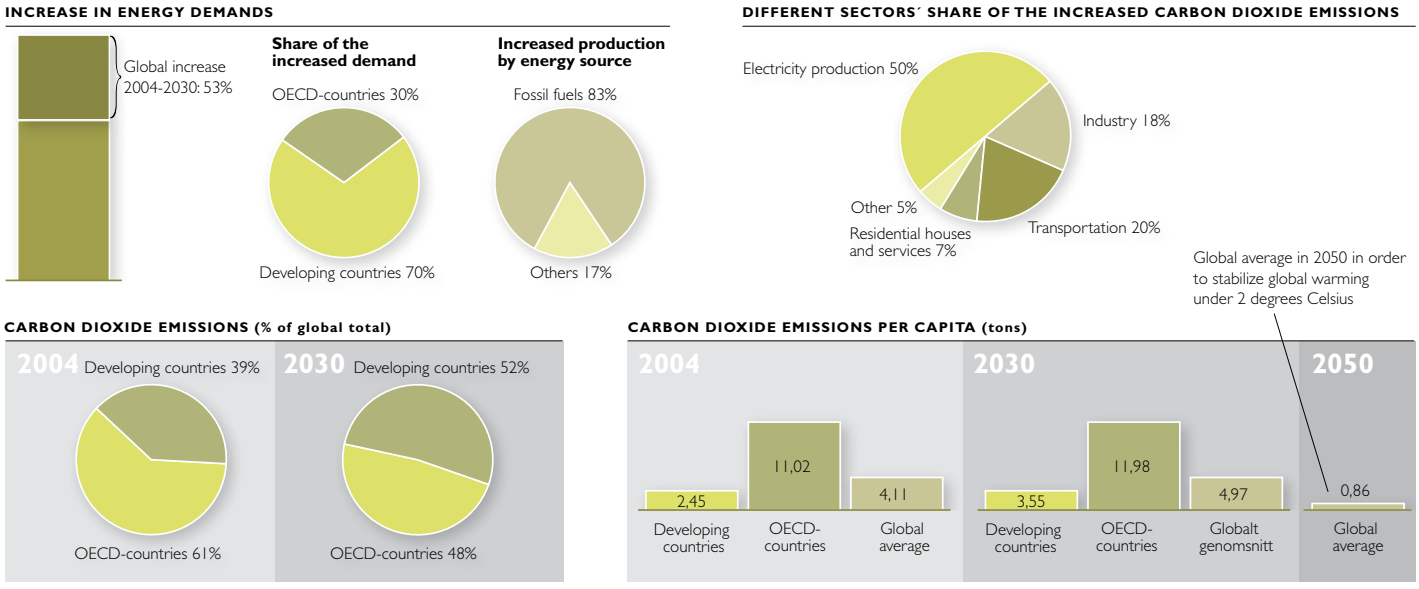
2 http://www.ipcc.ch

3 Including: Chinese Academy of Sciences (China), Académie des Sciences (France), Deutsche Akademie der Naturforscher (Germany), Indian National Science Academy (India), Science Council of Japan (Japan), Russian Academy of Sciences (Russia), Royal Society (Great Britain), National Academy of Sciences (USA). Source: National Academies (2007)

4 Oreskes (2005)

5 NEF (2004), p. 13, Greenpeace (2005), p. 8, WRI (2008) & World Business Council for Sustainable Development (2008b) & Stern Review (2006), p. 355

Change indicators under a business as usual scenario, 2004-2030



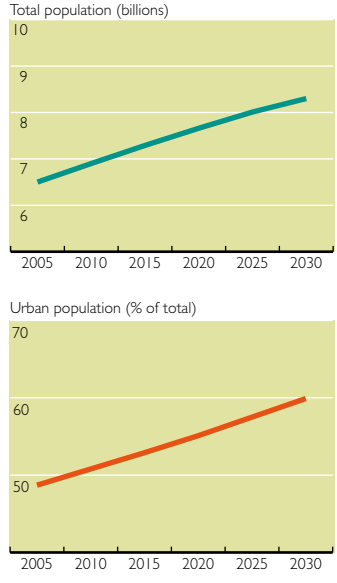
SOURCE: IEA (2006C), KAP 2, UN WORLD POPULATION PROSPECTS, WRI (2008) & IPCC (2007C), S. 21

nations, too). On the other, the greatest increases in emissions come from developing nations, and will continue to do so for the foreseeable future. The goal of a sustainable global society must be to develop societal and technological systems that offer the global population a high standard of living without threatening the common base for our existence. Solutions need to meet needs without creating massive climate change. In other words; the wealthy must radically cut their per capita emissions, in a way that can be leveraged globally, and at the same time help develop and implement climate-friendly solutions that enable the poor people of the world to increase their standard of living.

So far, the climate debate has focused on marginal changes to fundamentally unsustainable systems – as opposed to a discussion of how to reconceptualise and construct these entire systems to meet future demand. Today, there are 26 so-called mega-cities in the world (cities with more than ten million inhabitants).[6] Cities are responsible for 75 % of global energy use and 80 % of total greenhouse gas emissions.[7] By the year 2025, more than ten hyper-cities (cities with over 20 million inhabitants) will exist in Asia alone, and the urban population within China will be greater than 900 million.[8]

Global population is at the same time rapidly increasing. By 2030, we will reach 8.3 billion, with three-fifths residing in cities. If these 8 billion people were all to use the same infrastructure as the contemporary developed world, adopt as inefficient lifestyles, and consume the same amount of energy and products per capita, there is no way for us to meet our climate targets. We do not need change on the margin. We need new and efficient infrastructure, smarter transportation and communications, renewable energy, global political leadership, new financial frameworks, and an economy that is radically less resource intensive than the one of today.

Global population growth



6 Citypopulation: The Principal Agglomerations of the World, http://www.citypopulation.de, 2007-09-30

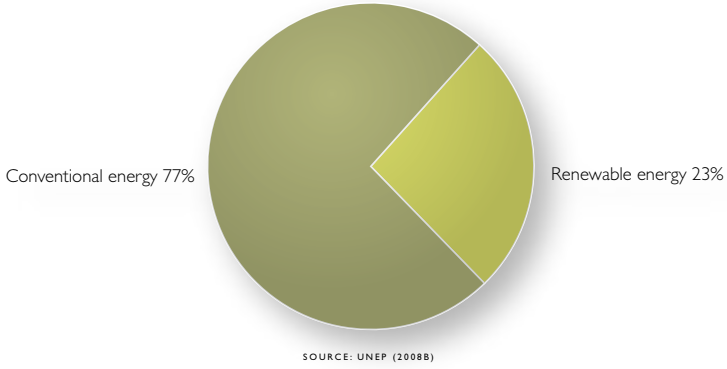
7 UN Habitat (2007)

8 Peoples Daily (2004) & Asia Times Online (2006)

To achieve long-term climate stabilisation, we have to move from the current fossil-dependent economy (where, on average, it takes 80 grams of fossil fuel to generate one dollar of economic value), to a low-carbon economy, with a carbon intensity of maximum a few grams per dollar, by 2100. Currently, fossil fuels provide four-fifths of all energy in the global economy. This fraction must eventually be cut down to only a few percent.[1] Only through innovation and entrepreneurship, supported by political leadership, will this transition to a low-carbon economy be possible.

The world is finally taking the climate issue seriously, and many want to contribute to solving this problem. Many initiatives are being implemented internationally to reduce emissions, but the process of achieving a broad and thorough transition towards a low-carbon economy has barely begun.

NEW POWER GENERATION CAPACITY ADDED IN 2007



SOURCE: UNEP (2008B)

1 Gardner, Prugh et al., (2008), p. 25 & s. 76

Many initiatives are being implemented internationally to reduce emissions, but the process of achieving a broad and thorough transition towards a low-carbon economy has barely begun.

Low-carbon visions

"If you do not change direction, you may end up where you are heading"

Lao Tzu

Find more inspiration and low-carbon visions at:
http://www.WorldChanging.com
http://www.TED.com

2006 and 2007 will go down in history as the time when consensus regarding climate change spread beyond the scientific community. The stage is now set for taking the next step and problem solvers have to be put in focus. First, we need a vision of a sustainable world; we need to conceptualise and visualise what we want the fossil-free society to look like.

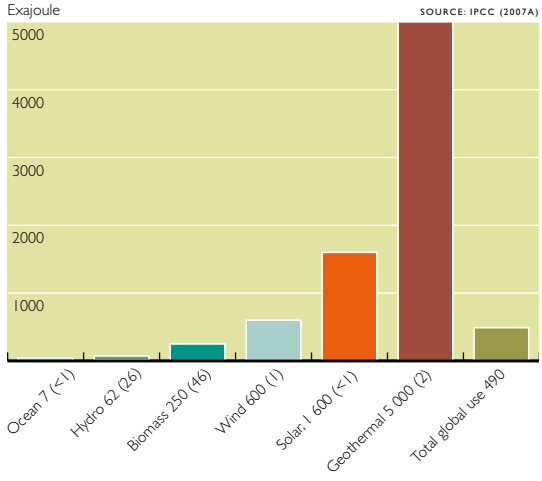
All humans living today have the opportunity to play a part in one of the most exciting periods in the history of humanity. By the end of the century, we will have transitioned to a low-carbon future, whether proactively or by reactionary adaptation in response to excessive climate change.

Meeting the climate challenge is not just about stopping global warming; it is also very much about seeing and taking advantage of the opportunities to make progress on any number of sustainability goals. Through global collaboration, we can create a future where lives are improved — more comfortable, fuller — a world where we use resources wisely and where energy and well-being can be offered to all without this at the same time threatening the future of humanity. This report demonstrates that this future exists not only in our dreams — it is here with us in the real world, today. To a large extent the technology, ideas, and solutions we need to transition already exist. And more are being invented daily. What we need now is determination, leadership, courage and a strong commitment from all members of our society. We cannot be satisfied with simply surviving the climate challenge. We need to create a better, more just, sustainable global future.

Our economies and our relationship with natural resources are essentially linear in the sense that what nature gives us eventually becomes nothing but waste. Less than 1% of the material used for production still exists as a valuable resource in the economy after six months (the rest of it is labelled garbage).[1] This kind of linear system can only work in a world with a small population or in one where only a small part of a bigger population uses a great deal of resources, and the rest use hardly anything at all. But in a modern sustainable society, the use of natural resources must be both fair and efficient. This can be accomplished, without compromising our standard of living, by becoming more efficient. By using resources in cyclical flows instead of linear flows, we can achieve better conditions without compromising our climate. We also need to keep an open mind toward new ways of doing things and new products to fit our needs. In order for low-carbon innovations to be able to compete with fossil systems, we need to start thinking in terms of functionality rather than in terms of products.

Access to energy is the key to both economic and social global development. Therefore, transitioning to renewable energy and greater energy efficiency are key in creating a sustainable future. There are massive resources of renewable energy, and new innovations for putting these to use are constantly under development and being deployed. But we need a greater commitment to transforming the global energy sector. In 2007, the US government spent as much on renewable energy during the entire year as it did in one day on the war in Iraq.[2]

Annual global renewable energy resources, current utilization in parenthesis



At the UN Climate Change Conference in Bali in 2007, the German Chancellor Angela Merkel encouraged the world to implement a global emission trading system. Her proposal suggested an early phase in which emission credits would allow two tons per

1 Gardner, Prugh et al., (2008), p. 32 f.

2 Ibid., p. 85

person per year, but called for a long-term zero-emissions target. If implemented today this system would require an immediate 80% emission cut for Europeans and a 90% cut for Americans.[3]

This sort of thinking, which focuses on what the world needs rather than a narrow minded idea on what can be achieved "realistically", should be a starting point when formulating new climate strategies. We must keep in mind that it is among policy makers, at universities, and in businesses that the solutions and influence for implementing these low-carbon visions in large scale can be found – and not on the level of every individual. If our ambition is to transition from a fossil economy and society to a low-carbon future within the next few decades, we have to seriously commit now to developing, deploying, and diffusing climate innovations.

A recent report showed that by greening the economy, over 4 million sustainable jobs can be created in the U.S. alone in the next 30 years. What are we waiting for?[4]

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3 International Herald Tribune (2007)

4 The United States Conference of Mayors and the Mayors Climate Protection Center (2008)

Technology optimism

"The good news is, we have everything we need now to respond to the challenge of global warming. We have all the technologies we need, more are being developed, and as they become available and become more affordable when produced in scale, they will make it easier to respond. But we should not wait, we cannot wait, we must not wait. We have everything we need - save perhaps political will."

Al Gore

Many claim to be optimists when it comes to technology, believing in the capability of smart solutions and innovations to eventually mitigate climate change. An adequate transition would mean that the world would no longer risk a situation of extreme climate change with devastating consequences.[1] To manage this preferred transition, global emissions must begin to drop within the next seven to ten years, followed by a 50-85 % reduction by the year 2050.[2] For developed and fossil-dependent economies, this means reductions of up to 90% in the coming 40 years.[3] Uncertainty about dangerous climate change should be mentioned. Natural feedbacks responding to the global temperature increase may kick in and further amplify warming. To be on the safer side, some say we may have to reduce emissions as far as to zero, by 2050.[4]

Unfortunately, many who call themselves technology optimists use the term as an excuse for their inaction in the face of climate change; they refer to technology which does not yet exist, instead of focusing on methods for deploying existing solutions. More research is, of course, important, but as this report shows with abundance; what we mainly need now is implementation – we need to develop new ways of deploying and diffusing existing technology.

Today there is a greater shortage of policies for deploying and spreading new technology than of actual technology. For new climate technology to compete against conventional systems, the new technology needs its own context. Without new knowledge and skills, reformed institutions, new legislation, modernised infrastructure, and changes in consumer habits, new low-carbon technology will not be able to replace the current fossil fuel based technology.

The transition will occur on several different levels (local, regional, national, and global) and will involve a number of different kinds of actors. Measures taken at "lower" levels should support measures at higher levels as much as possible and should be planned accordingly. For instance, local and regional action should support national and global action for maximum impact. Within a corporation, the transition strategy should include not only internal operations and profitable investments, but also be tailored to support co-workers, customers, and suppliers in becoming more climate-friendly. One example of a corporation taking precisely this approach is Citigroup, one of the world's largest financial services companies. Over a ten year period, from 2007-2017, Citigroup will invest 50 billion dollars in the low-carbon transition. Their plan includes changing their own activities as well as policies to help influence their customers and partners.[5]

WHAT IS CLIMATE TECHNOLOGY?

The European Commission defines "environmental technology" as: "all technologies whose use is less environmentally harmful than relevant alternatives".[6] A narrowing yields "all technologies whose use is less environmentally harmful for the climate than relevant alternatives".[7] This definition can be narrowed further. This report defines "climate technology" as all technologies with the potential to radically decrease emissions of greenhouse gases (meaning at least 5 million tons CO_2-equivalents by 2020) by replacing or modifying already existing technology, or through new installations. In energy and transportation technology, no fossil-dependent technology counts as climate technology.

12 CLIMATE ENTREPRENEURS

The low-carbon transition will not be possible without climate entrepreneurs spreading their innovations worldwide. Our world is heading for a low-carbon era, and if people do not invent, commercialize and mass-produce solutions (and find markets for them) for handling this transition, we will not make progress, regardless of how ambitious our targets are. For this reason, GlobalFOCUS, together with a panel of technology, innovation, and market experts from Sweden, China, and India, has identified

1 Read more about extreme climate change and positive feedback mechanisms: Lynas (2007), Roach (2007) & Steffen (2006)
2 IPCC (2007c), p. 21
3 WWF (2007), s. 34 ff. , Ses also IPCC (2007b) p. 791
4 Guardian (2007)
5 Citigroup (2007)
6 Commission of the European Communities (2004), p. 2
7 This definition is used by the Swedish Environmental Protection Agency among others (2006), p. 4

twelve of the most interesting climate entrepreneurs in Sweden, whose innovations can contribute to the transition toward a climate-friendly global society. Through our work, we want to emphasize the significance of maintaining a global perspective and explain why we believe that one of the most important initiatives a nation can take toward climate mitigation is to support climate entrepreneurship and deployment and export of low-carbon innovations.

The twelve climate entrepreneurs presented in this report prove that technological solutions capable of handling the transition do exist, but that we must literally realise the potential in these innovations. The time has come for a global wave of technology implementation, not only to lower emissions but to increase standards of living and to create jobs as well.

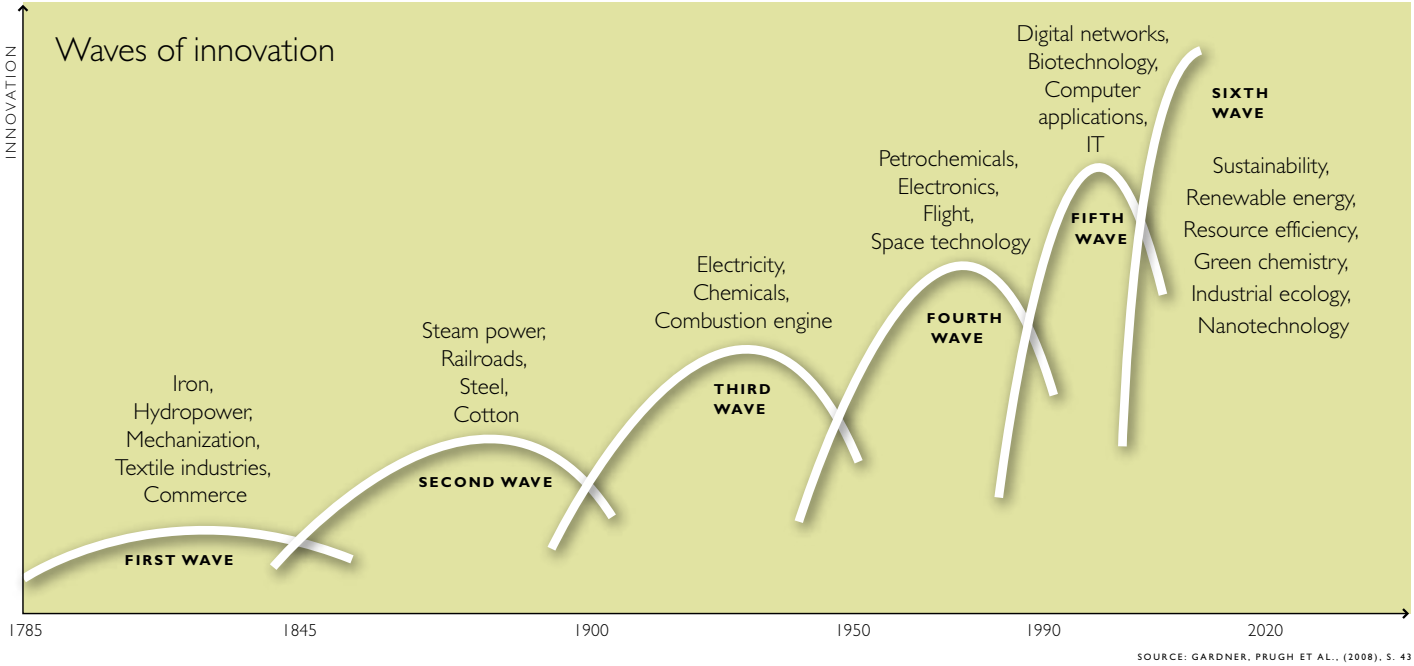
Fundamental shifts in basic technology systems happen in certain periods and drive development forward. These periods or "waves of innovation" are noticeable when new innovations replace old systems and a major societal shift follows. We are now facing the sixth major wave of innovations; this wave will be based on sustainability breakthroughs in how we use energy and natural resources efficiently and fairly. This wave of innovation is unique because for the first time in history, our survival is threatened by the technology that needs to be replaced. There has never been a greater opportunity for entrepreneurs to make the world a better place — this is indeed a challenge worthy of our efforts.[8]

Climate entrepreneurs have the technology and the ideas. Now it is up to policy makers, investors, and business leaders to implement the necessary system changes.

The main criteria by which the twelve climate entrepreneurs were chosen were:

- Products will generate greenhouse gas emission reductions on a global scale
- Products are suitable for a global market
- Company is ready for expansion and has a good strategy for reaching a global market
- Products can be used in large-scale and spread quickly within a few years

8 Gardner, Prugh et al., (2008), p. 43



SOURCE: GARDNER, PRUGH ET AL., (2008), S. 43

- Certification and/or expert opinions supporting the company's view of what the products can achieve
- Interest in exposure and attention as a role model in Swedish climate entrepreneurship

These criteria were used as a general guideline and exceptions were made in some cases because of outstanding performance on some particular criteria.

TOTAL CLIMATE EFFECT

In addition to analysing and presenting the twelve climate entrepreneurs, we have (when possible) added estimates of the climate mitigation potential for the company's products were they to be deployed globally and in large-scale. This estimate is not a scientific calculation (for simplicity, we have typically not used life cycle figures, for instance), but an indication of what is possible with new low-carbon innovations.

We have typically used the European, US, and Chinese markets for these estimates, assuming a 1.2 - 25 % market share. Using these assumptions, the twelve companies together have a climate potential of 600 million tons of carbon dioxide emissions reductions per year. This equals the combined annual emissions of Australia, Argentina and Belgium.[1]

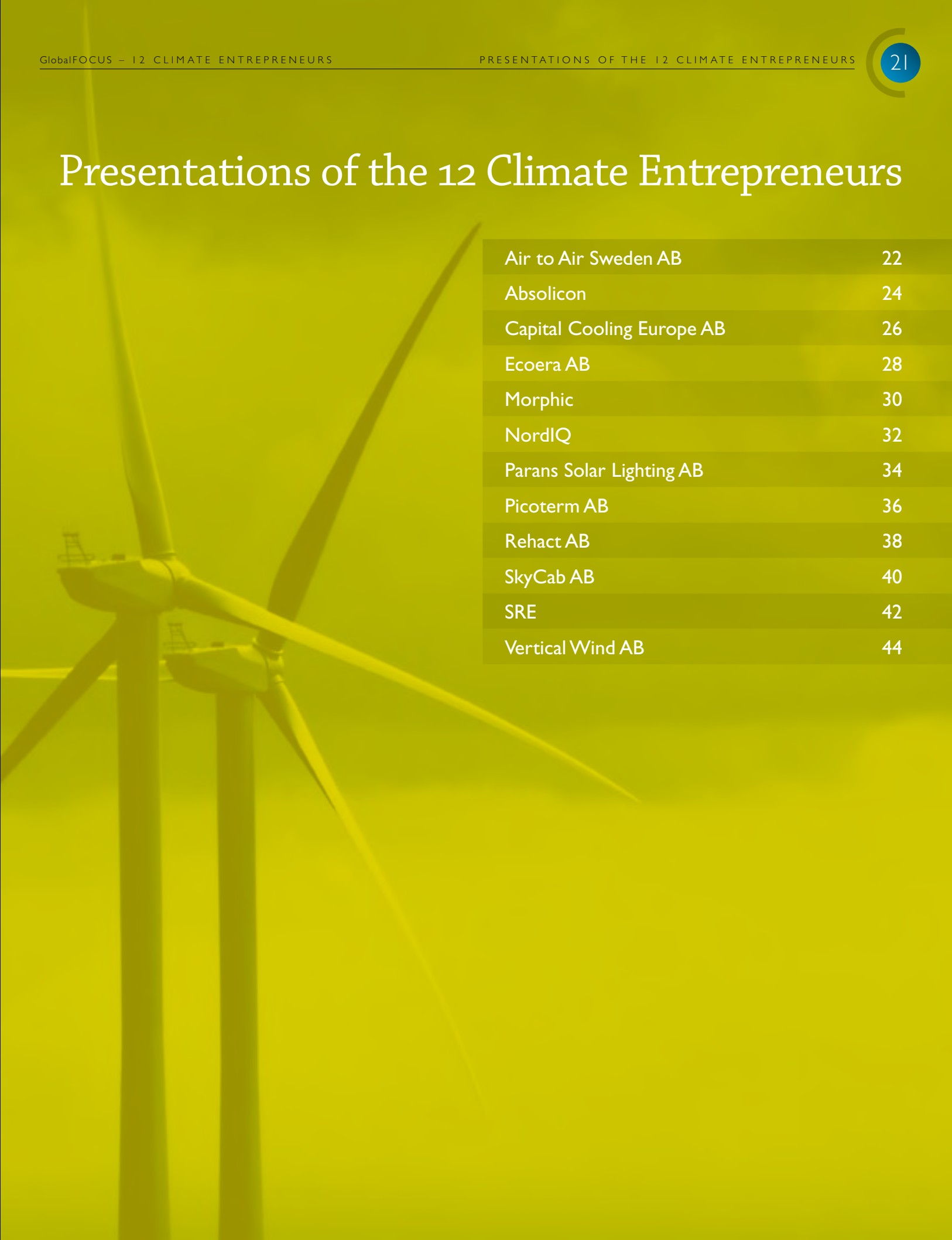
To calculate climate effect in terms of reduced emissions, different kinds of energy generation and adherent emission intensities have been used. Our estimates assume that coal-fired power is what is replaced on the margin.

All markets used as examples do have a lot of coal to replace. In Europe, 28 %[2] of the power generated comes from coal-fired plants, in the US the figure is 49 %,[3] and in China it is 82 %.[4] For coal emission intensities, we have used the following numbers; Europe: 835 gCO_2/kWh,[5] the US: 953 gCO_2/kWh,[6] China: 1,200 gCO_2/kWh.[7] Electricity generated from oil or gas in a boiler or heat pump has been estimated at 300 gCO_2/kWh.[8] Electricity from diesel generators is estimated at 730 gCO_2/kWh.[9] For market penetration and share, estimates have been made based on how the technology can be implemented and what the market looks like today. Other statistics used are presented in conjunction with the relevant calculations.

Estimates and projections may always be uncertain or unrealistic, but what is really realistic in this context? Is it realistic to keep filling up our atmosphere with climate pollution until we reach a total climate collapse — or is it realistic to believe in the power of human determination, creativity, and our ability to cooperate in solving problems?

