Prepared to Ride the Green Dragon?

欲乘绿龙飞九天?

An Estimate of the Markets For
Environmental Goods and Services in China,
With a Survey of Norwegian Companies and Recommendations.

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Photo: The photo of the classical green dragon on the front page was found on the Internet. WWF has not succeeded in finding information about the exact nature of the object represented or who is to be credited for the photo. If you have relevant information in this regard, please contact Rasmus Reinvang (rreinvang@wwf.no).

China for a Global SHIFT

This report highlights one of the key objectives of WWF's China for a Global Shift Initiative, which is to promote the trade of resource-efficient and energy-efficient products from China to other countries. The China for a Global Shift Initiative aims to support China to achieve economic development within the ecological limit of one planet by working with key sectors such as energy production, finance, trade and resource management.

龍	The dragon is a mythical creature in East Asian culture with a Chinese origin. In contrast to the European dragon which stands on four legs and is usually portrayed as evil, the Chinese dragon is a potent symbol of auspicious power in Chinese folklore and art. In the report title 'Green Dragon' is used as a symbol for the quickly developing Chinese Clean Tech sector, with which Western companies now have an opportunity to fly.	龙

Foreword

Over the last three decades, China has demonstrated an ability for economic development that is unparalleled globally in its speed and scale. In one generation China has leapt from being a low-technology agrarian economy to a mass producer of goods to developed countries!

Faced with environmental challenges and restricted resource availability, China is now engaged in taking another leap in order to ensure its continued development, this time towards a more energy-efficient, low-carbon and 'circular' economy. Massive investment, brainpower and Chinese dexterity will be devoted to realizing this goal this over the coming decades. And I believe China will succeed.

In the 20th century the world's largest companies were petroleum or petroleum-based transport companies. In the 21st century, the world's largest companies will most likely be the providers of low-carbon solutions, and China's development will be a decisive factor in this shift. The path taken by 1.3 billion people cannot fail to have an impact on the world. It is simply impossible for China not to play a leadership role.

Western entrepreneurs and stakeholders with access to effective or promising technological solutions now have an unprecedented opportunity to invest in and grow with the expanding Chinese market for low-carbon solutions, and thereby position themselves within an emerging, new global economy. Moreover, China's speed of development and economy-of-scale will allow for commercialization of environmental technologies that can be exported to the global market where OECD countries are posed to impose radical CO_2 emission cuts.

A crisis – whether climatic or financial – implies opportunities to rethink current modus operandi and take new steps to ensure a safe and prosperous future. An innovative, strong, global Clean Tech sector has the potential to ensure further development and job creation while addressing the looming environmental threats to the Chinese and the global communities.

China's future development provides immense opportunities for realizing global sustainable development. However, time is short if we are to tackle the climate-change challenge without experiencing the potentially severely detrimental and destabilizing effects of global warming.

The race against time is on for Western governments and commercial stakeholders to promote cooperation with China and spur the development of a Chinese low-emission society, if global warming is to be tackled effectively. In the process we may foster the winners in a 21st century low-carbon economy.

Børge Brende

Managing director, World Economic Forum
Vice-chair of the China Council for International Cooperation on Environment and Development (CCICED).

Former Norwegian Minister of Trade and Industry (2004–05), Minister of the Environment (2001–04), Member of Parliament (1997–2007) and chair of the UN Commission on Sustainable Development (2003–2004).

Summary

China – a key nation for ensuring global sustainable development

With its vast population, rapidly growing economy, huge research and infrastructure development investments, massive exports and huge spending on military, China is an emerging superpower. However, the Chinese model of economic development is faced with many challenges, one of the largest being environmental degradation of a severity and scale that threatens to undermine the development achievements of the Chinese people.[1] Hundreds of millions of Chinese citizens are also threatened by reduced access to crucial freshwater resources due to global warming, mainly caused by emissions of greenhouse gases in OECD countries and, lately, the rising emissions in emerging economies.[2]

China's predicament illustrates the fact that developing countries will not be able to achieve the Western nations' high standards of living by emulating the same historical development patterns in the West. There are simply not enough natural resources on the planet for developing countries to achieve Western living standards with current forms of production and consumption.[3] Radical innovation is needed if the world's population, which is projected to reach 9 billion people by 2050, is to achieve living standards comparable to those of the West today.

The current financial crisis provides the opportunity to reconsider frameworks for the global economy while taking global challenges such as climate change into account. There is now the opportunity to combine economic stimulus packages and international cooperation programs with targeted investments in the energy-efficiency, renewable energy and environment sector stimulating growth and jobs. Such investments will move the needed transition to a low carbon economy forward. Chinese PM Wen Jiabao recently called upon developed nations to "alter their unsustainable lifestyle" while stressing that the slowdown in the global economy caused by the financial crisis should not be allowed to hamper efforts to deal with global warming.[4]

To ensure energy security and attain high, sustainable living standards for its people, China needs to develop and implement more resource and energy effective production practices than OECD countries currently apply. China has a large opportunity to become a leader in global sustainable development practices if the potential for innovation is handled correctly. The China Council (CCICED), the international advisory body to the Chinese government, notes "China has both the capacity and the need to become a global leader in sustainable development and innovation in environmental technology."[5] The speed and scale of economic development, with low production costs combined with enormous investment flows in new infrastructure and in research and development provides an unprecedented opportunity for mass-market production and implementation of low-carbon technologies and other sustainable solutions.

Rolling out a 'clean revolution' in China will require consistent enforcement of environmental regulations, incentive mechanisms, and strategic government investment and procurement policies. Such a framework is gradually emerging. The Chinese government goals of an effective, 'circular' and innovative economy translates into policy goals which already have had significant effect, such as the target to increase energy efficiency by 20 per cent in the period 2005–2010, cut discharge of main pollutants by 10 per cent, double the percentage of

renewable energy it uses from 8 to 15 per cent by 2015, and increase wind power generation fivefold from 2007 levels to 30GW by 2020.[6]

As part of its recent economic stimulus package, the Chinese government has launched its first nationwide sewage treatment program with a budget of $41 (€32.5) billion for the coming three years.[7] Another example of the increasingly comprehensive framework for promoting clean development is the State Forestry Administration's recent statement that the central government will enforce a compulsory carbon trading policy to realise the goals of turning China into a 'low carbon civilization'. The new policy would require provinces that emit more greenhouse gases than they absorb to buy emission quotas from less developed but ecologically healthier regions.[8]

China is already showing signs of becoming a world leader in renewable energy, with the largest hydro-electric power production and fifth largest wind power production in the world.[9] Baoding, the centre for development of renewable energy technology in China, exported renewable energy solutions worth $430 (€314) million in 2007, an increase of 95 per cent since 2006. Chinese renewable energy companies are currently doubling annual revenues, showing stronger growth rates than established international companies, and moving to become strong players in the future global renewable energy market.

Growth of Chinese renewable energy companies compared with international renewable energy companies ($ millions)

Sector	*Company*	*Turnover 2004*	*Turnover 2006*	*Turnover 2007*	*Growth 04-07*	*Growth 06-07*	*Country*
Wind power	HuiTeng	7.3	75	197	2 599%	163%	China
Wind power	GoldWind	-	192	375	-	95%	China
Wind power	Suzlon*	430.0	1 768	3 315	671%	88%	India
Wind power	Vestas	2 938.0	4 841	6 662	127%	38%	Denmark
Solar power	YingLi	1.9	251	508	26 637%	102%	China
Solar power	REC	189.0	677	1 137	502%	68%	Norway

Source: Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008. **Year end March 31st.*

It would be a win-win opportunity of enormous magnitude if the future growth of China could come from developing solutions that will save the planet. Moreover, the input of Western knowledge and commercial practises in the rapidly growing Chinese market for environmental goods and services will not only ensure technology transfer, but also spur further joint innovation, tackling environmental problems to the benefit of China and the world. Western commercial stakeholders engaging in the Chinese market will likely grow with the expanding Chinese market, and position themselves among the global winners in an emerging green economy of the 21st Century.

<u>The opportunities of $1.9 (€1.4) trillion to be invested in environmental solutions</u>

The market for environmental goods and services (EGS) in China is booming. Chinese government pollution control related investments rose by 35 per cent in the period 2004–2006 period, totalling $84.52 (€67.82) billion and constituting 1.22% of China's GDP.[10] UNEP estimates Clean Tech investments in China will increase 24% from 2007 to 2008, reaching $720 (€526) million.[11] The Chinese government plans to spend around $196 (€143) billion (1.35% of GDP) on pollution control from 2008 to 2010.[12] The US government estimates the clean technology market in China will reach $186 (€136) billion in 2010 and $555 (€405) billion in 2020.[13] New Energy Finance predicts that $398 (€291) billion-worth of investment in renewable energy will be needed by 2020 to the reach official goals.[14] The French company, Viola, currently estimates the market for pollution control technologies to be $800 (€584)

million, "with more to come".[15] This study estimates that EGS investments in China will reach between $1.5–1.9 (€1.1–1.4) trillion by 2020.

The rapidly growing EGS markets in China provide significant opportunities for Western companies. On the one hand, there are already massive investments and an across-the-board need for adaptation to best available technology in areas like pollution control, energy efficiency, biomass, solar PV, wind power and hydropower. In addition, there is a great need for advanced design, production and management systems. Within renewable energy, small-scale hydropower is a rapidly developing field that in 2006 saw installations totalling 6GW completed, as well as 4GW in large-scale hydropower in the same year. The market is open to foreign and private companies and provides significant opportunities for experienced stakeholders. Competition is still moderate, and at present, small-scale hydropower development is largely driven by strong government incentives for rural development. The official goal is to increase the capacity of small-scale hydropower from 40GW (2006) to 125GW by 2020.

Wind and solar power are examples of sectors where China has a large potential for ramping up production, cutting costs, and gradually developing next generation technologies. In spite of weak domestic incentives and market development, China is currently second only to Japan in terms of volume with a production of 820 MW in 2007; 90% is exported to the world market. Yet, there is still demand for Western manufacturing technology to ensure quality improvement across the sector and a broad platform for further innovation.

Wind power is booming in China, with an annual growth rate of 50 per cent over the last 10 years.[16] China is likely to become the biggest wind power market in the world in the near future. Still, the development of wind power is slow compared with its huge potential with the total installed capacity at the end of 2007 being less than 1% of the total exploitable potential. The Chinese wind power market provides significant opportunities as it is open to foreign investors and competition is still moderate. Nevertheless, Chinese wind companies have stepped up production levels and are now also engaged in turbine manufacture and off-shore wind development, illustrating the innovation potential in China's renewable energy sector.

Norway – prepared to fly with the Green Dragon?

China is Norway's most import trading partner in Asia, and since 2005 Norwegian exports to China have increased by almost 70 per cent (exclusive of crude oil). The main non-petroleum Norwegian exports to China are engineering products, fish, seafood, and chemicals. Norway's imports from China increased by 90 per cent between 2001 and 2006, with a growing proportion of advanced products such as computers, electronics and office equipment.[17] On a per capita basis Norway uses more than three times its equitable share of the world's resources (2005).[18]

The growing imports from China are part of a trend where Norwegian imports are increasingly being produced in developing countries without obligations for reduction of CO_2 emissions under the UN Kyoto Protocol. A recent study estimated that Norway's carbon footprint in China almost tripled in the period 2001–2006, as CO_2 emissions in China resulting from production of Norwegian imports reached an estimated 6.8 million tonnes (2006).[19] On average, Norwegian household consumption was responsible for nearly the same amount of CO_2 emissions in China as the average Chinese (3.2t. vs. 3.8t) that year. Meanwhile, Norway is currently discussing terms for a free trade agreement with China.

Norway has a long tradition of cooperation with China on environmental issues dating back to 1995, with a wide range of environmental projects in China having been funded by Norway. Historically, this cooperation has focussed on cooperation between Norwegian and Chinese government institutions rather than commercial cooperation.

An ambitious Norwegian policy towards China was announced by Norwegian Prime Minister Jens Stoltenberg at Tsinghua University in 2007. The Norwegian Prime Minister declared that "we stand on the threshold of a new, green economy" and announced that "together, we must explore every technological and business opportunity that promotes change."[20] A Norwegian 'China Strategy' was published later the same year focussing on increased commercial cooperation and noting that the Norwegian government shall "seek to integrate environmental, climate change and sustainable development concerns into all Norwegian efforts vis-à-vis China."[21]

Norway is a nation at the forefront of global environmental standards with an advanced energy-industrial complex providing a solid base for developing and profiting from a strong Clean Tech sector. Norway has a number of small and medium sized enterprises (SME) producing cutting-edge pollution control technology for which China has enormous demand. In renewable energy, Norway is a global leader in commercial investment in hydropower and solar energy technologies. Norway is also a leader in innovative carbon capture and storage technologies, deep sea off-shore wind development, and early stage solutions such as harnessing the energy generated by the meeting of freshwater and salt water ("salt-power").

This study shows, however, that Prime Minister Stoltenberg's vision and the aims of the China Strategy have so far not been followed up by concrete instruments and initiatives, and Norway is not currently exploring "every technological and business opportunity that promotes change." However, in spite of the significant potential, Norway is lagging behind other European countries regarding Clean Tech export and in promoting commercial cooperation with China.

Norway generally lags behind peers in terms of Clean Tech exports. In 2005, Norway's export of Clean Tech was estimated to be €0.8 billion, but 12% of Danish exports in the same year (€6.7 billion) and 28.5% of Swedish exports (€2.8 billion).[22] In contrast to Denmark and Sweden, where governments have consciously promoted development of the sector, Norwegian institutions currently do not provide statistics on status and development of the Clean Tech sector.

Studies also show that Norwegian companies have less advantageous conditions than their European peers for developing the Clean Tech export sector for emerging economies such as China.[23] Norwegian companies receive less government support for feasibility studies and estimating market entry potential in developing markets compared with companies in other European nations. Norway only provides Official Development Assistance funds for cooperation with China, unlike other countries which also provide funds aimed at promoting commercial cooperation. Finally, Norwegian companies are barred from making use of EU financial mechanisms promoting commercial engagement with China as Norway is not a member of the EU and has not established similar mechanisms for Norwegian companies.

The survey of Norwegian EGS companies in this report shows that none of the major Norwegian commercial stakeholders regarding low carbon development – for example StatoilHydro's renewable energy division, solar company REC, and hydropower company SN

Power (owned by Statkraft) – are currently active in China. On the one hand this reflects significant challenges related to the Chinese market compared with other investment options. For example, the large-scale hydro market is not open to foreign companies such as SN Power (although the rapidly developing small hydropower sector is). Nevertheless, the non-involvement of the most important Norwegian commercial EGS stakeholders shows that even though the government has emphasized bilateral cooperation with China on environmental issues for more than a decade, frameworks are not in place leading to engagement of the most important Norwegian commercial stakeholders and their substantial financial, technological and human resources.

The fact that the Norwegian government is a majority owner in several of the most relevant major Norwegian companies (e.g. StatoilHydro and Statkraft), makes the contrast between political goals and lack of large company engagement even more stark. The recent launch of a 'Nordic Climate Cluster' of 16 large Norwegian and Swedish companies aiming to provide low-carbon solutions in the global market provides an interesting platform for the Norwegian government engagement when working to implement its China Strategy.

The current Norwegian commercial engagement in China is fragmented and dominated by small and medium-sized enterprises (SMEs). Only in one field ("energy efficiency") do the companies currently involved in China report that the engagement is "significant" for the company. This reflects the fact that most Norwegian companies are relatively new to the emerging Chinese market and that China has not yet become established as a key market. This also indicates that the Norwegian companies are still in a vulnerable start-up phase and that the next five years will be crucial for consolidating and the further development of the Norwegian SME engagement. In this context, the Norwegian SME consortium NEEC appears innovative and constitutes a basis to build on and possibly expand to include other Nordic/European SMEs.

Finally, Norway has a significant impact on the Chinese market through its $394 (€249) billion sovereign wealth fund (SWF) "the Government Pension Fund" (GPF), which is based on petroleum revenues and is the second largest SWF in the world.[24] In November 2007, the GPF established an office in Shanghai in order to invest in and profit from the emerging Chinese markets. The GPF ethical guidelines are premised on the fund having two fundamental obligations: a) to ensure current and future generations of Norwegians favourable long-term returns, and b) to avoid investments that entail an unacceptable risk of the fund contributing to serious ethical violations including human rights violations and severe environmental damage.

At the end of 2007 the Norwegian SWF's holdings in China (mainland) in the energy sector comprised ten companies which are strongly engaged in coal power production or extraction. In addition there were investments in three oil or gas companies. There were no investments in renewable energy companies. Out of the 122 Chinese companies the Norway's SWF invested in 2007, only one is easily identifiable as a Clean Tech company.[25]

A recent study[26] also shows that GPF lags behind its peers – such as pension funds ABP (Dutch) and calPERS (California) – concerning the application of instruments for socially responsible investments. There are two main reasons for this: 1) the Norwegian SWF does not apply positive screening ("best-in-class") by sector in its investment portfolio something which contributes to develop best practises, and 2) GPF has not set up any thematic fund targeting investments in Clean Tech or the wider EGS sector in spite of the documented

financial viability of such targeting. In contrast, the China Investment Corporation SWF has announced that it will target investments in environment friendly technologies.

The above implies that the Norwegian SWF investments in China (mainland) in 2007 generally supported unsustainable development trends which contribute to severe detrimental environmental impacts.[27] The fund's investment practises in China in 2007 also ran counter to the Norwegian government's China Strategy where the Government aims "to integrate environmental, climate change and sustainable development concerns into all Norwegian efforts vis-à-vis China." Moreover, the opportunities to target and profit from investments in the growing Chinese Clean tech sector were not actively explored.

Recommendations

Given the urgency of the climate change and sustainable development challenges, and the significant market opportunities in the EGS sector, WWF recommends that all countries and stakeholders with human and financial resources in the field to engage strongly with China in the areas where they are leaders. Strategic Clean Tech engagement with China and other developing nations should be part of a new "Green Deal", where major investments in application and further development of clean technologies stimulate renewed global growth while continuing to advance the transition towards a more sustainable and low carbon economy.

Within such a perspective, the following recommendations are provided for Norway as an example of a country with human and financial resources to invest in a global sustainable development through EGS engagement with China:

In order to contribute to equitable sustainable development, Norway first of all needs to make a transition to a development model compatible with and supportive of global sustainable development. The Norwegian government should heed Chinese Prime Minister Wen Jiabao's recent call to developed countries to "alter their unsustainable lifestyle" and do more to help developing nations adapt to climate change.[28]

In order to position themselves strategically Norwegian companies with relevant solutions need to increasingly embrace and invest in the opportunities provided by emerging markets in a global economy making a gradual transition towards a more equitable and green economy in the 21st Century, by:

- factoring in global perspectives for the EGS sector in business strategies and development, such as China's fast-paced growth in the EGS sector, low cost and rapid production capacity, possibilities for large-scale pilot projects, and potential role as technology and innovation hub in years to come;
- applying and investing in long-term strategies for developing and profiting from emerging markets such as China, thereby benefitting from first-mover advantage;
- focusing more on innovation and tailoring solutions to demand, rather than export of existing solutions that frequently fail to effectively match developing countries' needs;
- encouraging SMEs to be particularly active in exploring and realizing potential for creating consortiums and common platforms in order to scale-up and become relevant in a global market.

Given Norway's expertise in pollution control and renewable energy, the Norwegian government should invest pro-actively in the development of the national EGS sector in order to reduce CO_2 emissions and enable Norway to become a global solution provider by:

- monitoring the development of the national Clean Tech sector and providing strategic support while learning from the experience of nations such as Denmark and Sweden;
- initiating a dialogue with the Clean Tech sector, investors and large business concerning the need for Clean Tech infrastructure in overseas investments in order to frame a larger Clean Tech sector initiative that includes removing legislative and regulation barriers;
- conceiving procurement policies and large-scale government projects with EGS tenders;
- launching Clean Tech R&D programs with business participation and establishment of innovation competitions and tenders;
- investing ambitiously in a transition from being a fossil fuel energy provider to becoming a renewable energy provider, with an immediate emphasis on the advanced hydropower sector, carbon capture and storage technologies, and off-shore wind development as locomotives for innovation.

The Norwegian government should also engage relevant companies in a dialogue on a stimulus package to promote global low-carbon development through ambitious private-public partnerships in selected fields, by:

- actively following up Hu Jintao's recommendation to "strengthen [Sino-Nordic] cooperation in new energy and environmental protection, especially in raising energy efficiency in the construction sector and in hybrid energy and clean energy development";[29]
- making use of its position as majority owner of major Norwegian energy companies to ensure that business strategies and investments contribute to addressing the global climate challenge while securing return on investment for shareholders;
- taking the initiative to inform large Norwegian companies about low carbon solutions and innovation potential in the Chinese market in order to establish a bridge and also entry points for SME innovative companies;
- exploring possibilities for Sino-Norwegian private-public partnerships where Norwegian companies have significant potential for contributing to large-scale implementation of low carbon technologies, such as hydropower, CCS, PV-industry and offshore wind. Given the currently limited Chinese interest in cooperation on CCS and the closed large-scale hydropower sector, offshore wind and PV-industry are fields of particular interest for exploring potential cooperation.

The Norwegian government should also support Norwegian SME export of EGS and provide incentives for transfer of technology, by:

- actively following up Hu Jintao's recommendation to "encourage [Sino-Nordic] technological cooperation between our small and medium sized enterprises, to set up platforms for them to increase business contacts, and encourage them to share distribution channels and jointly develop products";[30]
- creating support mechanisms and incentives for the sector on a par with other OECD countries, and launching further initiatives to make Norway a leader in the field, especially by providing frameworks and incentives for export to and cooperation with developing countries where the needs are largest and markets less mature;
- providing relevant financial programme information from international financial institutions, nation states and the European Union in a condensed format to the Norwegian Clean Tech sector.

The Norwegian government should also aim to set new standards for Free Trade Agreements in current negotiations with China, by:

- applying documented best practise for integration of environmental concerns and stimulating cooperation and innovation in the EGS sector;
- providing incentives for increased employment of (often advanced) Norwegian EGS solutions in China and (often low-cost) Chinese EGS solutions in Norway;
- taking the initiative to jointly develop a model methodology for measuring the carbon footprint and environmental cost of bilateral trade, which should also provide a mechanism to allow the corresponding flow of money to be invested in reducing environmental impact.

Finally, the Norwegian government should make Norway's SWF a financially sound driver for global low carbon development, by[31]:

- introducing positive filtration by sector thereby supporting best in class companies;
- developing mechanisms to ensure that Norway strategically invests in a transition to a more low carbon economy in China and other emerging economies, through "best-in class" screening and separate Clean Tech investment funds.

欲乘绿龙飞九天? 摘要

中国-保障实现全球可持续发展的关键所在

中国以其众多的人口、飞速发展的经济、对科发与基础设施建设的巨大投资、大规模的出口和巨额的军费开支,已成为正在崛起中的世界超级大国。然而,中国的发展模式正面临着挑战,其中最重大的挑战之一是,其环境恶化程度之严重、范围之广，正在威胁和瓦解着中国人民向更高水平福利社会跨越的进程。主要应归咎于经合组织国家的温室气体释放、而近年来更是由于新兴经济国的增排所造成的全球变暖，也威胁着几亿万中国人所急需的淡水资源。

中国所处的困境说明了,发展中国家如果照搬西方的发展模式,是不可能逐步达到西方国家的福利水平的。以目前的生产和消费形式,地球上没有足够的自然资源使发展中国家能够效仿西方国家的生活方式。到 2050 年,如果预计中的全球 90 亿人口仍要能够享受今天西方国家所拥有的生活水准,那么,我们就必需对利用自然资源方式和清洁技术行业进行突破性的革新。

为保障能源供应安全,为国民创造高度和可持续发展的生活水准,中国需要开拓和实施比经合组织国家当前所应用的更具有资源与能源效益的解决方法。如果中国能正确地把握其创新的潜力,则会为全球可持续发展提供无限的契机。中国政府的国际性顾问机构国合会(中国环境与发展国际合作委员会)这样评述道:“中国既能够也需要在环境技术可持续发展与创新过程中走在全球的前列。”中国经济发展的速度和规模,其低廉的生产成本与巨额资金流入基础设施建设以及研发领域的这种结合,都为低碳技术和其它可持续解决方案的大量生产和推广使用，提供了前所未有的机遇。

要在中国推行一场“清洁技术革命”,就必需要有富于连贯性而更为严格的法规、相关的激励机制、具有战略性的政府投资和采购政策。而包涵这一系列因素的框架正在中国初显雏形。中国政府发展高效、循环和创新经济的目标，已经转化为一系列具体的、已在贯彻执行中取得了显著成效的政策目标,例如从 2005 到 2010 年将能耗降低 20%,将主要污染物排放减少 10%,到 2015 年要实现可再生能源使用比例翻一倍,从 8%提升到 15%,和将 2020 年风电产量扩大到 2007 年水平的五倍，达到 30 千兆瓦。

中国政府在其新近出台的刺激经济方案中,纳入了为时三年、耗资 410 亿美元(325 亿欧元)的首个全国污水治理方案。为促进清洁发展而不断创建更为全面框架的另一个实例,是国家林业局近来关于中央政府将执行一项强制性碳交易的政策、以实现中国向“低碳文明”转化的目标的声明。这项新政策将要求温室气体排放多于吸收的省份,向相对落后但生态环境较好的地区购买排污权。

以其在世界上独占鳌头的水电总产量和第五大风能产量,中国已经在可再生能源领域中展现出世界领军者的姿态。中国可再生能源产业化基地保定 2007 年出口了价值 4.3 亿美元(3.14 亿欧元)的可再生能源技术设备,与 2006 年相比增加了 95%。中国的再生能源公司目前的收入逐年实现翻一番，其增长率高出同行业国际知名公司，并正在成为未来全球可再生能源市场上的强势参与者。

中国可再生能源公司营业额的增长与国际可再生能源公司的对比（美元）							
行业	公司	*2004 年营业额*	*2006 年营业额*	*2007 年营业额*	*04-07 增幅*	*06-07 增幅*	*国家*
风能	惠腾	730 万	7500 万	1 亿 9700 万	2599%	163%	中国
风能	金风	—	1 亿 9200 万	3 亿 7500 万	—	95%	中国
风能	苏司兰	4 亿 3000 万	17 亿 6800 万	33 亿 1500 万	671%	88%	印度
风能	维斯塔斯	29 亿 3800 万	48 亿 4100 万	66 亿 6200 万	127%	38%	丹麦
太阳能	英利	190 万	2 亿 5100 万	5 亿零 800 万	26637%	102%	中国
太阳能	ＲＥＣ	1 亿 8900 万	6 亿 7700 万	11 亿 3700 万	502%	68%	挪威

来源：Reinvang 和 Tønjum 所著《欲乘绿龙飞九天?》，世界自然基金会 2008 年出版 *3 月 31 日为年终

如果中国未来的发展能够建筑在开拓拯救地球的技术方案的基础上，其间产生双赢效应的可能性将是巨大无比的。此外，涉足于迅速扩大中的中国环保产品和服务市场的西方专业与商业群体，将不仅确保技术转让的实现，进一步加强合作创新，为中国和世界解决环境问题，而且，这样的西方利益相关方也会乘着中国市场扩展的东风而成长，并在 21 世纪的新兴绿色经济中跻身于世界群豪之列。

中国的市场、增长和创新潜力

中国的环保产品和服务市场正日趋繁荣。中国政府 2006 年对污染控制的投资与 2004 年相比增长了 35%，达到了 845.2 亿美元(678.2 亿欧元)，相当于中国 GDP 的 1.22%。据联合国环境计划署估计，中国 2008 年的清洁技术投资将比 2007 年增加 24%，达到 7.2 亿美元(5.26 亿欧元)。中国政府计划在 2008 到 2010 年，为控制污染而投入约 1960 亿美元(1430 亿欧元)(GDP 的 1.35%)的资金。美国政府估计，中国的清洁技术市场将在 2010 年达到 1860 亿美元(1360 亿欧元)，并在 2020 年达到 5550 亿美元(4050 亿欧元)。英国新能源财经公司预测说，为了达到官方的目标，2020 年中国开发可再生能源的投资需求量会达到 3980 亿美元(2910 亿欧元)。法国维奥拉公司目前估计，污染控制技术与产品市场的价值高达 8 亿美元，“而且会越来越高”。挪威创新署驻北京办公室，即挪威驻华大使馆的商贸处在本报告中估计，到 2020 年，中国的环保产品和服务投资将达到 15000 到 19000 亿美元(11000-14000 亿欧元)之间。

中国环保技术市场的迅速扩大为西方公司提供了大好的商机。一方面,中国具有通过调整以采用可获得的最佳技术(污染控制、提高能效、生物质、太阳能光伏、风能、水电)以及先进设计、生产和管理体系的全面需求，而且各方踊跃大力投资。在可再生能源领域里，小型水电站建设发展势头如雨后春笋，2006 年的累计装机容量达到 6 千兆瓦，而同年的大型水电站累计装机容量为 4 千兆瓦。这个市场对外国和民营公司开放，对富有经验的利益相关方而言是一个难得的良机。市场上竞争仍然有限，而且主要是由政府扶持农村发展的政策在带动其发展。官方的目标是，将小型水电站的容量从 2006 年的 40 千兆瓦提升到 2020 年的 125 千兆瓦。

在风能和太阳能这样的行业里，中国具有成倍扩大生产、降低成本和逐步致力于开拓下一代技术的巨大潜力。尽管国内的激励机制不够完善，市场尚未成熟，中国已经成为国际市场上领先的高质太阳能电池板生产国。然而，为了确保提高整个行业的质量，并为未来的创新构筑更为宽广的平台，中国对西方制造技术仍然有所需求。

中国的风能产业正在蓬勃发展。在过去的十年中，风能发电年增长率达到了 50%。中国很可能在不久的将来成为世界上最大的风电市场。然而，风能开发利用的速度相对潜

力而言仍然偏缓。截止 2007 年年底，全国风电总装机容量还不到可利用量的 1%。中国风能市场向外国投资者开放，而且目前竞争尚属平缓，可谓机遇四伏。中国的风能公司已经加大了风电生产的力度，当前还致力于先进涡轮机的生产和海上风能开发，充分显示了中国可再生能源行业的创新潜力。

挪威-欲乘绿龙飞九天?

以人均计算，挪威目前所占用的资源比对按世界资源公平分配所应得的要高出三倍。中国是挪威在亚洲最重要的贸易伙伴。自 2005 年以来，挪威向中国的出口增长了将近 70%(不包括原油)，其主要出口产品(不包括原油)为工程产品、鱼类、海鲜和化工产品。挪威从中国的进口从 2001 年到 2006 年几乎翻了一番（增幅 90%），其中计算机、电子产品和办公设备等高级产品的比重不断提高。

从中国进口的增长，是挪威进口产品越来越多地生产于不承担京都议定书规定的 CO2 减排义务的发展中国家这个趋势的具体表现之一。据新近的一项研究估算，中国为生产出口挪威的产品而排放了 680 万吨的 CO2(2006 年)，因而使挪威在中国的碳足迹比 2001 年增长了两倍。平均起来，每个挪威家庭的消费在中国导致的 CO2 排放量，几乎等于中国 2006 年的人均排放量（前者为 3.2 吨，后者为 3.8 吨）。目前，挪威正在就达成一项自贸协议的条件与中国进行谈判磋商。

挪威与中国的环境事务合作始于 1995 年，并有着深厚的传统。挪威从中资助了一系列的环保项目。这种合作有史以来一直偏重于挪中政府机构之间的合作，而不是商贸合作。

挪威首相延斯·斯托尔滕贝格 2007 年在清华大学演讲时，宣布了挪威的一项雄心勃勃的对华政策。首相声明道，“我们即将跨入一个崭新的绿色经济”，并宣布说“我们必须携起手来，共同探索每一个能够促成变革的技术和商业机遇。”同年晚些时候，挪威政府出台了一项“中国战略”，把重点放在了扩展经贸合作上，并声明说，挪威政府将“力求在挪方所有(对华)的活动中，都要渗入环保、气候和可持续发展的意识”。

挪威是一个具有先进环保标准和现代能源产业集群的国家。这就为清洁技术行业的崛起和创收提供了高技术的支撑。对一系列挪威中小企业所拥有的世界领先的污染治理技术，中国有着极大的需求。在可再生能源领域里，挪威的水电和太阳能经贸群体跻身于世界前列。挪威在碳捕集和封存技术的创新、海上风能开发和利用淡水和咸水接触所产生的物理化学能(盐差能发电)等前期技术方案方面，也占据着领先地位。针对中国积极开展清洁技术业务，是挪威政府在其中国战略中所作出的展望之一。

然而，本项研究表明，延斯·斯托尔滕贝格首相的远见和中国战略的宗旨，至今仍然没有得到落实而体现在任何具体的机制和举措中。挪威目前并没有在探索“每一个能够促成变革的技术和商业机遇”。尽管享有不凡的潜力，挪威在清洁技术出口和促进与华商贸合作方面，仍然落伍于其它欧洲国家。

在清洁技术出口领域，挪威普遍地要落后于其它同类国家。挪威 2005 年的清洁技术出口总额估计为 8 亿欧元，仅相当于丹麦同年同类出口总额(67 亿欧元)的 12%和瑞典出口总额(28 亿欧元)的 28.5%。丹麦和瑞典的政府都在有意识地推动和扶持这个行业的

发展，而与此相悖的是，挪威政府机构到目前为止竟然还不能提供有关清洁技术行业现状和走势的统计数据。

多项研究还显示，在针对中国那样的新兴经济国开拓清洁技术出口业务的过程中，挪威公司所享受的条件与其它欧洲同行业公司比较则相形见绌:在对市场准入潜力进行可行性研究时，挪威公司得到的政府资助少于其它欧洲国家的公司。挪威仅向与中国的合作提供官方发展援助基金，而不象其它国家，同时还拥有旨在促进经贸合作的其它类型的基金。最后，挪威公司无法利用欧盟为鼓励拓展与中国的经贸关系而设立的融资机制，因为挪威不是欧盟成员国，也没有为本国公司建立类似的机制。

本报告中对挪威环保产品和服务供应商的调查显示了，挪威在低碳发展过程中主要的经贸利益相关方中，例如国油海德鲁公司的可再生能源部门、太阳能公司 REC 和(国电公司所有的)水电公司 SN 电力公司，目前没有一个在中国开展业务。一方面，这就反映了相对其它的投资选择对象而言，中国市场仍然充满了挑战。 其中的一点是，大型水电站市场对 SN 电力公司那样的外国企业并不开放(但正在迅速发展中的小型水电站行业却对外开放）。即使如此，挪威最重要的环保产业利益相关方不问津中国市场的事实证明了，虽然挪威政府十多年来始终强调与中国进行双边环境合作，能够使挪威最有影响的产业利益相关方调动其浩大的金融、技术和人力资源进发中国市场的框架仍然没有到位。

此外，挪威政府是相关行业多家大型挪威企业(如国油海德鲁和国电)的多数股权股东这一事实，使其制定的政治目标与这些公司的缺乏务实和参与之间形成了更为鲜明的反差。而新近由 16 家挪威和瑞典大型企业组成的“北欧气候产业集群”，将致力于向全球市场提供低碳技术方案，反倒为挪威政府在未来落实其中国战略提供了一个富有意义的平台。

挪威目前在中国的经贸活动仍缺乏整体性和协调性，并由中小企业占据主导地位。仅仅在一个领域(能效)中，目前在中国开展业务的挪威公司汇报说，其业务规模“显著”。这就反映了多数挪威公司在中国这个新兴市场上尚属初生牛犊，同时，中国还有待于成为这些公司的主要市场。此外，这还说明了挪威公司仍然处在脆弱的起步阶段，未来的 5 年，将是挪威中小企业加固其市场地位和进一步提升其业务实力的关键的 5 年。在这种局势中，挪威中小企业自发团体“挪威能源与环境联合会”营造起了创新的氛围，成为吸引其它北欧/欧洲中小企业与之携手共进的一股凝聚力。

最后,价值为 3940 亿美元（2490 亿欧元）的挪威主权财富基金“政府养老基金”，对中国市场也具有重要的意义。这个基金建筑在石油收入的基础上,是世界上第二大主权财富基金。2007 年 11 月，“政府养老基金”驻上海办公室正式开张营业,以在蓬勃崛起的中国市场上开展投资和创造收益。挪威政府所声明的目标是,要将本基金办成世界上管理经营最佳的基金。挪威政府养老基金的道德准则是建立在以下两个基本义务上的:一）确保这一代和未来的挪威人获得长期的丰厚回报;二)避免包含不可接受风险的投资,使本基金不至于介入与严重违反道德规范的行为，包括与侵犯人权和严重危害环境相关的经济活动。

最近的一项研究表明，就为开展社会责任投资而运用适当工具而言，挪威政府养老基金落后于其它同类基金，例如荷兰的 ABP 养老基金和美国加洲的公共雇员养老基金

calPERS。其中有两个主要的原因:挪威主权财富基金在选择投资组合时，并不采用正面筛选的手段(所谓的“同类最佳企业”)在各行业中确认投资对象，而正是这种选择手段能够促进最佳商业行为的形成;而且，尽管实践证明主题基金投资具有财务可行性,挪威主权财富基金并没有在清洁技术行业有的放矢地进行主题投资。(而中国主权财富基金中投公司最近宣布，将针对环境友好型技术开展投资)。挪威主权财富基金在中国的这种投资实践，就导致了它实际上是在普遍支持严重危害环境的不可持续的发展势头。另外,对中国清洁技术行业进行投资和从中获益的契机被没有被积极地加以把握和探索。对中国清洁技术行业的投资还能够助长这个产业的发展，从中也为挪威和其他的国际供应商带来惠利。

推荐:

面对气候的急剧变化、可持续发展所提出的挑战和环保产品和服务市场所蕴涵的良好契机,世界自然基金会建议，所有在这个领域里具有人力和财力资源的国家和利益相关方，都能在自己具有领先优势的专业范围内，尽可能扩大在中国的业务和与中国的合作。与中国和其它发展中国家之间的战略性清洁技术合作,应当成为一项“绿色新政”的组成部分。这项新政应提倡为清洁技术的运用和深入开发大举投资,以此来刺激恢复全球增长，并推动世界在更可持续的轨道上向低碳经济转化的进程。

以此为出发点,对挪威这样一个典型的有能力将相当的人力和财力资源投入中国环保事业、从而推动全球可持续发展的国家，我们提出以下推荐:

为了向公平的可持续发展作出自己的贡献， 挪威需要实现向符合并支持全球可持续发展理念的一种发展模式的过度与转化。挪威政府应当响应中国总理温家宝最近发出的“发达国家应当改变不可持续的生活方式”的呼吁，为帮助发展中国家应对气候变化作出更大的努力。

为了占据战略性市场位置，以受惠于日益壮大的环保产业市场，拥有相关技术的挪威公司需要通过以下等方式，在向 21 世纪更为公平的绿色经济的逐步转化中， 把握和利用全球新兴市场所蕴涵的投资机遇:

- 越来越多地在商业战略和开发中纳入环保产业发展的全球性视角，例如中国在环保技术领域中的迅速增长、低廉的成本和快捷的加工制作、启动大型试点项目的可能性和在未来几年中成为技术和创新中心的潜力;
- 针对开发中国这样的新兴市场和实现预期收益,制定和采用长期的发展和投资战略，从而充分得益于先发优势;
- 更加重视技术创新，根据市场需求调整技术产品，而不仅仅是出口现有的、并非总是满足发展中国家实际需求的技术设备;
- 中小企业尤其应当积极探索和发挥结盟与构筑共同平台的潜力，以在全球市场上拧成一股绳，形成一定气候。

当今的挪威人占用着多于他们按世界公平分配原则而应得的自然资源。为了向公平的可持续发展作出自己的贡献， 挪威需要实现向符合并支持全球可持续发展理念的一种发展模式的过度与转化。既然挪威在污染控制和可再生能源领域拥有专长，挪威政府就应当通过以下等途径，为国内环保技术行业发展大胆投资,以实现 CO2 减排，使挪威成为全球清洁技术供应者:

- 学习借鉴丹麦、瑞典等国经验,密切关注国内清洁技术行业的发展，并提供战略性支持;
- 就清洁技术在国外投资所需的基础设施，与清洁技术行业、投资者和大型企业主动开展对话，为有力推动本行业发展创造条件，包括消除立法和体制方面的屏障;
- 制定采购政策，为大型政府项目设立环保产品和服务招标方案;
- 依赖于挪威先进的水电生产经验,以碳捕集和封存以及海上风能开发为技术创新的龙头，大胆投资,推动实现从化石燃料供应者到可再生能源供应者的过度。

挪威政府还应当就在某些专业领域里大胆采用公共部门与私人企业合作模式、旨在促进全球低碳发展的一项刺激方案，与相关公司进行对话。具体措施包括:

- 积极响应胡锦涛主席“深化（中国与北欧之间的）新能源和环境保护合作，特别是在建筑节能、混合能源、清洁能源开发等方面加强合作”的倡议;
- 利用其挪威主要能源公司多数股权股东的地位，来确保在使这些公司的商业战略和投资有助于应对全球气候变化的挑战的同时，也为股东创造价值回报;
- 发动拥有先进低碳技术和创新潜力的挪威大型企业在中国市场上开展业务，以为中小型创新企业的参与铺垫道路和提供切入点;
- 在挪威企业可以通过大规模推广其低碳技术而发挥重要作用的例如水电、CO2 捕集和封存、光伏产业和海上风能等领域里，探索采用中挪跨国式公共私营合作模式的空间。出于中国目前对 CO2 捕集和封存技术合作的兴趣有限， 而大型水电站行业对外关闭的现状，海上风能(和光伏技术)便成为一个值得探索的新合作领域。

此外，挪威政府还应通过以下等多种方式，支持挪威中小企业出口环保产品和服务,并为技术转让设立激励机制:

- 积极响应胡锦涛主席“鼓励（中国与北欧）双方中小企业加强技术合作，积极为中小企业搭建合作平台，共享销售渠道，合作开发产品”的倡议;
- 向其它 OECD 国家看齐， 为环保产业设立扶持和激励机制，尤其是为针对技术需求最为迫切而市场不够成熟的发展中国家的出口与合作，提供框架和创造优惠条件，从而使挪威成为这个领域的佼佼者;
- 用简短的篇幅，为挪威清洁技术行业提供国际金融机构、各国政府和国际联盟（欧盟）的融资项目信息。

挪威政府应当在目前与中国进行的自贸协议谈判中,运用以下手段，力求为自贸协议树立新的标杆:

- 应用已获证实的兼顾环境的最佳实践方法，激励环保产业内的合作与创新;
- 以政策导向鼓励在中国推广应用挪威（多为先进的）环保技术方案，在挪威推广应用中国（多为成本低廉的）的环保技术方案;
- 发起调研活动,共同建立一种碳足迹和双边贸易环境成本的典型测量和计算方法。其间还应当通过研究，建立允许相应资金流动的体制，以保障环保投资来源。

最后,挪威政府应当通过以下措施,将挪威主权财富基金打造成全球低碳发展的富有金融实力的推动者:

- 在确认投资对象时，对企业按行业分类后进行正面筛选，以此来支持同类最佳公司;
- 通过以上所述的正面筛选和建立独立的清洁技术投资基金,切实保证挪威以促进中国和其它新兴经济国向低碳经济的转化为宗旨而开展战略性投资。

Table of Contents

1 The Chinese dragon rising

The People's Republic of China is the largest country in East Asia and one of the largest in the world. With a population of over 1.3 billion, roughly a fifth of the earth's total population, it is also the most populous country in the world. It has the world's fourth largest economy and second largest when measured by purchasing power parity. China is a developing country ranking 81 on the UN Human Development Index. The rate of economic development over the last thirty years is unparalleled globally and historically. Since 1978, China's market-based economic reforms have helped to lift over 400 million Chinese out of poverty, bringing down the poverty rate from 53 per cent of the population in 1981 to 8 per cent by 2001.[32]

With its vast population, rapidly growing economy, huge research and infrastructure development investments, the world's growing dependence on low cost Chinese products, and its huge spending on the military, China is considered an emerging superpower. However, the Chinese model is faced with challenges, one of the most important being environmental degradation of a severity and scale that possibly is unparalleled globally – also historically.