1 WRI (2008)
2 Directorate-General Energy and Transport (2007),p. 28
3 EIA (2007b)
4 Worldwatch Institute (2007c)
5 Fortum (2006), p.30
6 EIA (2000)
7 Kobayashi (2007), p. 7
8 National Energy Foundation
9 Davis (2004)

Presentations of the 12 Climate Entrepreneurs



Air to Air Sweden

Hard facts

BUSINESS

Energy efficient HVAC (heating, ventilating and air conditioning) systems

STAFF

One on fulltime and external consultants on demand

THE CLIMATE INNOVATION

ReHydrator – technology that reduces energy consumption in new and existing HVAC systems

CLIMATE EFFECT

– 28 000 000 tons CO_2/yr

OPERATIONS TODAY

Air to Air Sweden AB has so far developed a generic prototype to prove that the technology shows expected theoretical proficiency. The company now focuses on manufacturing an application-based prototype/beta series using the patented technology and expects to launch a product on the international market in 2010

BACKGROUND

Air to Air Sweden AB was founded in 2006, after having been run as a project since 2002 by the inventor, Johan Siverklev. The start-up was realized after contacts with organizations supporting entrepreneurs and after successful participation in innovation contests

FINANCING

The company was financed mainly with private money until 2006, even though smaller sums were received from different organizations which were used to prepare and file the patent and to build and test a prototype. External financers entered the company in 2006 through a risk capital group. Two venture capitalists became shareholders in the company in January 2007. More capital and strategic alliances will be brought in during 2008

Our climate innovation

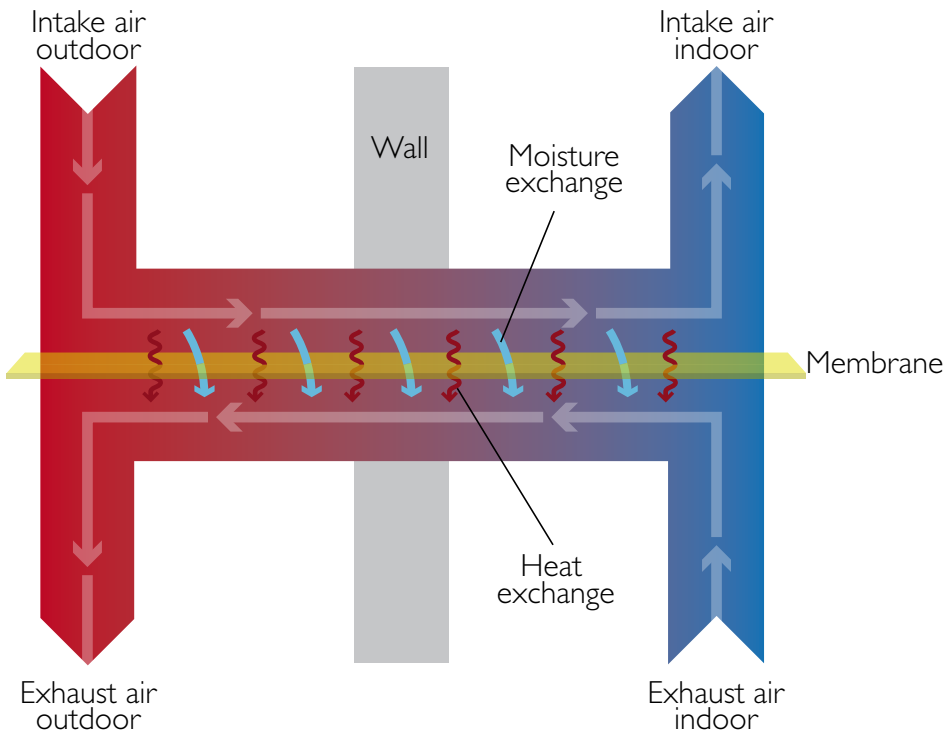
INTRODUCTION

Air to Air will market and develop a portfolio of ReHydrator products. The products will reduce energy consumption by up to 70% and reduce the operating and maintenance cost of both new and already installed HVAC systems.

By using the physics of diffusion and steam pressure to transfer water vapor and temperature between two separate air streams, ReHydrator lowers the energy consumption in climate control systems as these now need less energy to dehumidify and cool/heat the air entering the building. ReHydrator is essentially a passive heat exchanger which uses a semi-permeable membrane rather than the metal separator found in conventional units. The materials used have been developed to maximize water vapor permeability and also have anti-bacterial properties.

The technology can be used in several ways and implemented in an array of different systems. For example, ReHydrator can be used in a stand-alone fresh-air intake, in an integrated heat exchanger in a closed system air conditioner, as a module to increase energy efficiency in passenger transportation, and to recycle energy in industrial processes. The passive functionality allows for retrofitting which increases the potential market. When combined with a heat pump, the product becomes an energy efficient HVAC system.

Illustration – Cooling

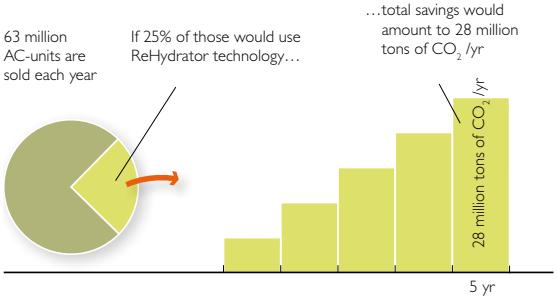


CLIMATE BENEFITS

Warm climates entail a large demand for cooling, mainly for spaces occupied by people, but also for other purposes. Improved living standards in many nations, along with rising temperatures, are rapidly increasing global use of AC. In China, where HVAC already consumes roughly 18% of the total energy supply, energy to power cooling systems is expected to increase dramatically in coming years.[1]

Measurements indicate that ReHydrator can reduce energy consumption by 50-60 % for cooling in fresh air intake space. A standard AC system for an office or apartment has a cooling capacity of 3.5 kW, comparable to 1kW electric capacity (energy consumed). Saving 50% means saving 0.5 kW or 2 kWh/day, if the unit runs 4 hours per day. Over the course of an entire year, this amounts to 730 kWh.

Every year 63 million AC units are sold globally.[2] If 25% of these were to employ ReHydrator technology, the energy consumption would be cut by 5.7 TWh. After five years, the annual savings would be 28.5 TWh or 28 million tons carbon dioxide.[3]



1 See for example: UNDP (2007), p. 11 & Worldwatch Institute (2007)
2 Airconditioning Zone (2007)
3 The average emissions for coal-fired power (996 gCO_2/kWh) in the US, China, and Europe.

CEO Johan Siveklev

The future

HOW WILL REHYDRATOR REACH THE GLOBAL MARKET?

Our concept is based on partnerships and joint ventures with multinational corporations with established lines of production, distribution, and sales. We will target several market sectors in the development of our marketing strategy, since the product can be used within an assortment of applications. Through collaborations with these large corporations, the product can quickly access separate markets and expand globally.

EXPANSION/EXPORT STRATEGY

We are focusing on tropical climate markets in Asia and Australia, primarily in applications where ReHydrator can work as an integrated part of an AC unit.

Air to Air sweden ab

CEO, JOHAN SIVERKLEV
TEL: +46 708 57 52 17
MAIL: johan@air2air.se
WEB: http://www.air2air.se

Absolicon Solar Concentrator AB

Hard facts

BUSINESS

Solar power

STAFF

Five full timers and three thesis researchers

THE CLIMATE INNOVATION

Solar8 – solar power system that, for the same electricity production, uses only one tenth solar cells compared to conventional solar panels

CLIMATE EFFECT

— 9 000 000 tons of CO_2/yr

OPERATIONS TODAY

The company is located in Härnösand, Sweden and is currently in the final stage of full-scale testing of the Solar8 system.

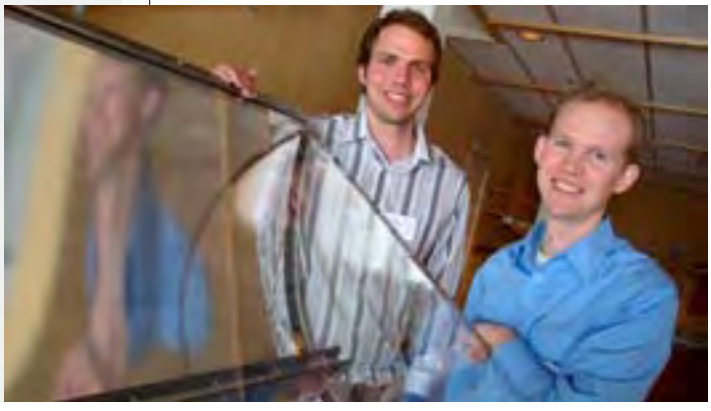
The company is right now looking for locations for the first large-scale installations in Spain.

BACKGROUND

Absolicon is a hiving off from the sawmill manufacturing company Logosol, and was created with the purpose of commercializing Swedish solar power research. The company is part of the Cleantech Demonstration Arena and cooperates with the solar energy research laboratory Lumicum and the solar energy school in Härnösand.

FINANCING

Absolicon has been founded with, essentially, € 200 000 private money, revenues from consultancy services, € 38 000 and loans from public authorities and € 30 000 from the county administrative board. In spring 2008, the investment company Exoro Capital and the Swedish Energy Agency provided € 900 000 in venture capital and loans to the company.



Johan Nilsson, Joakim Byström and a Solar8

Our climate innovation

INTRODUCTION

Solar8 is a sun-tracking parabolic trough that focuses sunlight on water-cooled solar PV cells. In a PV system, these cells are the expensive components, and Solar8 uses a tenth of the PV cells compared to a conventional system to produce the same amount of power. The costs are cut further due to cheap materials and optimization of the production process. Solar8 makes it simple to harness the sun for electricity and heat. Most of the product can be manufactured in a simple mechanical workshop, in any nation. Therefore, Solar8 is a short-cut to rapid growth for the solar energy sector.

The solution scales up with a good return on investment. In the subsidized markets in southern Europe, the system provides a 20% return on investment for the end user and a 50% contribution margin for the manufacturer. As the product adjusts to mass production, it will become profitable for energy production on the global level. The company aim is to cut the investment cost of solar power to one euro per watt, roughly one fourth of the cost today.

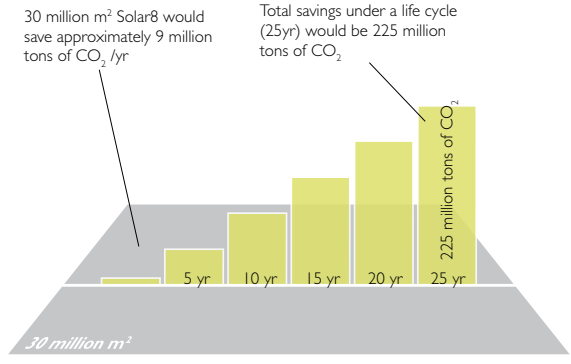
Solar8 fits into the existing solar thermal market and can easily be implemented in current systems. The system is optimized for use where there is a demand for both power and hot water. The hot water can be used primarily as domestic hot water in, for example, hotels or hospitals but can also be used for air conditioning – "solar cooling" – desalinization, or for industrial processes. The reflector technology

Joakim Byström receiving an award from the Swedish king Carl XVI Gustaf

can produce high temperatures, up to 200°C, which improves the efficiency of solar cooling and makes possible many industrial applications.

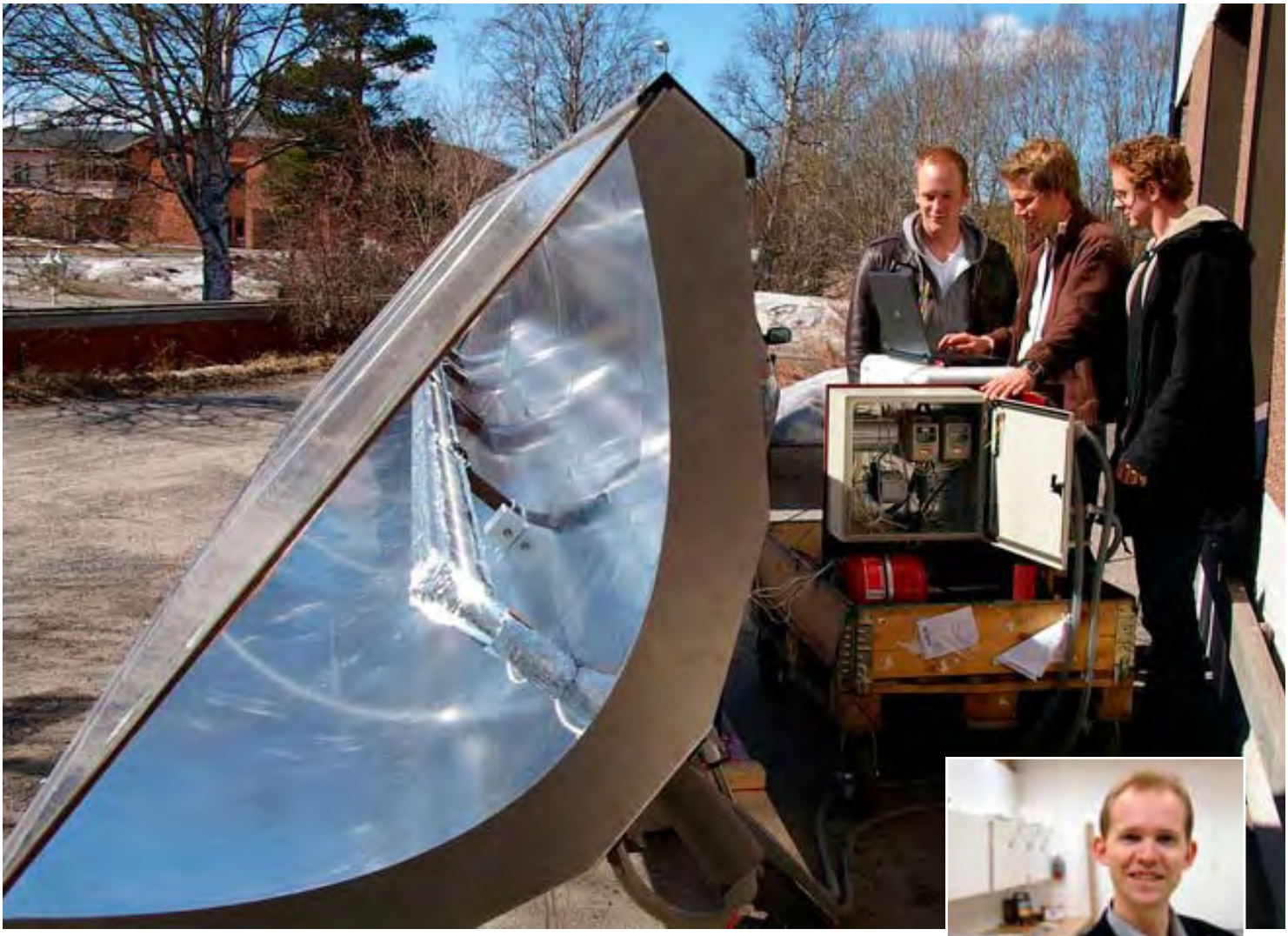
CLIMATE BENEFITS

Each square meter of mass-produced Solar8 generates 100 kWh electricity and 700 kWh heat per year, in sunny climates. With 996 gCO_2/kWh[1] for power and 300 gCO_2/kWh[2] for heat (e.g., oil or gas in a furnace or boiler, or a heat pump), Solar8 offers a lifetime reduction of 775 tons of carbon dioxide for a typical 100 m² installation. The effective lifespan, once the embodied energy has been subtracted, is 25 years.



1 The average emissions for coal-fired power (996 gCO_2/kWh) in the US, China, and Europe.

2 National Energy Foundation



Testing of a Solar8 unit

Absolicon Ceo, Joakim Byström

Were Absolicon to install 30 million m² Solar8 by 2020, this would entail roughly 9 million tons of avoided carbon dioxide emissions annually. As solar energy costs drop, the whole sector may grow rapidly and expansion of installed capacity, as well as climate benefits, will increase.

The future

HOW WILL ABSOLICON REACH THE GLOBAL MARKET?

By exporting key components and by production through licensed manufacturing abroad. The product is designed to work in the global mass market and the strategy includes licensing. India is one potential market. In general the product has a strong advantage in a market where production is cheap and energy is expensive.

EXPANSION/EXPORT STRATEGY

We have chosen to focus on Spain initially, which we consider to be the most advantageous market at present. Following Spain, we will approach other European markets and explore possibilities in China and India. Our first steps in new markets involve finding distributors and installers.

ABSOLICON

CEO, JOAKIM BYSTRÖM
TEL: +46 611 26 888,
+46 705 85 00 59
MAIL: joakim@Absolicon.se
WEB: http://www.Absolicon.se

Capital Cooling Europe

Hard facts

BUSINESS

District heating and cooling

STAFF

Three full timers and two working 50% for the company

THE CLIMATE INNOVATION

Systems for large-scale production and distribution of district cooling that are up to ten times more efficient than traditional cooling technology – and in addition can deliver district heating

CLIMATE EFFECT

– 36 000 000 tons of CO_2/yr

OPERATIONS TODAY

CONSULTANCY SERVICES: Energy utilities, municipalities and real estate developers are offered services within strategic business development, operational business controlling, support, financial settlements and risk management

JOINT VENTURES: Customers are offered a concept for developing of new business areas with technical turnkey solutions adjusted to local conditions

BUILD, OPERATE, TRANSFER (BOT): Using specific partners, Capital Cooling can assume responsibility for establishing new energy deals, including financing. A deal is developed using a team of professionals, and is then delivered to the customer when it's fully built-up

BACKGROUND

The company was formed in 2002 by five persons that had been active in the energy business for a long time. In a few years, the company has become one of the pioneers within district cooling, and today employs some of the world's leading experts in the industry

FINANCING

Capital Cooling has grown organically, but currently has a number of projects where partnerships are required to manage the expansion. The need for capital in BOT-projects is estimated at €30m the coming five years.

Our climate innovation

INTRODUCTION

District cooling is a modern, climate-friendly option for large-scale production and distribution of cooling. District cooling is produced centrally and is often based on natural cooling from the cold bottom water of lakes, ground water, rivers, the ocean, or from conversion of waste heat or bioenergy through absorption technology. District cooling is delivered to buildings via water at 6°C in a closed, in-ground pipe system. After performing the cooling service, the energy content of the now 16°C water can be recycled for use in a district heating system to provide heat and domestic hot water.

The district cooling is delivered to a sub-station on the customer's premises. This sub-station includes a heat exchanger which interfaces with both the energy company's district cooling network and the building's cooling distribution system. The sub-station is much smaller than conventional cooling equipment and can readily be placed in secondary facilities such as basement space.

District cooling is up to 10 times more efficient than conventional cooling technology.[1] The main idea behind district cooling is to use local sources for cooling that would otherwise be wasted or not used, in order to offer the local market a competitive and highly efficient alternative to conventional products. District cooling is an excellent option for shopping centers, hospitals, airports, and university and industrial campuses.

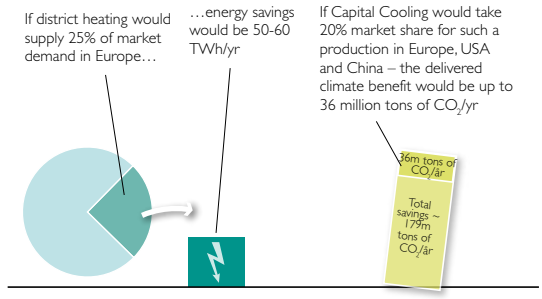
Globally, cooling needs are greater than heating needs. In Europe, roughly 40% of all commercial and institutional buildings are equipped with some kind of climate control for comfort cooling. In the US and Japan, this figure is about 80%, and the demand for cooling systems in nations like China and India is increasing rapidly. District cooling makes possible the large-scale leveraging of natural cooling and the delivery of this cooling in an energy efficient manner. This entails major climate benefits.

1 Ecoheatcool and Euroheat & Power (2005-2006b), p. 4

CLIMATE BENEFITS

Decreasing energy consumption means lower carbon dioxide emissions and a smaller climate impact. In Stockholm, Sweden, Capital Cooling has constructed systems for district cooling that have reduced emissions from 280 gCO_2/kWh to 60 gCO_2/kWh.[2] I Zuidas, Holland, their district cooling installation has reduced carbon dioxide emissions by 75 %.[3]

If district cooling were to expand to take 25% of the cooling market share in Europe, energy consumption would fall by 50-60 TWh resulting in 42-50 million tons less carbon dioxide released into the atmosphere each year.[4]



If Capital Cooling were to reach a 20% market share of district cooling markets of this size in Europe, the US, and China, they could deliver emissions reductions up to 36 million tons per year, as much as the sum of annual emissions in Croatia and Estonia.[5]

The future

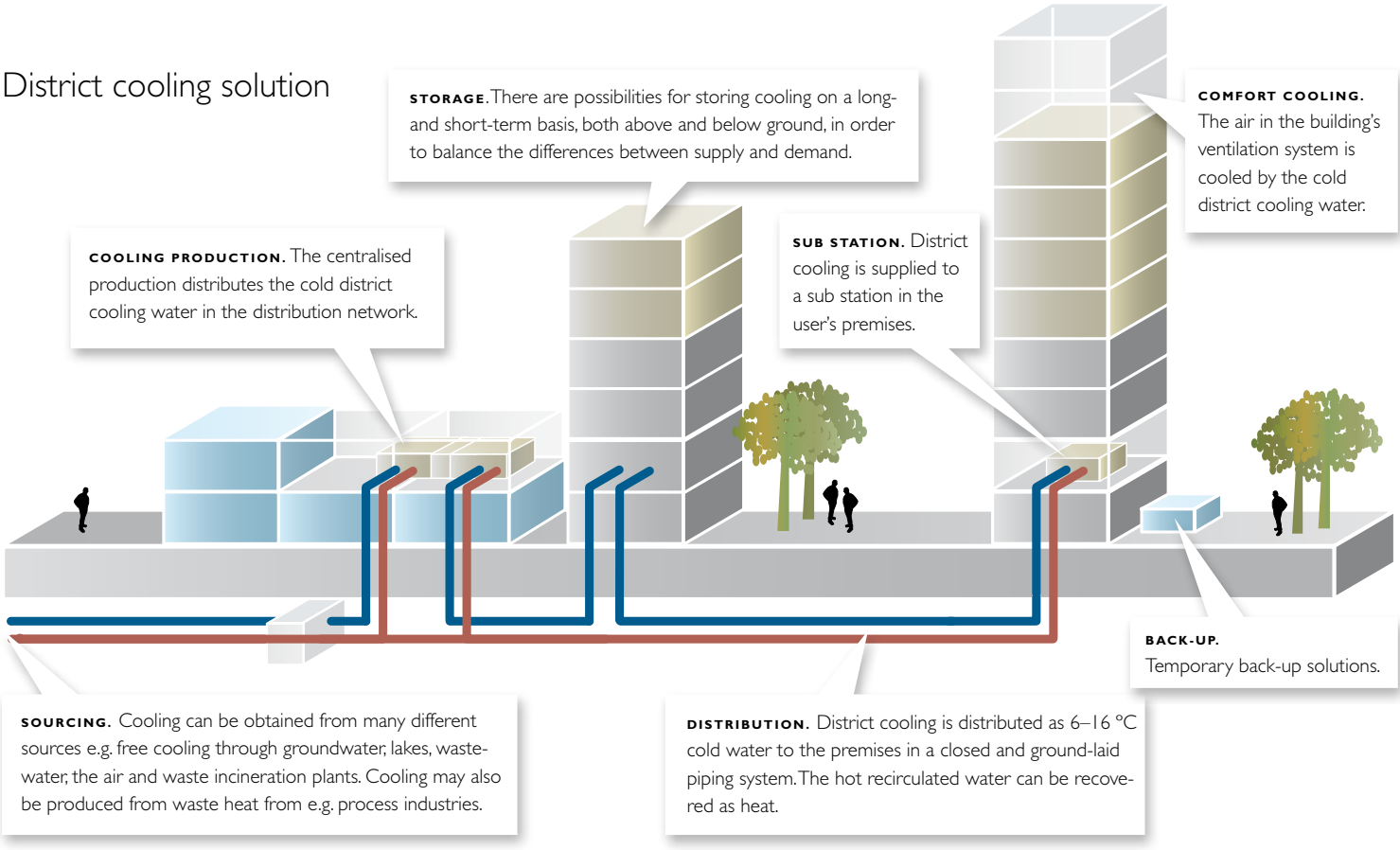
HOW WILL CAPITAL COOLING REACH THE GLOBAL MARKET?

We already have projects underway in collaboration with major energy corporations in Europe. In order to effect a substantial expansion in China and India, we need long-term partnerships within the energy and finance sector in these nations.

Our current goal is to be the market leader for deploying district cooling in Europe. We are also interested in entering the US and Chinese markets in collaboration with industrial partners.

2 Euroheat & Power (2006), p. 21
3 Ecoheatcool and Euroheat & Power (2005-2006b), p. 32
4 Ibid, p. 4
5 WRI (2008)

District cooling solution



EXPANSION/EXPORT STRATEGY

In order for us to expand rapidly, we need a distinct main strategy for entering new markets. Our priorities include developing brand recognition, human resources and our structural capital, as well as establishing partnerships.

The board of Capital Cooling

CAPITAL COOLING

CEO, BENGT UUSITALO
TEL: +46 84 59 96 43
MAIL: bengt.uusitalo@capitalcooling.se
WEB: http://www.capitalcooling.se

Ecoera

Hard facts

BUSINESS

Bioenergy

STAFF

Two on fulltime and several part time employees

THE CLIMATE INNOVATION

BIOAGRO – a system that enable conversion of agricultural residues into agropellet – a cheap and carbon dioxide neutral energy source

CLIMATE EFFECT

– 169 000 000 tons of CO_2/yr

OPERATIONS TODAY

Ecoera has its head office, with R&D, in Lidköping, Sweden, and a marketing office in Göteborg, Sweden. The company is today participating in the EU-project BIOAGRO, where the innovation is being tested full-scale. The system is now operational and is a solution for treatment and conversion of agricultural residues into a valuable and usable fuel.

BACKGROUND

The company was started as an innovation project at the Chalmers School of Entrepreneurship in 2006. Initially Ecoera was an idea based on research results from the Technical Research Institute of Sweden and a company, ÄFAB in Lidköping, Sweden. Primarily, however, it was actual customer demand that lead to the founding of the company.

FINANCING

To a large extent Ecoera is customer financed, but especially in the early stages, grants were awarded by the regional innovation system and others. The company's ability to settle deals has been critical for co-financing of public support.

Our climate innovation

INTRODUCTION

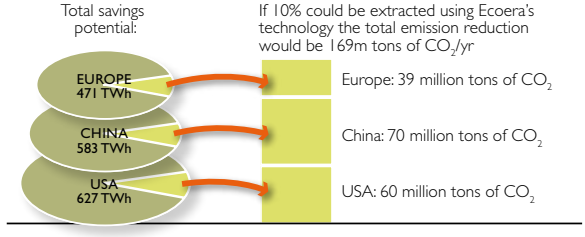
Ecoera enables the use of agricultural waste products – resources otherwise not utilized – to produce agropellets that can be burned for energy using custom-designed combustion equipment. This fuel is thereby not competing with biomass for food. Analysing the chemical composition of local feedstocks available at each individual site enables the optimal blend, resulting in more efficient combustion than separate treatment of each feedstock.

The technology is part of a complete system where the combustion equipment, developed by HOTAB, and the fuel mix made from waste biomass increase the potential amount of biomass available for pellet and subsequently bioheat and biopower production. Compared to wood, agro-waste biomass is more diverse in chemical composition and density; historically, this has made it harder to handle. Ecoera has solved three major problems associated with these feedstocks and created a complete solution that meets these challenges. The pellet manufacturing system itself is similar to those for pellets from forestry waste or other forestry products, but has the advantage of being deployable in regions where woody biomass is limited.

Additives reduce such emissions as sulfur dioxide by up to 80%. Optimizing the blend of additives and raw materials – creating an optimized pellet formula as it were – minimizes problems associated with ashes and strengthens the binding of compounds that otherwise pose combustion problems. The basic strength of this concept is that no matter which raw materials are available, with the aid of additives, the right pellet formula, and proper combustion technology, it is possible to turn a challenge into an opportunity. This challenge-turned-opportunity consists of converting large amounts of agro-waste (e.g., straw, husks, and chaff), that are currently left in piles or burned in the fields, to valuable fuel.

Each ton of agropellets replaces 2.7 barrels of oil; one cubic meter of oil corresponds to, in energy terms, an amount of agropellets worth, roughly SEK 1 000 on the Swedish market. This means agropellets are ten times cheaper than oil.[1] Waste biomass is essentially free. Along with partners, Ecoera are making it possible to leverage this resource with the aid of the all-in-one system, the BIOAGRO Transformer.

In lieu of completely new systems, another option is to retrofit existing systems. This is done by changing the matrix and mixer in order to make possible agropellet production. A system with modified combustion equipment can be enabled to produce biochar for carbon sequestration and agricultural soil enhancement. By this, agro by-products can be used to harvest CO2 from the atmosphere. Additionally, the system can be equipped with a fiber separation system for non-food crop fiber separation. Thereby the woody biomass can be used for higher class pellet fuel and the fiber incorporated into e.g biocomposites. This can elevate the profit for the bioenergy farmers.



CLIMATE BENEFITS

Estimates put the energy content of available agricultural residue biomass in 16 European nations at 471 TWh. If 10% of this potential were to be utilized with Ecoera technology, this would reduce carbon dioxide emissions by roughly 39 million tons.[2]
China generates 200 million tons agricultural residue each year.[3] Currently, due to lack of access to the correct technology, this resource is under-utilized for energy production, despite the sustainable potential energy content of the biomass residue being estimated at 583 TWh.[4] If Ecoera were to extract

1 At $94/barrel
2 Pellets for Europe (2002), p. 65
3 Grimm, Kilburg, Grassi, Lutter, Eppler (2002), p. 1446
4 Li Junfeng, Hu Runqing, Song Yanqin, Shi Jingli, S.C. Bhattacharya and P. Abdul Salam (2005)

David Andersson and Charlotta Ekman from Ecoera

10% of this potential, this would reduce emissions by 70 million tons, annually.

In the US, dry agricultural biomass residue is estimated at 113 million tons, with an energy content of about 627 TWh. Extracting 10% of this potential would cut emissions of carbon dioxide by 60 million tons annually.

Assuming a 10% market penetration by Ecoera, the total potential for emission reductions in these three regions is 169 million tons of carbon dioxide per year, about as much as Chile, Denmark, and Portugal emit, together.

The future

HOW WILL ECOERA REACH THE GLOBAL MARKET?

Each BIOAGRO-system is projected based on existing infrastructure at the customer site. Initial costs are determined by the number of feedstocks; a smaller subscription fee includes semi-annual recipe monitoring and modification, and outcome measurements. The costs vary according to conditions in each nation and access to local laboratories and analysis services.

The goal is to deploy BIOAGRO systems in collaboration with partners in several regions globally, starting in Europe, the US, China, and India. These systems will also serve as demonstration installations within their respective regions.

EXPANSION/EXPORT STRATEGY

Ecoera will focus on areas where there is little to no woody biomass and where the need for technology that can handle challenging fuels is the greatest. Currently Ecoera expect to have one larger BIOAGRO system up and running in 2009, and will aim to ramp up operations rapidly after that. Ecoera see an obvious market among public institutions such as schools and hospitals where decision makers can ensure progress toward climate-friendly energy. Other potential customers are smaller industries with access to their own byproducts.

Ecoera laboratory

ECOERA biofuel engineering

CEO, DAVID ANDERSSON
TEL: +46 703 80 54 10
Mail: david.andersson@ecoera.se
Web: http://www.ecoera.se

Morphic Technologies

Hard facts

BUSINESS

Group of companies with multiple areas of operation within environmentally friendly energy systems

STAFF

In total about 170 employees

THE CLIMATE INNOVATION

Cost effective production of flow plates for fuel cells and an innovative system for decentralized renewable energy production

CLIMATE EFFECT

– 12 000 000 tons of CO_2/yr

OPERATIONS TODAY

Morphics head office is located in Karlskoga, Sweden. The operational activity is carried out in Sweden in Karlskoga, Filipstad, Kristinehamn and Göteborg. International operations are today carried out in Patras, Greece,Lugano, Switzerland, Bologna, Italy and Tokyo, Japan

BACKGROUND

The company was founded 1999 in Karlskoga. The ambition was to develop and market technology that made high precision control of extreme dynamic forces possible, and thereby enable construction of components faster and cheaper than had been possible before. One area of application that was identified early was production of flow plates, the key component in fuel cells

FINANCING

The company's activities have from the beginning been financed by private investors. From early on, public trading in the company stock was made possible by an unofficial offering. As the company developed, the number of shareholders grew, and bigger investors entered. Expansion by acquisition has been made possible through new issues. Today Morphic has around 22 000 owners, including several big international investors in Europe as well as in the USA

Our climate innovation

INTRODUCTION

Morphic works on several different kinds of climate innovations, the most interesting of which includes the production of flow plates for fuel cells. Due to their long lifespan, negligible environmental impact, and superior energy exchange, fuel cells are a very promising low-carbon technology. Fuel cells can complement and replace fossil fuels and batteries in applications ranging from industries and buildings to vehicles and portable electronics.

Fuel cell systems produce electricity by transforming hydrogen so that it can react with oxygen. When hydrogen and oxygen react, large amounts of energy are released. This reaction takes place between flow plates; these are one of the most critical and costly parts of a fuel cell system. The market looks for low flow plate production costs and for plates to conduct the fuel well. A new technology developed by Morphic makes it possible to manufacture these flow plates at much lower cost, much faster, and at higher quality. Instead of milling the flow fields in the plates, a pattern is created by exposing the plates to a very high dynamic pressure for a fraction of a second. This method involves a number of advantages; the production time per plate is reduced dramatically while the possibility of accomplishing significantly finer resolution details in the plate pattern contributes to a more efficient flow.

Fuel cells have numerous applications one of which is the energy system Morphic has developed in-house. This system provides an entirely new way to convert, store, and use energy from renewable resources. The basic tenet of current electricity generation is that all power that is produced has to be used immediately; excess capacity cannot be stored. Wind power often provides intermittent power that depends on wind strengths and wind quality; in these cases, wind cannot provide base load power. Until now, no efficient method has existed for large-scale storage of energy that would allow use during periods of low production.

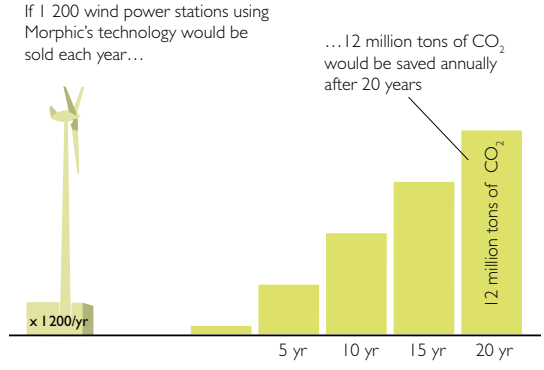
Morphic has developed a system which includes a fuel-cell based energy converter which converts power from, for instance, a windmill into a fuel, such as hydrogen or methanol, through a chemical process. This fuel can be stored and then converted back to electricity with a fuel cell system. In addition to the fuel converter, the system includes proprietary small and mid-sized, up to 500 kW, windmills.

The advantages of the Morphic system include the ability to generate electricity locally at a cost determinable in advance and the opportunity to increase the output of existing renewable energy sources. In the first case, the systems provide sustainable and cost-efficient alternatives to, for instance, off-grid diesel-powered generators. In the second case, the systems provide a capacity-increasing complement to existing renewable energy sources. By allowing for energy storage, the extraction rate is vastly improved, and a steady supply of power is made possible.

CLIMATE BENEFITS

The greatest climate potential rests in making fuel cells more competitive by the ability to deliver better flow plates at lower cost. In use, fuel cells emit no pollution; the only byproducts are heat and water. In addition, the efficiency is significantly higher than for conventional energy converters, roughly 60%, compared to a combustion engines` 25%.

The technology can replace fossil fuels in the transportation sector – which generates 5.6 billion tons of carbon dioxide annually.[1] Should Morphic reach its goal of 50% of the global market for flow plates by 2012, they will play a major part in having fuel cell technology reach its full potential. The climate benefits created would be enormous.



1 WRI (2008)

The founder of Morphic, Kurt Dahlberg, with a fuel cell car from Honda in the background

The developed energy system makes decentralized power production more attractive. Suppose sales of systems totaling 1 200 windmills per year averaging 300 kW, i.e., with a total capacity of 0.24 GW, or 1.8% of the global market for new installations.[2] Further, suppose these windmills produce 2 200 capacity hours per year and have a lifespan of 20 years. In the course of one life cycle, 24 000 windmills would be active and together reduce emissions by roughly 12 million tons per year.[3]

The future

HOW WILL MORPHIC REACH THE GLOBAL MARKET?

In 2008, we will start sales of our energy system to key customers. Applications include telecommunications hubs in inaccessible areas, back-up power for hospitals and care centres, food storage, or industries, as well as power for off-grid communities.

Close to two billion people lack access to the grid, have unreliable supply, or rely entirely on local diesel generators. At Morphic, we will target these markets and offer climate-friendly electrification.

EXPANSION/EXPORT STRATEGY

Our energy system targets nations with poor grid infrastructure. We will announce our strategy for expansion and our priority segments and nations within the next year or two.

One important aspect of deploying the energy system is to combine developing environmentally-friendly energy with developing living standards and democracy. Examples include aid projects that electrify important units in health care and food and water supplies. Our energy system can also be scaled to electrify other aspects in a community and support expansion of telecommunications and IP-traffic.

2 Global Wind Energy council (2008)

3 Assumes diesel generators are replaced. These generators emit ca 730 gCO_2/kWh. Source: Davis (2004)

morphic

JOHANNES FALK,
Director of Investory Relations
TEL: +46 706 76 73 93
MAIL: johannes.falk@morphic.se
WEB: http://www.morphic.se

NordIQ

Hard facts

BUSINESS

Heating systems with focus on district and residential heating

STAFF

Five fulltime staff

THE CLIMATE INNOVATION

A control system for real-time energy-balanced heating for buildings that make possible more efficient energy consumption

CLIMATE EFFECT

– 89 000 000 tons of CO_2/yr

OPERATIONS TODAY

The company's technology has been run and evaluated since early 2003 with successful results. Now NordIQ focus on bringing products to the market

BACKGROUND

NordIQ was founded in 1999 by Peter Gummérus and Matts Lindgren. Peter had worked within research and manufacture before, while Matts had been working with vehicle electronics and also successfully started and managed businesses. The first few years was spent on implementing Peters ideas in a control system borrowed from the car industry. Between 2003 and 2004 a pilot project was carried out with support from the Swedish Energy Agency. Evaluation of the project was made by the Swedish District Heating Association, and showed promising results – over 10% energy savings and 10°C increased cooling. After the evaluation, selling of district heating substations with smart controlling was started. Those substations were further evaluated by a third party, Telge Nät, and the results after one year were 23 % savings on heating and 14 % average savings on heating and hot water

FINANCING

Primarily private money, but also innovation support, conditioned loans and public grants

Our climate innovation

INTRODUCTION

NordIQ Softcontrol is a control system for real-time energy-balanced heating for buildings. The system aims to deliver exactly the right amount of energy at each point in time to achieve the desired building temperature – normally this entails maintaining the energy balance in real-time. If not enough energy is supplied at a given moment, this leads to complaints and a general tendency to turn up the heat. If too much is supplied, the excess heat is wasted. After a period of time, all variations will be above the tolerance level. A system that varies by 5°C, say, will result in an indoor temperature of 20-25°C, if the tolerance level is 20°C. A system that varies by 1°C will yield 20-21°C. All excess temperatures are losses that can be rectified with efficiency.

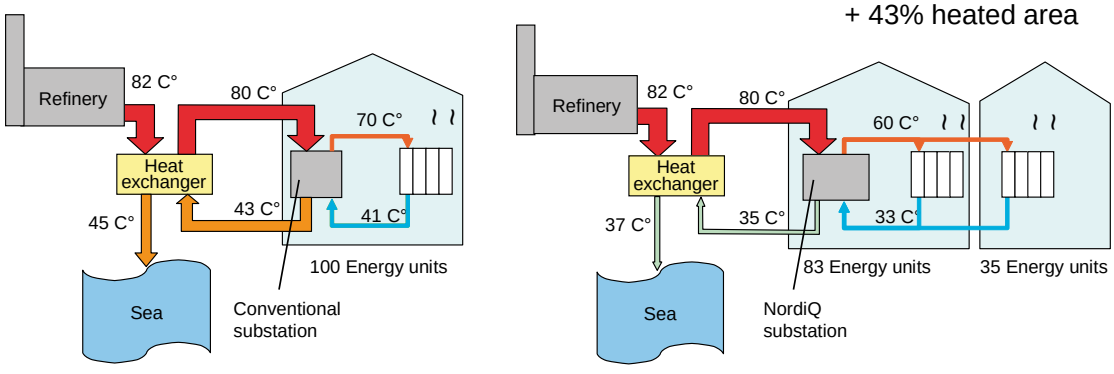
In addition to optimizing the amount of energy, there is also a large potential for environmental as well as financial savings by using energy of the correct quality. For building heating needs, all energy sources above 21°C are sufficient, in theory, while domestic hot water requires 55°C. Lighting, computers, engines, etc., typically require electricity. Energy systems are optimized when high quality energy is not used unnecessarily. The world is full of waste heat, essentially free, financially as well as environmentally speaking. Waste heat at 30°C can be used for building heating but not much else. Therefore, there is an optimal way to use energy which constitutes a target and theoretical limit for what can be achieved with a heating system, NordIQ Softcontrol adjusts energy use toward that optimal level.

Consider the concrete example shown below.

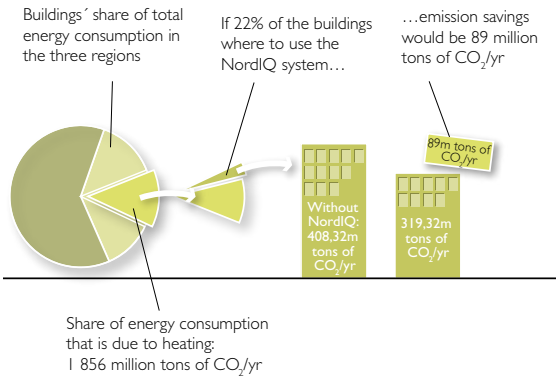
The home on the left uses 100 units of energy and the return temperature from the radiators is 41°C. The heat is supplied by district heating which can use waste heat from a refinery, down to ca 45°C. The remaining heat in the 45-degree warm water is wasted and flushed into the ocean. On the right, we see the same house after a NordIQ control system has been installed. By stabilizing the interior climate, energy use has dropped by 17%. Cooling optimization has lowered the return temperature to 33°C. The refinery can now use the 45-degree water and the energy exchange is improved by 18 energy units. 35 energy units have thus been saved for heating another home, and the heating capacity has been improved by 43%, while costs and carbon dioxide emissions have gone down.

CLIMATE BENEFITS

NordIQ Softcontrol can reduce energy consumption by 20% directly in all water-based systems and by an additional 20% if waste heat can be used to provide more of the remaining energy required. Carbon dioxide emissions can thus be cut by more than 40%.



In the US, residences and commercial buildings account for 38% of total energy consumption and 2.2 billion tons of carbon dioxide annually. Heating represents 474 million tons.[1] Deploying technology like NordIQ Softcontrol and assuming 20% emission cuts in 20% of the buildings and 40% cuts in 2%, the total carbon dioxide savings would be 23 million tons.



Matts Lindgren and Peter Gummérus from NordIQ

In Europe, buildings are responsible for 40% of total carbon dioxide emissions, 1.6 billion tons.[2] Residences and commercial buildings use on average 54.5% of the energy they consume for heating. [3] Using the same market penetration assumptions as above, NordIQ Softcontrol could cut 42 million tons of carbon dioxide in Europe.

In China, buildings consume 31% of the energy produced resulting in 1.5 billion tons of carbon dioxide of which 510 million tons are due to heating.[4] Calculated in the same way as above, 24 million tons could be cut with NordIQ Softcontrol.
These three examples give a total annual climate benefit of 89 million tons in carbon dioxide emission reductions, roughly the same as the sum of annual emissions from Norway and Sweden.[5]

The future

HOW WILL NORDIQ REACH THE GLOBAL MARKET?

NordIQ may in the future establish subsidiaries abroad for local manufacturing. We may also export complete district heating solutions through a consortium or employ a leasing model and package operations, maintenance, and equipment knowledge. For marketing purposes we are eager to participate in international demonstration projects.

EXPANSION/EXPORT STRATEGY

Currently, we are establishing the home market and only exporting by request. We anticipate entering a more active export marketing phase within a year or so.

1 Architecture 2030 & IPCC (2007a), p.393 & WRI (2008) & EIA, "Emissions of Greenhouse Gases Report", EIA (2007)
2 EU Observer (2007) & WRI (2008)
3 Commission of the European Communities (2001), p. 5
4 UNDP (2007), p. 11 & IPCC (2007a), p. 393 & WRI (2008)
5 WRI (2008)

NORDIQ

CEO, Matts Lindgren
Tel: +46 736 88 99 73
Mail: matts.lindgren@nordiq.se
Web: http://www.nordiq.se

Parans Solar Lighting

Hard facts

BUSINESS

Natural lightning

STAFF

Seven fulltime staff

THE CLIMATE INNOVATION

Products that lead natural light into buildings, and thereby reduce energy consumption for lightning and cooling

CLIMATE EFFECT

– 58 600 000 tons of CO_2/yr

OPERATIONS TODAY

Parans operate through a global network of sales agents on five continents

BACKGROUND

The company was founded at Chalmers School of Entrepreneurship in 2001 when an invention by Torsten Mattsson and Bengt Steneby was taken from idea to product by three students. In 2003 the company became limited and the year after the first installation was made at IKEA in Bilbao

FINANCING

Parans has been granted regional and national public loans as well as venture capital from private persons and institutions

Our climate innovation

INTRODUCTION

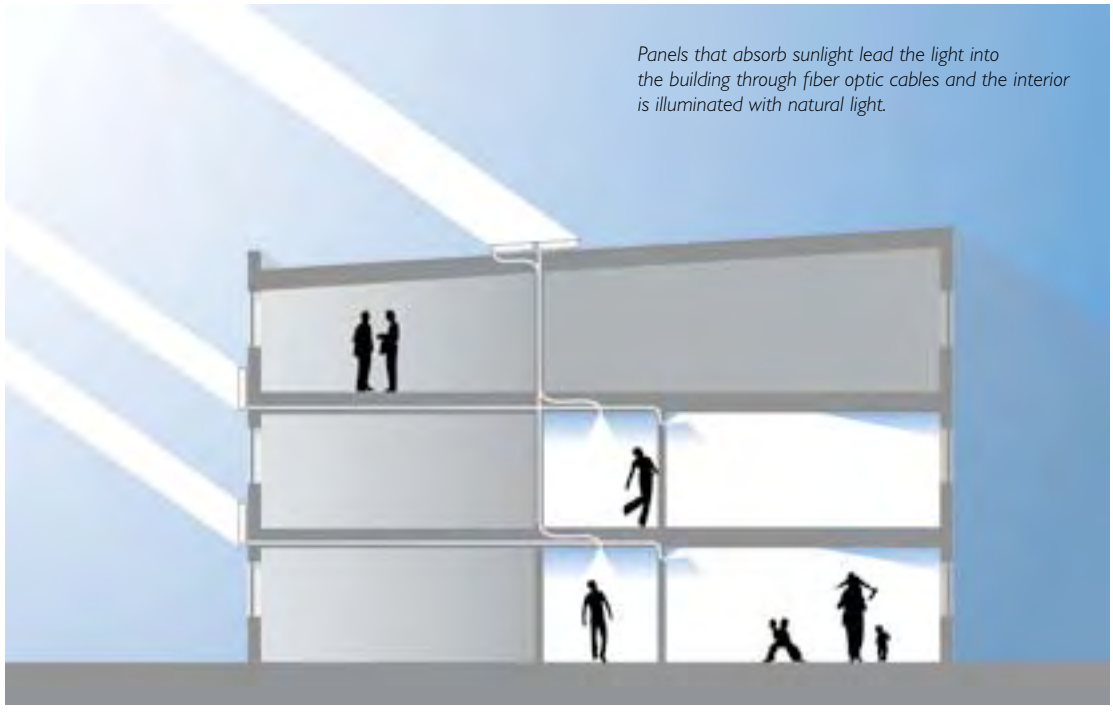
Parans takes lighting one step further than energy efficiency and truly thinks outside the box – why use electricity for light at all? The company has developed roof panels that absorb sunlight, the light is then led into the buildings through fiber optic cables, and the interior is illuminated naturally. The fiber optic cables connect to interior panels mounted on the interior ceiling or can be connected directly to spotlights.

Buildings can be retrofitted with panels, or these can be installed during original construction. Six exterior panels – 6 square meters – can transmit enough light via the cable to light up a 180 square meter room, with light intensity 300 Lux. This corresponds to the typical light intensity in larger work spaces. By leading natural daylight into the building, the lighting will vary during the day: the amount, intensity, and color tone of the light are reflected inside the building – as is the weather itself – creating a dynamic interior environment. Natural light uses no electricity, generates no waste heat, and is healthier than artificial light; medical studies have shown that daylight governs how we feel and how healthy we are and also has a positive effect on our productivity, increasing it by up to 16%.[1]

With the Parans technology, it is possible to think differently in new construction and plan for optimal use of space. In many larger buildings, such as hospitals and offices, it is hard to bring daylight into the entire building. Typically, this is solved with atriums and light shafts, which means foregoing the income that could be earned by renting out all the square meters these solutions require.

CLIMATE BENEFITS

Demand for lighting accounts for a large portion of global energy consumption. 17.5% of global power consumption goes toward lighting: 2 200 TWh[2]; this corresponds to roughly 1.2 billion tons of carbon dioxide each year, which, for comparison, is equal to 21.4% of all the emissions from the transportation sector.[3] If new smarter lighting technology does not replace the current system, lighting will consume 4 250 TWh annually by 2030, emitting 3 billion tons of carbon dioxide. Smart lighting systems would not

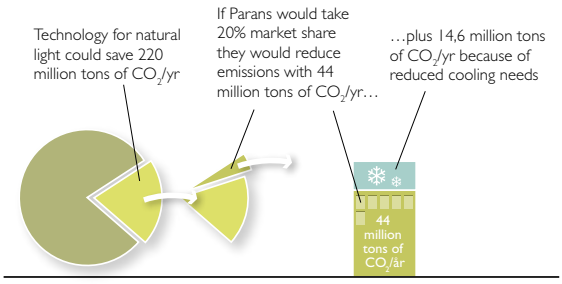


Panels that absorb sunlight lead the light into the building through fiber optic cables and the interior is illuminated with natural light.

only reduce emissions but also save $2 600 billion in energy bills for end consumers across the world, by 2030.[4] Buildings optimized to use natural light can meet 70% of lighting demand without using a single kWh power.

Today, the average building satisfies 20-25% of lighting needs with natural light.[5] Parans estimate that their technology can replace 50% of the lighting in 20% of buildings, worldwide. The projected reduction in carbon dioxide emissions would be 220 million tons per year.[6] If the company reaches 20 % of this market, it would correspond to 44 million tons carbon dioxide annually.

A significant amount of energy is also used for cooling, simply to compensate for the heat generated by lighting. The Parans technology reduces the need for artificial light and transmits daylight, which does not generate excess heat. This results in large potential energy savings. As a rule of thumb, cooling demand is reduced by one watt for every three lighting watts saved.[7] Using the same assumptions as above, this would indicate that the implementation of this technology reduces cooling demand by 14.7 TWh, resulting in additional emissions savings of 14.6 million tons of carbon dioxide annually.[8]
The total amount of emissions cut according to these estimates, including energy savings in both lighting and cooling, is 58.6 million tons of carbon dioxide per year. This is equal to the annual emissions in Hungary.[9]



Total emissions due to artificial lightning: 1,2 billion tons of CO_2/yr

The future

HOW WILL PARANS SOLAR LIGHTING REACH THE GLOBAL MARKET?

At Parans, we use a network of resellers who are specialists in their respective markets, including representatives from the conventional lighting sector, from natural lighting, engineering and consulting firms, architects, and more.

EXPANSION/EXPORT STRATEGY

We plan to expand our reseller network significantly in the next few years. We are not currently targeting specific markets – we work based on requests we receive. Our global expansion will continue in this way, which means meeting demand where it is greatest.


CEO Marcus Fransson

4 IEA (2006b)
5 IEA (2006a)
6 Average emission intensity (996 gCO_2/kWh) for coal-fired power in the USA, China, and Europe.
7 UNEP (2007), p. 15
8 Average global emission intensity: 557.2 g CO2/kWh. Source: WRI (2008)
9 WRI (2008)

parans
CEO, MARCUS FRANSSON
TEL: +46 739 85 40 81
MAIL: marcus.fransson@parans.com
WEB: http://www.parans.com

Picoterm

Hard facts

BUSINESS

Thermo acoustics – "the energy technology of the future"

STAFF

Four active owners

THE CLIMATE INNOVATION

Stack-free thermoacoustics – technology that in the future might replace the combustion engine and radically reduce the need for fossil fuels

CLIMATE EFFECT

Impossible to estimate

OPERATIONS TODAY

Today Picoterm is working with developing prototypes for possible applications of the technology. The company has also submitted a PCT (Patent Cooperation Treaty) on thermoacoustic technology for patent protection in 135 countries

BACKGROUND

Picoterm was founded with the vision of finding solutions to the energy needs of the future

FINANCING

Venture capital is now being sought

Our climate innovation

INTRODUCTION

Thermoacoustic technology is well-known and is the subject of research endeavors around the world, including substantial initiatives involving commercial applications. Los Alamos National Laboratory, as well as Penn State University have demonstrated working prototypes in this area. Swedish research projects are also underway, mainly at Chalmers University of Technology and at SP Technical Research Institute of Sweden. Thermoacoustics is based on pressure and temperature increasing and decreasing several hundred times per second in a forceful sound wave, an invisible piston as it were. This technology can be used for engines, heat pumps, and refrigeration.