1.1 The challenge of sustainable development

China's environmental challenges are numerous. Due to centuries of deforestation, over-grazing of grasslands, over-cultivation of croplands and – more recently – urban sprawl, the Gobi Desert is expanding by about 1,900 square miles annually and some reports estimate the 25% of China is now desert. Meanwhile, as much as 10 per cent of China's farmland is believed to be polluted. Two-thirds of China's approximately 660 cities have less water than needed, and 100 of these suffer severe shortages. Freshwater pollution is an enormous problem. The Yangtze River, stretching all the way from the Tibetan Plateau to Shanghai, receives 40 per cent of the country's sewage – 80 per cent of which is untreated.[33] Government figures show more than 70 per cent of waterways and 90 per cent of underground water supplies are polluted.[34] Air pollution is also a severe problem. The World Bank report "Cost of Pollution in China" (2007) estimated that 750,000 premature deaths per year are caused by respiratory diseases related to air pollution.[35]

The crisis is emphasised by the fact that China's natural resources per capita are low compared with the world average: farmland = 25%, forest area = 11%, grassland area = 30%, freshwater resources = 25%. In addition, the distribution of natural resources is quite imbalanced. Water resources are rich in southern and eastern China, and scarce in northern and western areas. The area suitable for habitation accounts for only 22 per cent of the total territorial area. These plains and basin areas constitute most of the farming lands but are also the main locations for the rapid urban growth and expansion of cities.

Furthermore, the problem of relatively limited access to resources is increased by a strikingly inefficient utilisation of energy and resources. According to the National Development and Reform Commission (NDRC), China's GDP has increased by a factor of 10 in the past 50 years while, at the same time mineral resource consumption has grown by a factor of 40. In 2006, in order to produce 5.5 per cent of the world's GDP, China burned 15 per cent of the world's coal consumption, and used 30 per cent of the world's steel and 54 per cent of cement.[36]

> *"To produce goods worth $10 000, we need seven times the resources consumed by Japan, almost six times the resources used by the U.S. and – a particular source of embarrassment – almost three times the resources used by India".*
>
> A Chinese official quoted in Der Spiegel, early 2006.
> (Excerpt from E. Economy: "The Great Leap Backward?", *Foreign Affairs* Sept/Oct 2007)

Several studies estimate that environmental degradation and pollution costs the Chinese economy between 8 per cent and 12 per cent of GDP annually.[37] The environmental crisis threatens to undermine the development towards higher welfare levels for the Chinese population.[38]

1.1.1 Climate change

China's environmental challenge must also be seen in relation to the climate change challenge. Authoritative reports by the UN and leading scientific publications estimate that a temperature increase in excess of 2° Celsius above preindustrial levels in this century, will negatively impact ecosystems and hundreds of millions of human beings.[39] China, with most of its population utilizing freshwater resources depending upon (now increasingly melting) Himalayan glaciers for its annual flows, is a country poised to be severely affected by increased global warming. While water-rich south and east China will probably see more extreme weather events with increasing rains and floods, the water-deprived west and north are poised to become even drier. Both Chinese and international scientists have warned that due to rising sea levels, Shanghai is at risk of becoming submerged by 2050.[40]

The UN Intergovernmental Panel on Climate Change (IPCC) suggests a reduction in Greenhouse Gas Emissions (GHG) of between 50 and 80 per cent by 2050 compared to 1990 levels if we are to avoid global warming of more than 2°C. Moreover, anthropogenic GHG emissions must peak and decline by 2015 in order to have a 50–50 chance of staying below +2°C.

China has a key role to play in this. China is now the world's largest emitter of CO_2 according to country (IEA 2007). On a per capita basis, however, CO_2 emissions in China in 2005 were only one third (35%) of those of the OECD.[41] Still, China shows huge regional differences illustrating the differentiated approach needed to address China's emissions. Heavy industry regions, such as Shanxi and Ningxia, show per capita emissions of 16.36t and 11.78t respectively in 2006. Shanghai is approximately at the same level as New York with emissions of 8.76t per capita, but much higher than Tokyo with approximate 5.25t per capita. Guangdong and Chongqing had average per capita emissions of 3.66t and 3.18t in 2006.[42]

The International Energy Agency (IEA) projects that China and India alone will account for more than 56 per cent of the projected global increase of CO_2 emissions 2005–2030.[43] With current trends, China's primary energy demand is projected to more than double during this period. Projected cumulative investments in energy supply infrastructure are estimated at 3.7 trillion year-2006 dollars during the period 2006–2030, three quarters of which goes to the power sector. Building a coal power plant with a 40-year lifespan effectively locks emissions for decades. The type of energy solution in which these funds will be invested will therefore decide future Chinese CO_2 emissions to a significant extent and the degree to which global warming is averted. Under the current trajectory, the use of CO_2 intensive coal in China is expected to grow rapidly and its share of total primary energy demand will with current trends stay high – at over 60 per cent in 2030.

The above data are part of IEA's "business-as-usual" scenario which will lead to a concentration of greenhouse gases (GHGs) in the atmosphere above the 450 ppm required for a 50/50 chance of keeping temperature increase below 2°C. If global warming of more than 2° is to be avoided, it will be of the highest importance that China realizes a low carbon development path.

1.1.2 Copying Western standards is not enough

Adopting the best environmental standards of the West will not be enough for China to solve its environmental crisis, as the Western development model itself is not sustainable. It is a key fact that there are insufficient natural resources on the planet for developing countries to emulate Western living standards with current forms of production and consumption.[44]

As an example, Norway is a top nation on the UN Human Development Index but still represents a fundamentally unsustainable development model. If every person on the planet was to consume the same quantity of natural resources as the average Norwegian does today, we would need 3.3 planets like the Earth to serve that need over time.[45] And if every country was to emit as much CO_2 per person as Norwegians (12t in 2007),[46] global warming would likely pass the +2°C threshold during the course of this century. Radical innovation is needed in the way we make use of natural resources and in the Clean Tech sector if it is to be possible for an estimated global population of 9 billion people by 2050 to experience living standards comparable to those of the West today.

There are not enough resources in the world for every Chinese and Indian to consume like Norwegians do.

In the *Living Planet Report 2008* by WWF, Global Footprint Network and the Zoological Society of London, the total bio-capacity of the world was estimated to 13.6 billion global hectares (g.h.) in 2005. On average, that translates into 2.1 g.h. per person if consumption is to be in line with the carrying capacity of the world's ecosystems and thereby sustainable in the long-term.

In 2005, the average Norwegian consumed 6.9 global hectares whereas the global average was 2.7 g.h. If the 2 billion (plus) people living in China and India were to consume similarly as did the Norwegians in 2005, we would need biological resources of more than 13.8 billion global hectares per year to serve that consumption. That overshoots the 13.6 billion hectares available for the *total* world population in 2005.

China's predicament illustrates the fact that developing countries will not be able to emulate Western welfare levels over time using the same development model as the West. To reach high and sustainable living standards, China must develop and implement more resource and energy-effective solutions than OECD countries currently apply.

1.2 Turning challenges into opportunities

As the world faces a financial crisis, it is a time to reconsider the framework for the global economy, and in that process taking also global challenges such as climate change into account. There is now the opportunity to combine economic stimulus packages and cooperation programs with targeted investments in the energy-efficiency, renewable energy and environment sector stimulating growth and jobs while advancing the needed transition to a low carbon economy.

UNEP recently launched a 'Green Economy Initiative', suggesting that mobilizing and re-focusing the global economy towards investments in clean technologies and 'natural infrastructure' such as forests and soils will provide the basic restructuring needed to combat

climate change while triggering an employment boom and securing sustainable growth in the 21st Century.[47] Chinese PM Wen Jiabao recently called upon developed nations to "alter their unsustainable lifestyle" while stressing that the slowdown in the global economy caused by the financial crisis should not be allowed to hamper efforts to deal with global warming.[48] US president-elect Barack Obama recently confirmed his campaign pledge to invest $15 billion a year in clean technology, stating: "This investment will not only help us reduce our dependence on foreign oil, making the United States more secure. And it will not only help us bring about a clean energy future, saving our planet. It will also help us transform our industries and steer our country out of this economic crisis by generating 5 million new green jobs that pay well and can't be outsourced."[49]

China provides not only a challenge for global sustainable development but also an immense opportunity if the innovation potential is handled correctly. The speed and scale of economic development, with low production costs combined with enormous investment flows in new infrastructure as well as research and development over the next twenty years, provides an unprecedented opportunity for mass-market production and implementation of low-carbon technologies and other sustainable solutions. The very scale could, in fact, transform the global economy, as countries jostle to gain a leading competitive position in the race to provide the low carbon, sustainable solutions of the future. It would be a win-win opportunity of enormous magnitude if the future growth of China could come from developing the solutions that will save the planet.[50]

1.2.1 China shows leadership

While China's environmental challenges are daunting, there are encouraging signs and trends addressing the potential for innovation and developing a new and more sustainable economy. First of all, the fundamental problem is increasingly recognized by the Chinese government which is crystal clear as to what it considers to be the remedy.

As summed up by President Hu Jintao in Stockholm June 2007:

> *We will continue to follow the scientific thinking on development that is people-oriented and calls for comprehensive, balanced and sustainable development. We will adhere to the basic state policy of resources conservation and environmental protection. We will pursue a new type of industrialization, adjust the economic structure, speed up changing the pattern of economic growth and boost our capacity for innovation. We will work vigorously to develop a circular economy and build a resource-conserving and environment-friendly society.*[51]

The government goals of an effective, 'circular' and innovative economy translate into policy goals which already have significant effect, such as the target to reduce energy intensity by 20% in the period 2005–2010, cut discharge of main pollutants by 10%, double the proportion of renewable energy it uses from 8% to 15% in 2015, and increase wind power generation fivefold from 2007 levels (which already exceeded the original 2010 target) to 30GW by 2020.[52]

There are signs that the government's environmental standards are starting to have effect. Enforcement of tougher environmental standards has helped reduce pollution during the first six months of 2008, China's Minister of Environment Zhou Shengxian announced November 2008. Zhou reports declines in chemical oxygen demand (a measure of water pollution) of 2.5%, and sulphur dioxide of 4% over the preceding year. In the period, 335 projects passed

environmental evaluations, and 104 projects, involving ¥304 billion ($46 billion) of investment, were rejected or postponed due to potential environmental problems.[53]

China's State Forestry Administration recently announced that the central government will enforce a compulsory carbon trading policy "to realise the ambitious goals of turning China into a low carbon civilization." The new policy would require provinces that emit more greenhouse gases than they absorb to buy emission quotas from less-developed but ecologically healthier regions. Environmental observer Wu Bing noted: "Political leaders no longer treat global warming and pollution as an excuse to get money and technology from developed countries. They have realised no one will save China's environment but the Chinese themselves."[54]

China is already the leading renewable energy producer in terms of installed generating capacity, with the largest hydroelectric fleet and fifth largest wind power fleet in the world.[55] In 2007, China ranked second for the absolute dollar invested in renewable energy with over US$12 billion, just behind the leading nation, Germany, which invested US$14 billion.[56] China is also becoming a world leader in expenditure on Research and Development (R&D), behind the US and the EU, but recently overtaking Japan,[57] indicating that China soon will be able to not only copy developed technology but also develop the next generation of technologies, for instance low carbon development. With increasing innovation and the incentives of an environmental crisis and climate change vulnerability, China may well become the provider of the new solutions and low carbon development paths.

The Chinese city of Baoding in Hebei province provides an interesting example.[58] Baoding National New & Hi-Tech Development Zone is recognized by the Chinese government as the industrial base for development of renewable energy in China. In the last three years Baoding's GDP increased annually by 14 per cent, encouraged by the expanding renewable industry, reaching $199 (€145) million in 2007. Baoding China Electricity Valley (CEV) is a cluster area for Chinese clean-tech companies and a strategic platform linking new energy manufacturing industry with policy and financial support, research institutions, as well as social service systems. Baoding CEV has six major industries: wind power industry, photovoltaic and solar power industry, electric power transmission and transformation and automation industry, new-type energy accumulation industry, high-efficiency energy saving industry, and biological material power industry. Baoding is also center for research and development of offshore wind in China, implementing a R&D program which is part of the largest national R&D program under the Chinese Ministry of Science and Technology.

Table 1: The Development of Baoding China Electricity Valley 2006–2007

Baoding China Electricity Valley	2006	2007	Growth
Tax income from CEV	¥1 030 million	¥1 700 million	61%
CEV exports	$220 million	$430 million	95%
Total production value	¥11 200 million	¥17 500 million	64%

Source: Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

Baoding's leading renewable energy companies are HuiTeng, which has around 50 per cent of the Chinese market for wind blades, and YingLi, which produces PV solar panels mainly for the global market. From a very limited production in 2004, HuiTeng and YingLi have burst ahead to reach annual turnovers in 2007 of $197 (€144) million and $508 (€371) million respectively, more than doubling from 2006. YingLi is set to double again, with a turnover of $1.2 (€0.8, ¥8.2) billion for the first 10 months of 2008. Total exports from Baoding CEV also doubled (95% increase) from 2006 to 2007, reaching $430 (€314) million. Chinese

renewable energy companies are currently showing stronger growth rates than established international companies and moving to become strong players in the future global renewable energy market (ref. Table 2).

Table 2: Growth of Chinese RE companies compared with international RE companies.

Growth of Chinese renewable energy companies compared with international renewable energy companies ($ million)							
Sector	*Company*	*Turnover 2004*	*Turnover 2006*	*Turnover 2007*	*Growth 04-07*	*Growth 06-07*	*Country*
Wind power	HuiTeng	7.3	75	197	2 599%	163%	China
Wind power	GoldWind	-	192	375	-	95%	China
Wind power	Suzlon*	430.0	1 768	3 315	671%	88%	India
Wind power	Vestas	2 938.0	4 841	6 662	127%	38%	Denmark
Solar power	YingLi	1.9	251	508	26 637%	102%	China
Solar power	REC	189.0	677	1 137	502%	68%	Norway

Source: Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008. *Year end March 31st.

Thomas L. Friedman: China Greening (Reporting from Guangzhou, Guangdong Province).

You are starting to see the emergence of Chinese clean-tech companies [-] and real environmental awareness among officials and students. [-] In recent years, fossil-fueled energy has become expensive, exhaustible and toxic, and rising wages – to some extent because of rising environmental considerations and social security requirements – have meant that the workshops of Southern China are no longer the low-cost producers of Asia. Vietnam and Western China now beckon.

The only way forward, say officials, is for China to gradually develop a cleaner, knowledge-based, service/finance economy. [-] In short, the economy here has to become greener and smarter. [-] The problem for the ruling Communist Party is this: China can't have a greener society without empowering citizens to become watchdogs and allowing them to sue local businesses and governments that pollute, and it can't have a more knowledge-intensive innovation society without a freer flow of information and experimentation. What surprised me is how much the Party is thinking about all this.

I actually came her at the invitation of Wang Yang, the Communist Party Secretary, i.e. the head of Guangdong Province. [-] Wang is also a member of the Politburo in Beijing and is considered one of the most innovative thinkers in China's leadership today. He has been given room to experiment and has begun advocating something he calls "mind liberation" [-]. Right now he is focused on trying to shift dirty, low-wage manufacturing out of Guangzhou to the countryside, where jobs are still scarce. And he is trying to attract clean industries and services to the city. His goal, he said, was a more "low carbon economy."

"Please put in your column that Party Secretary Wang Yang welcomes [Western] clean energy technology companies to come to Guangdong province and use it as a laboratory to develop their products," he told me. "We will be most willing to participate in the innovation and provide the services they need."

So my postcard from Guangzhou would read like this:
"Dear Mom and Dad. This place is so much more interesting than it looks from abroad. I met wind and solar companies eager for Western investment and Chinese college students who were organizing a boycott of an Indonesian paper company for despoiling their forest. An 'Institute of Civil Society' has quietly opened at the local Sun Yat-sen University. The Communist Party is trying to break the old mold without breaking its hold. It's quite a drama. Can't wait to come back next summer and see how they are doing…"

Excerpts from column in International Herald Tribune, September 1 2008.

1.2.2 The global community needs China to succeed

It is of global interest that China succeeds in realizing equitable, sustainable, low-carbon development. Firstly, the effect of China not succeeding in implementing new low-carbon solutions will be felt globally in the form of escalating global warming. Secondly, if China succeeds in developing and providing sustainable energy solutions large-scale while simultaneously lifting hundreds of millions out of poverty, China will present a path to be emulated by the rest of the developing world. And thirdly, China has the potential for mass-market production of low cost low-carbon technologies that can help OECD countries to reach *their* CO_2 reduction targets in a cost-effective manner – for instance the production of LED lights, electric cars, or wind turbines – as the OECD countries adapt to a more equitable one-planet economy. In a gradual global transition to a low carbon civilisation, all economies are transition economies. The starting points of OECD countries and China are different and their comparative advantages are different, but their ultimate interests are the same – a stable world economy within the environmental limits of this planet that can ensure long term welfare for all.

When the Chinese government unveiled a 62-page climate change plan in June 2007, it promised to put climate change at the heart of its energy policies but also insisted that developed countries had the responsibility to take the lead in cutting greenhouse gas emissions – referring to the "common but differentiated responsibility" principle agreed on in the UN agreements on climate change. It also called for transfer of technology to developing nations in accordance with Kyoto Protocol commitments, commenting that "We have heard a lot of thunder but have yet to see the rain".[59]

Ahead of the IPCC negotiations in Poznan, Poland, November-December 2008, the Chinese government has called on developed countries to contribute 1% of their GDP to a fund that would help developing nations adapt to the challenges of global warming. Chinese PM Wen Jiabao has also called upon developed nations to "alter their unsustainable lifestyle" while stressing that the slowdown in the global economy caused by the financial crisis should not be allowed to hamper efforts to deal with global warming.[60]

Beijing advises west to step up climate efforts
"It took developed countries several decades to solve the problems of saving energy and cutting emissions, while China has to solve the same problem in a much shorter period. So the difficulty is unprecedented," Mr. Wen said at a United Nations-sponsored conference in Beijing on climate change. "Developed countries shoulder the duty and responsibility to tackle climate change and should alter their unsustainable lifestyle," he said. *Excerpt from "Beijing advises west to step up climate efforts, Financial Times Nov 8, 2008.*

China tells rich states to change
Mr. De Boer, executive secretary of the UN Framework Convention on Climate Change, also said richer nations should pay more to tackle the problem. "If international technology transfer happens, countries like China will be able to take action which is not affordable to them at the moment," he said, speaking at the same conference as the Chinese premier. He urged developed countries to speed up the transfer of these technologies. *Excerpt from "China tells rich states to change", BBC News Nov. 8 2008.*

In the 21st Century, boosting cooperation with China on developing and mainstreaming the markets for environmental goods and services is a win-win endeavour: for China ensuring continued growth while tackling the severe environmental crisis; for a partner country's knowledge- and commercial milieus wishing to remain competitive and grow with one of the main trends of the 21st Century, and for the whole planet – and especially the world's poor – facing the threat of increased global warming.

2 The markets for EGS in China towards 2020

2.1 A rapidly growing market setting new standards

The markets for environmental goods and services in China are growing rapidly, reflecting the immense environmental challenges faced by the Chinese community and the increasing focus and investments in solving these problems.

In 2006, according to official statistics Chinese pollution control related investments increased by 35% in the period 2004–2006, totalling $84.52b (€67.82) and constituting 1.22% of GDP. Although this is not a complete picture of investments made in China in order to further a cleaner environment, it illustrates the level of investments, focus areas and the general trend in official spending.

Table 3: Chinese pollution control related investments 2004 - 2007 (CNY(¥)100 million). ** Not announced*

Chinese pollution control related investments 2004 - 2007 (¥100 million)	2004	2005	2006	2007
Urban Environmental Infrastructure	1141.2	1289.7	1314.9	1467.5
• Gas supply	148.3	142.4	155.0	160.1
• Centralized heating	173.4	220.2	223.6	230.0
• Drainage works	352.3	368.0	331.5	410.0
• Gardening and Greening	359.5	411.3	429.0	525.6
• Environmental sanitation	107.8	147.8	175.8	141.8
Environmental Pollution	308.1	458.2	483.9	*
• Waste water	105.6	133.7	151.1	*
• Waste gas	142.8	213.0	233.3	*
• Solid wastes	22.6	27.4	18.3	*
• Noise pollution	1.3	3.1	3.0	*
• Other pollution	35.7	81.0	78.3	*
Environmental Investment for New Projects[I] (sub-cat: New Projects, Expansion, Tech. Improvement)	460.5	640.1	767.2	*
Total Investment ¥ (100 million) = 6863.8 (2004-06)	**1909.8**	**2388.0**	**2566.0**	**n.a.**
USD (100 million) = 845,17 (2004-06)	***231.10***	***291.86***	***322.21***	**n.a.**
EUR (100 million) = 678,17 (2004-06)	***186.01***	***235.41***	***256.75***	

Statistics: Table 11-45, China Statistical Yearbook 2008, China Statistics Press 2008. Average annual exchange rates: www.oanda.com .
Reinvang & Tønjum, "Prepared to Ride the Green Dragon?", WWF 2008.