With other current technology, thermoacoustic engines achieve 40% efficiency, but this figure drops dramatically as the load increases. Following years of research, Picoterm has found a solution that maintains high efficiency at full load. The company has developed a stack-free thermoacoustic engine that can be run on any fuel and has the potential to virtually eliminate the need for fossil fuels. It also has the potential to open the door to new applications that are completely unimaginable today. Picoterm aims to achieve triple the efficiency of a conventional combustion engine –while reducing volume and weight by up to 90%.

Another possible application is for heating, cooling, and power in buildings. With a thermoacoustic unit installed in the building and solar collectors on the roof, the sun's rays can be harnessed to provide heating, cooling, and power. Heat from the sun is led from the roof to the thermoacoustic unit which, because of the temperature difference, then works as an efficient heat pump.

A conventional heat pump has an annual heat factor of 3, which means that if it typically costs $ 6 000 to heat a given home, the cost with a heat pump is reduced to $ 2 000. A thermoacoustic heat pump on the other hand has an estimated heat factor of 8, which means the heating cost would be further reduced to $ 750. The thermoacoustic heat pump can also provide air conditioning as needed. The unit can also generate electricity, requiring only an absorbent surface, such as a black roof. This sys-

tem will generate electricity with a much smaller up-front investment than a conventional solar PV system.

CLIMATE BENEFITS

Picoterm is convinced that thermoacoustics has the potential to radically reduce global use of fossil fuels. If the technology should prove successful and be deployed widely, entirely new innovation areas will open up at the application level. The limits of our collective imagination are the only obstacle. In order to effect the transition to a climate-friendly energy system, we need new solutions. This innovation may be the biggest development in engine technology since the internal combustion engine entered the scene at the end of the 19th century.

Moving ahead with an innovation of this kind naturally involves risk and uncertainty, but the possibilities are essentially limitless. For society and industry, the incomparably largest risk lies in continuing down the already established paths and ignoring the need for radical leaps ahead in terms of deployment of new technologies.

The future

HOW WILL PICOTERM REACH THE GLOBAL MARKET?

Once a fully functional prototype has been constructed, the Board will determine the global strategy.

EXPANSION/EXPORT STRATEGY

All sales will take place via licensing; Picoterm will not be involved in the manufacturing process. Hopefully, many businesses will improve their competitiveness on the global market with reliable, high-quality, and environmentally-friendly products.

CEO Ulf Sundman

Thermoacoustics – the engine technology of the future?

Picoterm

ROLF DJÄRF, Economics
TEL: +46 709 93 00 00
MAIL: rolf@picoterm.com
WEB: http://www.picoterm.com

REHACT

Hard facts

BUSINESS

Heating, cooling and ventilation for buildings

STAFF

Three fulltime and two part time employees

THE CLIMATE INNOVATION

The Rehact Intelligent Energy system – an intelligent energy system that in an energy efficient way handles both heating, cooling and ventilation in buildings, reducing external energy need by up to 85%.

CLIMATE EFFECT

– 95 400 000 tons of CO_2/yr

OPERATIONS TODAY

Today Rehact is operating in Sweden and in Poland. The company has recently entered the market and has received orders for projects in Sweden, Poland and Cyprus. The first reference system is being installed in Poland, and more will follow in the near future. Inquires about the products has also been received from countries such as China, USA and India. Rehact has begun a process of acquiring external financing for a global growth

BACKGROUND

The company was founded in 2005 by students from Ideum Inventor School in Lidköping, Sweden. The technology is built around a product developed by Jerzy Hawranek from Poland

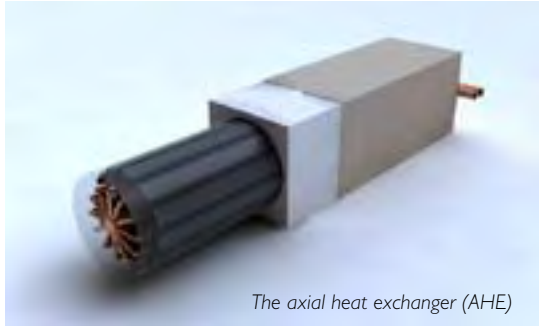
FINANCING

The owners have invested private money in the form of stock, totaling approximately € 50 000. Friends and family have lent the company € 35 000 and a Swedish state run company supporting enterprise has contributed € 25 000 in soft loans

Our climate innovation

INTRODUCTION

The REHACT Intelligent Energy system (a.k.a IVS) provides full HVAC services: ventilation with heat recovery, floor heating, a heat pump, and vacuum solar collectors efficiently distribute energy in buildings. Climate benefits include energy savings and less resource consumption for ducts and fan systems.



The axial heat exchanger (AHE)

An in-house developed proprietary axial heat exchanger is a central component in IVS. In axial heat exchangers the water used for cooling or heating flows parallel to, and in the opposite direction to, the air. This feature is unique to axial heat exchangers. This allows for a greater contact surface between the media in the heat exchanger without unnecessary space requirements. This means the system can utilize a smaller temperature difference between the air and the water, relative to other heat exchangers, and that the air flow can be reduced, which reduces losses and increases comfort. This method also allows for the heat exchanger to be situated at the air intake; conventional exchangers are instead placed at the exhaust. With the IVS, air enters the building via the ceiling in each room while the outflow is at about 1.5 m above floor level. This generates a temperature stratification in the room which creates comfort and saves energy by decreasing the volume of air affected. There are fewer temperature losses through ceiling and walls as well.

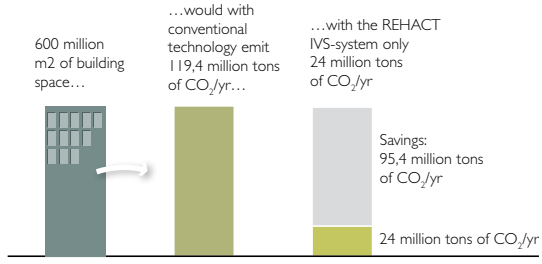
Vacuum solar collectors complement the heat pump in the system, increasing the heat pump's capacity to transfer heat to the building. A heat pump does not reduce a building's energy demand; rather it transfers ground heat or cold to the building's interior heating system, reducing the need for externally supplied energy.

A great advantage with this system is that its flexibility allows it to take into account that people have varying needs for heating and cooling. This means that retrofits to increase ventilation or heating – often consuming vast amounts of energy – can be avoided.

CLIMATE BENEFITS

Globally, buildings consume 50% of the electricity and heat produced by the power sector, emitting 5.4 billion tons of carbon dioxide annually.[1] Without improvements in energy efficiency, energy consumption in buildings in China is expected to double by 2020, and at that point consume as much energy as the nation as a whole did in 2000.[2] Existing technology could reduce building energy consumption by 30%. A fully installed IVS system reduces energy consumption to 15% through making the heat distribution in the building more efficient and by letting the heat pump work with smaller temperature differences.

The average new building in the US, Europe, or China consumes roughly 200 kWh/year/m² for heating and cooling. REHACT IVS can cut this to 40 kWh/year/m² and cut emissions by 159 kg CO2/year/m².[3] If IVS deployment were to service 600 million square meters, emissions would be cut by 95.4 million



1 HM Treasury/Cabinet Office (2007), p. 1

2 UNDP (2007), p. 11

3 Average emission intensity of coal-fired power (996 gCO_2/kWh) in the US, China, and Europe.

Svante Bengtsson, Jerzy Hawranek and Staffan Mastling from REHACT

tons of carbon dioxide annually. To put this in perspective, 2 billion square meters of new space is constructed in China alone, each year. 80% of these buildings are not energy efficient, which means heating systems waste up to 37% of their heating capacity with no heating benefit.[4]

The future

HOW WILL REHACT REACH THE GLOBAL MARKET?

Today, REHACT are selling the product to architects and construction companies. Within a few years, partnering businesses will be licensed to allow them to manufacture and sell the products via their regular distribution networks. There is no reason why the product should not be sold with the same ease as radiators or radiant floor heating. REHACT is seeking partnerships with businesses working world-wide in ventilation services or energy pumps. Manufacturing and sales can profitably be done locally, for instance in China or India, to reduce transportation costs and be closer to consumers. A major advantage with our system is that it is cost-effective for the user without government aid. This reduces the political risk involved and sets the stage for a global market.

EXPANSION/EXPORT STRATEGY

The company is currently developing stable and well-functioning sales channels in Poland and the rest of Eastern Europe. Within a few years the plan is to enter markets such as China and India. Within this time-frame suitable international partnerships for joint ventures will be sought. During 2008-2009 REHACT expect to see an inflow of $ 1.5 million. These funds will be used to build relationships in China and the US. In the coming 4 years, we project capital investments in the region of $ 17 million as we enter the global market.

4 Worldwatch Institute (2007)

Awards and recognition

May 2008 – Globe Forum Business Network, Stockholm, Sweden

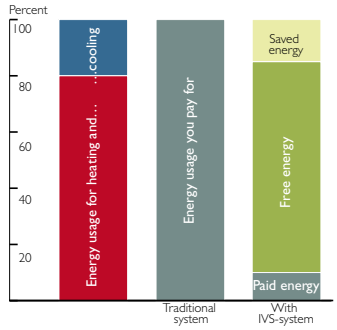
"Globe Award – Best CSR Entrepreneur 2008"
"For changing and improving the energy efficiency within the building and construction sector, by a combined innovation technology that works simultaneously with heating, cooling and optimizing ventilation, while also reusing all possible heat that is already present in the system."

April 2008 – Venture Challenge, San Diego, USA

"The R. Michael Pack Award for Environmental Awareness in Entrepreneurship"
This award is given to the company who show the greatest level of environmental awareness.
"Craig P. Dunn Award for Social Innovations in Entrepreneurship"
This award is given to the company that implements the social aspect within its business model.

April 2008 – The One Big Thing, Stockholm, Sweden

The American Ambassador to Sweden, Ambassador Michael Wood, has put together a list of Swedish companies within the clean-tech segment. To be submitted to the list the company must be growth-focused and have a technology that will be attractive on the US market.



Rehact

SVANTE BENGTSSON,
Chairman of the board
TEL: +46 709 56 67 56
MAIL: svante@rehact.com
WEB: http://www.rehact.com

SkyCab

Hard facts

BUSINESS

Transportation

STAFF

Directorate consisting of nine hand-picked experts within various fields

THE CLIMATE INNOVATION

Personal Rapid Transit (PRT) – a new way to travel, independent of fossil fuels and ready to meet the transportation needs of the future

CLIMATE EFFECT

Climate friendly travels

OPERATIONS TODAY

In 2006 SkyCab inaugurated the first test-track for PRT in Sweden and made an agreement for the next step – construction of a full scale track and a center for PRT – with the municipality of Hofors, Sweden. Several cities, both inside and outside of Sweden, have expressed interest in the SkyCab system

BACKGROUND

The company started its activities in the 1990s with the ambition to create a small-scale, environmentally friendly and flexible transportation system in a planned theme park in southern Europe. Since then the technology has been developed in close cooperation with a multitude of different actors

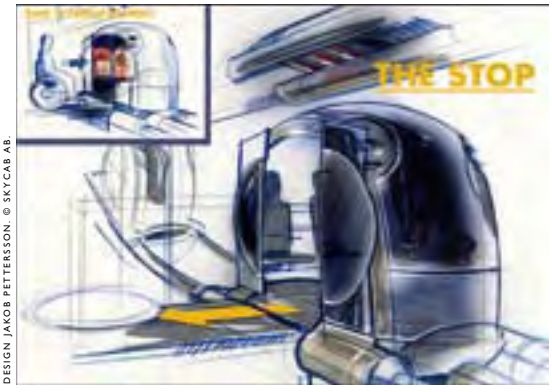
FINANCING

The company and its ideas got noticed early on and received public financing in the form of grants. Some municipalities financed pre-studies and others contributed with other forms of support. The Swedish Rail Administration has financed the development the last few years and the project is also in part privately funded

Our climate innovation

INTRODUCTION

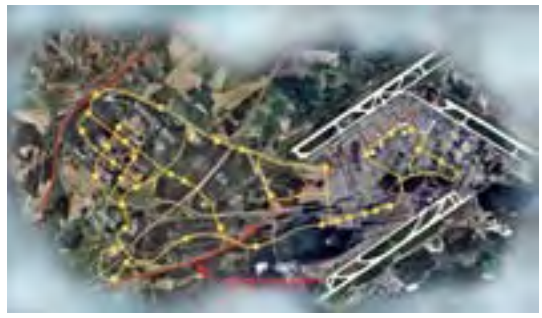
SkyCab is a Personal Rapid Transit System (PRT). It is a system of small vehicles for individual journeys in public transport in urban areas. A SkyCab system requires no timetable, no waiting time, and generates no exhaust or noise pollution. SkyCab is energy efficient and will be powered without fossil fuels. The automatic vehicles (no drivers) are small units, typically on a elevated guideway, with room for up to four people who get on and off at stations on side tracks. Users can select individual routes and are thus not forced to follow a specific track.



DESIGN JAKOB PETTERSSON. © SKYCAB AB.

PRT introduces significant improvements to today's public transportation systems and functions as a complement, especially in high density areas with poor conditions for regular public transportation, and where communications otherwise require travel with cars. PRT are also suitable for connecting lower-density urban areas to larger railway systems, as well as to subways or trams. Properly designed, this system will not compete with existing public transportation, but rather complement them by increasing accessibility. A SkyCab system offer a new way to provide on demand and non-stop service for environmentally friendly transportation. Several countries around the world have shown great interest in the technology, but no commercial systems are in use yet.

PHOTO SAMUEL BENGTSSON. ILL. MATS FALK. © SKYCAB AB.



© SKYCAB AB.

A glimpse through the clouds at Stockholm-Arlanda Airport and its surroundings. A studied SkyCab Demonstration System for 7 million passenger trips for criss-cross individual travels on demand with non-stop service in automatic (no driver) vehicles between 37 stations on 30 kilometers of guideway.

The up-front investment cost per system-kilometer is 50% less than for tram or rail and roughly a quarter compared to subway or highway. The capacity is 9 000 passengers per link per hour. SkyCab runs at roughly 40 km/h, significantly faster than the average transportation speed in congested urban areas. The benefit to society has been estimated at up to 1.9; which means that each Yuan, Yen, Dollar or Euro invested returns 1.9 of the same to society.

CLIMATE BENEFITS

SkyCab power usage is 0.11 kWh/vehicle kilometer. Were SkyCab to be powered by the average electricity generated within the EU, emissions would amount to 38.9 gCO_2/km.[1] The European Commission has proposed a limit for new passenger cars of 130 gCO_2/km starting in 2012; SkyCab emissions from the average EU power supply are less than a third of this limit.[2] SkyCab carbon dioxide emissions are one fifth of the average emissions for passenger vehicles in the UK.[3] The greater the portion of SkyCab power that comes from renewable resources, the greater the emission reductions, all the way down to almost zero if renewable energy can provide all the power.

Because different power sources imply different amounts of emissions and different alternative

1 Emission intensity in Europe (EU-25) = 353.9 gCO_2/kWh. Source: WRI (2008)
2 Business Day (2008)
3 Defra (2007), p. 7

PHOTO SAMUEL BENGTSSON. ILL. MATS FALK. © SKYCAB AB.

transportations have different energy requirements, it is hard to estimate the climate mitigation impact of SkyCab in terms of tons of emission reductions. Furthermore, SkyCab complements other public transportation systems and makes these more accessible. This in turn leads to greater climate gains.

In order to meet future demand, the world needs new and sustainable transportation systems – passenger cars cannot meet this demand, even if every car were powered by fossil-free fuel. Beijing, for example, where more than 3 million cars fill crowded roadways and are joined by another 1000 each day,[4] needs new solutions. SkyCab offers climate benefits but also a system that, in contrast to passenger cars, can meet the future of transportation demand.

The future

HOW WILL SKYCAB REACH THE GLOBAL MARKET?

SkyCab is part of the Swedish government's and the Swedish Trade Council's initiative SymbioCity – Sustainability by Sweden.[5] A communication platform has been developed for this particular purpose.

The company will in part be marketed together with other businesses in so-called clusters through Nordic Environmental Technology Solutions, the new database and network of the Nordic Council of Ministers.[6] Exports will also be coordinated through this network.

The SkyCab main business plan is to build systems through public private partnerships, but licensing and franchising are also possible options. When installing a system the company will coordinate action between local or regional partners.

DESIGN NIKLAS WEJEDAL. © SKYCAB AB.

SkyCab Vehicle Vision Design.

EXPANSION/EXPORT STRATEGY

A signed contract for a full scale pilot in Hofors, Sweden, signals that SkyCab has reached the milestone of realistic implementation and demonstration. The pilot system will allow for technical and operational testing with passengers. The pilot system is also an important step toward developments in other locations.

Future plans include development of a second PRT generation technology in cooperation with international partners. Working with China, India and the Middle East will give opportunities for this and the goal is to take a global leading position in sustainable public transportation.

4 BBC (2008)
5 See: http://www.symbiocity.org
6 See: http://www.nordiccleantech.net

SkyCab

CEO, DR ÅKE ÅREDAL
TEL: +46 8 661 05 75
MAIL: info@skycab.se
WEB: http://www.skycab.se

SRE/Opcon

Hard facts

BUSINESS

Fossil free energy production and products for energy efficiency

STAFF

SRE employs around thirty of Opcons total 340 employees

THE CLIMATE INNOVATION

Three different innovations that enable utilization of vast amounts of energy that are today wasted in energy production, manufacture and shipping

CLIMATE EFFECT

– 94 000 000 tons of CO_2/yr

OPERATIONS TODAY

SRE has made about 70 system installations, primarily in Sweden, the Baltic States, Germany and Holland. Today the company is experiencing strong international growth. During the last year agreements were made with sales agents in Poland, Germany, Finland and North America. Together with the parent company Opcon – that already has a factory in China – there's an interest also for more distant markets.

BACKGROUND

SRE was started in 1992 by the entrepreneur Lennart Granstrand. From 2002 to 2005 turnover increased tenfold, and the company received its first export order. In 2007 the company became a part of the limited company Opcon and took lead of their newly formed Renewable Energy division.

FINANCING

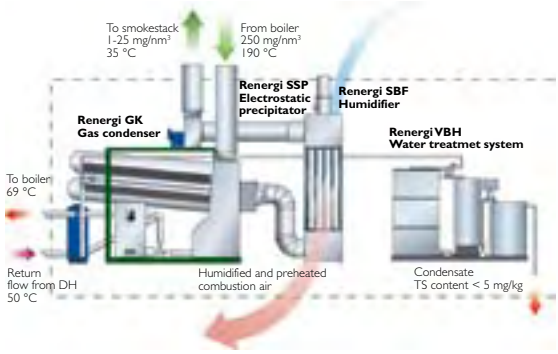
Up until 2007 the company was privately and loan financed. Because of strong expansion, and with respect to the large international market potential, SRE then chose to become a part of Opcon

Opcon Powerbox

Our three climate innovations

INTRODUCTION

SRE Renergi technology captures the energy content in warm flue gases, instead of simply releasing this as waste heat from heat plants fired with green biomass. By increasing the surface available for heat exchange several fold, with the aid of very tiny water drops, and leading moist flue gases across this surface, the Renergi system cleans the flue gases and increases energy efficiency by 25-30%. This means a 25-30% reduction in carbon dioxide, near particulate-free emissions, reduced sulfur emissions, and reduced odor. An intelligent manufacturing process has cut costs providing the end-user with a pay-back period of two to three years. SRE currently market a standardized range of products for boilers from 1 MW up to 30MW..



The SRE drying system connects an extra drying unit to a flue gas condenser and uses the combined system to capture the surplus energy in smoke stacks at sawmills and pellet plants. This energy is subsequently used to dry biomass. With this system, a producer can reduce energy needed to dry biomass by 40-50%.

Opcon Powerbox generates fossil-free electricity from waste heat already at a low 55˚C, heat that would otherwise be lost and dumped in the closest recipients. The waste heat gasifies a work medium which then expands and drives a generator. One unit running year-round can deliver 3 400 MWh power, on average. Investment per kWh produced is around half that for conventional wind power.

CLIMATE BENEFITS

With SRE Renergi, the energy efficiency of a biomass-fired heat plant increases by 25-30%, significantly improving its competitiveness relative to fossil-fueled power plants. The system is particularly suited for regions with heating needs and a good supply of forestry products, and which are structured to allow for district heating systems. District heating implies large climate benefits. In Växjö, Sweden, emissions per person were reduced by 30% between 1993 and 2006, mainly due to switching to district heating. Now the goal is freedom from fossil fuels altogether.[1] If biomass-fired heat plants producing 50 TWh heat energy – equivalent to the production in Sweden today[2] – were to use Renergi, the same amount of biomass as used by those plants could instead yield 65 TWh and reduce the end user's need for complementary electric heat by the same amount. Deployment on this scale on the European, US, and Chinese markets would save a total of 45 million tons of carbon dioxide.

With the SRE drying system, the climate benefits come from the large energy savings in production of bioenergy products. Currently, pellets are mainly manufactured in Canada and Europe, but the market is expanding rapidly as opportunities for replacing fossil fuels with biomass are understood. New technology that makes manufacturing pellets from agricultural biomass possible is expected to affect growth significantly.[3] In many developing economies, large amounts of biomass are burned directly today, with very low efficiency. For example, China burns 200 million tons of biomass at an efficiency of 5-8%, compared to a pellet stove that uses 90% of the energy.[4]

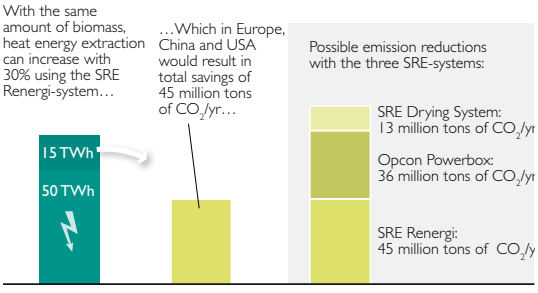
The system would save a large pellet manufacturing plant roughly 80 GWh per year. In terms of reduced emissions, this means 76 240 tons saved in

1 Fossil-fuel free Växjö: http://www.vaxjo.se/vaxjo_templates/Page.aspx?id=638
2 Swedish District Heating Association
3 See Ecoera, p. 28
4 CRESP

Canada,[5] 66 800 tons in Europe, and 96 000 tons in China. If 20 large pellet manufacturers were to use the drying system in Canada, 100 in Europe, and 50 in China, the annual emission reductions would be 13 million tons of carbon dioxide.

Opcon Powerbox could produce as much as 30 TWh fossil-free power from the more than 300 TWh annually lost as waste heat by European industries.[6] If Opcon Powerbox were used to extract just 20% of this potential, 6 TWh, in each of the industrial sectors in Europe, the US, and China, the climate benefit would be a cut in carbon dioxide emissions of nearly 18 million tons.

The technology can also be used for generating power on board large ships. This would reduce fuel consumption by 5-10% and reduce both CO2 and NOx emissions. Today, there are roughly 90 000 ships above 100 tons and another 20 000 equally large military ships; their combined capacity is 450 000 MW.[7] According to estimates, international shipping uses 289 million tons of fuel annually and emits roughly 920 million tons of carbon dioxide.[8] If Opcon Powerbox were used to reduce fuel consumption by 5-10% on board one-fifth of these ships, this would cut emissions by 9-18 million tons of carbon dioxide. NOx and SOx particulate emissions would be cut too, as would be emissions of hydrocarbons.



The climate benefits from these innovations would amount to 94 million tons per year, as much as the total sum of emissions from Israel and Peru.[9]

5 We have used the same value for the emission intensity for coal-fired power generation in Canada as in the US, i.e., 953 gCO_2/kWh.
6 Ecoheatcool and Euroheat & Power (2005-2006a), p.31
7 Journal of Geophysical Research (2003)
8 Journal of Geophysical Research (2003)
9 WRI (2008)

The condenser in SRE Renergi

The future

HOW WILL SRE/OPCON REACH THE GLOBAL MARKET?

SRE/Opcon has limited resources; currently production is located in Sweden and China only. The company would like to expand, and then primarily through local partners who need to be well-placed and informed within their sectors.

EXPANSION/EXPORT STRATEGY

The first SRE drying system and the first full-scale Opcon Powerbox went online in 2008. The new drying system has already been sold for export and should have great international potential. SRE is also focusing more on greenhouses, in terms of flue gas cleaning and efficiency, with an eye to exports. The goal is for exports to yield more than 40% of 2008 revenue, through financial growth and international partners, and for this share to continue growing. Market focus is now on nations that have built and are building biomass-fueled district heating systems and cogeneration plants. Shortly, SRE will also work with process industries, with flue gas cleaning and energy efficiency measures.

SRE
CEO, PER EGEBERG
TEL: +46 8 58 08 73 04
MAIL: per.egeberg@sre.se
WEB: http://www.sre.se

OPCON ENERGY SYSTEMS AB
CEO, PER HEDEBÄCK
TEL: +46 8 466 45 16
MAIL: ph@rotor.se
WEB: http://www.opcon.se

Vertical Wind

Hard facts

BUSINESS

Vertical-axle windpower

STAFF

Nine persons in the company and four PhD students working on related research

THE CLIMATE INNOVATION

Vertical-axle wind power stations that enable cost-effective energy production and that may lay the foundation for an accelerated expansion for wind power production internationally

CLIMATE EFFECT

– 10 600 000 tons of CO_2/yr

OPERATIONS TODAY

The company is based in Uppsala, Sweden and are today involved in discussions with potential customers, subcontractors and partners in Sweden as well as the nearest neighboring countries. Patents are today granted in USA and within the EU

BACKGROUND

Vertical Wind was founded in 2002 by Mats Leijon and Hans Bernhoff together with the investment company Energy Potential limited, Uppsala Universitet limited and researchers at Uppsala University. The research on vertical-axle wind power stations pursued since 2002 has amongst other things resulted in a basic aerodynamic theory for energy conversion with vertical turbines, published in Journal of Applied Physics. The latest advancement has been the successful construction of smaller pilot stations

FINANCING

Financing has mainly been secured by issuance of stocks, but expenditures have been kept to a minimum. Smaller support has also been acquired from an innovation foundation. The technology developed is based on research from Uppsala University, Sweden, and where financing has primarily consisted of external research grants

Our climate innovation

INTRODUCTION

Vertical Wind is developing a new kind of wind power technology. The aim is to offer energy producers wind power with lower investment costs and significantly less maintenance. The innovation combines a simple vertical axis turbine with modern generator developments and produces a complete solution, minimizing the number of moving parts. The technology can reduce the cost per installed capacity (kW), but, more importantly, per amount of converted energy (kWh).

Today, a wide variety of wind turbines exist but propeller turbines, with power coefficient (Cp) up to 0.5, dominate the market. The fluid dynamical properties of vertical turbines are much harder to model; today the Cp is 0.4 for these turbines but could very well surpass 0.5 in the future.

Power conversion does not in itself determine commercial applicability, but cost per converted energy does. The latter is hard to estimate for new technology, but the required amount of material is often used as a proxy, since it is correlated to the construction cost. Previously, vertical turbines have been thought to require a greater amount of material, but more recent research has shown that actually the same amount or even less is required. In addition, conventional turbines are heavy and difficult to install because, as opposed to in vertical turbines, the heavy generator is placed at the top of the tower.

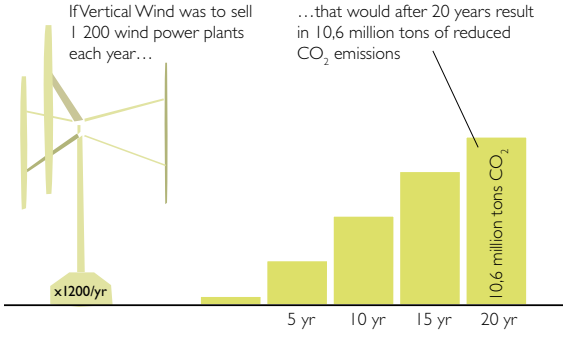
The technology of earlier vertical wind turbines has entailed the use of over-dimensioned mechanics. Vertical Wind solves this by using a direct-drive generator that can handle large overloads. The basic idea is to use technology with simple mechanics, place the generator at ground level, and use a vertical turbine that reacts regardless of wind direction and is relatively insensitive to turbulence.

Compared to conventional technology, wind turbines from Vertical Wind have several advantages:

- Simple and robust technology, in terms of electronics and mechanics, with few moving parts – simplifies installation, reduces maintenance, and increases efficiency.

Wind power plant with turbine on vertical axis

- The wind turbines are easy to install, and the generator maintenance is easy at ground level.
- The power converted is controlled electrically by the generator; this means the system can deliver power across a wide spectrum of varying conditions without sensitive mechanical control devices.
- The low blade speed produces less noise, and the horizontal movement may also provide less visual interference; together these factors should increase acceptance of wind power.
- The wind turbine can be constructed to generate useful energy over a wide wind range which allows for high efficiency even at low power converted.



CLIMATE BENEFITS

The potential for wind power development is huge; global wind energy resources amount to 600 exajoule (EJ), of which we today use 1 EJ. Global annual energy consumption is 490 EJ, with fossil fuels such as coal, natural gas, and oil delivering 80%, nuclear power 5%, and renewable energy 15%.[1]

The US could produce 150% of its current power consumption using only wind power.[2] In China, renewable energy is expected to supply 16% of the energy supply by 2020, compared to 7% in 2005. The contribution from wind power is expected to increase by 2 400% during this period. In Europe, where wind power capacity has increased five-fold since 1999,[3] wind is also expected to grow rapidly in the coming years, not least due to the EU target of 20% renewable energy by 2020.[4] If Vertical Wind can develop more cost-efficient and robust solutions in wind power, our contribution will be important in accelerating expansion of wind power internationally.

The company is now working to develop 200 kW wind turbines. Suppose this kind of wind turbine with a 20 year lifespan is placed to yield 2 200 capacity hours per year, it will reduce carbon dioxide emissions by 8 800 tons during the course of its life.[5] If Vertical Wind sells 1 200 wind turbines per year, which corresponds to 0.24GW or 1.2% of the global market for new capacity,[6] this would yield 24 000 wind turbines over the course of a life cycle. Together, these would reduce emissions by 10.6 million tons per year. If the company also expands the product portfolio to include larger wind turbines and sales accelerate over time, climate benefits could increase dramatically.

CEO Hans Bernhoff

The future

HOW WILL VERTICAL WIND REACH THE GLOBAL MARKET?

Vertical Wind will develop, manufacture, and market complete wind power systems. Initially, production will be established in Sweden; should the venture prove successful, production will take place close to markets and consumers globally.

EXPANSION/EXPORT STRATEGY

The company is currently working on a technology demonstration project and to establish partnerships with sub-contractors and future customers. Focus is on the Swedish market for now. Next, however, production will be established in or near large international markets.

1 IPCC (2007a), s. 264
2 US Department of Energy
3 EWEA

4 For more information about the European Commission program Climate Action, see http://ec.europa.eu/energy/climate_actions/index_en.htm
5 The average emissions for coal-fired power (996 gCO_2/kWh) in the US, China, and Europe.
6 Global Wind Energy council (2008)

Vertical WIND

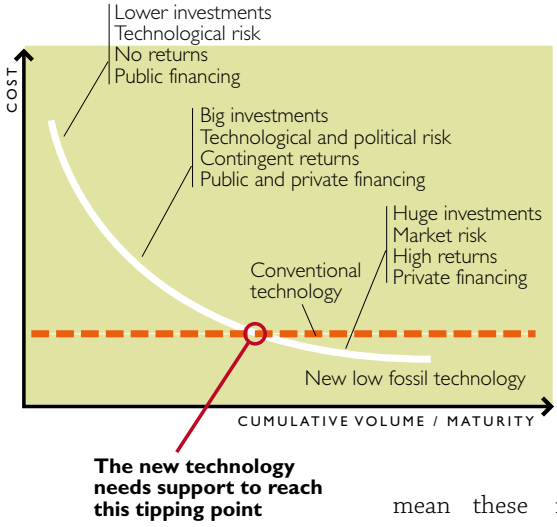
CEO, HANS BERNHOFF
TEL: +46 18 471 58 14
MAIL: hans.bernhoff@angstrom.uu.se
WEB: http://www.verticalwind.se

Technological and institutional lock-in –

barriers to low-carbon innovation

An innovation system can be defined as the elements and relationships which interact in the production, diffusion, and use of new, and economically-useful, knowledge.[1] To innovate is to create something with new knowledge or to use prior knowledge in a new way, but also to find and disseminate ways to use the knowledge. The innovative process is highly influenced by the institutional and cultural context. Rules and regulations, norms, and fashion and cultural characteristics influence innovation and creativity. Innovation systems are constrained in several ways because existing institutions and interested parties are typically tied to existing technologies and systems, thereby reinforcing these — this is the lock-in phenomenon. Four different kinds of lock-in can be identified: scale economies, learning effects, adaptive expectations, and network economies.[2]

Scale economies favor the dominant technology system through cost-effectiveness barriers to entry for innovations, such as large production volume, built up knowledge base, established networks, secure supply channels, and optimized manufacturing processes. These barriers allow established systems to reduce prices when competing with new solutions. Consequently, the latter have a hard time entering the market. For an individual business, examples include large sunk costs in manufacturing plants, supply chain partnerships, and distribution networks built on a particular technology. Fundamental changes in technology mean these investments lose value. Further, the new system cannot immediately generate compensating advantages. For these reasons, the scales are heavily tipped in favor of old technology. Risks associated with first mover status further delay innovation deployment.[3]



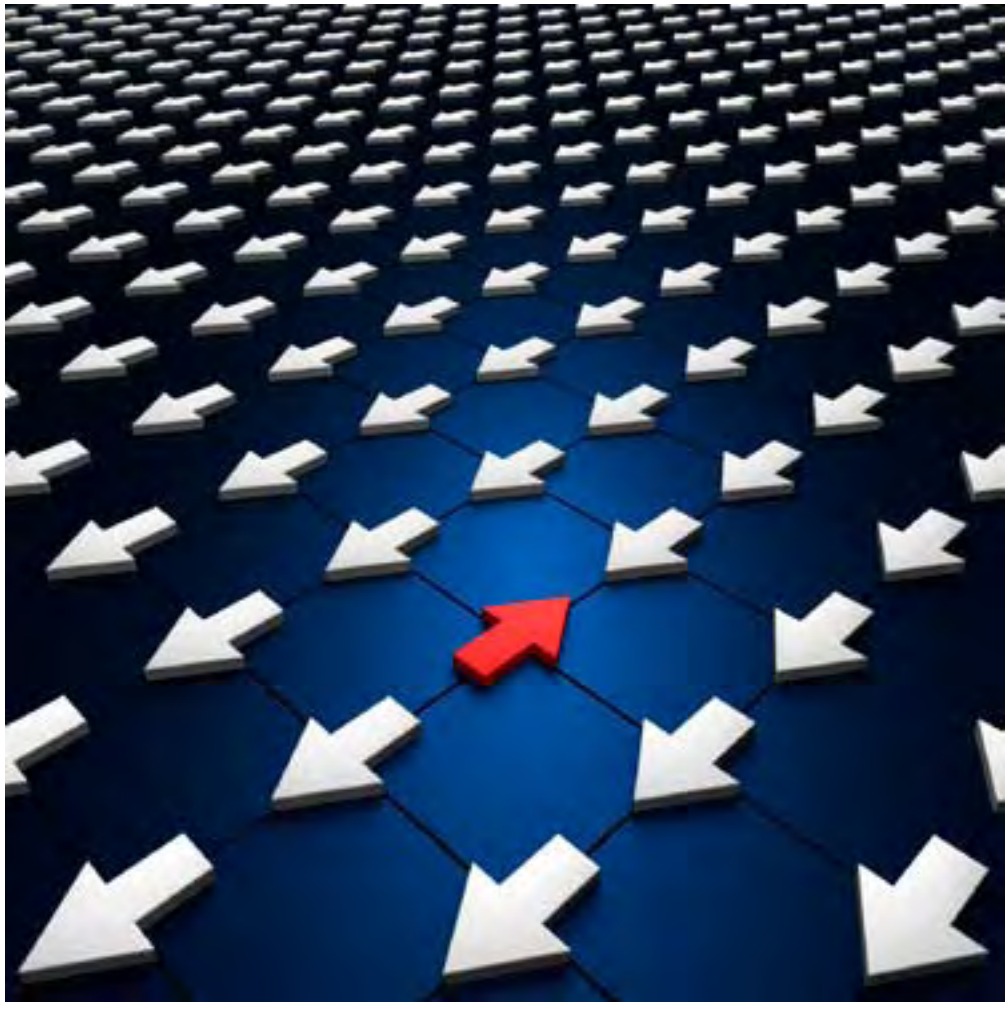
A related challenge is the chicken-and-egg dilemma that can arise when several different actors have key roles in realizing a technology transition, but everyone waits for the others to act first. One example is the market for hydrogen vehicles, since neither the automotive industry nor petrol stations have sufficient incentive to start producing vehicles or distributing fuel before the other part invests their share in the system.[4]

Learning effects are the benefits which arise with a large knowledge-base, distributed across a large group of relevant parties, with respect to a given technology. The cost barrier for a new system can be significant, because of current competence among engineers, administrators, and users in running and maintaining the current technology. Learning effects can also cause technology lock-in by locking in patterns of thinking and problem solving. For instance, we may focus on the product delivering a certain utility or service, rather than this service itself.[5] People are often conservative with respect to new solutions, even if these offer the same service. Learning effects can also influence government officials since it is easier to administer well-known technology than to try to understand new solutions. Revolutionary innovations can, thus, easily fall between the cracks and stay there.

Adaptive expectations favour established technology. Consumers, distributors, and producers all derive a sense of security from their experience with established systems because they know what to expect in terms of quality, performance, and life expectancy. This serves to diminish interest in new, potentially better, but more uncertain, solutions.[6]

Network economies arise when system-use creates incentives for others to use the same technology. The benefits to each user increase the greater the number of users. First adapters then face disadvantages such as non-compatibility and lack of competence.[7] Operating systems for computers display powerful network economies. Computer software designers will typically base their products on com-

1 Johnson, Edquist, Lundvall (2003)
2 Atkinson, Dietz, Neumayer (2006), Chapter 22 & Brown, et al. (2007) Ibid.
3 Atkinson, Dietz, Neumayer (2006), Chapter 22
4 Chakravorti (2007), p. 118
5 Andersen (2004), p. 14
6 Atkinson, Dietz, Neumayer (2006), Chapter 22
7 Farrell & Klemperer (2001), Chapter 1.2



There are many obstacles for new solutions in the competition with conventional ideas

patibility with Windows operating systems, thus causing an obstacle for new operating systems. For low-carbon technology, there is great uncertainty as to which solutions will become dominant. Consequently, few incentives exist for a single actor to choose and invest in one technology since the future potential network economies are unknown.

Technological and institutional lock-in prevents the replacement of conventional technology with better alternatives. This holds for much of the carbon-dependent technology within infrastructure, industry, construction, energy, and transportation in use today.

Due to lock-in, new knowledge, new ideas, and superior technology are not enough to effect the transition to a low-carbon economy. Replacing carbon-intensive technology with low-carbon or carbon-free solutions amounts to transitioning to a new industrial era. With time, this transition will indeed gather its own momentum, but the situation today is unique because we do not have time to wait – our very existence is threatened by our old technological systems. The transition has to happen now, and new innovative solutions have to replace the old over a period of just a few decades.

To make the required transition possible, development and implementation of innovative climate technology must be analysed in the context of a carbon-free society and on the basis of interaction with new business models, new policies, and new habits. Information technology can serve as an example: how can new technology (smart IT-systems) be used together with new business models (such as dematerialised products) and new behaviours (such as video conferences instead of travelling to meetings) to minimize emissions of greenhouse gases?

Policies, institutions, and attitudes have to change to promote structures that appreciate low carbon innovative thinking and give incentives to initiatives in the transition to new technological systems. For example, current energy systems are adapted to yesterday's carbon technology and large-scale centralised energy production. The regulatory framework for planning, permitting, and grid tie-in are barriers to new solutions.[8] Actors with large investments in conventional energy technology actively contribute to blocking the energy transition through powerful lobbying organisations. The remaining chapter outlines what politicians and businesses can do to overcome technological and institutional lock-in and become winners in the transition to the climate-friendly society.

8 Unruh (2000) refers to this as the "Techno-Institutional Complex," consisting of technological systems and the public and private institutions in control of the use and diffusion of these. The different parts are inter-dependent, creating lock-in. More information can be found in the Stern Review (2006), p. 354 ff.

Policies for transitioning to a climate-frien

"We cannot go on this way for long... We cannot continue with business as usual. The time has come for decisive action on a global scale"

Ban Ki-Moon (UN Secretary-General))

This chapter offers recommendations for policies to effect the low-carbon economy transition, covering innovation, entrepreneurship, and leadership. Specific examples from around the globe are also presented below.

Any number of claims has been made regarding the desire to lead on this issue — but anyone who wants to lead had better get going. In February 2008, the United Nations Environmental Programme launched the Climate Neutral Network (CN Net). This network lets states, municipalities, cities, and businesses who are serious about the low-carbon economy transition exchange knowledge and co-operate toward reaching climate neutrality. Four progressive countries are already participating:

- Costa Rica – aiming to be climate neutral by 2021
- Iceland – implementing a new plan to decrease emissions by 75 % by 2050
- New Zealand – aiming to have 90% renewable electricity by 2025
- Norway – aiming to be climate neutral by 2030

Read more and join the network at:
www.climateneutral.unep.org

Transitioning to a climate-friendly, greener society and managing effects of climate change are not simply environmental issues; these are over-arching issues for society. Climate care needs to be seen as a central factor for all policy-making and especially central to research, innovation, infrastructure, energy, business, agriculture, industry, the economy, and trade. In December 2007, Australia appointed Penny Wong as the first climate minister with overall responsibility for climate policies,[1] and just recently a parliamentarian committee in Great Britain proposed that the country should follow Australia's initiative and appoint their own climate minister.[2] Appointing a climate minister to co-ordinate climate policies between all departments is an important step forward in managing the transition to a low-carbon economy.

JUST DO IT!

According to a widespread misconception, the transition to a low-carbon economy will be expensive and painful. However, a study by the McKinsey Global Institute shows that technology that is already cost-efficient can provide half of the global emission reductions — reductions that pay for themselves — necessary to meet the two degree goal.[3] These technologies and measures mainly concern leveraging energy efficiencies, capturing waste heat, smart construction, and energy-efficient systems for heating, cooling, refrigeration, and lighting. The climate entrepreneurs in this report cover all of these areas. The remaining emission reductions required to reach the two degree goal could, according to McKinsey, be achieved at a marginal cost of 40 Euros per ton carbon dioxide.[4]

According to the IPCC Fourth Assessment Report, the world could stabilise the long-term concentration of greenhouse gases in the atmosphere at an acceptable level and avoid a global average temperature increase of more than two degrees at a cost of less than 0.12 percent reduced annual global GDP growth rate through 2030. The IPCC also states that it is possible to eliminate six billion tons carbon dioxide emissions with negative cost measures (i.e. money-saving options). These options are not being used today due to implementation barriers such as technological and institutional lock-in.[5]

Studies such as those mainly focus on existing technology and do not consider the opportunities inherent in a serious commitment to innovation and climate entrepreneurship. Large initial investments in development and deployment of climate innovations could quickly turn profitable and drive, rather than hold back, the global economy. Studies cited by both the IPCC and the Stern report indicate this and demonstrate an increase in global GDP as a result of stabilizing the climate and transitioning to a low-carbon economy. Meanwhile, not reducing emissions and continuing on a business as usual

1 See: http://www.environment.gov.au/minister/wong/index.html
2 Guardian (2008)
3 Diana Farrell (2007)
4 The McKinsey Quarterly (2007), p. 38
5 IPCC (2007c), p. 12

dly society

path could cost up to 20% of global GDP at the end of this century.[6]

The twelve climate entrepreneurs presented in this report clearly prove that cost-efficient solutions exist but that support is required for these systems to be deployed large scale, to let them win out over fossil technology. Obviously we lack neither technology nor good ideas; rather the lack of investments, innovative leadership, and global diffusion of climate technology is preventing the transition to the low-carbon economy.

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The world is looking for leaders that can move forward in solving the climate crisis – who will deliver?

A study by Greenpeace and the European Renewable Energy Council (EREC) on the global energy sector explains how the climate goals can be realized by phasing out fossil fuels. According to this report, existing technology allows us to cut energy-related emissions by half and save one trillion dollars per year in energy costs, by 2050. Capital investments in this energy transition could in part come from the 250-300 billion dollars annually spent on subsidizing coal, oil, and gas.[7]

RESEARCH AND DEVELOPMENT

Today, climate technology needs to be deployed faster while research and development also are accelerated. Because of the large sums involved, the high degree of uncertainty, and the monumental scale involved (a complete overhaul of infrastructure and energy systems), the private sector alone cannot be expected to generate the capital required, not least because the major socio-economic gains (such as clean air and better quality of life) are not easily monetized by private companies. Therefore, large amounts of public funds should be invested in research in, and commercialization of, new climate technology.[8]

Public funds need to be used in the much-too-slowly advancing area of development and deployment of energy-related low carbon technology. The OECD nations only spend half as much as they did in the 1980s on energy R&D, even though the current energy crisis is much more serious than the ones of the past. Technological and institutional lock-in mean that a majority of public funds are being spent on subsidising fossil-fuel energy production and nuclear energy research, instead of renewable energy. [9] In a statement to the World Economic Forum, the G8 Climate Change Roundtable wrote that "Technology-specific government support [of new low-carbon technologies] is essential for basic research that offers long-term prospect of success but remains too risky to attract private sector investment."[10]

6 IPCC (2007a), s. 205 & Stern Review (2006), p. 232 ff. & p. 143
7 Greenpeace & EREC (2007)
8 UNDP (2007b), p. 143 f.
9 Ibid.
10 G8 Climate Change Roundtable (2005)

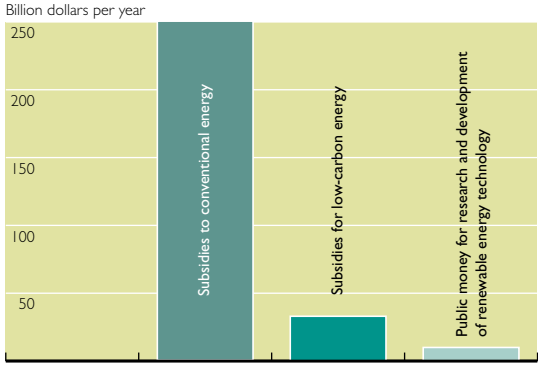
"In order to halve GHG emissions by 2050, it will be absolutely critical that there be breakthroughs in technological innovation. This is a very challenging task and it will require a tremendous investment in technology"

Yasuo Fukuda (Prime Minister of Japan in January 2008. Regarding a newly announced public investment program of 40 billion dollars for low-carbon innovation support at home and abroad)

A report published by the Swedish Ministry of Finance regarding the role of low-carbon technology in climate policy came to the same conclusion: "public funds will have to carry a substantial part of the research and development costs of new climate-friendly technologies. This is because promises of future rewards to private investors in technology development are not convincing, in particular when the rewards are more or less directly controlled by governments. Thus, government support, in the form of direct subsidies to R&D and other means such as setting standards and goals for the future, are necessary supplements to a cap-and-trade regime."[1]

The Stern report reaches the same conclusions and implies that one of the three most important parts of an effective climate policy is to support development and deployment of innovative climate technology. [2] The UN additionally supports increased political involvement in research and development of new technology: "Governments have an important role and responsibility in supporting the basic research and development (R&D) that any wise response to the climate crisis requires."[3]

Global energy subsidies



GREENPEACE (2005), S. 8, WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (2008B) & STERN REVIEW (2006), S. 355 & S. 372

When public funds are used to finance research and development of low-carbon innovations these efforts should involve private enterprise. One way of doing this is through tax credits for climate-technology related research. Another way is through public-private partnership programmes. In Great Britain, the government non-profit company, Carbon Trust, aims to accelerate the transition to a low-carbon economy. Carbon Trust engages in public-private partnerships to reduce emissions and collaborates with innovators and entrepreneurs to develop new low-carbon innovations. Carbon Trust also manages venture capital funds focusing on climate technology start-ups; it is financed in part by climate taxes. An important part of the Carbon Trust mission is to aid promising climate entrepreneurs — all the way from the research stage through deployment and large-scale climate benefits.[4]

CLIMATE INNOVATION POLICY

Innovation is often identified with inventing new products. But climate innovation needs to be seen in a wider perspective, as a process where services, behaviour, and legislation are just as important. The technology has to be contextualized and the border between technology and lifestyle erased. Developing innovative climate technology requires support at the research stage; in order to reach markets, business models, attitudes and regulations may have to be changed; and in order for a new technology to achieve its full potential, user attitudes may also need to change.

A shift from product focus to service focus will be central. The focus should be on the need instead of on a specific way of meeting that need (with a specific product). Climate innovation encompasses new technology for changing carbon-intensive habits and the new institutional structures and policy frameworks that support the necessary transition. Policies that provide clear and meaningful support for climate entrepreneurs mean leadership on reducing emissions, and also in developing and deploying new low-carbon technology globally, a market that will be worth thousands of billions of dollars annually within a few decades and employ tens of millions of people.[5]

The Porter Hypothesis, developed by Michael E. Porter of Harvard Business School in the 1990's,[6]

1 Alfsen & Eskeland (2007), p. 9-14
2 Stern Review (2006), p. 573
3 UNEP (2008), p. 35
4 http://www.carbontrust.co.uk
5 Stern Review (2006), s. 270
6 Porter, M. (1991) & Porter, M. & Van der Linde (1995)

suggests that environmental damage caused by a corporation's activities stems from inefficient use of resources. Therefore, decreasing environmental damage entails increasing resource efficiency and profits. Porter tested his hypothesis and found that environmentally sound legislation drives environmentally-friendly innovation and that financial gains from these innovative initiatives can more than cover the costs. In addition, international competitiveness, compared to less resource-efficient enterprises, is improved. Later studies have also supported the Porter Hypothesis, in particular with respect to regulatory frameworks in support of efficiency standards.[7]

Many potential markets for climate technology outside of OECD are now in the process of tightening legislation and regulations concerning energy efficiency, buildings, transportation, emissions, etc. In June 2007, China released its first national climate strategy, including the goal to reduce energy intensity by 20% per unit of GDP by 2010.[8] China's renewable energy legislation ranks among the most progressive globally, with feed-in tariffs, tax credits, and subsidies. This legislation has already generated explosive growth in renewable energy production, large investments in climate-friendly technology, and a plethora of new businesses.[9] In India, the government has also introduced numerous forms of support for renewable energy, and the market for clean energy is currently growing by 25%, annually.[10] In the EU, binding emission reduction targets are set at 20% by 2020, and all member states are currently constructing policy measures toward this goal. In the United States, too, many new initiatives are underway, and the new post-Bush government is expected to implement more defined climate policies.

As fossil energy loses more and more of the competitive advantage associated with not paying for climate and other environmental externalities, global market interest in climate technology will increase in parallel. Nations with strong climate technology industries focusing on exports stand to gain substantially. These countries can of course also contribute to decreasing emissions internationally. Denmark is already putting this capability to use. Using subsidies totalling roughly 1 300 million dollars, Denmark has supported the wind power industry for the last decade or so. Danish wind power now boasts revenues of three times that amount (90% from exports) and over 20 000 employees.[11]

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Political systems have to develop strong support for low-carbon innovation

In the transition to the low-carbon economy – even though large amounts of financing must come from the public sector – most of the funding will need to come from the private sector. However, policy makers also play an important role here, by encouraging first movers, leading the process forward, and creating the regulatory framework of incentives that support climate entrepreneurs and level the playing field.