2.1.1 A positive showcase for the world: The Beijing Olympics 2008

In 2007, the Beijing Environmental Protection Bureau invested $3.3 (€2.4b) billion in pollution control measures. The director, Mr. Shi Hanmin, also noted that Beijing spent Chinese Yuan (¥) 120 billion on pollution control 1998–2007, with the annual investment rising sharply from ¥5.4 billion in 1998.[61]

Under the Beijing Sustainable Development Plan, China launched 20 projects to improve the quality of Beijing's environment for the Olympics, with an overall investment of $12.2 billion. The city ordered coal-burning power plants to reduce emissions and moved 200 heavily-polluting factories out of the city, established new wastewater treatment plants, solid-waste processing facilities, and green belts and set up a fleet of clean buses for the Olympic Games.

[I] This category refers to the so-called "three simultanities" rules, which require environmental protection facilities to be designed, constructed and put into operation simultaneously with the main body of a construction project.

Beijing also phased out ozone-depleting substances ahead of schedule, made use of water- or air-source heat pump systems to save energy in Olympic stadiums, introduced solar power technology and replaced 47,000 old taxis and 7,000 diesel buses, and began to acquire vehicles to meet EU emissions standards. In addition, natural gas (use of which has risen tenfold), geothermal, and wind power are gradually beginning to replace coal. Much of Beijing is now covered by trees, bushes, and lawns—a radical departure from the past—and before the Games Beijing set up 20 natural reserves to protect forests, wild plants, animals, wetlands, and geological formations.

Despite concerns over Beijing's air pollution, the UNEP environmental review report of the Beijing Olympic Games (2007) considered that the 2008 Olympics would be one of the most environmentally-friendly ever. The Games also provided a positive showcase for duplication of especially the variety of clean energy and energy-saving solutions being employed.[62] Greenpeace China noted that "China has launched impressive green policies in the run up to the 2008 Beijing Olympics", but also added that crucial opportunities to kick start ambitious environmental initiatives across the city were missed and that best environmental practices were not always applied.[63] Greenpeace pointed out that the authorities "could have more aggressively enforced pollution controls on industry, pursued a zero-waste policy, adopted Forest Stewardship Council (FSC) certification on all new construction and comprehensive water conservation policies."

2.1.2 New billion dollar/euro markets

The last decade has seen the mushrooming of tens of thousands of new Chinese companies exploring and developing the growing low-carbon markets, creating a whole new generation of "low carbon entrepreneurs".[64] UNEP estimates that Clean Tech investments in China totaled $580 million (€424 million) in 2007, and is likely to total more than $720 million (€526 million)[65] in 2008.[66] The Chinese government plans to spend more than $193 (€143) billion (1.35% of GDP) on pollution control 2008-10, mostly on reducing water and air pollution.[67] The French company, Viola, currently estimates the market for pollution control to $800 (€584) million, "with more to come".[68]

According to the Climate Group (quoting Google Finance), China's six largest solar photovoltaics (PV) manufacturers had a total market value of over $15 billion (€9.6b) by July 2008. Most of these companies did not exist 10 years ago. Other rapidly growing markets are: the solar water-heater market, which is worth over $2 billion (€1.3b) per year, and which is growing at 20 per cent annually, currently employing over 600,000 thousand people in China; the energy efficient compact car market, which was worth over $50 billion (€36.5b) in 2007; and the electric bicycle market, which was worth over $6 billion (€4.4) in 2007. China's leading wind turbine manufacturer has a rapidly rising market value of over $6 billion (€3.9).

> "This latest report shows that it [i.e. the low carbon economy] is not just a niche market for rich countries, but rather that – with their cost advantages and abundant abatement opportunities – investment in low carbon solutions can be equally, if not more profitable, job-creating and socially beneficial in developing nations. China in particular has embraced this opportunity, once again showing that moving to a low carbon economy is consistent with growth, development and energy security objectives."
>
> The Climate Group: China's clean revolution, 2008.

2.2 Investments in EGS up to $1.9 (€1.4) trillion towards 2020

Looking to the future, we see that massive investments are expected for all kinds of environmental goods and services, from wastewater treatment to renewable energy, spurred by stricter regulation and goals set by the government. Based on various sources in a not very transparent market, we estimate that at least US$1.5–1.9 trillion (€1.1–1.4 trillion) will be invested in environmental goods and services in China towards 2020. This does not include effects of the recent ¥4 trillion economic stimulus package launched by the Chinese government. Part of the package is the first nationwide sewage treatment program of $41 (€32.5) billion over three years.[69] It is still unclear, however, how much of this package is additional funds compared with already planned investments.

Table 4: Estimation of investments in EGS in China towards 2020 (in $).

Market	Expected Investments	Period	Annual Average Market Potential
Renewable Energy	265.0 billion	2008-2020	22.00 billion
Pollution Reduction	80.0 billion	2008-2010	40.00 billion
Energy Efficiency			
• Old buildings	325.0 billion	2008-2020	27.00 billion
• New buildings	600.0 billion	2008-2020	50.00 billion
Water Supplies and Wastewater Treatment	250.0 billion	2005-2015	25.00 billion
Aggregated total EGS investments China 2008-2020 = $1.5*-1.944 trillion *Aggregated total in Euro (€):€1.1*-1.4 trillion*			**$162 billion** *€118.4 billion*

**Taking into account potential overlap in categories. $ to € exchange rate = 2007 average. Based on available estimates Spring 2008.*[70]
Reinvang & Tønjum, "Prepared to Ride the Green Dragon?", WWF 2008.

Precise estimates of future investments are notoriously difficult to make. In addition, definitions of "environmental good and services" and the possibly narrower term "Clean Tech'" are not standardized, something which provides multiple options when identifying and aggregating relevant numbers. The number above does not, for instance, include projected investment of $240 billion (€175.4b)[71] in railroads towards 2015.[72] Recent estimates by the US government predict that the clean technology market in China will amount to $186 billion (€136b) in 2010 and $555 billion (€405b) in 2020.[73]

Investments in environmental goods and services in China towards 2020 will probably be even higher than the above estimates as new needs, solutions and possibilities are identified. New Energy Finance predicts that $398 billion (€291b) of investment in renewable energy will be needed by 2020 to the reach official goals, a number far above what has been used in the table above.[74] Moreover, the potential for the EGS sector in China to grow in conjunction with China becoming an exporter of low carbon solutions to the global market is tremendous.[75] If Clean Tech export becomes a stronger part of China's official growth strategy, national and foreign investments will likely significantly surpass these estimates.

2.3 The market for renewable energy

The low-carbon market in China is booming, leading some analysts to use language such as "China unleashes clean revolution."[76] In a recent overview study, the Climate Group notes that China is, or soon will be, the leading manufacturer of various critical low carbon technologies. China is, for instance, currently a leading manufacturer of solar photovoltaic technology, with 820 Megawatts of production at the end of 2007, second only to Japan. China's wind power installation increased by some 120% in 2007. The Global Wind Energy Council announced in early 2008 that China will become the world's leading manufacturer of wind turbines by 2009. China is also competing for, or taking the lead in the production of

other critical renewable and low carbon technologies such as solar water heaters (holding 60% of the global market), energy efficient home appliances and rechargeable batteries.

This section summarizes main trends related to renewable energy in China with notes on the market situation. An overview is provided in Table 5.

Table 5: Renewable energy in China: Targets and competitive situation

Source	Capacity 2006	Target 2010	Target 2020	Competitive Situation
Hydropower	130 GW	190 GW	300 GW	Large scale: National control, large energy groups. Small scale: Moderate competition, international presence.
Wind	2.6 GW	10 GW	30 GW	Strong international presence, moderate competition.
Solar PV	0.08 GW	0.3 GW	1.8 GW	Strong national and international presence; Rapid-growth industry; Additional supply and technology needed.
Solar Thermal	100 M m²	150 M m²	300 M m²	Strong national competitive industry.
Biomass Power	2 GW	5 GW	30 GW	Fragmented and young developing industry; need for technology.
Biomass Pellets	~0	1 Mt	50 Mt	Fragmented industry, need for technology.
Ethanol	1 M tonnes	2 Mt	19 Mt	National control.
Bio Diesel	0.05 M tonnes	0.2 Mt	2 Mt	National control.

Reinvang & Tønjum: "Prepared to Ride the Green Dragon?, WWF 2008.

2.3.1 Hydropower

Hydropower is well-established as a sector in China, being the main green electricity source, accounting for 6% of the market. According to estimates, less than a third of China's hydropower resources are currently being utilised. Hydropower accounts for half the ¥2 trillion ($265 billion) the Chinese government expects to be invested in renewable energy towards 2020.

The Chinese hydropower industry is divided into two main sectors:

- On-grid large-size hydro power stations (85 GW capacity, 2006)
- Off-grid small-scale (50MW or less) hydro power stations for local (mostly rural and remote, mountainous areas) communities (ca. 40 GW capacity, 2006).

Large hydropower capacity is scheduled to increase to 175 GW by 2020. The large-scale hydropower industry is government-controlled and dominated by a number of well-established, large state-owned groups. More than ten of these companies are listed on the national stock exchange, and the majority operate on a national scale. These large state-owned companies operate across the value chain, both constructing and operating hydropower plants and also owning subsidiaries that cover business activities such as design, engineering, construction and power generation. This is a maturing market segment and Chinese hydropower companies are starting to also engage in international activities.

Small-scale hydropower capacity is planned to increase to 125 GW by 2020. The power generated by small-scale hydro facilities supplies electricity to nearly 50 per cent of the geographical area of China, and is consumed by a quarter of the population. Small

hydropower plays an important role in powering China's poorer rural areas, with more than 45,000 plants having been installed across the country.

The market segment for small-scale power installations has shown the strongest growth in recent years. In 2006, small hydropower installations with a total capacity of 6 GW were completed, whereas the large hydro projects installed reached a total of 4 GW. Small-scale hydropower is a market that is open to both private and foreign companies. The involvement of foreign companies in the sector remains limited but several independent power producers are engaged in the market.

Government incentives for rural areas have been driving the growth of the small-scale hydropower industry with investments of approximately 30 billion ¥ each year in recent years. This investment trend is expected to continue as the State Electrification Development Plan continues to be implemented towards 2010. The Chinese government has also launched a series of programmes to promote small-scale hydropower development, such as "Sending Electricity to Villages", "Replacing Firewood by Electricity" and "400 Rural Electrification Counties". China is becoming a significant arena for small-scale hydropower, accounting for 39% of the worldwide capacity under construction (2004).[77]

Considering the stage of market development, more opportunities are to be expected for Western companies in the small-scale hydropower industry. Here, private and foreign companies are allowed to enter the market, both as investors and suppliers, thereby facilitating the possibility of broader market integration across the value chain. Sales of Certified Emission Reductions (CER) under the Clean Development Mechanism of the Kyoto Protocol, will generally increase the number of financially viable hydropower projects.

2.3.2 Notes on wind power

China has huge wind power resources. Data collected from meteorological stations in China indicate that the exploitable and utilizable potential wind resources on land are approximately 253 GW, and off-shore potential to be 750 GW. In total, China has a potential wind power market exceeding 1000 GW.

The wind power sector is booming in China. The China Wind Power Report 2008[78] notes that by end of 2007, the total installed capacity of wind power in China reached 6.04 GW with annual growth rate of over 50% in the past 10 years. China ranked the tenth in the world in 2004 in terms of installed capacity; in 2007 it had risen to fifth place. Furthermore, China is likely to become the biggest wind power market in the world in near future. If the current growth rate is maintained, the target of 10GW for 2010 is likely to by the end of 2008. Yet, the development of wind power is still slow in China. Total installed capacity was only 6 GW at the end of 2007, less than 1% of the total exploitable potential.

The areas with rich wind resources in China are the south-east coastal areas and islands, the northern parts of China (North-east, Northern China, North-west) and certain inland locations. In addition, China also has rich offshore and inland wind resources. These include:

- Coastal areas and islands. The coastal areas and islands are about 10 km wide along Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong and Guangxi with energy density above 200 W/m2, similar to coastal line wind energy density.
- Northern parts of China. The northern parts of China are about 200 km wide including the three North-east provinces, Hebei, Inner Mongolia, Gansu, Ningxia and Xinjiang. The energy density is from 200 W/m2 to 300 W/m2. In some areas, the density can

exceed 500 W/m2 such as in Alashankou, Dabancheng, Huitengxile, Huitengliang of Xilinhaote and Chengdengweichang.

- Inland. The density is below 100 W/m2, but can be much higher in some lake areas or areas with special geographical features.
- Off-shore areas. Eastern parts of China have wide sea areas with seawater depth from 5 meters to 20 metres, but the technically exploitable potential is reduced by the impacts of sea routes, ports and sea food feeding. Offshore wind resources are, however, rich in Jiangsu, Fujian, Shandong and Guangdong. These places are close to load centres and are likely to be the centres of offshore wind power in the future.

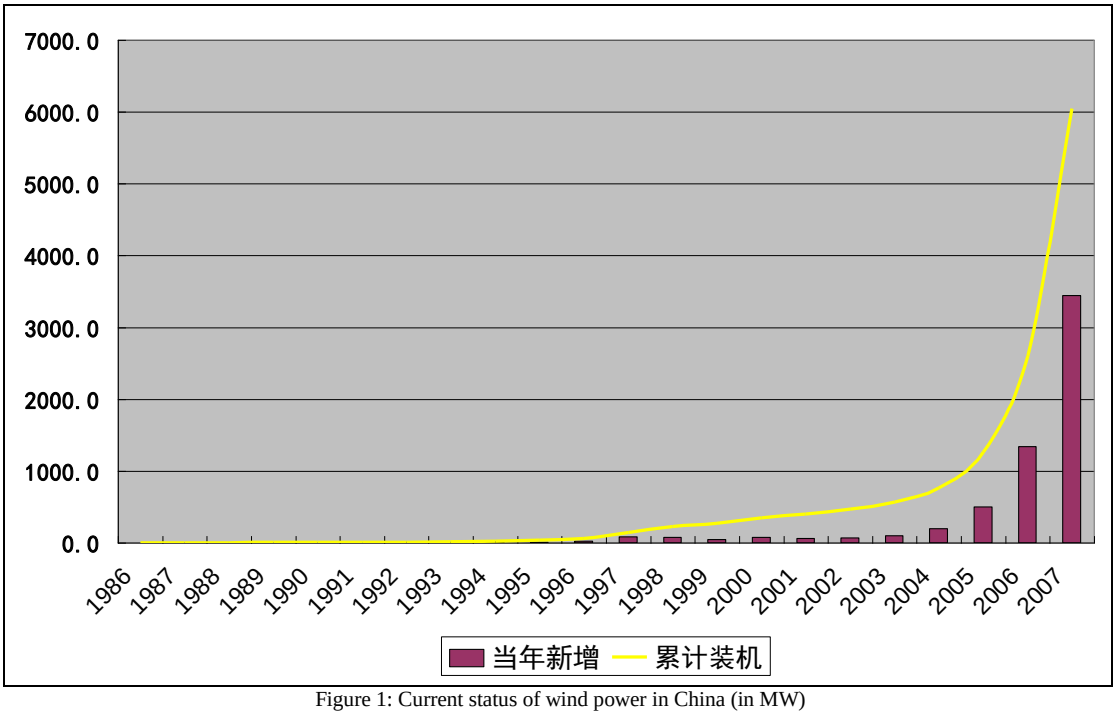


Figure 1: Current status of wind power in China (in MW)
Source: China Wind Power Report 2008, CREIA and WWF.

Since 2003, China has held public tenders for wind farm projects with the practice of allowing the investor to obtain 25-year project authorization for utilizing the wind power technology investment. Normally, the bidder with the lowest price will win the tender. Since 2006, the government states that the bidder should include turbine manufacturers as co-investors. This regulation has boosted the development of domestic wind-turbine manufacture and many Chinese energy groups have won tenders. In May 2008, the government introduced tax rebates in the form of VAT and import duty refunds on core wind power turbine parts and materials in a move to further promote the development of the sector.

The recognized leader in the Chinese wind power market is the Longyuan Electric Power Group Corp., part of the state-owned enterprise Guodian Group, which in 2007 had annual output of 350 GWh. Longyuan EPGC owns nearly one-third of China's wind power installation capacity.[79] The wind farm developers are mainly Chinese state-owned power generation companies. Another company, China Shenhua Group, has entered into a joint venture with Hong Kong-based China Wind Power Group to facilitate development in the wind farm area. In 2006, China had 91 operational land-based wind farms with a total of 3,311 wind power turbines deployed in 16 provinces and municipalities.

The first offshore wind park is currently under development in Shanghai Donghaidaqiao, and which is planned to be connected to the grid in 2010 with a production of 100 MW. The project is being carried out by Shanghai Electric Power, Datang Electric Group (one of the five national power companies) and China Guangdong Nuclear Power Group. Off-shore wind parks are also under planning in Shanghai Fungxian, Shanghai Nanhai, Xingshui in Jiangsu province and Cixi in Zhejiang province.[80] The China National Off-shore Oil Corporation (CNOOC) in 2007 started a trial project for offshore wind power generation to provide electricity to oil platforms in Bohai Bay.

Among wind power generator equipment companies, there are few Chinese producers. Xinjiang GoldWind holds approximately a 35 per cent market share. Zhonghang (Baoding) HuiTeng Windpower Equipment Co. holds about 50 per cent of the market for wind blades in China. Foreign companies or Sino-foreign joint ventures represent sixty per cent of the manufacturing market, as Chinese manufacturers lag behind regarding technology. Well-established foreign equipment suppliers such as Vestas, Gamesa and Suzlon, have set up wholly-owned foreign invested plants in China[81] The Global Wind Energy Council announced early 2008 that by 2009 China will become the world's leading manufacturer of wind turbines.

The rapidly developing wind power market in China is open to, and interesting for, Western companies. Sales of Certified Emission Reductions (CER) under the Clean Development Mechanism of the Kyoto Protocol, will generally increase the number of financially viable wind power projects. Chinese turbine manufacturers still lack knowledge and competency in constructing turbines above 1 MW capacity. In addition, key components such as bearings, vanes, gearboxes, and generators for large projects are imported. Companies with advanced machine technology, expertise in manufacturing and commissioning key components, and know-how related to design and operation of wind farms, will have substantial opportunity to gain a share of the rapidly growing wind power generation market.

2.3.3 Notes on solar energy

China has a significant national solar energy industry with a strong export focus, even though the Chinese solar power market is small. It can be divided into two areas of industrial application: the solar thermal utilization industry and the photovoltaic (PV) industry.

China is a leading manufacturer of solar PV technology with 820 Megawatts of production at the end of 2007, second only to Japan. The manufacturing industry has shown continuous rapid expansion and more than doubled its production capacity from 2005 to 2006, and from 2006 to 2008 (380 MW to 820 MW). However, only a small percentage was actually sold inside China, reflecting the small Chinese market and how the Chinese solar cell industry is strongly export driven.

While China is playing an increasingly important role in providing PV products to the world, the market in China for PV products is small and growing slowly, restrained by lack of government incentives to accommodate the high production cost. The cost of solar electricity is currently 10 times higher (4–5 ¥/kWh) than coal generated electricity (0.5 ¥/kWh). This is a major challenge for the growth of the national solar energy market which requires technological advancements in both utilisation of raw material and energy transmission efficiency levels.

The Chinese PV industry is dominated by crystalline solar cell production. There is, however, an increasing focus on development of thin-film solar cells which is expected to provide a unit cost of 1 ¥/kWh by 2010.[82] As production costs decrease, large-scale desert power plants will become more interesting. In the *China Solar PV Report 2007*, Li Junfeng and Wang Sicheng estimate that if 1 per cent of the desert area in China is used to install solar cells, the total capacity for this type of solar power could be 1000 GWp, illustrating that current common estimates for China remain conservative.[83]

A national programme started in 2002 to secure electric power for remote townships in West China stimulated the beginning of an increasing growth trend. The market remains small, however, as PV grid connected power generation systems remains very limited. The market for village electrification is seen to represent growth in the short term whereas the development of urban grid-connected solar power generation is planned to grow more in the longer term. China has set development objectives for the Chinese solar power market to reach a total 1.8 million kWp installed capacity by 2020. Compared to goals set in other world markets (Table 7), this cannot be regarded as ambitious and it is not having much effect in developing the national solar industry.

Table 7: PV Installed Peak Capacity Estimates (GWp) in world markets

Year	2004	2010	2020
Japan	1.200	4.80	30.0
Europe	1.200	3.00	41.0
US	0.340	2.10	36.0
China	0.065	0.30	1.8
Others	1.195	3.80	91.2
World Total	4.000	14.00	200.0

Li J. & Wang S., China Solar PV Report, China Environmental Science Press, 2007.