CENTRE FOR CLIMATE ENTREPRENEURSHIP

To lower emissions and secure employment opportunities and welfare improvements offered by the transition to a low-carbon economy, climate entrepreneurship and low-carbon innovations must be considered central issues in economic, business, infrastructure and trade policies. One way to coordinate these efforts is through a climate innovation and climate entrepreneurship centre where all support systems are organized. In addition to coordinating all public programmes pertaining to climate entrepreneurs, this centre should also interact with private agents, incubators, and research universities. The centre should focus on four areas:

- Research and development
- Commercialization
- Deployment
- Export

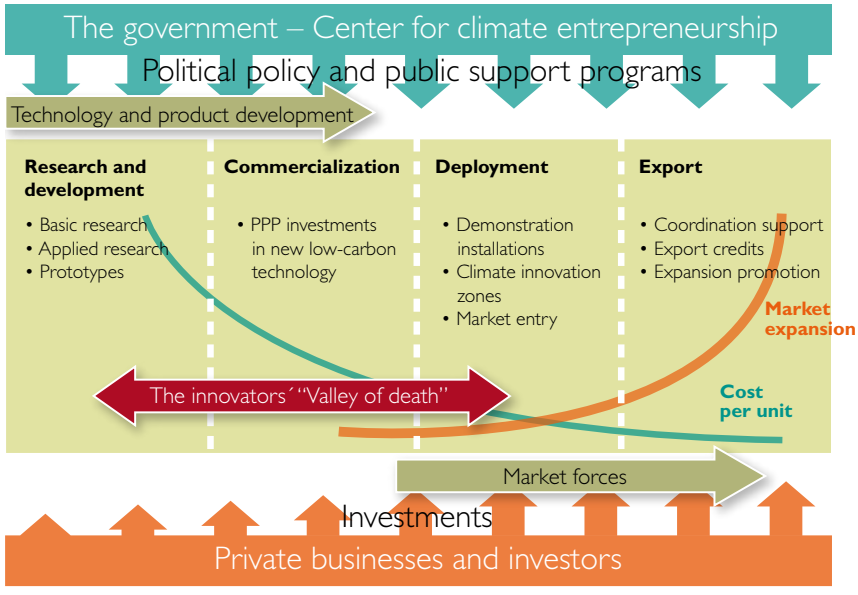
7 Lanoie, et al. (2007), Murty & Kumar (2001) & Francisco J., et al. (2007)
8 Worldwatch Institute (2007)
9 Worldwatch Institute (2006b) & UNDP (2007), p. 31 f.
10 World Business Council for Sustainable Development (2008) & Export.gov (2008)
11 Carbon Trust (2003), p. 6 & Danish Wind Industry Association: http://www.windpower.org

Centre staff should proactively seek out new climate entrepreneurs and offer assistance with application processes and collaborations with other government agencies and other businesses. This support should aid projects at each stage, in a streamlined, non-redundant fashion. For instance, fantastic technology may be coupled to a bad business plan at an early stage — the centre would then ensure networking to improve this part. Once commercialization is feasible, but funding is lacking, the centre would work with the start-up to find investors or grants. The centre should also connect innovators with entrepreneurs to bring climate-friendly technology all the way to the global market.

In addition to the other programmes coordinated at the centre, four new funds powered by substantial financial resources should be created to support climate entrepreneurs. These funds should aid development in the four parts of the centre.

- The R&D resources should primarily be used to support small companies and innovators performing research at the early stages of new climate technology as well as construction of prototypes.
- The Commercializating fund should be used to co-finance new technology in co-operation with investors.
- The Deployment fund should primarily help finance demonstration plants and support the establishment of innovation zones where climate technology can be presented in integrated systems. This fund can also help climate entrepreneurs find their first customers and markets.
- The Export fund should offer help and support by identifying interesting markets and providing assistance in entering these. This fund should also support loans for export initiatives, with attractive rates and conditions, specially designed for climate technologies.

How much should be allocated for these funds? The Japanese government will invest 40 billion dollars in climate technology both nationally and internationally in the coming five years. Relative to GDP, this figure can be used as a guideline for other countries that aspire to promote innovative climate technology.[1]



1 Carbon Finance (2008)

The centre mission should include specific objectives in terms of outcome for innovations aided by the centre, and output in terms of new businesses and commercialized innovations. In addition, the centre should track emissions reduced abroad as a consequence of deals supported by the centre.

A method for measuring the effect of climate technology exports should be developed. The long-term goal should be to encourage other nations to develop similar centres and to establish international collaboration on developing and deploying climate technology.[2]

Currently, such initiatives are confined to specific sectors and without a holistic vision for the transition to a climate-friendly society.[3] National centres for climate entrepreneurs, and an international network, would help climate entrepreneurs easily find the markets where their innovations can matter most. If the climate technology is not spread internationally, but only within the borders of one nation, this will create employment opportunities and local income — but will not significantly contribute toward meeting the climate challenge.

Private companies looking for new low carbon solutions should also be encouraged to join the centre. Those companies can, for example, get help with trying out pilot and demo applications. This help can also include evaluating and finding the best suitable technology, attractive loans to get started, and guarantees of reimbursement if the technology fails.

The climate technology industry is often fragmented with small and medium-sized companies and many of the most remarkable ideas are furthermore kept by innovators and entrepreneurs. International marketing and embarking on billion-dollar projects is very difficult under these circumstances. Within the climate technology centre, several of these actors could collaborate and take on international projects together, backed up by public funds and support.

Climate entrepreneurs should be offered coordinated services for public-private partnerships for entry into important markets, such as China, India, and Brazil. For larger systems sales, municipal companies could be brought in too. These often have significant expertise and cutting-edge technology, but the knowledge and solutions are hardly spread at all internationally and therefore do not contribute globally toward reducing greenhouse gas emissions. In this context, "privatizing" municipal know-how makes sense: let the climate entrepreneurs disseminate this know-how globally, while creating export income and jobs. Partnerships with larger, established corporations should also be explored to deploy climate solutions.

It is important (especially when considering the export market) to offer legal advice and support regarding intellectual property rights. To have the back up from a climate technology centre (and in the future also an international network) is a matter of security and reliability, which are otherwise frequently in short supply for innovative solutions competing with conventional ones.

Finally, government decision makers and agencies must participate in an active dialogue with the centre and climate entrepreneurs in order to inform themselves regarding how policies, legislation, regulation, and institutions can develop to aid the climate transition as best they can. For instance, by breaking technological and institutional lock-ins, as described further in the next chapter.

2 See Stern Review (2006), Chapter 24.3 for models of international technology co-operation

3 For example Global Bio energy Partnership: http://www.globalbioenergy.org

Climate change goals in New Zeeland
(New Zealand Government (2007))

- 90% renewable electricity by 2025
- 50% less emissions from the transportation sector by 2040
- Becoming the first country in the world to introduce electric cars in large scale
- Being the world leader in reducing emissions from the agricultural sector
- Increase in forest area of 250 000 hectares by 2020
- Achieve those goals in close cooperation with business and civil society

"Why shouldn't New Zealand aim to be the first country which is truly sustainable – not by sacrificing our living standards, but by being smart and determined?"

Rt. Hon. Helen Clark (Prime minister)

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SOLUTION-ORIENTED CLIMATE POLICY

Climate policy has to start from a perspective of seeing possibilities and opportunities. Climate policy measures are too often analysed in terms of businesses and jobs at risk, rather than in terms of opportunities for job creation, entrepreneurship, and enterprises that go hand in hand with the low-carbon economy. Technology transitions unavoidably lead to job losses in companies that choose not to modernize, but also to new jobs elsewhere.

The state of California estimates that reducing emissions by 25% below 1990 levels by 2020 would create 83 000 new jobs, save 4 billion dollars, and reduce emissions by 174 million tons carbon dioxide.[1] Other studies show that California, by becoming a market leader in climate technology, could grow this into a 60 billion dollar industry by 2020.[2]

This attitude allows for policy that capitalizes on and realizes the relevant opportunities. Given the negative reactions in January 2008 to the EU policy package for climate and energy, the solution-oriented perspective appears to still have very limited penetration. Instead of protecting climate damaging businesses, the political focus should be on forcefully supporting the businesses that deliver the solutions. This is where job creation and growth will take place in the future. This focus should of course be implemented through public-private partnering. In New Zealand for example, the government co-finances energy efficiency measures in energy intensive companies.[3] Another possible area for partnerships is in utilizing the large amounts of waste heat that are available in industry (in Europe, more than 300 TWh annually[4]); policy makers should do more to ensure that this resource is put to better use.

Climate, employment, trade, and welfare policies must be based on a common vision of an overall transition to a climate-friendly society and should define long-term dynamic policy instruments and performance-based incentives. Certain measures should also grow more stringent with time, and this should be communicated to the market, for instance, concerning the planned rate of increase in the price of carbon emissions. Policy makers need to work together with market actors, including climate entrepreneurs, to create meaningful, societally overarching transition strategies. Goals should then be clearly communicated to the market while support and room to experiment are provided to make sure that the most efficient solutions are developed and deployed.

One interesting example in this context is the Dutch strategy for energy transitioning, in which the state plays a central role in forming a vision and strategic goals for a multitude of technology and system transitions. The strategy seeks to create a sustainable energy system by 2050. When policy makers partner with private enterprise, academia, and society, they take responsibility for, and play an active role in, creating opportunities for experimenting with, developing, and deploying innovative technology.[5]

1 This was discussed in a speech by John Doerr at the TED- conference in Monterey in March 2007

2 Stern Review (2006), p. 272

3 See: ECCA – Energy Intensive Businesses: http://www.eecabusiness.govt.nz/eib/

4 Ecoheatcool and Euroheat & Power (2005-2006a), p.31

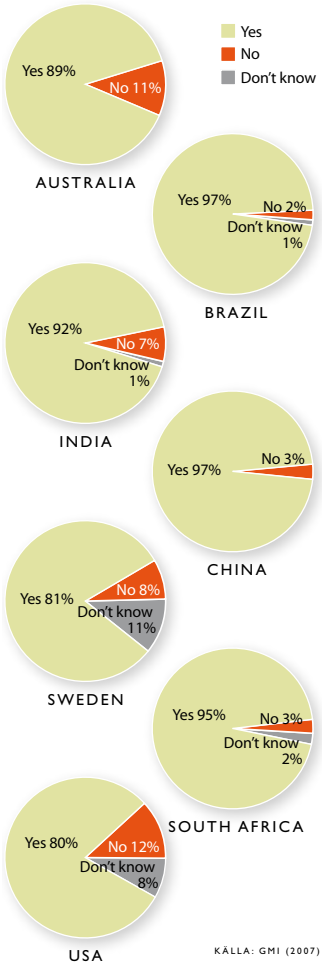
5 Read more on "Energy Transition – Creating energy" at: http://www.senternovem.nl/energytransition/index.asp

The Dutch have created seven different theme groups, and each group coordinates transition support and aid. Each theme has been developed to cover an area identified as central to the transition. Themes include environmentally-friendly raw materials, sustainable mobility, sustainable energy supply, and sustainable energy use in buildings. Within each theme, a number of transition road maps have been created, such as hybridization of vehicles, increased use of biomass, modified energy behaviour, and decentralised power generation. Each road map has measurable objectives. Businesses and organizations can identify barriers to satisfying these objectives and propose legislative and regulatory changes to remove these barriers. Corporations and organisations can also receive guidance and support for adapting activities. The government is also proactive in building networks and coalitions for actors in transition, including financial institutions and "early adopters". This policy is characterised by the realization that marginal improvements will not suffice to meet the climate challenge—structural and system-wide changes are required, and climate entrepreneurship must be actively supported.

Meaningful transition policies should include:

- National innovation strategies to effect the technology transition. Strategies that analyse and adapt all current legislation to support the overall goal of sustainable development through the transition to a climate-friendly society and the relevant industry-specific goals including improved resource efficiency.
- Instruments for measuring how policy and sustainable innovation interact. This is needed in order to determine which measures work and which do not. Quantifiable objectives are required, such as targets for amount of fossil technology replacements within various industries, targets for the number of climate innovations that should receive commercialization support from the government, and the amount of exported climate technology that should receive support through public programmes.
- The framework for public- private partnerships for institutional change must be improved. Forums should be set up through which the government can provide information about long-term objectives for the transition and support to established industry and new entrepreneurs to promote the innovative driving force needed. The centre for climate entrepreneurs described above is a suitable forum.
- Economic policy should be integrated with environmental and climate aspects. The ministries of finance and enterprise should for example work closely with the ministry for environment. Each department should also have their own climate co-ordinator focusing on supporting climate entrepreneurship, push for the transition to a climate-friendly society, and support export of climate technology.

In your opinion; should the government do more to stop climate change?



KÄLLA: GMI (2007)

Read more about the world's first carbon-neutral city
http://www.masdaruae.com

NEED AND DEMAND FOR SYSTEM CHANGES

To enable the economy to respond more efficiently to societal needs, a legislative and regulatory framework for handling market failures—e.g. massive emissions of climate pollution—is needed. Many corporations are now ahead of policy makers when it comes to understanding the need for policies that enable and actively support efficient management, in the general economy, of the climate issue. In February 2007, a large number of the world's largest corporations (including ABB, Citigroup, General Electric, and DuPont) encouraged policy makers to act: the companies suggested that "Government policy initiatives should address energy efficiency and de-carbonization in all sectors."[1]

One year later, in February 2008, Sony, Nokia, Tetrapak, Hewlett Packard, and others signed the "Tokyo Declaration." These companies have committed to raising the targets for their own emissions cuts and point out that on the international level, the required leadership from policy makers is lacking today.[2] The United States Climate Action Partnership, another association supported by many of the world's largest companies, is also asking for political leadership and adjustments of financial frameworks in order to help private businesses rationally partner and act on the climate issue.[3]

Public attitudes mirror those above. More than 80% of the populations of most large countries around the world want their government to take more actions to prevent climate change. The same percentage wants to increase the use of wind- and solar-energy as well as the use of climate friendly transports.[4] Despite this, action on climate change is frequently conceptualized at the individual level—and almost only ever with the individual understood as energy-consumer, never as a citizen with influence and responsibilities pertaining to climate policy. Lifestyle changes are important and necessary, but far from sufficient as long as the fundamental systems remain unsustainable. A study concerning climate policies and technology reached the conclusion that: "Adaptive changes to our lifestyles, etc. while useful, will most likely not by themselves be able to deliver the huge reductions that are required."[5]

We cannot expect everyone to have the opportunity to adapt their entire lifestyle so as not to damage our climate. An overwhelming majority of the world's population want to live so as not to damage climate, but prefer for this to be built into societal systems rather than have to obtain all the information required so as to make the right choices at each and every stage every day (see figure in margin). We don't individually expect to have to check to ensure that our homes were not built by slaves or the products in our stores made by children—and we should not individually have to expect to have to ensure that our regular everyday activities do not contribute to catastrophic climate change or other environmental damage. A study commissioned by the British government determined that: "The focus needs to be on creating a supportive framework for collective progress, rather than exhorting individuals to go against the grain."[6]

National and local policy makers have an important role to play in initiating the transition towards a climate-friendly society and the necessary system changes that are needed. Geneva, Switzerland has decided to use 100% renewable energy by 2050. Santa Fe, New Mexico will, by 2030, have replaced all use of fossil energy in buildings. Masdar City, currently being built in Abu Dhabi, will be an international centre for environmental technology and will be completely carbon-free. In China there are similar projects, such as Dongtan Eco-City which is being built close to Shanghai, and the city Baoding which is already a cluster for innovative companies in the field of renewable energy technology. In London, emissions will decrease by 60% by 2035, this with the aid of a specially-founded climate agency which will develop renewable energy systems for the city in co-operation with the private sector. In 2012, London will also hold the first Olympic Games completely run by low-carbon technology.[7]

1 Global Roundtable on Climate Change (2007), p. 3
2 WWF (2008b)
3 USCAP (2007)
4 GMI (2007)
5 Alfsen & Eskeland (2007), p. 74
6 Sustainable Consumption Roundtable (2006), p. 1
7 The Climate Group (2006), s. 25 ff. & Greater London Authority (2007)

Policy makers do not have all the answers and should not "pick winners". But the climate transition is necessary, and policy makers must realize this and the central role they play in creating and changing legislation to yield policy instruments that effect this transition as soon as possible. In the UNEP "Yearbook 2008" the environmental programme states: "There are incentives and stimuli for good habits, and disincentives for bad habits, that only governments can provide. What has been missing so far is the political will and policy coordination that is needed to unleash the full creative capacity of the private sector and civil society partners".[8]

POLICIES FOR IMPLEMENTING CLIMATE TECHNOLOGY

Policy must to a greater extent support implementing innovative climate technology and restrain investments in fossil technology. Australia took the lead and became the first nation to ban inefficient lighting systems, thus saving four million tons of CO_2 annually.[9] In 2007, opinion polls in 14 countries found that 80% of those asked favoured policies for phasing out technologies that cause climate damage.[10]

Policies promoting deployment of innovative climate technology can also save society money. California residents stand to save 43 billion dollars between 2001 and 2013, through tougher efficiency requirements for buildings and standards for appliances.[11] But if more resource- and climate-efficient technology is available and widely favoured, why is it not implemented more rapidly?

The technological lock-in described above presents one challenge. A further problem is the fact that carbon emitting technology does not carry its full climate cost. A third challenge for sustainable solutions is that they typically require higher upfront investment than fossil intensive systems—while subsequent costs for operations are lower. Short-sighted financial analyses thus favour fossil intensive systems.

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In Holland 28% of all urban journeys are made on bicycles, in USA that number is 1%

(KÄLLA: PUCHER & DIJKSTRA (2003)).

8 UNEP (2008), p. 33

9 Australian Government, Department of Climate Change. See: http://www.greenhouse.gov.au/energy/cfls/index.html

10 GMI (2007)

11 The Climate Group (2006), p. 3-8

According to the Stern Review, public support for implementation of new low-carbon technologies is even more important than support for research and development. Models that are used in the report suggest that for each public dollar spent on research and development of low-carbon technology – eight should be spent on technology implementation

For these reasons, policy makers need to promote long-term perspectives and sustainable reasoning via economic policy. Just as we cannot expect individuals to change the energy and transportation systems without changing policy, we cannot expect individuals to correct system-wide market failures in our economy without changing policy, either. The market is not governed by laws of nature but by conceptual, legal, and institutional frameworks. Innovations, such as cap and trade, can correct system-wide market failures and improve the overall function of the system. Today, the market for instance fails to consider services from eco-systems[1]—this value has been estimated at 54 trillion ($54 \cdot 10^{12}$) dollars.[2] Accounting for this value would change the relative costs of low-carbon innovations and fossil energy dramatically. Note for comparison that the total global GDP is 48 trillion dollars.[3] Ecological reality needs to inform our willingness to re-conceptualize and improve economic frameworks and policies.[4]

We need policy instruments that make low-carbon innovations more competitive by valuing their positive externalities, as well as measures that support consumers in their role of driving demand for climate technology. The tie-in between initial investors and consumers of fossil energy also needs to be strengthened, for example the relation between builders and those subsequently paying the bills for operating them. Studies of lifecycle costs of buildings show that only 10% of the cost is allocated to initial construction; 90% is operational cost. Despite this, initial investment costs are typically of much greater concern during construction, favouring short-term solutions that are cheaper than low-carbon technology but more expensive to operate—and more expensive for the climate.[5]

In multi-unit housing, individual unit metering is one way to generate demand for higher efficiency. In the US, one study showed that improving building efficiency with existing technology would save enough energy to shut down 30 major coal power plants and save up to 70 billion dollars.[6] Another example where policies are playing a positive role already is through the requirement that a seller has to provide information on a building's energy performance, via energy labeling. This ties investors closer to consumers by requiring information regarding energy efficiency.[7] However, these kinds of policies need to be designed not to lock-in on traditional and marginal technology improvements.

Markets fail in the absence of information. We need energy and climate labelling for more than just (some) buildings. These labels inform consumers of the total environmental costs of a product. The label could include information on energy used during production, emissions generated, and energy required for use.[8]

Standards and regulations are needed for new investments, but also for upgrading existing technology. This could for example include minimum climate efficiency standards when renovating buildings. Thanks to regulatory initiatives, energy use for heating in renovated buildings in Austria has gone down by 64% since 1994.[9] Energy savings of the same magnitude can be achieved by retrofitting climate efficient and cost efficient technology in existing buildings. Politicians should use financial incentives to encourage programmes such as the Clinton Global Initiative's: "Energy Efficiency Building Retrofit Program". The programme enables partnerships between city governments in some of the world's largest cities (New York, London, Mumbai, Sao Paolo, etc.) and financial institutions, energy service corporations, and trade associations to improve energy efficiency in buildings and cut emissions. Improvements will be made to public buildings, but the private sector will also be offered attractive solutions for installation and maintenance

1 Ecosystem services are the services produced by the ecosystem. These services can include water purification, carbon capture and storage, biodiversity, pollination and climate control.

2 Costanza et al., (1997). The statistics has been corrected for inflation between 1997-2007. Inflation statistics from Federal Reserve Bank of Cleveland: http://www.clevelandfed.org/research/Infl ation/World-Infl ation/Index.cfm

3 Statistics from the World Bank

4 See: Hecht (2005), Morillaa et al., (2005) & Cairns (2006)

5 Miljöaktuellt (2008)

6 The New York Times (2008)

7 Read more about the energy declaration for constructions in the UK : http://ec.europa.eu/environment/etap/pdfs/july06_building_energy_perf_certificate.pdf and in Sweden: http://www.boverket.se/templates/Page.aspx?id=3210&epslanguage=SV

8 Find out more about climate labelling of products in Britain and France http://ec.europa.eu/environment/etap/pdfs/jan08_carbon_label.pdf

9 The Climate Group (2006), p. 21

The mayor's office in London. The building has been designed and constructed to save energy – and uses only 25% of the energy consumed by a conventional office building

of innovative technology.[10] Programmes such as this one support climate entrepreneurship by creating markets and demand for low-carbon innovations.

SUPPORT LOW-CARBON INNOVATION WITH PUBLIC PROCUREMENT

Public sector economic activities have to be climate-friendly and optimized to support development and deployment of low-carbon innovations. The public sector in Europe consumes 1,800 billion Euros annually. By taking the lead and investing in climate technology, the public sector can create new markets, cut emissions, generate positive external effects, and stimulate innovation.[11]

Policies often support innovation from the supply side, not the demand side. There must be a balance here and the public sector should take the lead as "early adopters" of innovative climate technology and assume the risk of investing in immature inno-

10 Clinton Foundation (2007)

11 Climate Action Network

vations; this would give climate technology a test market for improving products before entering the global market. The public sector can also help lower costs for new technology and give low-carbon innovations within different sectors the opportunity to build up competitive advantages.[1] Demand-side incentives can also play an important role in pushing down costs for new technology and provide low-carbon innovations in different types of businesses a chance to build up scale economies, learning effects, adaptive expectations, and network economies.

Regulation for public procurement programmes should assure that the public sector takes the lead in increasing climate technology sales and unlocking technological lock-ins. All procurement should consider lifecycle costs and climate efficiency. Product procurement should also be replaced by service procurement when possible and businesses offering cyclical instead of linear material flows should be favoured. By focusing on which function to purchase and not on which product, innovation is generally favoured.[2]

One strategy for lowering costs and making low-carbon technology more competitive is by leveraging municipal purchasing power at the regional level to let climate entrepreneurs bid on larger projects. This allows smaller companies to take advantage of some scale economies, increase production, and cut costs. In some cases it will still be difficult for smaller companies to bid on large projects. One solution is to combine two procurements for one project, where the smaller part of the order specifically calls for untested low carbon technology. If the untested technology proves successful, procurement of this technology can be scaled up afterwards.[3]

Larger publicly funded construction projects should include a requirement for some percentage of the cost to support low-carbon innovations within the field, in analogy with common regulations requiring construction budgets to set aside a certain percentage for artistic styling.

Read more about sustainable public procurement
http://www.procuraplus.org/
http://www.epa.gov/opptintr/epp/

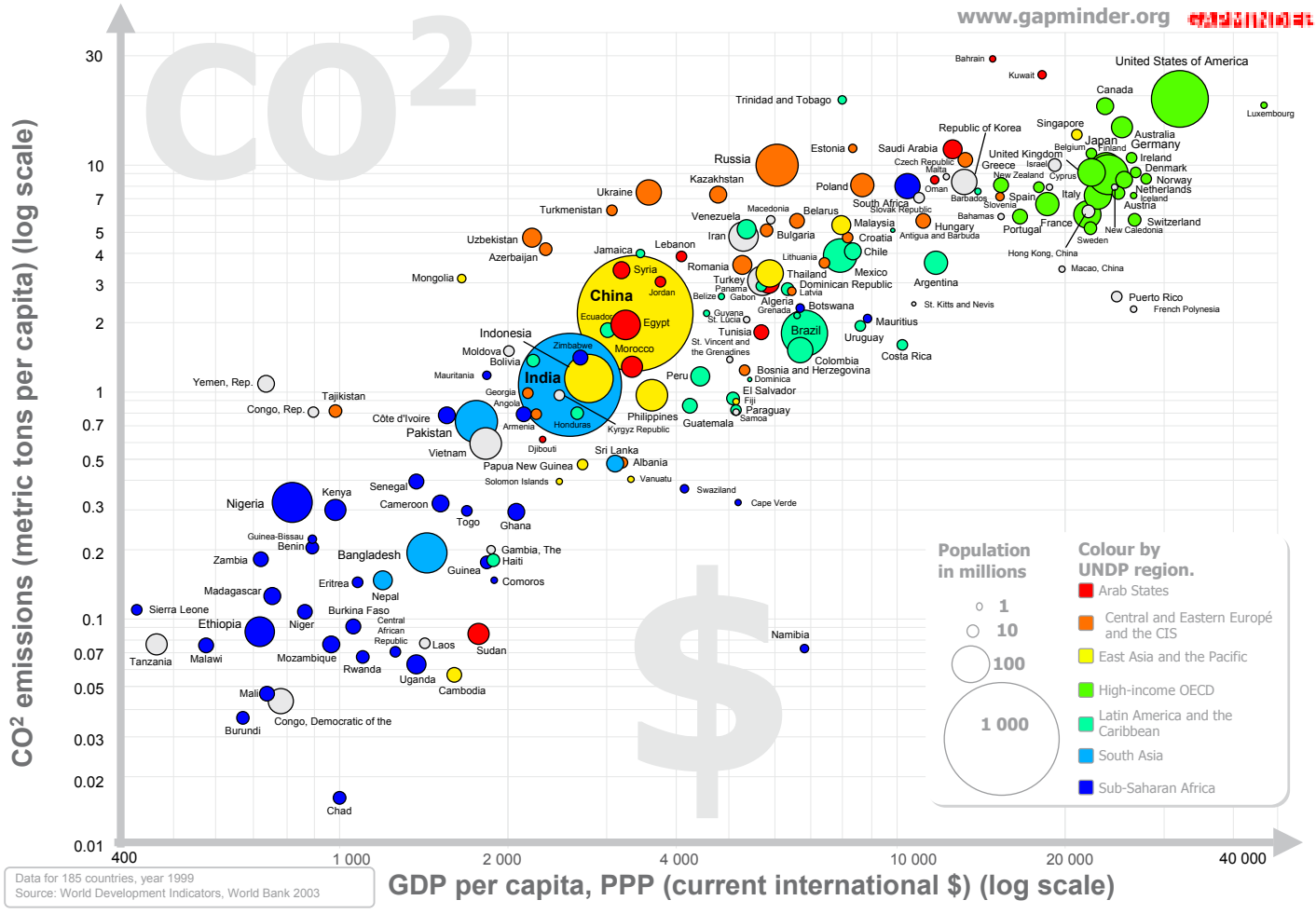
GLOBAL CLIMATE POLICY

National climate policies must be global. That is, a national policy must consider its effect on global emissions and not only domestic effects. Reducing emissions to a sustainable level domestically is one important goal, but international contributions need to be considered, too. For developed economies, the transition to a climate-friendly society is mainly about replacing existing fossil intensive systems. For developing economies, the transition to a larger extent concerns changing the course for new technology installations. By 2030, 70% of the increased energy demand will come from developing countries, and investments in energy infrastructure there will total 10 trillion dollars.[4]

Nations not yet subject to fossil technology and institutional lock-in could potentially skip certain development stages (such as the fossil era), thus "leap-frogging" into the new low-carbon economy.[5] Cell phones are often used to exemplify the leapfrog concept: many developing nations have simply skipped widespread landline telecommunication use and went for wireless mobile systems directly. Indeed, fast-growing economies will have to leapfrog past much fossil technology, or we will not be able to meet the climate challenge.