With the lack of favourable government pricing incentives for solar energy, cost-effectiveness measures are in high demand. Western companies with leading manufacturing technology which can be used in the fields of equipment and material supplying, technology to transfer, and direct investments have entry points in the export-oriented and rapidly developing Chinese PV industry. Improvements in production technologies for polycrystalline silicon and advancements of the manufacturing process are key focus areas for the future success of the Chinese PV industry. Any technologies and equipment that are used indirectly in the PV production process that help to improve cost-effectiveness face bright opportunities.

China also has a tradition of solar water-heating for industrial, commercial and domestic use. In 2006, China held a 64 per cent share of the total world market, with an export value of US$50 (€40) million and exporting to more than 50 countries throughout the world.[84] The market is saturated with over 3000 solar water-heater manufacturers, and industry focus is on efficiency in manufacturing as well as innovation to improve the converting efficiency. Future business potential may exist for companies that see opportunities in this field for improving the cost-effectiveness of solar water-heating systems.

2.3.4 Bio-energy

China commenced R&D into the use of biomass for energy as early as 1958. This expanded in the 1970s and 80s when the Chinese government introduced the methane generator from 6 million digesters to the rural farming population as a step in modernisation. By the end of 2006, total capacity of bio-energy power generation reached 2.2 million kW.[85]

There are several means by which biomass energy has been developed in China. The most widely-practiced means of utilization of bio-energy resources is to substitute fuels and other primary resources such as coal or natural gas for power generation by methane for civil or domestic use in rural areas. The methane is generated based on treatment of agricultural, animal or human waste. By mid-2007, over 25.38 million households nationwide – equal to 10 per cent of China's households engaged in farming activities – had been facilitated with their own methane generators producing energy for household cooking and heating. In addition, more large-scale methane generators at breeding farms are also being built. In 2007 alone, 750 breeding farms were equipped with this system which also aids in the provision of a more circular agricultural practice and stimulating ecological farming as methane marsh dregs and liquid can be used as fertilizer.[86]

Biofuels feature strongly in China, with China being the third largest ethanol producer in the world, and with plans to produce 12 million metric tons of low carbon fuel per year by 2020.[87] China has begun converting an area of marginal land half the size of the United Kingdom into biofuel forest, hopefully easing the competition between biofuels and grain crops that has contributed to food price increases.[88] A number of fuel-gas supply stations powered by thermal decomposition and gasification of biomasses have also come into operation in order to explore the centralized options of utilizing biomasses. By the end of 2006, 602 centralized gas supply stations utilizing straw gasification (coal gas) were established in rural areas in China. An additional 180 new stations had been built by mid-2007.[89]

Investment in the straw-fuelled power generation plants has begun to increase. Fifty projects have been authorized, of which 38 were approved by the government in 2006. Seven of them are now operational, supplying electricity to the grid.[90] The challenge of securing steady straw supplies at a cost that can compete with the on-grid electricity price may explain partly why these projects are developing at a slower pace. Energy experts are evaluating the environmental feasibility and commercial benefit of such bio-energy plants, and there is a need for further technological development.

Regarding the competitive situation, the biomass market is fragmented into Chinese energy groups running pilot projects, smaller regional Chinese manufacturers, and foreign-owned companies. Project developers such as the China Energy Conservation Investment Corporation, which built two biomass (straw-firing) power plants partly financed by CERs, are also engaged in this market.[91] Within the field of ethanol fuel the market is strictly government controlled with the National Development and Reform Committee administering four Chinese companies supplying ethanol fuel to PetroChina and Sinopec.[92] The panel below provides two examples of companies operating in this market segment with very different areas of activities, illustrating the variety of market players.

Profile of Two Selected Bio-energy Companies in China	
Beijing Shenzhuo Daxu Bio-Energy Technology Company Ltd. o Founded in April 2005 by Mr Pan Shijiao o 2006 turnover – approx. £0.6 million o In 2007 reached 160 employees o Develop and commercialise improved biomass stoves that are used for cooking. Some models incorporate a back boiler for hot water and central heating. o Straw briquettes or crop residue instead of coal give a cost saving of 50% as well as a reduction of over eight tons/year of CO^2. o By March 2007 had sold 25,000 stoves o Production capacity of 100,000 stoves/year from 5 factories o Market potential; annual sales of 20 million wood and coal stoves sold each year in China[93]	**China Power, Inc** o Fully owned by China Holding o Founded in 2002 by Ms. Julianna Lu and registered on NASD OTC BB o A development stage company that engages in projects via M&A or Joint-Venture Partnerships o Aims to become a globally leading renewable energy holdings company o By 2013 aims to have a pipeline of bio-mass and hydropower energy projects totalling potential power capacity of 3200 MW o By March 2008 had total potential of 320MW in Development portfolio o Five biomass energy projects in the pipeline, each representing a 50MW Biomass Power Generation Plant. o Each project is done in close cooperation with the local provincial government to secure resources needed o Aim to use world leading biomass energy technology such as CAPS-II [94]

Regarding future market potential, it is clear that the raw material is available. China has a sizeable farming community and the main types of agricultural waste include straw and stalks, with annual output of approximately 700 million tonnes, of which 300 million tonnes are utilizable for energy generation, equal to 150 million tonnes of standard coal. It is also estimated that industrial organic waste water and waste water resources in livestock and poultry farms can produce methane equivalent to 57 million tons of standard coal.[95]

The goal of the government is to increase the total capacity of bio-energy to 30 million kW by 2020. This represents a growth of 600% on today's levels and requires major market investment and technological development. Technological innovation and new, high efficiency methods of using bio-energy will be the key success factor in order to realize the goal.

The needs of the Chinese bio-energy sector provide opportunities for Western companies. Although China has had a market for biomass energy for several centuries, it now has a need for more efficient generators. Technologies that generate energy from non-food sources such as cattle waste or sewage waste will also be of interest to the Chinese market. The development of large-scale power generation plants that can supply the national grid profitably and have a secure and continuous raw material supply is currently a challenge that requires further development. Also, modern biomass generators can have an efficiency level of 30–40% versus rural generators that can have an effect as low as 2–5%. Introducing more efficient ovens will be of benefit in resource use as well as turnover generated from rural farming.[96]

2.4 Energy efficiency

Energy efficiency achievements in China – a snapshot by the Climate Group

The energy intensity of the Chinese economy has dropped by over 60% since 1980. Moreover, China has targeted a further 20% reduction between 2006 and 2010. Fossil fuels still provide 80% of China's power, but by replacing small and inefficient power stations with high efficiency super-critical technology, China hopes to avoid approximately 37.6 million metric tons of CO2 emissions every year.

The Chinese Government has also put in place an ambitious monitoring, benchmarking and control system for China's 1,000 largest energy-consuming companies, between them responsible for 33% of national energy usage. The programme stipulates that these companies must reduce their energy intensity to accomplish an overall energy saving of 100 million metric ton standard coal equivalent (over 833 million Megawatt-hours) by 2010.

Beyond its traditional reliance on bicycles and public transport, China is now introducing measures to limit oil consumption from its growing motor vehicle fleet, implementing fuel efficiency standards for cars 40% higher than those in the USA, although still lagging behind those in Europe and Japan.13 China has also succeeded in scaling up a range of low carbon transport technologies; over 21 million electric bicycles and 1.64 million energy efficient compact cars were sold in 2007, and domestic hybrid and electric vehicle technologies are progressing rapidly.

In addition to the overarching 20% energy intensity reduction target and the 15% renewable energy target, a comprehensive set of complementary regulations have been developed covering almost every sector of China's economy. Fuel economy standards (see above) were issued in 2005; one of the world's most comprehensive mandatory energy efficiency testing and labeling standards for home appliances was implemented the same year; a tax of up to 20% on gas guzzling SUVs was introduced in 2006 while compact cars are only taxed at 3%; strict building efficiency design codes have been introduced which will cut energy consumption of new buildings by 50%; and China's Renewable Energy Law, which also came into effect in 2006, mandates that the power grid purchase renewable power, giving subsidies for wind and biopower projects.

Across power, efficiency and transport, China has frequently taken the route followed by most countries focusing policies on new buildings, factories, vehicles or products, instead of replacing or retrofitting old ones, which is a more complicated and expensive approach. For this reason it will take several years to see the full effect of the initiatives which have been introduced. Many opportunities still exist for China to further speed up the phase out of older technologies. Another qualifying factor, when considering the data presented in this report, is level of implementation. It is inevitable that some companies will evade the system.

However China's clear improvement in energy intensity to this point indicates that it has been as successful in overcoming resistance to new efficiency policies as any country. For example, China's energy intensity has recently shown two consecutive drops, of 1.79% in 2006 and 3.66% in 2007. As more Chinese companies and products begin to comply with the new regulation, China will face the continuing challenge of monitoring and ensuring compliance, encouraging innovation and continually pushing up standards to best-available technology.

The Climate Group: "China's clean revolution", 2008 (executive summary).

Improving energy efficiency is an inevitable measure in tackling energy constraint challenges and simultaneously realizing environment protection targets. Following strong growth in energy consumption, mainly stimulated by the rapid development of the energy intensive industrial sector, the Chinese central government announced in its "Plan for Medium- and Long-Term Energy Conservation" that it will focus on energy saving in the industrial sector, in the transportation and construction industries, and in commercial and civil power use. The

panel below outlines the ambitious program that will aid China as it reaches its goal of reducing energy intensity per unit of GDP by 20 per cent during the period 2005–2010.[97]

China Central Government
Announced Program Focus for Energy Efficiency Measures in the 11th Five-year Period (2006-2010):

1. Upgrade of approx. 500,000 coal-burning industrial boilers (kilns)
2. Local cogeneration with combined heat and power systems
3. Make use of exhaust heat and pressure
4. Save and replace petroleum with through introducing alternative energy
5. Energy conservation in electrical motors by improving efficiency
6. Optimise energy system in major intensive energy industries
7. Energy conservation in buildings to be improved by 50%
8. Environment-friendly lighting systems that can make 70-80% power saving
9. Energy conservation focus in governmental departments
10. Capacity building of energy monitoring centres

The government's programme is ambitious but struggles to show productivity gains against the explosive growth in the Chinese heavy industrial sector as well as growth in electricity use by the commercial and private sectors. However, in 2007 China's energy intensity declined by 3.66%.[98]

In October 2007, President Hu Jintao emphasised that the government would carefully foster the adoption of energy efficient technologies through central government initiatives such as financial incentives, but also through the evaluation of local governments' ability to stimulate energy efficiency improvements in their jurisdictions. [99]

2.4.1 Energy efficiency in the industrial sector

The industrial sector in China is energy intensive and has driven the growth in overall energy consumption over the last 10 years by 80 per cent. In 2006, it accounted for 71 per cent of total energy consumption, amounting to 246.2 million tons of standard coal equivalent.[100] China's industrial energy efficiency has improved since the 1980s, but compared with developed countries, its efficiency is still lagging behind world levels.[101]

Over the last decade China has developed a rapidly growing commercial Energy Service Company (ESCO) industry. The industry in China has grown from just three ESCOs in 1998 to more than 200 in 2006.[102] ESCOs implemented over 400 energy conservation projects in 16 provinces in 2006 with a total investment of US$280 million; investment levels in 2007 are expected to be double that amount.[103] If the Chinese firms do not have a strong technological advantage, they have a clear competitive advantage in their low cost manufacturing abilities which have been found to be 80 per cent lower than similar plant production costs in the US or the EU.[104]

China has a significant need for and an increasing commitment to energy efficiency improvements. Expertise in relation to energy efficiency for industrial applications will be in strong demand across most industries of China over the next decade. The key market drivers underlining this growing market potential include the following:

- Cost of energy and power tariffs continue to rise. During 2007, the price of Chinese thermal coal used to produce electricity jumped by over 10 per cent and this continued to increase by another 15 per cent in the first half of 2008.[105]
- The elimination of export tax rebates for 553 energy-intensive industries put in place by The Ministry of Commerce during 2007 means an additional cost to end-user prices. [106]

- The competitive landscape gets tougher as market oversupply in several heavy industries means they are not able to push the higher overheads on to customers.

The changing business environment means it is clearly in the commercial interest of factories in energy intensive industries to focus on reducing the cost of energy consumption in order to remain competitive.

Considering the low cost of Chinese-made energy efficient technologies, knowledge in energy efficiency that assists the solving of particular energy efficiency challenges will be mostly of interest to Chinese industries. Western consultancies in this area will have good business opportunities in China to transfer the knowledge to Chinese customers on a commercially viable basis. Already, Norwegian expertise in energy efficiency in the ferroalloy industry and other relevant metallurgy sectors has gained the attention of Chinese industries.

2.4.2 Energy efficiency for public & commercial buildings

China currently has over 43 billion square meters of floor space in existing buildings, yet energy-efficiency measures have been implemented for only four per cent (primarily for heating), thus illustrating the emerging nature of this market in China. In 2007, there were 11 "green cities" and 140 "green buildings" under construction in China, but few met international standards for low energy use, recycled water systems, and "intelligent" integrated design and materials. Although China cannot claim to be at an international technological level, this has stimulated the work for a national standard to support investment in green building practices for the whole supply chain, incorporating construction parts, materials and knowledge.[107]

Regarding the competitive situation, the Chinese construction and real estate development market is complex and the number of enterprises is steadily increasing. In 2006 there were 60,166 construction enterprises and 58,710 real estate developers, of which approximately 15% had foreign ownership.[108] The market for energy efficiency and green buildings is slowly moving into a more clearly defined market, driven also to some extent by the market where high-end customers and businesses are starting to push for more sustainable construction. Traditionally, buyers have been typically more concerned about location, design, or neighbourhood than environmental variables when selecting buildings. Historically, enthusiasm for "green" buildings was dampened by the higher construction cost, on average ¥100–200 more per square meter than a standard building.[109]

With Leadership in Energy and Environmental Design (LEED) slowly being implemented as the preferred method for certifying green buildings, a segment for construction of green buildings is starting to emerge in the Chinese market. LEED was first used in China in 2004 for the construction of the Ministry of Science and Technology in Beijing. It uses 70 per cent less energy and 60 per cent less water through integrating highly efficient shells and windows, a roof garden storm water system, and a combined cool thermal storage system.

Regarding the market potential, the growth in the property market is rapid. China is currently constructing 2 billion square meters a year, equivalent to one-third of Japan's existing building area.[110] The number of households is increasing steadily. The strongest development is expected to be in urban households with an estimated growth of 94% in 2000–2020 to +250 million.[111] China's floor space per capita is also expected to increase from 25 m² to 38m² by 2020.[112]

In general, it is estimated that 40 per cent of energy use is derived from buildings and the absolute figure is rising fast. As income rises and generates a demand for more spacious housing, the penetration of energy-consuming appliances is also expected to rise. The annual growth in energy demand is anticipated to be 7.1% for commercial sector buildings, and 4.1% for the residential sector. The growth is stimulated not only by the increasing use of electrical appliances, but by also by a switch to the use of more energy-intensive appliances. According to a McKinsey Global Institute report, if the residential sector takes advantage of currently existing technologies that pay for themselves, an energy saving of 21 per cent is expected, illustrating the sizable potential in this market. [113]

The market is being increasingly encouraged through government incentives, and there is an aim to decrease energy use on all new construction by 50 per cent before 2010, and by 65 per cent before 2020.[114] Together with the development of national standards to support local green building practices, it is hoped that these are steps will stimulate the development of a "green supply chain" of construction parts, materials and knowledge.

There is clearly a large market potential for the introduction of new construction and energy efficient technologies and products that can provide both old and new buildings with more sustainable systems. However, since China is a latecomer in energy conservation in the construction sector, international players need to share their technology with domestic counterparts, as well as educating the market. Already proven and well-established technology and commercially feasible solutions are clearly of interest to the Chinese market.

Western technologies will be able to contribute to designing energy-saving buildings, supplying products to the management or operation of the buildings as well as knowledge transference to the Chinese architects and real estate developers. Western companies may also offer interesting green building technology within the area of water-saving systems and sanitation as well as good insulation products that should be of interest to the Chinese market if produced at local cost. Norwegian certification bodies and consulting firms already enjoy a good reputation within Chinese industry. Their expertise in improving energy efficiency through knowledge transference, competency building and project management should see good opportunities in this market.

2.4.3 Transportation and city planning

Transportation is the third area of energy demand that is growing by 6.3% a year, driven by the continued strong growth in vehicle sales of 23% between 2000 and 2005 From 26 million vehicles in 2003, the total is estimated to increase to 120 million by 2020.[115] Chinese vehicle and engine emission standards are based on European regulations, but often adopted with a certain time delay. For example, Euro III came into effect on January 1, 2000 in the EU whereas similar emission standards came into effect on December 30, 2005 in Beijing and from July 1, 2007 for the whole of China.[116] Beijing and Shanghai have adapted Euro 4 standards for light duty vehicles from 2008, whereas the rest of the country will follow this standard from 2010.

China has introduced a pilot program in the use of bio-fuels such as ethanol. In 2006, 1.02 million tons of fuel ethanol was produced using grains. This was distributed throughout 9 provinces and over 100 cities nationwide as ethanol-blended gasoline.[117] Recently, the Chinese National Development and Reform Commission (NDRC) urged Chinese carmakers to cooperate in making electric cars and suggested that "incapable" carmakers leave the

industry.[118] NDRC also revealed that the central government is considering ways to assist the industry, including subsidies to explore new technology and raising the consumption-tax for large petrol-engine vehicles.

The enormous and rapid growth in transportation industry is causing a headache in China's major cities as traffic flow becomes severely congested. As well as improved engine emission controls, city planning and public transportation is in severe need of improvement in many cities..

2.5 The Clean Development Mechanism (CDM) market

The development of the greenhouse gas emissions trading market has meant the rise of a whole new "industry" in China. The prospect for generating additional funding from sales of Certified Emission Reductions (CERs) has resulted in a wide range of greenhouse gas emission reduction projects that otherwise may not have been realised now being put into effect. When looking at the CDM pipeline, China is currently the world leader in terms of CERs issued as illustrated in Figure 2.[119]

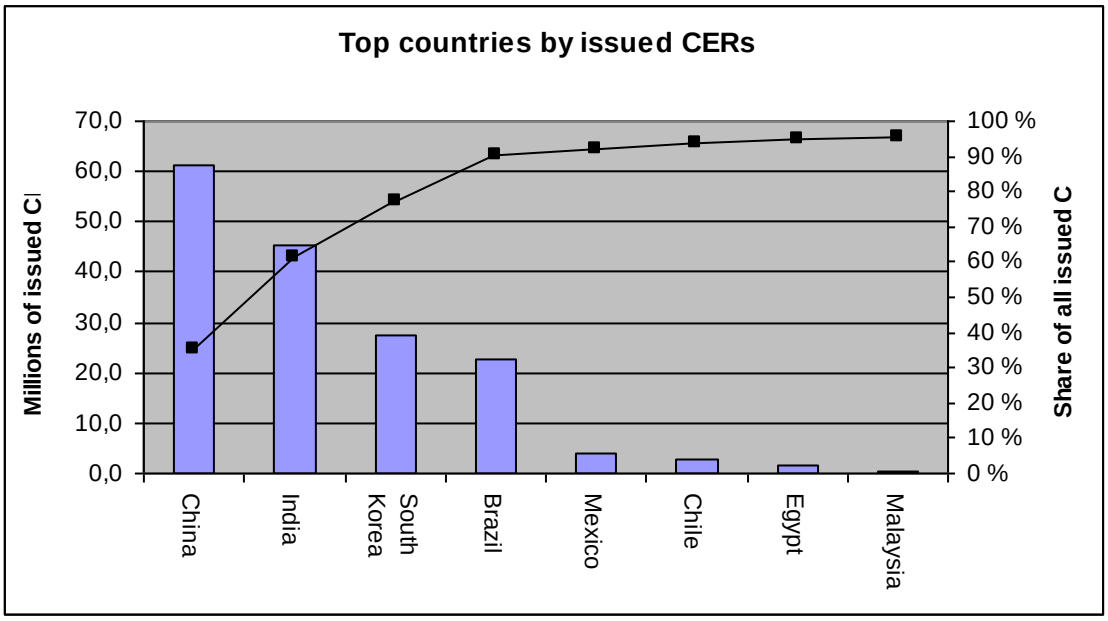


Figure 2: Top Countries by Issued CERs with accumulated % of world total.
Source: UNEP Risøe Centre, CDM pipeline overview, 1 May 2008.

China has seen a rapid growth in registered CDM projects, especially since late 2006 and as of May 2008 has a solid pipeline with 895 projects under validation and a total of 202 registered projects. The Chinese government has established its own CDM website, run by the Office of National Coordination Committee on Climate Change where all approved projects and purchases are published.[120]

Revenues from CERs generated in China shall be shared by the government of China and the project owner according to the type of emission reduction in question. For priority areas such as renewable energy, energy efficiency and forestation/reforestation projects, the government takes 2%; for N_2O projects, 30%; and for HFC (hydrofluorocarbons) and PFD (perfluorocarbons) projects, 65%. This group includes potent greenhouse gases such as methane. The revenue collected from CER transfer benefits will be used for activities addressing climate change through a state owned CDM fund created for this purpose.[121] The World Bank and The Asian Development Bank will also contribute to the fund.

Regarding the competitive situation, the market for CDM consulting and project development in China has a fair number of Chinese as well as international players. It is a young market and no company has so far gained a dominating role. The way of engaging in the CDM process may also vary, something which contributes to further fragmentation in the market. There are currently some 30 Chinese companies operating in this market as well as a number of foreign consulting and investment companies.

For all projects in China where approval is sought for CER quotas, a Project Design Document must first be presented to the NDRC, which acts as the Designated National Authority (DNA) in China. The NDRC demands that any Chinese CDM project should have at least 51% Chinese ownership, implying that in the case of a foreign project-owner, a joint-venture model has to be made with a Chinese company which will hold the controlling votes.

Concerning the future market potential, the official CDM priority areas are:[122]

- Energy efficiency improvements
- Development and utilization of new and renewable energy
- Methane recovery and utilization.

The market potential for CDM project development companies and financial institutions to obtain CERs for emission trading from Chinese projects is vast, although not without risk. This is illustrated by the fact that by March 2008, a total of 1104 projects were registered in China, increasing to 1173 projects by May 2008. Only 200 of these have been issued with CERs, illustrating the large pipeline of projects that are to receive approval by the UN system. Projects related to hydropower, wind power and energy efficiency from own generation are dominant in the pipeline.

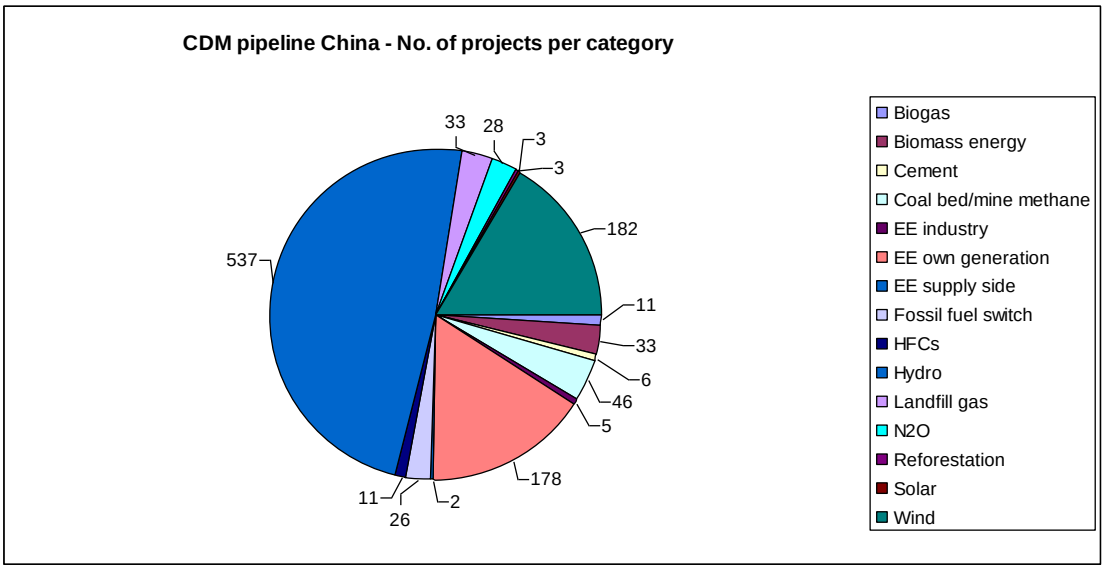


Figure 3: Number of Chinese CDM Registered Projects in the Pipeline per category, March 2008.
Source: UNEP Risøe Centre, CDM pipeline overview.

In line with the Chinese government's renewable energy targets, the potential of yet unidentified projects remains significant, perhaps only limited by the trading uncertainties for issued CERs after 2012 when the current Kyoto Protocol regime expires.

Regarding opportunities, Western companies may engage in several areas of the CDM process. Norway is an example of a country with certification institutions that have already grasped the opportunity to verify Chinese CDM projects. In areas where Western companies possess strong technical expertise, there is also a possibility to find success in the Chinese market as a project developer. A third opportunity is through involvement in the financing of a project as a CER investor in the early stages of project development.

2.6 Environmental pollution

2.6.1 Air pollution

Since coal combustion accounts for around 72 per cent of China's energy needs, SO_2 and Total Suspended Particulate (TSP) are considered the main pollutants in China. In northern China, despite indigenous coal with low sulphur content, higher energy demand results in higher absolute pollution. This growth in energy use causes severe acid rain problems affecting large parts of Chinese territory. Official Chinese air pollution statistics do not incorporate greenhouse gas emissions. However, the country has focused on reducing sulphur dioxide emissions and aims to achieve a level below 2.3 million tons by 2010. This is equivalent to a reduction 10% from the 2006 level. Fifty per cent of SO_2 industrial emissions are released from non-power generating industries (construction materials, metallurgy, cement, and non-ferrous metal smelting). As seen in Table 7, there has been a slowdown in the increase of sulphur dioxide emission. However, further significant efforts have to be made to meet the 2010 target. [123]

Table 7: Air Pollution Indicators for China (2001-2007)

Pollution Item	**2001**	**2004**	**2006**	**2007**	**Change (2001-2007)**
Industrial waste air emission (100 million cubic metres)	160 863	237 696	330 992	388 169	141%
Fuel burning	*93 526*	*139 726*	*181 636*	*209 922*	124%
Production process	*67 337*	*97 971*	*149 353*	*178 247*	165%
Sulphur dioxide emission (10 000 t)	1 947	2 255	2 589	2 140	-10%
Soot emission (10 000 t)	1 070	1 095	1 089	771	-28%
Industrial dust emission (10 000 t)	991	905	808	698	-30%
Industrial sulphur dioxide removed (10 000 t)	565	890	1 439	1 942	244%
Industrial soot removed (10 000 t)	12 317	18 075	23 565	25 166	104%
Industrial dust removed (10 000 t)	5 322	8 529	6 454	7 669	44%

Source: 2001-2006 figures from Table 12-1, China Statistical Yearbook 2007, China Statistics Press 2007. 2007 numbers from Table 11-23, China Statistical Yearbook 2008, China Statistics Press 2008 Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

Rapid increases in the number of vehicles on China's roads have also contributed to the worsening of the air pollution situation. Beijing's vehicles quadrupled from 1986 to 1996, reaching 1.5 million in 1999, with 2008 witnessing more than 3 million vehicles on the roads. Car emissions–including CO_2, volatile organic compounds (VOCs) and NO_X–are now clearly on the rise in many of China's major cities, causing heavy smog, as well as ozone and acid deposition.

Regarding the competitive situation, Chinese companies have been providing air pollution control equipment for over three decades. The market is fragmented with many different product types being used in the different emission control processes. These emission control processes also may vary by industry. Table 8 provides an overview of the larger companies competing in this market where more than 50 Chinese companies are observed operating. There is also a good presence of foreign companies in this established market. [124]

Table 8: Selection of Chinese Companies Operating in the Air Pollution Market (2007) [125]

China / Companies in the field of air pollution	2007 Revenue (Yuan)
Fujian Longking Company	2.522 billion
Zhejiang Feida Envir. Sci. & Tech	1.482 billion
Jiangsu Sujing	No information
Henan SINOMA (China National Material Group)	19.6 million (50% growth 2006)
Wujiang Kelin	250 million from annual sales of bag filters

Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

Future market potential. Although the Chinese government is taking steps to try to curb increasing air pollution, many more steps have to be made before this negative environmental trend is under control. The government has announced an investment of 1.35% of GDP annually in environmental protection for three years (2008–10), and will spend $75 (€55, ¥600) billion on air pollution control.[126]

Demand for air pollution control products in China is estimated to increase by almost 18% annually for the next years. It is expected to reach an annual market level of $8.1 (€5.9, ¥67.2) billion by 2010. Demand is expected to be primarily driven by government air pollution spending plans and increasingly stringent environmental protection legislation. [127]

Considering the major challenge of CO_2 emissions, and the fact that coal-fired power stations represent a large part of this emission, future carbon capture and storage technology should be particularly interesting to develop in China. This new technology is currently in use in pilot projects in the Western world and Sino-foreign joint venture initiatives are starting to form in China.

The £3.5 million, UK-funded consortium, "The Near Zero Emissions Coal Initiative", aims to reduce the carbon dioxide emitted by coal-fuelled projects, such as thermal power plants, to less than 20% by 2020. This project focuses on capacity building and information sharing in initial phases and aims to develop a pilot plant in later phases of the project development.[128] As illustrated in the panel below, GreenGen is developing a pilot plant where the first phase is estimated to be completed by 2009. At this stage an Integrated Gasification Combined Cycle (IGCC) plant with carbon dioxide separation will be up and running. By 2015, it is estimated that carbon capture technology will be introduced, and the aim is to have 80% of carbon dioxide separated and stored by 2020.[129]

China's first carbon capture & storage plant to be operational by 2009

China's first coal-fired power station employing carbon capture and storage is planned to begin operations in 2009, under a joint venture partnership, GreenGen, between a group of (Chinese) state-owned enterprises and American firm Peabody Energy. The $1bn, 650 MW plant to be built at Tianjin near Beijing will capture the majority of its emissions for storage underground and the manufacture of by-products for use by nearby chemical companies. The GreenGen project will use advanced coal-based technologies to generate electricity. The plant will be capable of hydrogen production and will advance carbon dioxide capture and storage, providing a clean energy prototype to address carbon dioxide concerns.

The GreenGen Co., led by managing partner China Huaneng Group, will design, develop and operate an Integrated Gasification Combined Cycle (IGCC) power plant near Tianjin, southeast of Beijing. A 250 MW plant will be built during the initial phase. During later phases, the plant will be expanded to 650 MW. Project design and review is complete, and a site has been selected at the Lingang Industrial Park. Construction is expected to commence early in 2008.

Source: Power Engineering 31.12.2007 / Innovation Norway 2008.

Niches for Western companies. Within the areas of equipment and products, air pollution control technologies and equipment are facing an annual increase in demand of 20%, a trend that will continue in the future. The most promising products are electrostatic precipitators, baghouse systems, particulate removal products and vehicle catalysts. The Chinese people are also starting to realize that advanced management models are very important in improving environmental quality. All industrial and construction projects now have to pass an environmental assessment and obtain approval from the local environmental protection agency. Knowledge and tools to facilitate environmental planning and evaluation is a market to be looked into more closely.

Several Western countries have specific technological insight into carbon capture and storage used in the oil and gas industry. The Chinese industry and market needs to develop a better knowledge and understanding of CCS technology, which can then be of environmental as well as economic benefit to the oil and gas industries. This potential benefit also extends into the massive coal-fired power plant market in China.

2.6.2 Water pollution

The main current water problems in China are scarcity and pollution. Inadequately treated or untreated municipal and industrial wastewater is discharged into rivers, lakes, sea and groundwater. Government figures show more than 70% of waterways and 90% of underground water supplies are polluted.[130]

During the first nine months of 2007, Chemical Oxygen Demand (COD), a key water pollution index, showed a positive trend for the first time amounting to 0.28 per cent. China's Minister of Environment, Zhou Shengxian, recently reported a decline in chemical oxygen demand (a measure of water pollution) of 2.5%, and in sulphur dioxide of 4% over the twelve-months ending in the summer of 2007. Government initiatives are starting to take effect. In 2007, urban wastewater treatment facilities were expanded to treat an additional 9 million tons daily. More than 1,700 plants adopted intensive water pollution treatment, and small but heavy-polluting plants were shut down. Operations in more than 900 paper mills were suspended while they were renovated or had been instructed to improve wastewater processing facilities. Provincial environmental watchdogs also strengthened enforcement, and more than 10,000 pollution cases were investigated.[131] Minister Zhou also recently reported that in the period from the summer of 2007 to summer 2008, 335 projects passed environmental evaluations and 104 projects involving investments totalling ¥304 billion ($46 billion)
were rejected or postponed due to potential environmental problems.[132]

Pollution of lakes and seawater remains a major problem. According to the "2007 China Ocean Environment Report" made by the State Ocean Administration (SOA) of China, the general situation of the sea pollution along the Chinese coastline is getting worse. Eighty-seven per cent of the pollutant outlets to the sea discharge pollutants beyond the upper limit standards. In addition, the total amount of pollutants brought to the sea by rivers is continuously increasing as is the case with certain pollutants brought by air currents to the sea. The major pollutants are inorganic nitrogen and active phosphate. This is affecting China's aquaculture industry, which in itself is also struggling with controlling organic wastes in the farming regions and maintaining and recovering marine ecological systems.

Lake Tai's pollution inflicted economic losses of ¥5 billion

In May 2007 millions of residents were forced to rely on bottled water as toxic and foul-smelling algae in Lake Tai, China's third largest freshwater lake, destroyed plants and fish. The algae have been attacking the lake every summer for the past decade but first after last summer's record breakout did the government take steps against the many factories on the banks of the lake. Around the lake many small mills churning out textiles, chemicals, iron and steel, food and other commodities have created high pollution levels of ammonia nitrogen. Untreated sewage was another major factor stimulating the algae growth.

In second half of 2007, more than 700 small and medium-sized factories were closed down, and a further 2000 are planned to be closed by the end of 2008. Large factories with the know-how and financial capability to upgrade their pollution treatment facilities were asked to move inland. People living near the lake have also been moved. Now, one year later, the algae is coming back, indicating that further measures have to be taken.

Source: South China Morning Post, 1 April and 25 May 2008.

Regarding the competitive situation, the water treatment industry is characterised by many international players that have operated in China since the 1990s. The market also has more than 350 Chinese companies which are anticipated by some analysts to increase to 6000 companies by 2010.[133]

Considering future market potential, the severity of water pollution, together with the fact that 300 of China's 663 cities face water shortages (100 of which are in a severe situation), there is a strong potential for future market development. Annual water shortages of 29 billion cubic metres in 2000 are predicted to rise to 50 billion cubic metres by 2020.[134]

The water and wastewater market is expected to reach an annual size of US$33.2 billion by 2010.[135] Some of the major challenges are ensuring funding for projects as well as securing continuous high quality operation of facilities once they have been installed.

China is the biggest aquaculture country in terms of aquaculture water area (7.8 million hectors) and total annual production (36 million tons a year). However, there is far to go in developing (1) technologies covering the whole value chain of aquaculture, (2) aquaculture water resource management and (3) a greater awareness of economic and modern aquaculture amongst farmers.

Opportunities for Western companies. Sewage treatment and industrial wastewater treatment is mostly needed to solve water shortage and pollution control problems. Technologies in treatment of high-density organic waste, heavy metals, oil containing, chemical effluents, pharmaceutical effluents, and recycling and resources retrieval are prioritised areas where, for instance, Norwegian companies may offer interesting solutions.

Western countries with strong maritime traditions and a marine industry can find opportunities for exporting more long-term and sustainable business models. However, a single product, facility or system cannot solve the whole problem. For example, automatic feeding machines may reduce the organic elements of the pollutants entering the sea, but the utilization of the machine is also dependant on the price, animal husbandry, type of feed and affordability, and so forth. Research know-how and products in relation to vaccination, breeding and hatching, feeds, for example, can contribute significantly in reducing pollution entering the sea as a result of farming activities.

Sea monitoring equipment and systems, and tools for coastal planning can be of interest for SOA and MEP. Norway is an example of a country which has technology and products that

are suitable for Chinese application and demand. Some Norwegian companies engaged in this field have already made exports to Chinese authorities and research institutions involved in ocean-watching. Norway's off-shore industry also has equipment, facilities and solutions for emission reduction and control that can be of relevance to oil platforms located in Chinese waters which need better monitoring systems, disaster prevention and handling solutions for cases of oil-spills, hazardous chemical emissions, etc. Similar products, technology and systems for harbours should be of interest to the port authorities and design institutes for maritime transportation.

2.6.3 Solid waste management

Solid waste has become a serious problem in China. Each year, 650 million tons (industrial) and 140 million tons (municipal) solid waste are produced, and this is increasing at a rate of 9% each year. In large cities, such as Beijing, Shanghai and Shenyang, the growth rate is 15–20%. Among urban domestic waste, inorganic waste accounts for 60% of total waste, with organic waste accounting for 31–36%, and waste from discarded products accounting for 4–6%. Prior to 2000, the accumulated waste in China had already surpassed six billion tonnes nationwide, occupying 500 million square meters.[136]

Urban domestic wastes collected and transported before central disposal are not sorted at the household level. Programs calling for garbage sorting by city inhabitants have been implemented in a few cities, but without much success. The current solid waste management systems – consisting of 70% landfill, 20% high-heat compost, and 10% incineration – are inadequate. For municipal waste, most of the cities still use centralized stacking and simple landfill treating methods.

Many landfills in China do not meet Chinese or international construction or environmental standards. Some garbage sites are open pits located on the urban fringe or in stream or river valleys and wetlands. Landfills lacking properly implemented treatment procedures should be regulated and monitored to prevent secondary pollution. China has recognized the need to improve its waste sites and has set a goal of disposing 60 per cent of municipal refuse in sanitary landfills.[137] Regarding industrial waste, the volume has increased dramatically, although the increase has been slower than the growth rate of industrial output. Most industrial solid waste in China is composed of waste from smelting plants, coal ash, slag, coal refuses, chemical waste residues, tailings and radioactive waste. These kinds of industrial waste have caused severe pollution problems.[138] The actual amount of hazardous waste generated every year in China is believed to range from 20–40 million tonnes, of which less than half is treated or re-used. The remainder is largely disposed of in general waste disposal sites. The main processes for the treatment of hazardous waste in China are landfills, solidification, recycling and incineration.[139]

Opportunities. Technologies and solutions needed in this area include municipal solid waste collection, transportation, incineration, landfills and overall management. Recycling industrial solid wastes such as electronic products, chemicals and hazardous wastes, and so forth should be in focus. Norwegian commercial actors are providing some good solutions in a number of niche markets such as technologies and solutions for solid and hazardous wastes on vessels and oil platforms. The offshore and shipping industries may be one area where Norwegian solid-waste technology offers the greatest advantages and opportunities.

There is also a need in the market for waste resource recycling and disposal of plastics, paper, wood, chemical products and metals. Better resource utilization that can include value-added

reuse of industrial waste, cleaner production technology and equipment, and comprehensive utilization of agricultural waste is also of interest to this market.

3 Norway in China: Prepared to fly with the green dragon?

3.1.1 Sino-Norwegian cooperation 1996-2005

Norway commenced its diplomatic relations with the People's Republic of China in 1954, and has developed a basis for cooperation that has fostered increased trade and assisted a focus on environmental sustainability. Since the signing of a Memorandum of Understanding (MoU) between the National Environmental Protection Agency of China and the Norwegian Ministry of Environment in 1995, Norway has been financing or partly-financing 117 bilateral environmental projects[140] worth NOK 342 ($55, €42) million which was developed by Chinese institutions in cooperation with Norwegian partners.[141]

Norwegian companies with a focus on green products and services have been present in China since the early 1990s. Historically, air pollution and water management have been the main focus areas. However, in recent years, there has been increasing involvement in the fields of energy efficiency, renewable energy and communications technology.

The Sino-Norwegian environmental cooperation 1996–2005 was reviewed in 2007.[142] The consultants note that, given Norway's limited size as a partner (Norway's financial contribution to China constitutes 0.45% of Official Development Assistance (ODA) to China in 2005), it is not the scale of tackling concrete environmental problems that is the most important but rather the access to knowledge and technology from Norway which this arrangement has facilitated.

The review notes that while project objectives generally appear to have been successfully achieved, the policy dialogue has had limited impact. While consisting of good individual projects, the cooperation in an overall perspective appears fragmented with "no clear trend related to a particular field or form of cooperation (commercial, institutional, research cooperation)." Cooperation has tended to gradually substitute research/consulting cooperation by cooperation with Norwegian state institutions (without competition or assessments of cost efficiency on the Norwegian side), while commercial cooperation has been limited. The cooperation is reported to have become more mainstreamed after the Norwegian Embassy in Beijing overtook responsibility in 2004.

The apparent lack of an overall and long-term strategic engagement in the period is probably largely due to the fact that the Norwegian support is provided as ODA, making funding dependent on the (shifting) aid development agenda. Historically, the Norwegian Labour governments have focussed on cooperation with China while the Conservative governments have been more reluctant to see cooperation with China as part of Norwegian aid. The review notes that Norway is the only OECD country which exclusively engages with China through ODA (Figure 4). The consultants recommend that Norway rather regard cooperation with China as regular bilateral cooperation and which also establishes funding mechanisms that allow for flexibility in promoting commercial cooperation.

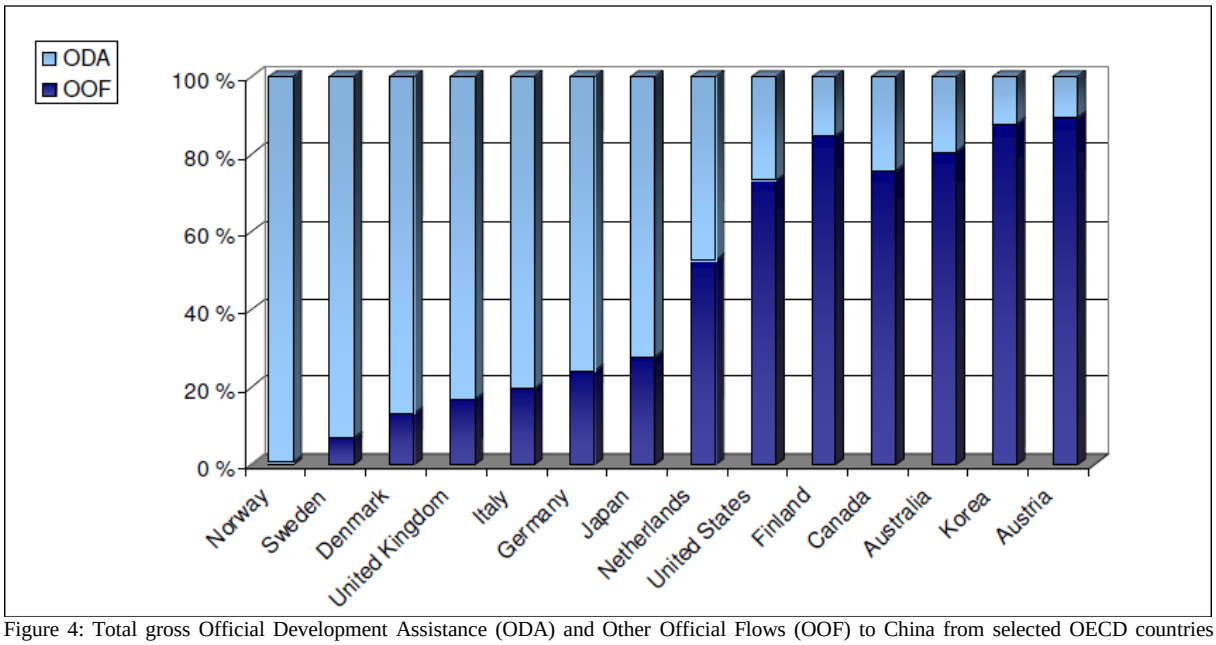


Figure 4: Total gross Official Development Assistance (ODA) and Other Official Flows (OOF) to China from selected OECD countries (average 2001–2005 in mill. US$).
Source: J. Claussen and S. Hansen, *Promotion of commercial cooperation between Norway and China with specific reference to energy and environment*, Nordic Consulting Group, November 2007.