1 NESTA (2007) & Stern Review (2006), p. 354 ff.
2 Read more on cyclical material flows : McDonough & Braungart (2003)
3 Georghiou (2007), p. 22
4 IEA (2006c), p. 65
5 For more examples and a review see WorldChanging (2004)

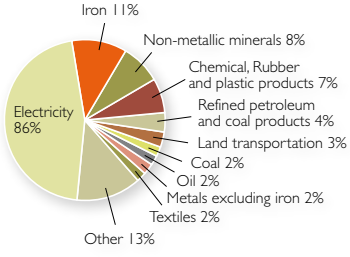
Ivory Park EcoCity outside Johannesburg in South Africa



The graph shows CO_2 emissions per capita vertically and GDP per capita horizontally. Every circle represents one nation; the size of the circle represents the size of the population. In order to transition to a climate-friendly society, rich countries must travel far down toward the lower right corner, whereas poor nations, by leapfrogging, must go straight to the lower right corner without first passing the carbon-intensive stage the rich countries have difficulty leaving.

Nations need to skip, and where it's too late for that, break out of, the carbon era – but global development is today essentially moving diametrically opposed to this, with more and more people in more and more nations becoming more and more carbon-dependent. In China, two new coal power plants are built every week.[1] Multinational companies in search of new markets contribute to this development and so do foreign investments. As much as 40 % of the institutional investments in developing countries are spent on fossil energy infrastructure.[2]

Carbon dioxide emissions in China resulting from production of goods exported to Norway, by sector



KÄLLA: WWF (2008)

Carbon intensive technology is also supported by import of products from countries such as China and India. A WWF report indicates that imports from China and India to Sweden generate 4.7 million tons of carbon dioxide annually. This is emissions not accounted for in national statistics, but that is equivalent to nine percent of total Swedish domestic emissions.[3] A similar study in Norway shows imports account for 6.8 million tons of carbon dioxide, twelve percent of total domestic emissions.[4]

Emissions associated with imports cannot be disowned. A minimum goal should be to invest as much in sustainable technology in the exporting nations, as it would have cost to avoid those emissions domestically. For Sweden and Norway, this would mean 156 and 226 million dollars, respectively, in China alone.[5]

1 BBC (2007)
2 Maurer & Bhandari (2000)
3 WWF & The Global Footprint Network (2007)
4 WWF (2008) & WRI (2008)
5 Estimated price: 33 USD per ton. For current prices: http://www.pointcarbon.com

Governmentally-controlled investments such as pension funds should, as part of their climate strategy, not invest in fossil-dependent systems anywhere in the world. The government should also initiate partnerships with the private financial sector to work out strategies for how to encourage investments in both domestic and international innovative climate technology, including tax credits for early investments in innovative climate technology. If policy makers send clear messages to investors regarding long-term commitments to the climate transition, and come to international agreements on the same, this decreases new climate technology investment risk.

EXPORTING CLIMATE TECHNOLOGY

Climate technology exports should be encouraged, for instance through tax credits and free trade agreements on selected technologies. Smart export policies for low-carbon innovations promote climate entrepreneurship and help bring smart solutions to the markets where they can make the biggest difference, quickly. National targets for exporting emission reductions through products and services should be set, and statistical methods for measuring impact developed.

It is important that trade and development aid policies adapt to climate mitigation needs. An international standard methodology for measuring and paying for emissions generated abroad needs to be developed. One way to reduce emissions associated with trade is creating an international network for climate entrepreneurs through which national centres for climate entrepreneurs connect. The purpose of this network would be to aid climate entrepreneurs secure financing and entry to new markets. This network should provide one-stop shopping for climate entrepreneurs, including international contacts, financial support, and market information. The international programmes existing today which support transfer of low-carbon technology to developing countries are insufficient. For example, the Clean Development Mechanism (CDM), the Kyoto Protocol's premier initiative for technology transfer, will only turn over 2.5 billion dollars between 2001-2012. In context, this is not even a drop in the bucket.[6]

An international network of climate entrepreneurs would also be a resource for investors and buyers looking to find and invest in the best available climate technology. Financial capital for co-financing large investments with venture capital firms could be allocated from fees for emission rights and trade with carbon intensive products. Implementing these ideas should prove possible. Already in 2003, the G8 countries agreed that "[We will] promote rapid innovation and market introduction of clean technologies, in both developed and developing countries ... stimulate fundamental research in renewable energies ... collaborate on sharing research results, development and deployment of emerging technologies in this area ... work towards making renewable energy technologies more price competitive".[7]

The Liberta Institute's proposal for a fund for innovation and entrepreneurship of non-fossil technology provides an example of what international co-operation on research and development might look like. In the proposal the EU would earmark 10% of the income from emission trading from 2008 to 2012; 20 billion Euros, to be set aside to finance the fund. An independent panel of experts would choose projects and the funds´ public money would be used to co-finance these projects with private venture capital firms.[8]

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Sankampaeng solar energy station in Chiang Mai, Thailand

It is important to stress that a globally-minded climate policy cannot be an excuse for protectionism and support of domestic carbon-intensive industry. The goal must be to find options for innovations in support of sustainable international trade, namely to use international trade to transfer smart solutions that increase welfare and prevent reliance on inefficient fossil-based products and services. Besides new products and services new financial innovations will probably also be needed to develop and disseminate low-carbon technology fast enough on a global level.

6 UNEP (2008), p. 25

7 G8 Summit (2003)

8 CNBC (2008b) & Libertas

Low-carbon transitioning and business ma

"Increasingly, companies will need to understand and manage their GHG risks in order to maintain their license to operate, to ensure long-term success in a competitive business environment, and to comply with national or regional policies aimed at reducing corporate GHG emissions"

World Business Council for Sustainable Development (WBCSD) & World Resources Institute (WRI)

Today the question is not whether the world will transition to a low-carbon economy, but how, when and who will be the winners in this transition. We are entering a third industrial revolution; the time has come to stake our claims. Within a few decades, the global business climate will be fundamentally different. According to a report by Lehman Brothers, climate change, is akin to globalisation, "a slow, but powerful and inexorable force that progressively changes relative prices, relative costs, structures of demand, and hence the structure of production."[1]

There are already clear trends emerging and those will grow in strength the coming years. Investors will see carbon intensity as a risk, consumers will demand climate-friendly products and the price of climate damage will be much higher than today when policy makers put a price on carbon emissions and carbon-intensive products and services. Those trends will converge and will lead to a change in profit margins and in consumer choices. Changes in attitudes will most likely enhance this process as information on the climate issue and its consequences reach even greater numbers. Companies selling carbon-intensive products and services will find it harder to transfer higher costs to consumers and watch profit margins decline.[2]

In "Climate Change: What's Your Business Strategy?" authors Andrew Hoffman and John Woody state: "If you want to be a winner in a carbon-capped world, you and your management team must do a careful analysis of your company's position on climate change and develop a strategy to create opportunities. The ultimate goal of any good business strategy is to create a measure of control over your future business environment."[3] A survey by McKinsey & Co. shows that many major companies have realised this, but for smaller businesses it is not as obvious. Of 391 CEOs surveyed, 71% of those at major corporations picked climate change as the most critical issue for ensuring future success. Among mid-size companies, the corresponding figure was 44%, and for small businesses, it was only 31%.[4]

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For businesses, transitioning to the low-carbon economy means developing new products and services as well as replacing existing fossil-dependent technology with low-carbon solutions. Sustainable business management means adapting new internal practices, but also focusing on how products and services can be optimized to yield the greatest climate benefits externally by helping customers reduce emissions. Chemical giant BASF has performed a precise climate analysis of all its products and how these can be used to decrease customers' emissions. Their conclusion: potential climate pollution reductions with these products equal three times their lifecycle emissions.[5] By studying the products and services provided by new climate entrepreneurs it is possible to map out the degree of climate efficiency that will soon be demanded by the market.

In October 2007, Harvard Business Review issued a special report on climate change and its implications for consumers: "the effects of climate on companies' operations are now so tangible and certain

1 Llewellyn (2007), p. 58
2 See Ibid., Annex 2. for a review of how different effects influence different industries. .
3 HBRGreen.org (2008)
4 McKinsey (2007), p. 14
5 BASF

nagement

that the issue is best addressed with the tools of the strategist, not the philanthropist."[6] Businesses that understand the nature of the low-carbon economy early on, and the need to adapt—those that analyze the implications for their sector and adjust operations as well as strategies—will succeed and become winners in the third industrial revolution. Practically this requires:[7]

- Establishing a positive and constructive attitude to the transition to a low-carbon economy within management
- Encouraging employees to get involved in the transition and offering the tools necessary for them to do this
- Initiating research and development projects necessary to handle the transition
- Transforming research results into behaviour change and suitable investments in material and human resources
- Accepting that status quo is not an option in any industry or business

Doing this is not an easy task; for many businesses the transition will mean big changes in rigid organizations and a true test of courage and leadership. A first step in adjusting operations is to set up internal climate targets. Which targets, of course, depends on the individual organisation, but the most common areas where emissions can be reduced by implementing innovative solutions and practices are energy- and material-efficiency, recycling, sustainable buildings, switching to renewable energy, efficient industrial processes, and communications/travel practices.[8]

Start by analysing the sources of climate pollution in enterprise activities and products' and services' entire lifecycles. Then take action within two areas: efficiency and implementation of innovative technology. Buying emission credits (so called "Carbon Offsets") could be a good complementary solution but presupposes careful monitoring of what exactly is being purchased. The "Gold Standard"[9] label for emission credits implies that the projects are serious and aim to contribute to a real shift away from the fossil-based economy. However, "offsetting" should not be allowed to detract from monitoring a business' own pollution and eliminating these emissions. The entire chain from supplier to self and on to the consumer can, and should, be adjusted for climate-friendly performance. Technology and knowledge to handle the task already exist; the only things potentially missing are leadership, vision, and courage.

There are no purely financial arguments against starting the transition today; many low-carbon investments have a payback period of less than a year. Dow Chemicals saved 4 billion dollars between 1994 and 2005 through energy efficiency measures, decreasing emissions by 32%. British Telecom has decreased emissions by 35% since 1996 through efficiency measures and by implementing new climate innovations; this helped them save 800 million dollars from 2005 to 2006.[10] Chemical giant DuPont has lowered emissions by 72% since 1990, thereby saving 3 billion dollars. They also developed many new competitive products for the low-carbon economy and made their products more resource efficient.[11] With "Mission Zero", the international carpet company Interface aims to diminish all negative influence on the environment by 2020. Interface has reduced emissions by 60% since 1996 and waste by 70%, thereby saving 336 million dollars in waste management.[12]

When products and practices are made more climate-friendly this generally results in a more efficient use of all inputs, which further increases profits.[13] Companies that transition also derive the benefit of independence from fossil fuels and the risks associated with these fuels, including an increasing price on carbon.

"There is recognition within industry that this [move to a low carbon economy] is going to change fundamentally the framework within which business is operating and any company that ignores it is going to lose out through higher costs and missing opportunities that arise"

Chris Tuppen (Director of sustainable development, British Telecom)

KÄLLA: CNBC (2008)

6 Harvard Business Review (2007)
7 Llewellyn (2007)
8 The Climate Group (2006)
9 See: http://www.cdmgoldstandard.org
10 The Climate Group (2006), p. 3-8
11 DuPont Sustainability: http://www2.dupont.com/Sustainability/en_US/ & Gardner, Prugh et al., (2008), p. 32
12 Interface Sustainability: http://www.interfacesustainability.com
13 Llewellyn (2007), p. 56.

A GLOBAL PERSPECTIVE

Good ideas often arise where they cannot reach their full potential; this is especially true for innovations that can reduce climate pollution. One example is Renewable Energy Corporation (REC), one of the world's leading Solar PV companies, which was built up in not-so-sunny Norway. The need for a global perspective in developing and marketing climate technology cannot be overemphasized.

Together, China and India will be responsible for almost half the increase in global energy demand by 2030.[1] However, this does not mean that other nations should reduce their focus on transitioning—to the contrary, this means that efforts to enable deployment of climate solutions globally need to be intensified.

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The global perspective should be present in research and development within industry and academia through exchanges and networking. The classic model with internal research and development departments responsible for all innovative work for a company could be replaced with a multifaceted model more suitable for a global economy. "Open Innovation"[2] is a model where innovative work is performed in collaboration with customers, universities, competitors, entrepreneurs, and other external parties. The most famous open innovation model is perhaps Procter & Gamble's "Connect and Develop". With broad-based collaboration among external parties, this model led to a 60% increase in R&D productivity while lowering costs.[3] Many revolutionary climate technology innovations can be found at small companies, universities, or with entrepreneurs, while major companies are stuck with carbon-based technology due to committed investments.[4] By establishing a model for open innovation, new competence is brought in to climate-adjust a company's products and business model.

Companies that do not sell climate efficient products and services will have a harder time surviving on the global market in the coming decades. Recently the Chinese government directed banks to consider adherence to environmental legislation on the part of loan applicants. The Central Bank of the Republic of China has consequently developed a credit database in which major borrowers are ranked with respect to an environmental standard. Company emissions will also be more important in the global economy as programmes such as the Carbon Disclosure Project (CDP) develop. Institutional investors with more than 57 trillion dollars in capital—representing a third of the global capital markets—are already connected to CDP. CDP encourages businesses to voluntarily report their emissions.[5]

THE INFRASTRUCTURE CHALLENGE

Much of the infrastructure in use today was developed and designed over a hundred years ago. Some ideas can be traced all the way back to the Roman Empire. Systems used in developed nations, and now mass-exported to developing economies, were conceived in a time with no knowledge of climate change and with little or no understanding of limited natural resources or the value of ecosystem services. We depend on an infrastructure not designed to meet our energy needs—our transportation, communication, water, food, etc. needs, in a resource- and climate-efficient manner.[6]

1 IEA (2007)

2 Find more information at: http://www.strategy-business.com/press/enewsarticle/22190?pg=all, http://www.openinnovators.net

3 Harvard Business Review (2006)

4 See: Technological lock-in on p. 46

5 Gardner, Prugh et al., (2008), pp. 188 & 194 & http://www.cdproject.net

6 See: Worldchanging (2008) & Strategy Business (2007)

In the next 25 years, the world needs to invest 40 trillion dollars in infrastructure modernisation.[7] One of the most important questions of our time is how to ensure that these financial resources are invested in low-carbon technology instead of conventional carbon-dependent systems. In developed economies investments will mainly involve replacing out-of-date technology, while developing countries will be looking to implement new entire systems.[8]

According to the International Energy Agency's reference scenario, China will double and India triple the use of coal-fired power by 2030, ensuring fossil fuel lock-in.[9] CO_2 emissions from the transportation sector in Asia are predicted to more than double, within the next 25 years.[10] All the while, China, India and the rest of the world fully realize that this development is not compatible with stabilising climate. Enormous resources will be invested in order to avoid this development; this poses difficult challenges but also great opportunities for enterprises and entrepreneurs. To make rational investments of time and money in a world going through a transition means thinking innovatively. The only successful strategy is development and deployment of products and services that will thrive in the low-carbon economy. The main future export products will not be fossil-fuel-dependent, and the sooner corporations realize this, the better.

The problem to keep in mind in all innovative work within all companies is how to develop low-carbon technology and how to reach the global market. Building new coal-fired power plants, as major power companies such as Vattenfall, REW, and Enel are doing, does not position energy companies strategically in the transition to the new energy economy.[11] Investing in developing osmotic power plants, as Norwegian Statkraft is doing, does.[12]

According to China's national climate change program, the country will reduce their emissions by 550 million tons from 2005 to 2010. In the same period, climate pollution from energy production will decrease by 700 million tons.[13] A sizable market exists for companies that can deliver products to contribute to the aims of this programme. As more ambitious transition policies are implemented, the global market for climate innovations will only grow.

Enterprises should design strategies to ensure a leadership position in the transition, by reconceptualising business and export plans.

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Solar panel at hut on Lake Titicaca in Bolivia

"We need to make sure that the systems we end up with in 2030 actually enable the future we want, not rebuild the past"

Alex Steffen (CEO at World Changing, as well as one of the worlds foremost thinkers on innovation for sustainability)

7 Strategy Business (2007)

8 By 2030 energy demand will increase by 70 % in developing countries and the need for investments in energy infrastructure will be up to 10 trillion dollars according to: IEA (2006c), p. 65

9 IEA (2007), p. 119

10 Asian Development Bank (2006)

11 New coal power plants are planned in Europe by Swedish Vattenfall, German RWE, and Italian Enel. For more information: Economist (2007) & Spiegel (2007) & Vattenfall (2006), p. 11

12 Norwegian Statkraft, using an open innovative model, is developing power plants using osmotic technology to extract renewable energy from the power released when fresh water is mixed with ocean water.

13 National Development and Reform Commission, People's Republic of China (2007)

"You remember that Internet? Well I'll tell you what – green technologies, going green, is bigger than the Internet. It could be the biggest economic opportunity of the 21st century"

John Doerr (Ranked by Forbes Magazine as one of the world's foremost investors in new technology. Doerr arranged venture capital for Google and Amazon start-ups amongst others.)

New strategies need to be developed in order to deal with the transition to total sustainability in an efficient way, to avoid risk and seize opportunities

TRANSITIONING IN THE REAL WORLD

It is not enough to implement a transition marginally by having some investments in different fields of innovative technology or by improving pre-existing unsustainable technology to be a bit less unsustainable. To handle the climate challenge, models need to be developed to replace all pre-existing carbon-intensive technology with new solutions, and the political policies needed to support this must be put in place. Albert Einstein once said that we cannot solve problems by using the same kind of thinking we used when we created them; the transition to a climate-friendly society is based on new products and services as well as on new business models and practices supporting these.

Through the project "Planet Me," the Dutch express delivery service TNT has started to adapt its business model to fit the realities of the 21st century. By investing 2.8 million Euros in videoconferencing systems, they are saving 3.2 million Euros per year in travel costs and cutting travel emissions by 20 %. The situation has improved for the employees as a result of more efficient time management. The company's main office is moving into a building that will use modern technology that is not just carbon neutral, but also produces a surplus of renewable energy. TNT is also in the process of measuring the pollution of all their services to report to their customers, a strategy which offers the customers transparency and puts pressure on the company to keep improving climate efficiency. Reports on emissions will also be tied to a bonus system and presented in the same manner as normal accounting.[1]

Transitioning to the low-carbon economy should be fun, too! British BSkyB has in three years decreased emissions by 27 %, implemented many climate innovations, replaced all energy in their buildings with renewable energy, started to climate-adjust their products and invested in four different projects for renewable energy plants in Asia. Employees at the company are involved and have been given so called "Carbon Credit Cards" which load credits every time the owner has done something to decrease pollution, such as: biking to work and

1 Read more at: http://www.tntplanetme.com

renting a hybrid vehicle or having a videoconference instead of travelling to a meeting. The credits on the card can then be used to claim various prizes. Events are also organised with discussions or movie screenings to encourage suppliers to transition toward more climate-friendly practices, too.[2]

It is not merely a question of lowered emissions but also a question of efficient use of resources within a company – hundreds of millions of Euros can be saved in Europe alone by more energy efficiency.[3] It is in the interest of investors and shareholders that their companies manage emission reports seriously and start investing in less carbon-dependant technology as well as make their products climate-friendly in order for their products to secure a place in the future market.[4]

A study from Goldman Sachs shows that the most sustainable businesses have seen their shares outpace the MSCI World Index by 25% since August 2005 when the measurements were initiated. 75% of the companies analyzed as sustainability role models developed better than other companies in the same industry during the same time period.[5] From a shareholder's perspective, a sustainable business should include:

- Increased profit
- Decreased risks
- Increased creativity and innovation
- A more efficient use of inputs
- A better reputation
- More efficient processes throughout the entire value chain
- Increased product differentiation
- A more attractive workplace
- Better working environment

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By changing ways of reasoning and thinking in terms of systematic changes, profits can increase while pollution decreases. By sticking to carbon-dependant technology and focusing on marginal improvements a business will lose. With this knowledge and long-term strategies toward climate-friendly practices, the most innovative solutions and exciting ideas can be found with climate entrepreneurs such as those presented in this report. A minimum requirement when purchasing and for one's own products should be that the climate efficiency is equal to the efficiency these climate entrepreneurs offer.

2 See: http://www.jointhebiggerpicture.com/HealthyEnvironment

3 Europa (2006)

4 An interesting programme for emission reporting is the Carbon Disclosure Project: http://www.cdproject.net. For sustainable reporting there is the Global Reporting Initiative: http://www.globalreporting.org. For sustainable and responsible investment policies: UN Principles for Responsible Investment at http://www.unpri.org. For investors there is also the Investor Network on Climate Risk: http://www.incr.com.

5 Goldman Sachs (2007)

Conclusion

Who will be the winners in the low-carbon economy? GlobalFOCUS believe that climate entrepreneurs will be the ones pushing forward the innovation wave the world now faces. They will lead the way into a third industrial revolution. This transformational change will require changes in systems and structures; new technology in itself is not enough. Politics, economics, business, attitudes and behaviors will also need to change. We are living in a globalized world and we must learn how to think globally. The world's population and rate of urbanization are increasing rapidly, and a large portion of humans on the planet are poor and seek higher standards of living. Those people will have to be offered a better life in a way that doesn't at the same time result in fossil dependency and a dangerously large climate impact. At the same time, the rich people of the world need to change their lifestyles and develop, implement and spread new solutions for sustainable living.

A prerequisite for success is low-carbon innovation. In order for the creativity and ingenuity of the world´s climate entrepreneurs to result in a global implementation wave of low-carbon technology, we need to see more courageous leaders. It's time to start building the sustainable world we all yearn for.

Source reference

AIRCONDITIONING ZONE (2007): "LG dominates global air conditioner market", 14/02/07 http://www.airconditioning-zone.co.za/index.php?option=com_content&task=view&id=55&Itemid=2

ALFSEN & ESKELAND (2007): Alfsen, Knut H & Eskeland, Gunnar S, "A broader palette: The role of technology in climate policy", Ministry of finance, Stockholm

ANDERSEN (2004): Andersen, Dr. Maj Munch, "An Innovation System approach to Eco-innovation – Aligning policy rationales"

ARCHITECTURE 2030: "The Building Sector - A Hidden Culprit" http://www.architecture2030.org/current_situation/building_sector.html

ASIAN DEVELOPMENT BANK (2006): "Report Warns on Climate Change Implications of Asia's Motorization", 14/12/06 http://www.adb.org/Media/Articles/2006/11166-asian-climate-change-implications/default.asp

ASIA TIMES ONLINE (2006): Escobar, Pepe, "Book Review - The accumulation of the wretched - Planet of Slums by Mike Davis", 20/05/06 http://www.atimes.com/atimes/Front_Page/HE20Aa01.html

ATKINSON, DIETZ, NEUMAYER (2006): G. Atkinson, S. Dietz and E. Neumayer, "Handbook of Sustainable Development", Edward Elgar, Cheltenham, UK

BASF: "BASF products help to protect the climate", http://corporate.basf.com/en/produkte/energieeffizienz.htm?id=UW2nrBu.ubcp2*-

BBC (2008): "Record car ownership in Beijing", 14/01/08, BBC News http://news.bbc.co.uk/2/hi/asia-pacific/7186635.stm

BROWN, ET AL. (2007): Brown, Marilyn A., Chandler, Jess, Lapsa, Melissa V., Sovacool, Benjamin K., "Carbon Lock-In: Barriers To Deploying Climate Change Mitigation Technologies", 11/07, U.S. Climate Change Technology Program, Oak Ridge http://www.ornl.gov/sci/eere/PDFs/ORNLTM-2007-124_rev200801.pdf

BUSINESS DAY (2008): Harrison, Pete, "Car makers have tough targets", 27/08/08, Reuters/Business Day, http://www.businessday.co.za/articles/world.aspx?ID=BD4A830860

CAIRNS (2006): Cairns Robert D., "On accounting for sustainable development and accounting for the environment"

CARBON FINANCE (2008): "Fukuda promises $40 billion for climate efforts", 30/01/08 http://www.carbon-financeonline.com/index.cfm?section=lead&action=view&id=10996

CARBON TRUST (2003): "Building options for UK renewable energy", 10/03 http://www.carbontrust.co.uk/Publications/publicationdetail.htm?productid=CT-2003-08

CHAKRAVORTI (2007): Chakravorti, Bhaskar, "Innovation Without Borders", Innovations, Summer 2007

CLIMATE ACTION NETWORK: "The power of green public procurement in the EU", 25/02/08 http://www.climateactionprogramme.org/features/article/the_power_of_green_public_procurement_in_the_eu/

CLINTON FOUNDATION (2007): "President Clinton Announces Landmark Program to Reduce Energy Use in Buildings Worldwide", 16/05/07 http://www.clintonfoundation.org/051607-nr-cf-pr-cci-president-clinton-announces-landmark-program-to-reduce-energy-use-in-buildings-worldwide.htm

CNBC (2008): "Profit from a changing climate - The new climate change debate", 01/08 http://cnbceb.com/2008/01/01/profit-from-a-changing-climate/1/

CNBC (2008B): "Viewpoint – Only Alternative", 01/08 http://cnbceb.com/2008/01/01/viewpoint-11/

COMMISSION OF THE EUROPEAN COMMUNITIES (2001): "Directive of the European Parliament and of the Council - on the energy performance of buildings" http://ec.europa.eu/energy/library/en_bat_en.pdf

COMMISSION OF THE EUROPEAN COMMUNITIES (2004): "Stimulating Technologies for Sustainable Development: An Environmental Technologies Action Plan for the European Union" http://eur-lex.europa.eu/LexUriServ/site/en/com/2004/com2004_0038en01.pdf

COSTANZA ET AL., (1997): R. Costanza, R. D'Arge, R. DeGroot, S. Farber, M. Grasso, B. Hannon, K. Limburg, S. Naeem, R. O'Neil, J. Paruelo, R. Raskin, P. Sutton and M. van den Belt, "The value of the world's ecosystem services and natural capital", Nature 387 (1997), pp. 253–260.