The review also notes that the projects and partnerships entered into have been for a too short term with projects being supported for just 3 to 4 years. In order to fully reap the benefits of such projects, many years of sustained cooperation are essential. Finally, the consultants point out that Norwegian stakeholders in several respects have less conducive framework conditions than, for instance, the other Scandinavian countries. While feasibility studies for engagement may be fully covered by the state in countries like Denmark, Germany and Italy, the Norwegian government only provides 50% co-funding. In addition to more flexible financing mechanisms (including non-ODA), commercial stakeholders in neighbouring countries also have the benefit of being able to supplement national mechanisms with EU funding mechanisms. Norwegian stakeholders are barred from this as Norway is not a member of the EU.

3.1.2 The Norwegian Government 'China Strategy'

In August 2007, the Norwegian government published a 'China Strategy' outlining Norway's vision and priorities towards China, recognizing China's increasingly important role for Norway and the global community. In the strategy[143] the Norwegian government notes that there is growing interest by China in cooperation in areas such as development of social welfare policy, management, particularly those of energy and the environment, research and education expertise. This also applies to goods and services in sectors where Norway is in the forefront, such as environmental and energy technology and the maritime and marine sectors.

The Norwegian government stresses that its future policies towards China shall "seek to integrate environmental, climate change and sustainable development concerns into all Norwegian efforts vis-à-vis China." It also lists five priority areas of cooperation of which "expanded economic relations with emphasis on increased market access for Norwegian goods and services" and "development that is sustainable at the local, regional and global level" are the two first.

"Today, we stand on the threshold of a new, green economy"

Speech by Norwegian PM Jens Stoltenberg Tsinghua University, Beijing 27 March 2007.

Excellencies, faculty members, students

It is a great honour to be here today and to address a gathering of people who will have a decisive influence on how the world will develop. [-] This is where the torch is being passed to new generations of leaders. You have a unique opportunity and mission. No generation before you has been in a similar situation. Not only will you be able to lift additional hundreds of millions out of poverty. So that all of China can be free from that scourge. But you may also save the global environment for future generation. By making technology leaps of unprecedented scale and scope. [-]

Norway is privileged to be working with China at this exciting moment in history. We have much to gain from working with China, but we also believe that China will gain from working with us. A Chinese-Norwegian partnership would be a win-win-situation. Or shuang-ying! [-]_I am convinced that much of the change we will see the next couple of decades will come here in China. Because of your bristling economic growth. Because of population density. And because the modern Chinese will demand a more healthy environment. This kind of political awareness and concern comes with rising incomes, as more and more people are entering the middle and higher income levels. The answer lies in technology, management and human ingenuity. [-]

Global warming has come about because western countries have used fossil fuels to develop since the industrial revolution. Now we are looking forward. Towards the most serious rounds of global talks ever. [-] And China must play a central role. Or else we will all fail this calling. [-] China has a right to develop. Make no mistake, none of us are asking China to slow down its ascent towards prosperity. We are calling on China to leap-frog the more polluting stages of development that many of us went through in the past. Together, we must explore every technological and business opportunity that promotes change. I believe that China will assume a leading role in this period of change, because few countries have so much to gain. Today, we stand on the threshold of a new, green economy. A truly new world order. Which can rid the world of poverty. And save the climate. This is our calling. This can be done. [-]

Great achievements often start with a vision that seems to be bordering on madness. And many of the most important scientific breakthroughs were underrated to begin with. How much money was it right to spend on developing the first electric light-bulb? China's need for more energy may prove to be the driver of change that helps humankind solve the climate problem. Norway is eager to work with China on solutions that will benefit both our countries and the whole world.

The government announces an ambitious level in expanding commercial cooperation, noting for instance that "the government will, in cooperation with the business sector, seek to ensure the best possible framework conditions and the greatest possible predictability for the Norwegian business sector". It also promises that "it will assist Norwegian firms and conduct activities in China aimed at promoting Norwegian business." Regarding sustainable development, the government announced the intention of a broad engagement to support development of China's institutional technical capacity and "promoting energy efficiency and the use of hydroelectric power and other renewable energy sources." It also notes that is in Norway's own interests to provide such assistance. In addition, the government announced that it will "intensify development cooperation with China on the environment, energy and climate change". Among other forms of engagement, such as investing in CDM Mechanism projects in China, it also notes that "by utilising Norway's high-technology expertise and its position as a supplier of oil and gas, the government wishes to promote cooperation between Norwegian and Chinese companies and institutions in the areas of petroleum and offshore technology, environmental technology, services and expertise."

The strategy has an ambitious environmental agenda noting that environmental, climate change and sustainable development concerns shall be integrated into all Norwegian efforts vis-à-vis China. It is also clear that commercial cooperation related to environmental goods and services is a main, although not exclusive, area for expanding cooperation. Still, the strategy appears less ambitious and visionary than Norwegian PM Jens Stoltenberg's speech at Tsinghua University in Beijing five months earlier (March 2007), where he called for China to leap-frog the more polluting stages of development, announced that "we stand on the threshold of a new, green economy" and that "together we must explore every technological and business opportunity that promotes change" (cf. panel above). The strategy also leaves it unclear exactly what the Norwegian government will do to increase commercial cooperation in the field of environmental goods and services, besides working for a free trade agreement ensuring stable framework conditions.

In 2008, new MoUs with NDRC and MEP, as well as an increase in bilateral funds and increasing investments in CDM projects, the Norwegian government has followed up on its ambitions to promote the use of Norwegian environmental knowledge and technology. A consistent topic in high-level meetings with Chinese officials is Norwegian technology for carbon capture and storage (related to gas), in which the Chinese have shown little interest hitherto.[144]

3.1.3 Norway vs. Scandinavia on EGS exports

It is difficult to identify reliable and up-to-date statistics for the green business sector export activities as no official categorisation and methodology exists. However, OECD and Eurostat have been working on this since the 1990s and the Nordic countries have produced selective statistics that offer a rough basis for comparison (Figure 5).[145]

The pre-study provided by the Nordic Innovation Centre (NIC) for 2006 is clear: Denmark is the Nordic champion on Clean Tech exports with an export volume worth €6.7 billion (2005), with renewable energy technology (wind turbines) alone amounting to €4.9 billion. Although being the largest country in the region Sweden comes second, with Clean Tech exports worth €2.8 billion (2004). Finland's EGS export was estimated to €1 billion (2003). By comparison, Norway (with almost the same population as Denmark) is a laggard with an export in 2005 estimated by NIC to €0.8 billion. Contrary to Denmark and Sweden, there are no public statistics in Norway on volume and export of the environmental technology sector.

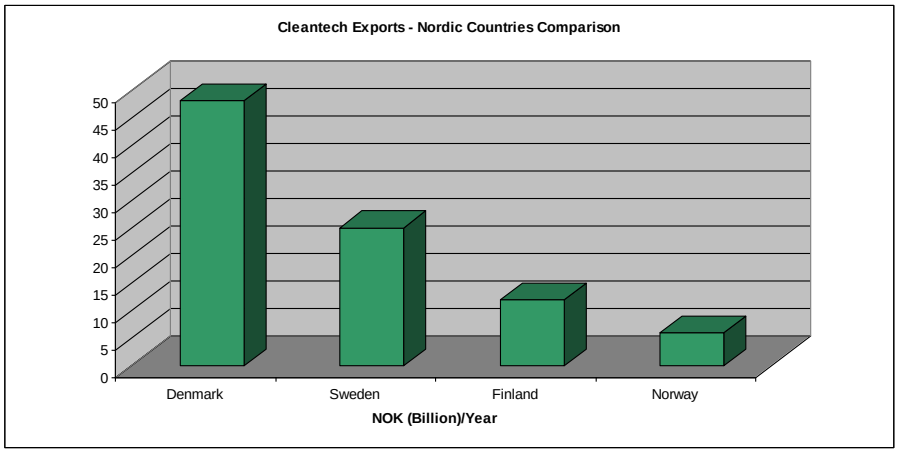


Figure 5: Clean Tech Exports – A Comparison of Nordic Countries using available data (2003-2005).
Nordic Innovation Centre: Prestudy on Co-operation between Environmental Technology Networks in Nordic Countries on Export, 2006.

The NIC pre-study notes that the world markets for environmental technologies is expected to grow more than other technological markets, constituting a market in 2006 of more than €500 billion, and expected to reach €780 billion by 2010. Sweden is achieving significant growth in the sector, far exceeding the expectations the sector itself expressed when the Swedish government started focussing on the sector in 2001. In 2004, three thousand new jobs were created in the Clean Tech sector in Sweden.

USA – Sweden – the Volvo Group
A public-private partnership for developing next generation green technology

July 1st 2008, the U.S. Department of Energy (DOE), the Swedish Government and the Volvo Group, agreed to expand cooperation to develop more fuel-efficient trucks. The cooperative partnerships objective is to demonstrate heavy-duty engine systems with at least 10 per cent higher fuel efficiency than conventional diesel engines. The overall value of the cooperation will be $48 million, with the U.S. and Swedish governments providing $9 million each over the next three years and the Volvo group $18 million.

DOE Assistant Secretary Alexander Karsner said. "The clean-vehicle technology developed under this international public-private partnership will further the Bush Administration's goals of ending our addiction to oil and confronting the serious challenge of global climate change."

"The Volvo Group is a major player in the North American truck market with key facilities for research, development and manufacturing on U.S. soil," says Leif Johansson, CEO of the Volvo Group. "The climate issue and increasing fuel prices make energy use and energy efficiency some of the most important societal issues of our time. The transportation industry has a special responsibility and this research and development co-operation with the U.S. Government is crucial in our efforts to develop the drivetrains and technology required by both our customers and society as a whole."

Source: "DOE Expands International Effort To Develop Fuel-Efficient Trucks", press release by United States Embassy Stockholm, July 1 2008.

Nevertheless, Denmark stands out as the Nordic leader, probably as a result of a targeted focus on the sector since the early 1990s (promoting exports to the new EU member states of the period as they were facing severe environmental challenges) and a model where the government, state institutions and business cooperate to promote Danish Clean Tech export.

The Scandinavian Clean Tech companies are present in the same markets and there is a high degree of common products (except for Denmark's specialization in wind turbines and Iceland's specialization is geothermal), meaning that the Scandinavian region generally appears homogenous regarding the sector. Scandinavian companies face common problems in that they are mostly small and medium-sized enterprises (SME) lacking resources for penetrating the market and carrying out the initial investments that are often needed, but also lacking financial muscles to leverage financial solutions required by the buyer.

The pre-study suggests that the Nordic countries must look further into the possibilities for mainstreaming efforts to promote export of environmental technologies, in order to share and scale up networks, make common use of human infrastructure/facilitating institutions in countries targeted for export, further develop a 'Nordic' brand, and to be able to provide larger and more integrated solutions to customers in the global market.

"As I see it, there's a horse-race on to see who can develop the most, build the most, invent the most green technology."

Remark by U.S. Ambassador Michael M. Wood
at the signing of the U.S.-Sweden Implementing Arrangement on Renewable Energy Cooperation, Stockholm June 28 2007.

In April 2008, 16 large companies in Norway and Sweden announced coordination and cooperation in the provision of low-carbon solutions to a global market, and launched the Nordic Climate Cluster (NoCC). NoCC includes companies with experience across the energy sector, from nuclear power to solar, including Norwegian energy giant StatoilHydro, hydropower companies Statkraft and Vattenfall as well as Swedish industry locomotives SAAB and Volvo. At present, NoCC is assisting working groups in defining focus areas. The NoCC web page is only available in Norwegian, indicating that the plan to create and brand the Nordic region as a world-leading cluster for environment-friendly renewable energy is still at an early stage.

Nordic Climate Cluster – the beginning of big Nordic low-carbon engagement?

April 2008, 16 big Norwegian and Swedish companies from several sectors established the Nordic Climate Cluster (NoCC). Together the companies cover most of the sectors relevant for solving the climate problem, and can provide leading competence. NoCC recognizes that solving the climate challenge will entail cooperation across sectors and between countries, and between companies and governments, in order to address the future huge opportunities in the global market. The aim of NoCC is to over time create a strong Nordic engagement and world-leading cluster for environment-friendly renewable energy.

Together the NoCC companies cover a comprehensive specter of relevant solutions; hydropower and nuclear power, oil and gas, bio-energy for heating as well as transport, solar and wind power. There are companies that provide energy efficiency solutions through improved use of materials and technology, and also demanding users of stationary energy and fuel with experience from that side. The largest Nordic oil refinery is among the companies and competence on future bio-refineries based using timber is also represented. In addition, the companies have world leading competence within engineering as well as large scale project development and management.

Source: www.nordicclimatecluster.com

3.1.4 Sino-Norwegian Trade: Increasing volumes (including CO_2)

China is the most import trading partner for Norway in Asia. Since 2005, Norwegian exports to China have increased by almost 70 per cent (excluding crude oil, which has shown strong fluctuations in the past), and showing a steady annual growth of approximately 30%, representing 2.6% of total Norwegian exports (excluding crude oil). The main export areas for Norwegian industry to China (excluding crude oil) are engineering products, fish and seafood, and chemicals (including fertilisers).

Norwegian official statistics unfortunately do not provide information on environmental technologies. The Norwegian Statistics bureau is in the process of improving this situation, starting with water and sewage treatment technology. The lack of good statistical information is a weakness in terms of promoting development in the environmental sector as a whole, since it is almost impossible to measure and highlight the impact of activities initiated, as well as clearly defining and illustrating developments in this sector in Norway.

Norway's import from China is booming, up by 90 per cent between 2001 and 2006. Only Sweden, Germany, the UK and Denmark have higher levels of imports from China. The main sectors are machinery, electric appliances, computers and office equipment.

A recent report by WWF and the Norwegian University of Science and Technology shows that the increasing Norwegian imports from China constitute an example of unchecked carbon leakage.[146] Briefly, the production of Norwegian consumer goods (and the CO_2 emissions related to that production) is increasingly moving from countries with restrictions on CO_2 emissions under the Kyoto Protocol to countries without such restrictions (mainly China). Due to increased imports, Norway's carbon footprint in China almost tripled from 2001 to 2006, from 2.4 Million tonnes (Mt) CO_2 to 6.8 Mt. The growth in the carbon footprint far exceeds the growth in volume, showing that the CO_2 intensity of the products imported into Norway is increasing since the import of products such as machinery, electric appliances, computers and office equipment increased more than the import of less CO_2-intensive products such as clothing.

The study estimates that through consumption, an average Norwegian causes emissions of approximately 1.5 tonnes of CO_2 in China, and that Norwegian consumption generates more than 2 million tonnes of CO_2 emissions annually from coal fired power plants in China. By putting a price on Norway's carbon footprint in developing countries using an estimated EU carbon market price of €20 per ton, the report estimates the price of Norway's footprint in China in 2006 to be €136 ($171) million (i.e. what it would cost to emit such amounts of CO_2 in the EU). Putting this into perspective, the report notes that the Norwegian government's *daily* revenue from oil and gas extraction in 2006 was about €350 ($440) million.

The report notes that today, the Norway–China trade relationship promotes increased consumption based on unsustainable models of production. If incentives are developed to make the Norwegian-Sino relationship a driver for mutual low carbon development, chances will increase for both Norwegian and Chinese commercial stakeholders to develop further and to become winners in a future low carbon economy.

The importance of China to Norway as a trading partner has lately encouraged a move towards considering the establishment of a free trade agreement (FTA). The pre-study highlights that significant complementarities exist between the Chinese and Norwegian economies and that an FTA would benefit the people and economies of both countries. It

recommends that negotiations on an FTA between China and Norway should commence as soon as possible.[147]

Hu Jintao on Prospects for China and the Nordic countries

"We will pursue a new type of industrialization, adjust the economic structure, speed up changing the pattern of economic growth and boost our capacity for innovation. We will work vigorously to develop a circular economy and build a resource-conserving and environment-friendly society." [-]

"Sweden and other Nordic countries have over the years followed development models suited to your national conditions and made remarkable achievements in many areas. In particular, in the face of deepening economic globalization, the Nordic countries have made timely adjustments to industrial structures and vigorously promoted scientific innovation and the development of knowledge-based economy, thus leading the world in international competitiveness and innovation, and you have state-of-the-art technologies and products for telecommunications, energy and environmental protection.

There is therefore a broad prospect for China and the Nordic countries to draw on each other's strengths and enhance mutually beneficial cooperation. I hope that the business communities of the Nordic countries will seize the opportunity to increase your share of the Chinese market.

To strengthen our business ties, our two sides may take the following steps:

- Increase trade and improve trade structure, enhance mechanisms for trade cooperation and dialogue to create a more enabling and efficient trading environment and enhance our cooperation, particularly in scientific innovation and services trade.
- Strengthen cooperation in new energy and environmental protection, especially in raising energy efficiency in the construction sector and in hybrid energy and clean energy development.
- Encourage technological cooperation between our small and medium sized enterprises, set up platforms for them to increase business contacts and encourage them to share distribution channels and jointly develop products."

Excerpts from speech by Hu Jintao, President of the People's Republic of China, at the welcome dinner hosted by Sweden-China Trade Council, Stockholm, Sweden, 10 June 2007.

3.1.5 Norway's sovereign wealth fund and China

Norway is home to the world's second largest Sovereign Wealth Fund (SWF), the $394 (€249) billion[148] 'Government Pension Fund' (GPF) which is based on petroleum revenues. The Norwegian government's stated objective is that the fund shall be the best-managed fund in the world. The GPF ethical guidelines are premised on the fund having two fundamental obligations: a) to ensure current and future generations of Norwegians favourable long-term returns, and b) to avoid investments that entail an unacceptable risk that the fund contributes to gross or serious ethical violations including human rights violations and severe environmental damage. In November 2007, the GPF established an office in Shanghai in order to invest in and profit from the emerging Chinese markets.

A recent study by WWF and financial analysts, Innovest,[149] points out that the financial sector has an important role to play in the global economy in terms of where they channel their funds. By investing in particular companies or projects, the financial sector sends signals to the broader market on the future value of those companies and indirectly influences what the future economy will look like. This makes it important for the financial sector to consider the longer-term implications of their investment decisions today in order to contribute to a sustainable and prosperous global economy in the future. Institutional asset managers today control an estimated 86% of investment in the world, according to the study.

The study stresses that as the driving force behind the global market place, large institutional investors such as sovereign wealth funds must be aware of how climate change may affect investment value. It will be important to identify those companies which are leaders in a low carbon future, and also to encourage companies to move in the right direction. Doing this, SWF will secure the investment potential in a global economy adapting to 21st Century environmental limitations and contribute to ensuring environmental stability important for a well-functioning global economy.

The study shows that GPF lags behind its peers – such as the Dutch pension fund ABP and calPERS – when it concerns application of instruments for socially responsible investments. There are two main reasons for this. The Norwegian fund does not apply positive screening ('best-in-class') by sector in its investment portfolio, something which contributes in the development of best practices, and secondly, the GPF has not set up any thematic fund targeting investments in Clean Tech or the wider EGS sector in spite of the documented financial viability of such targeting. (In contrast, the China Investment Corporation SWF recently announced that it will target investments in environment friendly technologies.)

Regarding China (mainland), the Norwegian SWF's holdings in 2007 in the energy sector comprised ten companies which are strongly engaged in coal power production or extraction, including main Chinese companies such as China Shenhua Energy Co Ltd and China Coal Energy Co which is the third largest coal mining enterprise in the world. In addition there were investments in three oil or gas companies. In total Norway's SWF pension fund had holdings worth NOK917.828 ($157, €115) million at end of year 2007 in coal or petroleum companies in China. There were no holdings in renewable energy companies. Out of the 122 Chinese companies the Norway's SWF invested in, only one is easily identifiable as a Clean Tech company: Bio-Treat Technology Ltd. which is engaged in waste water treatment.[150]

The above implies that the Norwegian SWF investments in China (mainland) in 2007 generally supported unsustainable development trends which contribute to severe detrimental environmental impacts.[151] The fund's investment practises in China in 2007 also ran counter to the Norwegian government's China Strategy where it aims "to integrate environmental, climate change and sustainable development concerns into all Norwegian efforts vis-à-vis China." Moreover, the opportunities to target and profit from investments in the Chinese Clean tech sector were not actively explored.