CRESP: "China Renewable Energy Scale-up Program, Jiangsu Province" http://www.cresp.org.cn/uploadfiles/73/613/jiangsu.html

DAVIS (2004): "Determination of Emission Factors from Back-Up Generators" http://www.energy.ca.gov/pier/notices/2004-10-06_seminar/2004-10-06_DAVIS.PDF

CITIGROUP (2007): "Citi Targets $50 Billion Over 10 Years to Address Global Climate Change", 08/05/07 http://www.citigroup.com/citigroup/press/2007/070508a.htm

DEFRA (2007): "Guidelines to Defra's GHG conversion factors for company reporting" http://www.defra.gov.uk/environment/business/envrp/pdf/conversion-factors.pdf

DIANA FARRELL (2007): "A Simple Plan to Cut Energy Demand Growth and Carbon Emissions", 07/06/07 http://www.mckinsey.com/mgi/MGInews/businessweek/simpleplan.asp

DIRECTORATE-GENERAL ENERGY AND TRANSPORT (2007): Energy & Transport : Figures and Main Facts, "Statistical pocketbook 2007", Part 2: Energy http://ec.europa.eu/dgs/energy_transport/figures/pocketbook/2006_en.htm

ECONOMIST (2007): "Coal Power – Still going strong", 15/11/07 http://www.economist.com/business/displaystory.cfm?story_id=10145492

ECOHEATCOOL AND EUROHEAT & POWER (2005-2006A): "Possibilities with more district heating in Europe" http://www.euroheat.org/ecoheatcool/documents/Ecoheatcool%20WP4%20Web.pdf

ECOHEATCOOL AND EUROHEAT & POWER (2005-2006B): "Ecoheatcool - Work package 5, Possibilities with more district cooling in Europe" http://www.euroheat.org/ecoheatcool/documents/Ecoheatcool%20WP5%20Web.pdf

ECOHEATCOOL AND EUROHEAT & POWER (2005-2006C): "Europe's consumption of fossil fuels for heating and cooling" http://www.euroheat.org/ecoheatcool/documents/Ecoheatcool%20Results%20Web.pdf

EIA (2000): Energy Information Administration, "Carbon Dioxide Emissions from the Generation of Electric Power in the United States", Department of Energy, Washington, DC 20585 & Environmental Protection Agency Washington DC 20460, 07/00 http://www.eia.doe.gov/cneaf/electricity/page/co2_report/co2report.html

EIA (2002): Energy Information Administration, "Biomass for Electricity Generation – Table 3" http://www.eia.doe.gov/oiaf/analysispaper/biomass/table3.html

EIA (2006): Energy Information Administration, "Annual Energy Review 2006", US Dept. of Energy http://www.eia.doe.gov/emeu/aer/pdf/pages/sec8.pdf

EIA (2007): Energy Information Administration, "Emissions of Greenhouse Gases Report" 28/11/07 http://www.eia.doe.gov/oiaf/1605/ggrpt/carbon.html

EIA (2007B): Energy Information Administration, "Net Generation by Energy Source by Type of Producer", Electric Power Annual with data for 2006, Report Released: October 22, 2007 http://www.eia.doe.gov/cneaf/electricity/epa/epat1p1.html

EU OBSERVER (2007): "Buildings to play key role in global warming fight", 12/06/07 http://euobserver.com/877/24207

EUROHEAT & POWER (2006): "District cooling - Cooling more with less" http://www.euroheat.org/documents/PositionPapers/EHPCoolingMoreWithLess.pdf

EUROPA (2006): "Saving 20% by 2020: European Commission unveils its Action Plan on Energy Efficiency", 19/10/06 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/06/1434&format=HTML&aged=1&language=EN&guiLanguage=en

EUROPA (2007): "Commission proposal to limit the CO2 emissions from cars to help fight climate change, reduce fuel costs and increase European competitiveness", 19/12/07 http://europa.eu/rapid/pressReleasesAction.do?reference=IP/07/1965

EUROPEAN ENVIRONMENT AGENCY, GREENHOUSE GAS DATA VIEWER: http://dataservice.eea.europa.eu/dataservice/

EWEA: European Wind Energy Association, "Statistics" http://www.ewea.org/index.php?id=180

EXPORT.GOV (2008): "Mission Statement - 2nd U.S. APP Clean Energy Trade Mission to China and India" http://www.export.gov/cleanenergymission/doc_cem_mission.asp

FARRELL & KLEMPERER (2001): Farrell, Joseph, "Coordination and Lock-In: Competition with Switching Costs and Network Effects"

FORTUM (2006): "Fortum and Climate Change", 09/07 http://www.fortum.com/gallery/environment/2006/FortumandClimateChangeSep2006.pdf

FOXON (2006): Foxon , Timothy J., "Technological lock-in and the role of innovation" http://www.hm-treasury.gov.uk/media/C/0/climatechange_imp_3.pdf

FRANCISCO J., ET AL. (2007): Francisco J., André, Paula, González, Nicolás, Porteiro, "Strategic Quality Competition and the Porter Hypothesis" Strategic Quality Competition and the Porter Hypothesi

G8 CLIMATE CHANGE ROUNDTABLE (2005): "Statement of G8 Climate Change Roundtable - Convened by the World Economic Forum in Collaboration with Her Majesty's Government, United Kingdom", 09/06/05 http://www.weforum.org/pdf/g8_climatechange.pdf

G8 SUMMIT (2003): Science and Technology for Sustainable Development - A G8 Action Plan http://www.g8.fr/evian/english/navigation/2003_g8_summit/summit_documents/science_and_technology_for_sustainable_development_-_a_g8_action_plan.html

GARDNER, PRUGH ET AL., (2008): Gardner, Gary, Prugh, Thomas et al., "State of the World 2008 - Innovations for a Sustainable Economy", Worldwatch Institute, New York

GEORGHIOU (2007): Georghiou, Luke, "Demanding Innovation Lead markets, public procurement and innovation", NESTA 02/07 http://www.nesta.org.uk/assets/pdf/demanding_innovation_provocation_NESTA.pdf

GLOBAL ROUNDTABLE ON CLIMATE CHANGE (2007): "The Path to Climate Sustainability" http://www.earthinstitute.columbia.edu/grocc/documents/GROCC_statement_2-27_1.pdf

GLOBAL WIND ENERGY COUNCIL (2008): "Continuing boom in wind energy – 20 GW of new capacity in 2007", 18/01/08 http://www.gwec.net/index.php?id=30&no_cache=1&tx_ttnews[tt_news]=121&tx_ttnews[backPid]=4&cHash=f9b4af1cd0

GMI (2007): Global Market Research, "2007 World Environment Review" https://www.gmi-mr.com/gmipoll/release.php?p=20070605

GOLDMAN SACHS (2007): "GS Sustain", 22/06/07 http://www.unglobalcompact.org/docs/summit2007/gs_esg_embargoed_until030707pdf.pdf

GREATER LONDON AUTHORITY (2007): "Mayor unveils London Climate Change Action Plan", 27/02/07 http://www.london.gov.uk/view_press_release.jsp?releaseid=11011

GREENPEACE (2005): "Energi Revolution - A Sustainable Pathway to a Clean Energy Future for Europe", Greenpeace, Netherlands http://www.greenpeace.org/raw/content/international/press/reports/energy-revolution-a-sustainab.pdf

GREENPEACE & EREC (2007): Greenpeace & European Renewable Energy Council (EREC), "Energi [r]evolution - A Sustainable World Energy Outlook", Greenpeace, Netherlands http://www.greenpeace.org/raw/content/international/press/reports/energyrevolutionreport.pdf

GRIMM, KILBURG, GRASSI, LUTTER, EPPLER (2002): "European Bioenergy Technology for the Exploitation of the Huge Agri-Forestry Residues Potential in China" http://www.eubia.org/uploads/media/2002_-_EBC12_-_European_bioenergy_technology_for_the_exploitation_of_the_huge_agri-forestry....PDF

GUARDIAN (2007): Monbiot, George, "This crisis demands a reappraisal of who we are and what progress means" http://www.guardian.co.uk/commentisfree/2007/dec/04/comment.politics

GUARDIAN (2008): Seager, Ashley, "MPs call for climate change minister", 05/02/08 http://www.guardian.co.uk/business/2008/feb/05/greenbusiness.climatechange

HARVARD BUSINESS REVIEW (2006): "CONNECT AND DEVELOP: Inside Procter & Gamble's New Model for Innovation", Vol. 84, No. 3, 03/06 [En förkortad version finns på: http://hbswk.hbs.edu/archive/5258.html]

HARVARD BUSINESS REVIEW (2007): "Forethought Special Report - Climate Business | Business Climate", 10/07

HBRGREEN.ORG (2008): Hoffman, Andrew J. & Woody John, "Winners and Losers in a Carbon-Constrained World", 19/02/08 http://www.hbrgreen.org/2008/02/winners_and_losers_in_a_carbon.html

HECHT (2005): Hecht, Joy E., "National environmental accounting: Bridging the gap between ecology and economy", RFF Press, 2005

HM TREASURY/CABINET OFFICE (2007): "Stern Review on the Economics of Climate Change", (HM Treasury, London), Annex 7.e Emissions from buildings sector http://www.hm-treasury.gov.uk/media/2/D/annex7e_buildings.pdf

IEA (2006A): International Energy Agency, "Light's Labour's Lost - Fact Sheet", IEA, Paris http://www.iea.org/textbase/nppdf/free/2006/light_fact.pdf

IEA (2006B): International Energy Agency, "Light's Labour's Lost - Policies for Energy-efficient Lightning - Executive summary", IEA, Paris. http://www.iea.org/textbase/npsum/lll.pdf

IEA (2006C): International Energy Agency, "World Energy Outlook 2006", IEA, Paris

IEA (2007): International Energy Agency, "World Energy Outlook 2007 - China and India Insights", IEA, Paris. Executive summary: http://www.iea.org/Textbase/npsum/WEO2007SUM.pdf

INTERNATIONAL HERALD TRIBUNE (2007): "Merkel calls for global emissions trading agreement to follow Kyoto protocol", 09/10/07 http://www.iht.com/articles/ap/2007/10/09/europe/EU-GEN-Germany-Climate-Conference.php

IPCC (2007A): Intergovernmental Panel on Climate Change, Fourth Assessment Report Working Group III, Report "Mitigation of Climate Change" http://www.ipcc.ch/ipccreports/assessments-reports.htm

IPCC (2007B): Intergovernmental Panel on Climate Change, Fourth Assessment Report Working Group I, Report "The Physical Science Basis" http://www.ipcc.ch/ipccreports/assessments-reports.htm

IPCC (2007C): Intergovernmental Panel on Climate Change, Fourth Assessment Report Working Group III, "Summary for policymakers" http://www.ipcc.ch/ipccreports/assessments-reports.htm

JOHNSON, EDQUIST, LUNDVALL (2003): Johnson, Björn & Edquist Charles & Lundvall Bengt-Åke, "Economic Development and the National System of Innovation Approach" http://www.globelicsacademy.net/pdf/BengtAkeLundvall_2.pdf

JOURNAL OF GEOPHYSICAL RESEARCH (2003): J Corbett, H Köhler., "Updated emissions from ocean shipping", Vol. 108

KOBAYASHI (2007): Kobayashi, Kensuke, "Development of Inventory Data Related to Electric Power in China", SETAC Case Study Symposium 03/12/07 http://www.setaceumeeting.org/lca2007/1B_2_Kobayashi.pdf

L. EDWARDS, P. TORCELLINI, (2002): "A Literature Review of the effects of Natural Lighting on Building Occupants", NREL. http://www.nrel.gov/docs/fy02osti/30769.pdf

LANOIE, ET AL. (2007): Lanoie, Paul, Laurent-Lucchetti, Jeremy, Johnstone, Nick, Ambec, Stefan, "Environmental Policy, Innovation and Performance: New Insights on the Porter Hypothesis" http://www.cirano.qc.ca/pdf/publication/2007s-19.pdf

LI JUNFENG, HU RUNQING, SONG YANQIN, SHI JINGLI, S.C. BHATTACHARYA AND P. ABDUL SALAM (2005): "Assessment of sustainable energy potential of non-plantation biomass resources in China", Energy Research Institute, National Development and Reform Commission, Beijing, China Energy Field of Study, School of Environment, Resources and Development, Asian Institute of Technology

LIBERTAS: "The Libertas Energy Initiative - European Energy Innovation Fund" http://www.libertas.org/content/view/188/107/

LLEWELLYN (2007): Llewellyn, John, "The Business of Climate Change - Challenges and Opportunities", Lehman Brothers http://www.lehman.com/press/pdf_2007/TheBusinessOfClimateChange.pdf

LYNAS (2007): Lynas, Mark, "Six Degrees", Harpercollins Publishers

MAURER & BHANDARI (2000): Maurer, C., Bhandari, R., "The Climate of Export Credit Agencies", Climate Notes, World Resources Institute, Washington, DC http://www.wri.org/publication/climate-export-credit-agencies

MCDONOUGH & BRAUNGART (2003): McDonough, William & Braungart, Michael, "Cradle To Cradle - Remaking the Way We Make Things", Rodale Press

MCKINSEY (2007): Oppenheim, Jeremy, Bonini, Sheila, Bielak, Debby, Kehm, Tarrah, Lacy, Peter, "Shaping the New Rules of Competition: UN Global Compact Participant Mirror", 07/07

MILJÖAKTUELLT (2008): Salo, Mikael "Fastighetsbranschens klimatpionjär" 16/01/08 http://dagensmiljo.idg.se/2.1845/1.140599

MORILLAA ET AL., (2005): Morillaa Carmen Rodríguez, Díaz-Salazarb Gaspar Llanes & Cardente M. Alejandro, "Economic and environmental efficiency using a social accounting matrix"

MURTY & KUMAR (2001): Murty, M.N. & Kumar, Surender, "Win-Win Opportunities and Environmental Regulation: Testing of Porter Hypothesis for Indian Manufacturing Industries", Institute of Economic Growth, Delhi University Enclave http://www.iegindia.org/dispap/dis25.pdf

NATURVÅRDSVERKET (2006) "Klimatteknik på export - En översikt av svensk export för minskad klimatpåverkan" http://www.westander.se/kunder/Klimatteknikpa-export.pdf

NATIONAL ACADEMIES (2007): "Joint science academies' statement on growth and responsibility: sustainability, energy efficiency and climate protection", 05/07 http://www.nationalacademies.org/includes/G8Statement_Energy_07_May.pdf

NATIONAL ENERGY FOUNDATION: "CO_2 Calculator" http://www.nef.org.uk/greencompany/co2calculator.htm

NATIONAL DEVELOPMENT AND REFORM COMMISSION PEOPLE'S REPUBLIC OF CHINA (2007): "China's National Climate Change Programme" 07/07 http://en.ndrc.gov.cn/newsrelease/P020070604561191006823.pdf

NEF (2004): New Economics Foundation, "The price of power - Poverty, climate change, the coming energy crisis and the renewable revolution" http://www.neweconomics.org/gen/uploads/3lskha55xjuxeu45mvbftgmb180620041736 46.pdf

NEW ZEALAND GOVERNMENT (2007): "New Zealand's climate change solutions: An overview", 09/2007 http://www.climatechange.govt.nz/files/NZ-Climate-Change-Solutions.pdf

NESTA (2007): "Driving innovation through public procurement", NPRU Policy Briefing 02/07 http://www.nesta.org.uk/assets/pdf/driving_innovation_through_public_procurement_policy_briefing_NESTA.pdf

ORESKES (2005): Oreskes, Naomi, "The Scientific Consensus on Climate Change", Science Magazine 3/12/04 http://www.sciencemag.org/cgi/reprint/306/5702/1686.pdf

P. DEGLAIRE, O. ÅGREN, H. BERNHOFF, M. LEIJON (2007): European Journal of Mechanics - B/Fluids, "Conformal mapping and efficient boundary element method without boundary elements for fast vortex particle simulations", doi:10.1016/j.euromechflu.2007.03.005

PELLETS FOR EUROPE (2002): "Data collection on pellets utilization from agricultural residues in the rest of Europe"

PEOPLES DAILY (2004): "China's urban population to reach 800 to 900 million by 2020: expert" http://english.people.com.cn/200409/16/eng20040916_157275.html

PORTER, M. (1991): Porter, Michael E., "Americal gren strategy", Scientific American 264, 168

PORTER, M. & VAN DER LINDE (1995): Porter, Michael E. & Van der Linde, Claas, "Towards a new conception on environment-competitiveness relationship" Journal of Economic Perspectives 9, 97-118

PUCHER & DIJKSTRA (2003): Pucher, John, Dijkstra, Lewis, "Promoting Safe Walking and Cycling to Improve Public Health: Lessons From The Netherlands and Germany", American Journal of Public Health, Vol 93, No. 9, 09/03 http://www.ajph.org/cgi/reprint/93/9/1509.pdf?ck=nck

REGERINGEN (2007): Regeringens proposition 2006/07:1, "Budgetpropositionen för 2007 - Förslag till statsbudget för 2007, finansplan, skattefrågor och tilläggsbudget m.m.", Stockholm http://www.regeringen.se/content/1/c6/06/96/26/f9078b24.pdf

REUTERS (2007): "Costa Rica plants 5 million trees", 06/12/07 http://uk.reuters.com/article/environmentNews/idUKN05959120071206

ROACH (2007): Roach, Rachel, "Two Degrees, one Chance", 05/07 http://vsa.vassar.edu/~operationdonation/2_Degrees_One_Chance.pdf

SCB (2008): "Nationalräkenskaper, kvartal och preliminära årsberäkningar (NR)" http://www.scb.se/templates/Product____22908.asp

SCIENTIFIC AMERICAN MAGAZINE (2007): William Collins, Robert Colman, James Haywood, Martin R. Manning & Philip Mote, "The Physical Science behind Climate Change", August 2007 http://www.sciam.com/article.cfm?chanID=sa006&colID=1&articleID=B1182F51-E7F2-99DF-30CB2EAAC975FE93

SPIEGEL (2007): Knauer, Sebastian & Fröhlingsdorf Michael, "The Energy Challenge German Energy Policy At The Crossroads", 26/07/07 http://www.spiegel.de/international/germany/0,1518,496691,00.html

STATKRAFT: "Osmotic power - A huge renewable energy source" http://www.statkraft.com/Images/Statkraft%20Osmotic%20Power%20Update%20SCREEN_tcm4-8318.pdf

STEFFEN (2006): Steffen, Will, "Stronger Evidence but New Challenges: Climate Change Science 2001-2005", Australian Government, Department of the Environment and Heritage, Australian Greenhouse Office, Canberra http://www.greenhouse.gov.au/science/publications/pubs/science2001-05.pdf

STERN REVIEW (2006): Sir Nicholas, Stern, "Stern Review on the Economics of Climate Change", HM Treasury/Cabinet Office http://www.hm-treasury.gov.uk/independent_reviews/stern_review_economics_climate_change/sternreview_index.cfm

STRATEGY BUSINESS (2007): Viren Doshi, Gary Schulman & Daniel Gabaldon, "Lights! Water! Motion!" http://www.strategy-business.com/press/article/07104?gko=a8c38

SUSTAINABLE CONSUMPTION ROUNDTABLE: "I will if you will - Towards sustainable consumption", 05/06 http://www.sd-commission.org.uk/publications/downloads/I_Will_If_You_Will.pdf

SVENSK FJÄRRVÄRME: "Fjärrvärme- och kraftvärmestatistik 2004" http://www.svenskfjarrvarme.se/index.php3?use=publisher&id=30&lang=1

SVENSKT NÄRINGSLIV (2008): Lundius, Annika, "Klimatet kräver smart politik" 18/02/08 http://www.svensktnaringsliv.se/kommentaren/article44626.ece

THE CARBON GROUP (2006): "Carbon Down Profits Up", 3rd edition, London http://www.theclimategroup.org/assets/resources/cdpu_newedition.pdf

THE MCKINSEY QUARTERLY (2007): "A cost curve for greenhouse gas reduction", The McKinsey Quarterly 2007 Number 1

THE NEW YORK TIMES (2008): "Digital Tools Help Users Save Energy, Study Finds", 10/01/08 http://www.nytimes.com/2008/01/10/technology/10energy.html?ei=5124&en=f85a709b9a01b442&ex=1357707600&adxnnl=1&adxnnlx=1202652271-VdW53W+9Kfh/WygjMacIrw

THE UNITED STATES CONFERENCE OF MAYORS AND THE MAYORS CLIMATE PROTECTION CENTER (2008): "U.S. Metro Economies - Current and Potential Green Jobs in the U.S. Economy", http://www.usmayors.org/pressreleases/uploads/GreenJobsReport.pdf

UNEP (2008B): United Nations Environment Programme, "Global Trends In Sustainable Energy Investment 2008 - Analysis of Trends and Issues in the Financing of Renewable Energy and Energy Efficiency", http://sefi.unep.org/english/globaltrends

UNRUH (2000): Unruh, Gregory, "Understanding Carbon Lock-in", Energy Policy 28

UN WORLD POPULATION PROSPECTS: Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision and World Urbanization Prospects: The 2005 Revision http://esa.un.org/unpp

UNDP (2007): United Nations Development Programme, "Human Development Report 2007/2008 - Mitigation Country Study – China" http://hdr.undp.org/en/reports/global/hdr2007-2008/papers/li_junfeng_china.pdf

UNDP (2007B): United Nations Development Programme, "Human Development Report 2007/2008", Palgrave Macmillan, New York http://hdr.undp.org/en/media/hdr_20072008_en_complete.pdf

UNEP (2007): United Nations Environment Programme, "Buildings and Climate Change - Status, Challenges and Opportunities" http://www.unep.fr/pc/sbc/documents/Buildings_and_climate_change.pdf

UNEP (2008): United Nations Environment Programme, "Year Book 2008 - An Overview of Our Chaning Environment", Nairobi http://www.unep.org/geo/yearbook/yb2008/report/UNEP_YearBook2008_Full_EN.pdf

UN HABITAT (2007): United Nations Human Settlements Programme, "Climate Change - Statement by Brian Williams, Chief Energy and Transport Section, Nairobi, Kenya", UN Commission on Sustainable Development, 15th Session New York, 30 April – 11 May 2007 http://www.un.org/esa/sustdev/csd/csd15/statements/habitat_2may_cc.pdf

USCAP (2007): U.S. Climate Action Partnership, "A Call for Action - Consensus Principles and Recommendations from the U.S. Climate Action Partnership: A Business and NGO Partnership" http://www.us-cap.org/USCAPCallForAction.pdf

US DEPARTMENT OF ENERGY: Wind Energy Resource Potential http://www1.eere.energy.gov/windandhydro/wind_potential.html

VATTENFALL (2006): Dr. Klaus Rauscher, "Vattenfall Capital Markets Day 2006" http://www.vattenfall.com/www/vf_com/vf_com/Gemeinsame_Inhalte/OCUMENT/360168vatt/397942pres/P0273416.pdf

VINDFORSK (2007): "Programbeskrivning - 06-08", s. 4 http://www.vindenergi.org/underlag/vindforsk_programbeskr0702.pdf

WORLD BANK, POVCALNET: http://iresearch.worldbank.org/PovcalNet/jsp/index.jsp

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (2008), "India to provide subsidy for solar power plants" 02/01/08 http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=Mjc4ODY

WORLD BUSINESS COUNCIL FOR SUSTAINABLE DEVELOPMENT (2008B), UNEP calls for end to barriers on fast-growing 'green economy'" 20/02/08 http://www.wbcsd.org/plugins/DocSearch/details.asp?type=DocDet&ObjectId=Mjg1Nzg

WORLDCHANGING (2004): Cascio, Jamais, "Leapfrog 101", 15/12/04 http://www.worldchanging.com/archives/001743.html

WORLDCHANGING (2008): Steffen, Alex, "Infrastructure for the Future We Want", 13/02/08 http://www.worldchanging.com/archives/007838.html

WORLDWATCH INSTITUTE (2006): Jianxiang, Yang, "China Speeds Up Renewable Energy Development", 26/10/06 http://www.worldwatch.org/node/4691

WORLDWATCH INSTITUTE (2006B): Li, Zijun, "China's Renewable Energy Law Takes Effect; Pricing and Fee-Sharing Rules Issued", 18/01/06

WORLDWATCH INSTITUTE (2007): Jianqiang, Liu. "Buildings Are China's Energy Black Holes", 19/04/07 http://www.worldwatch.org/node/5036

WORLDWATCH INSTITUTE (2007B): Li, Ling, "China Releases Plan on Climate Change", 07/06/07 http://www.worldwatch.org/node/5108

WORLDWATCH INSTITUTE (2007C): Liu, Yingling, "China to Shut Down Smaller Power Plants; Effects Remain to Be Seen", 08/02/07 http://www.worldwatch.org/node/4899

WRI (2008): Climate Analysis Indicators Tool (CAIT) Version 5.0. (Washington, DC: World Resources Institute, 2008) http://cait.wri.org

WWF (2007): "Climate Solutions - WWF's vision for 2050" http://www.wwf.fr/content/download/1761/8746/version/1/file/WWF-Vision-Energie-07.pdf

WWF (2008): Reinvang, Rasmus & Peters , Glen, "Norwegian Consumption, Chinese pollution. An example of how OECD imports generate CO2 emissions in developing countries" http://www.wwfchina.org/english/downloads/ClimateChange/Norwegian%20Consumption%20Chinese%20Pollution_WWF_Jan%202008.pdf

WWF (2008B): "Leading brands call for action on climate change", 15/02/08 http://www.panda.org/index.cfm?uNewsID=124900

WWF & THE GLOBAL FOOTPRINT NETWORK (2007): "The import of CO2 emissions from China and India: Sweden's contribution to reduction of CO2 emissions – a global dimension", http://www.wwf.se/source.php/1061675/Ciimate%20impact%20of%20Swedens%20import%20from%20China%20and%20India-Final.pdf

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”The world needs leadership – and we should all ask ourselves how we can contribute to solving climate change on a global scale, as individual citizens as well as in our professional lives. We need to develop strategies to fundamentally change our policies and our economy. Mahatma Gandhi urged us to be the change we want to see in the world. When it comes to the climate crisis, this will not suffice – we must also mass-produce and spread globally the change we want to see.”

Jakob Rutqvist, Global Project Leader, GlobalFOCUS

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WWF is the initiator of GlobalFOCUS. WWFs aim is that young, smart students shall find new solutions to our global resource allocation problems. The ambition is that GlobalFOCUS will in time grow and develop into a self-sustaining project.