3.2 Survey: Norwegian EGS companies in China

In 2007, approximately 150 Norwegian companies were registered as being active in China.[152] The market for green products and services is fragmented and in many aspects an emerging one. This means that the market is very dynamic with a high number of new entrants. At present, around 40 Norwegian companies have been identified as being engaged in the green products and services market in China, twenty of which are part of this survey.[153] The companies are quite evenly spread across sectors, though with wastewater treatment clearly attracting the most companies (Figure 6).[154] Some companies are engaged in several industry sectors.

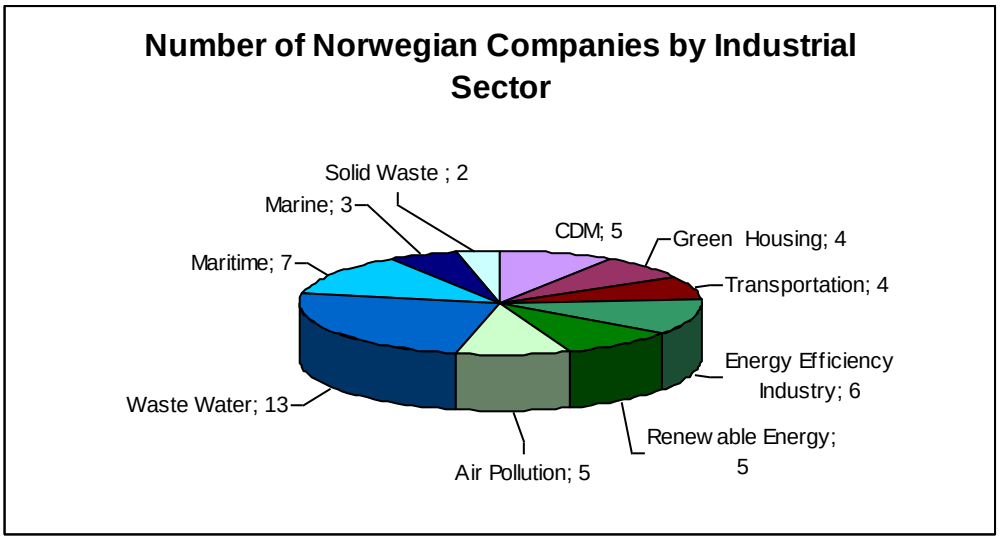


Figure 6: Number of Norwegian Companies by Industrial Sector Engaged in the Chinese Market for Green Products and Services, Spring 2008. Source: Innovation Norway 2008.

More than half of all Norwegian companies observed in the market for green products and services have less than a 5-year history of working in China, underlining that this market is characterised by a steady flow of new entrants. The number of new entrants is especially high in the sector of wastewater, but also in renewable energy, green housing and CDM.

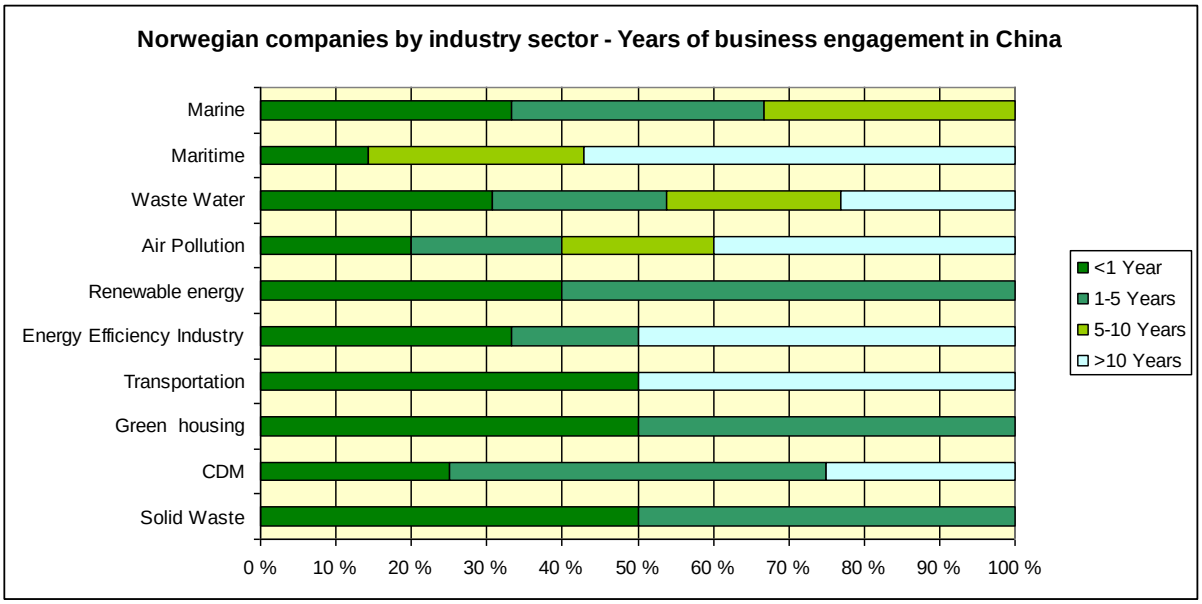


Figure 7: Norwegian Companies: Years of Business Engagement in the Chinese EGS Market
Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

When looking at the stage of market entry by industry sector, it becomes clear that the sectors for renewable energy and related energy efficiency, CDM, solid waste and maritime industry seem to experience a faster move to market implementation than other sectors. Generally, it is not unusual to spend up to 5 years before reaching the stage of business implementation in the Chinese market.

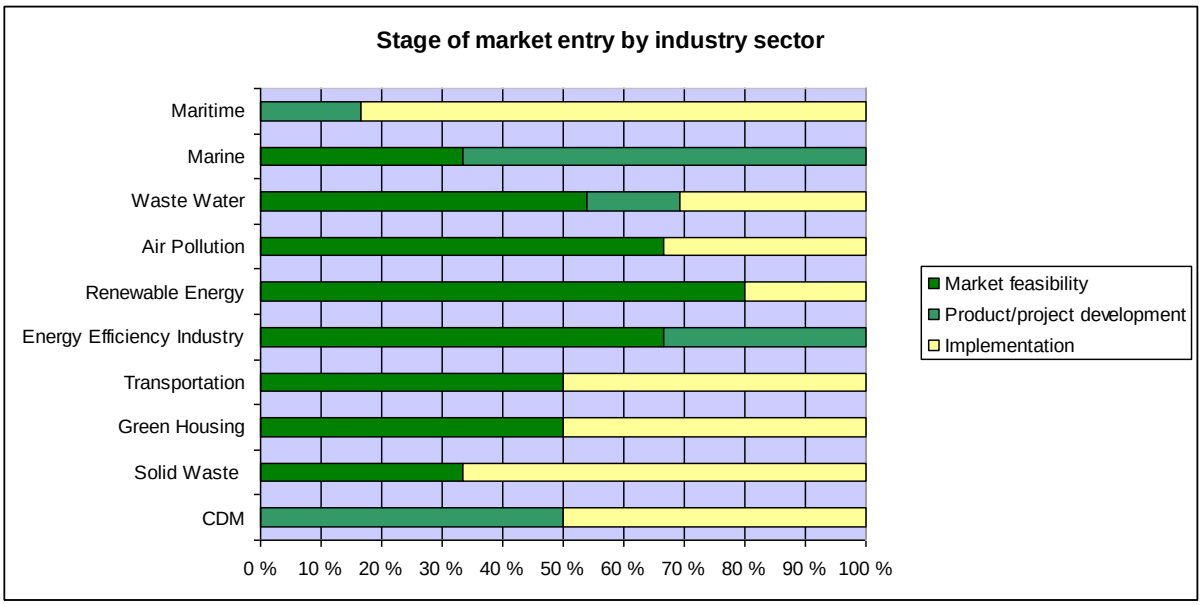


Figure 8: Norwegian Companies in China - Stage of Market Entry by Industry Sector.
Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

There is currently substantial activity by Norwegian companies in the early stages of market entry. This indicates that there is a "good pipeline" of Norwegian companies considering entering China, but also underlines the fact that revenue generation could be slow as it takes time to reach market implementation.

Approximately 50 per cent of Norwegian companies involved in business activities aimed at the Chinese market for green products and services have fewer than 10 employees engaged in their China operations. Many of these companies are SME in nature, underlining their vulnerability to low returns on investment caused by slow market entry as equity is limited. In total, less than five Norwegian companies engaged in this market can be characterised as large, having more than 100 employees engaged in their Chinese operations.

Norwegian companies engaged in the market for green products and services have, in most sectors, a small or insignificant market presence. Most sectors witness only a few Norwegian market players, except for maritime and water management industries.

Table 9: Market Sector Importance to Norwegian Business Working with China

Sector	Number of Norwegian Companies 2008	Norwegian Stage of Market Entry	Importance of China for Company Revenue	Importance of China for Global Dev. of Sector	Key Market Challenges
Renewable energy	5	Market assessment - Project implementation	Low	Highly significant	National majority ownership in most energy areas
Energy efficiency industry	6	Market assessment	Significant	Highly significant	Market acceptance and financing
Energy-efficient and green buildings	4	Market assessment	Medium	Significant	Immature market with a strong potential
Transportation	4	Market assessment – generating sales	Low	Moderate	Immature market Strong national preference
CDM market	6	Market assessment – generating sales	Medium/High	Highly significant	Rapidly developing 2012 limit
Air pollution	6	Market assessment – generating sales	Medium	Moderate	Lack strict standards that are monitored
Water management	13	Market development-generating sales	Medium	Moderate	Financing
Maritime industry	30	Well established	Medium	Significant	Green standards developing
Solid waste management	2	Market assessment-Project implementation	Medium	Medium	Fragmented and developing Lack of standard

Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

When asked about the importance of China to their company's overall business, most indicated that it was of low to medium importance, illustrating that their business is not so dependent on China in terms of revenue/profit generation (see Table 9). However, China was emphasised as being of high significance across several sectors, illustrating China's importance as an investment destination in the future. It is clear that some of the key market challenges, and also barriers (discussed later in this report) play an important role in determining the degree of involvement of Norwegian business in China.

3.2.1 Renewable energy

Norway has a strong national position and high level of knowledge and expertise within the field of renewable energy, in particular hydropower energy. However, very few Norwegian renewable energy companies are currently represented in China.

Regarding hydropower, the lack of engagement may to some extent reflect the traditionally national focus of Norwegian hydroelectric companies, as well as the requirement of national majority ownership from Chinese authorities. Currently, only one Norwegian hydropower company is known to be looking at the possibility of obtaining a licence for small-scale hydropower stations. Although this market segment is open to foreign ownership, the company has experienced easier market access in other countries.

SN Power: A Long-term Responsible Investor in Emerging Markets

SN Power is a growing international hydropower company and is a commercial investor, developer and operator of hydropower projects in emerging markets. SN Power is a Norwegian company owned by Statkraft (owned by the Norwegian state), a leading player in Europe within renewable energy, and Norfund, a Norwegian development financial institution which invests risk capital in profitable private enterprises in developing countries. SN Power is headquartered in Oslo, Norway, and currently operates hydropower plants in Latin America and Asia and is expanding into Africa.

"SN Power is a long-term industrial investor in the hydropower sector. Our business model is based on active ownership, the transfer of Norwegian Hydropower expertise, and responsible, sustainable development of renewable energy. We emphasize close cooperation with all stakeholders - financial, governmental, industrial and particularly local communities. We maintain high social, environmental and ethical standards in all our activities.

Norway is the world's fifth largest hydropower producer and the only industrialized nation meeting its domestic electricity demand almost exclusively through hydropower. Electricity from hydropower was the key factor in transforming Norway from one of the poorest countries of Europe about a century ago into the industrialized and wealthy nation of today.

SN Power draws its expertise from this long-tradition of hydropower in Norway. Its core staff includes experienced Norwegian hydropower engineers as well as staff with broad international backgrounds in energy, infrastructure, manufacturing industries and corporate finance. The business is also underpinned by our owners' deep knowledge of hydropower development and risk capital investment."

SN Power has so far not made any investments in China.

Source: SN Power's webpage.

Wind power is an emerging market in China and three Norwegian companies are currently engaged in different stages of market entry in China, from feasibility studies to partnership agreements and construction of wind turbine parks. At the meeting and signing of the new MoU between Norwegian Minister of Environment and Development, Mr. Erik Solheim, and Minister Zhou Shengxian in Beijing July 2008, Minister Zhou noted that China is interested in cooperation with Norway regarding the booming wind industry.[155]

Norwegian Developed Wind Farm to Start Deliver Electricity to the Chinese State Grid

The Norwegian company NBT AS, together with Chinese partners, plans to start power production from their first wind farm in Baicheng, Jillin province Spring 2009. The wind farm has a size of 49.5 MW and is estimated to provide CO_2 reduction equal to 115,000 tons per year. Thirty-three 1.5MW wind turbines from the Indian company Suzlon will be installed in the first project.

NBT has been working in the Chinese wind power market since 2004. A total investment of US$90 million, financed through Chinese bank loans and private investors, has been agreed on for their first wind farm. In China, the company plans to build a further three to four wind farms of similar size, as well as one biomass 50MW combined heat and power plant within the next 18 months. The company has a target of CER quotas by 2010 of approximately 1 million tons CO_2 equivalent. In total, NBT estimates it will invest more than US$400 million in Chinese renewable energy projects during the next two years. NBT has a long-term strategic plan for wind farm development in China and aims to build 8-12 wind farms, each with a capacity of 49.5 MW, per year from 2010.

Source: Innovation Norway Beijing Office

In 2007, the off-shore wind potential of Norway was calculated for the first time and amounted to a massive 14,000 TWh.[156] The estimate is conservative, as it only includes

resources on depths down to 300 meters. Given Norway's competitive advantages from its national offshore petroleum industry, Norway is in a position to take the lead and benefit economically from developing the offshore wind industry. The Minister of Oil and Energy at the time, Ms Åslaug Haga, has highlighted Norway's potential to become a massive exporter of renewable energy to the EU over the next decades drawing on a combination of Norway's huge hydropower resources and offshore wind.

Developing and commercialising offshore wind in Norway will require significant investment. Firstly, there is the question of the basic grid infrastructure. Norway does not have capacity to absorb the potential energy produced, and will require to export it. But the present land-based national electricity grid does not have sufficient capacity for the extra energy and requires to be developed accordingly. In addition, a green offshore infrastructure must be built to transfer the energy from the offshore wind parks to land-based grids. Secondly, there is the question of developing, testing and commercializing off-shore wind technology and solutions – the off-shore mills themselves and systems for construction and maintenance. A number of Norwegian companies such as Hywind, Sway and NorWind are currently developing prototypes while the Norwegian government is looking into increasing support for renewable energy innovation and development.

Norwegian companies are also showing interest in the Chinese market for bio-energy. At least two projects are currently at the early stage of development and Norwegian research institutes and universities are also engaged in projects concerning biofuel and bio-energy. Telemark University College has had an academic exchange agreement with Huazhong University of Science and Technology since 2005 for the development of a highly efficient small-scale biogas plant. The project aims, in particular, to make existing biogas plants more efficient, both in terms of energy extraction and cost, by making remaining mass clean and weed-free fertilizing products. The Norwegian research centre CICERO (Centre for International Climate and Environmental Research – Oslo) has conducted research on bio-energy in rural China, looking especially at possibilities for replacing coal ovens in farmer's houses with an oven running on bio-fuel that can be used for both heating and cooking.

Can Norway help change the future of Wind Power?

Norwegian energy giant **Statoil-Hydro** is investing in commercializing off-shore wind. The company is presently investing NOK400 million in building the first full-scale floating windmill outside the coast of Rogaland, Norway for testing in the period 2009-2011. The device will integrate existing technologies in new ways as well as new technology developed with Norwegian research institutions. The wind turbine will be built by Siemens and placed on a 120 meter floating chassis of concrete. The blades will have a diameter of 80 meters and the tower will rise 65 meters above sea level. The floating device will reach 100 meters below sea level and be chained to the bottom with three cables. The windmill can be placed on depths between 120 and 700 meters. (Source: www.statoilhydro.com)

Statoil-Hydro also owns considerable shares in the small Norwegian renewable energy company **Sway**, with the patented SWAY® system for wind turbines that produce power in deepwater locations. The system is a floating foundation capable of supporting a 5 MW wind turbine in water depths from 80 to more than 300 meters within 50-60 km from the coast in some of the world's roughest offshore locations. The SWAY system is suitable for electrification of off-shore oil & gas platforms. A detailed case study for the integration of wind power to an oil platform off the cost of Norway was successfully completed in 2004. The study concludes that it is both technically and economically feasible to integrate wind power with the existing gas and diesel generators on the offshore oil & gas platforms. (Source: www.sway.no)

NorWind AS is a newly established Norwegian Engineering, Procurement, Construction and Installation (EPCI) contractor uniquely dedicated to offshore wind energy. NorWind aims to become the leading supplier of foundations and installation services for offshore wind farms in water depths above 20 meters. A basic element of the NorWind strategy is to invest in complementary technologies and participate in the development of companies. As part of this strategy, NorWind has taken a substantial ownership position in OWEC Tower, so far the only technology installed on more than 30 meters water depth. The OWEC technology is designed for depths between 20 and 90 meters, making it well suited for installations i.e. in the southern parts of the North Sea. NorWind is initiated, supported and owned by renewable energy incubator Scatec and maritime services provider the Grieg Group. (Source: www.norwind.no)

'Salt power' – a new renewable energy source invented in Norway?

Norwegian hydropower giant Statkraft, Europe's largest provider of renewable energy according to its own website, has over many years invested in developing 'salt power'. At Christmas 2008, the world's first salt power plant prototype will be ready outside of Oslo in Norway.

Salt power arises when freshwater and salt water meets on each side of a membrane. This creates a pressure which can be used to generate electricity. Statkraft has for many years invested in developing membranes to harness this energy, which arises wherever freshwater runs into the ocean. Statkraft estimates a global salt power potential of 1600-1700 TwH, equal to China's electricity use in 2002. Stein Erik Skilhagen, leader of Statkraft's salt power development unit notes that salt power has certain advantages compared with other forms of renewable energy. For instance, it produces electricity constantly throughout the day and night.

Norwegian companies in China consider the field of renewable energy in China to be significantly important for investment purposes. However, with the exception of one company, China is rated as being of little importance for their own current business activities, highlighting that other geographical markets as well as their home market are of greater importance, both currently and for the forthcoming five-year period.

Norwegian Solar Energy Company REC Chose to Establish Production in Singapore

Renewable Energy Corp (REC) is currently investing 6.3 billion Singapore dollars (US$4.3 billion) to build the world's largest solar manufacturing complex, and it's first on the Asian continent, in Singapore. When fully operational, the integrated solar manufacturing complex will be able to produce both wafer, cell and module production up to a total capacity of 1.5GW each year. This will be equivalent to more than 70 per cent of the total global output of 2 GW last year (2006), according to REC. Established in 1996, REC is one of the world's largest manufacturers of multi-crystalline silicon wafers for solar cells. In 2007 it had revenues of $1.1 (€0.8) billion NOK6.642 billion and an operating profit of $0.44 (€0.32) billion.

Source: China Daily 26 October 2007 and REC annual report for 2007.

3.2.2 Energy efficiency in industry

Energy intensive industry in China produces large amounts of waste heat, and one area of interest to Norwegian industry has proven to be the ferroalloy industry where knowledge transfer in terms of heat recovery technology for production of electricity and/or heat can be exploited.

The six Norwegian companies observed working towards the energy efficiency field in China, are currently engaged in the market assessment. In general, they have rated this field to be of little importance to their business at the present time. However, they consider its potential to be of significant importance for their business over the next five years, and foresee that as an investment destination seen from a global perspective, China will play an important part for business opportunities in this field.

NEEC – Norwegian Energy and Environment Consortium

NEEC is organized as a multi-client project within Innovation Norway and consists of more than 30 members, from the Norwegian private, industrial and research sectors closely engaged by and in this sector in China.

NEEC's Energy Management Program is a prioritized part of the energy and environmental sector work performed by the Innovation Norway Beijing Office (Commercial Section of the Royal Norwegian Embassy). The aim of the program has been to support energy efficiency efforts in Chinese heavy industry and buildings through the transfer of Norwegian experience, technology and competence.

The program is based on the MoU on Climate Change between the Norwegian and Chinese government, and is part of a longstanding relationship between the Confederation of Norwegian Enterprise (NHO) and CEC (China Enterprise Confederation). Several Chinese CEOs and experts have been introduced to Norwegian technologies, and several project opportunities have been identified, amongst others the possibility of recovering heat in the ferroalloy industry that can be used for the production of process steam, heat and electricity.

The NEEC consortium creates the advantage of a multi-client project group. Norwegian member companies strengthen their competitive positioning to become interesting partners for Chinese companies as they can offer a complete energy efficiency project, not only playing a role as technology provider or energy specialist.

Source: Innovation Norway 2008.

3.2.3 Energy-efficient and green buildings

The Norwegian companies present in China focusing on environmental technologies and solutions for the housing market are of a very diverse nature. They cover product areas such as paint, sanitary systems, generic building modules, and services such as architectural design and construction development of sustainable industrial buildings. Most companies are at an early stage of market entry in this green market sector. This is linked with the stage of development of this market in China, which is rated to be very immature by all companies.

The forthcoming World Expo in Shanghai in 2010, where the theme for the exhibition is "Better City, Better Life", provides an opportunity for further focus on this sector. Current housing standards in China are highly variable, and mostly not of a sustainable nature. Areas such as energy efficiency, environmentally-friendly construction materials, isolation standards, water usage, and sewage systems – to mention a few – are all potential areas identified for improved sustainability. However, the level of market awareness and investor interest has been experienced to be low in China. This has meant that earlier projects initiated by Norwegian companies did not go past the project-planning stage of market entry. Economic benefit to the customer has been observed to be a key element in any product or service to be offered in this area.

3.2.4 Transportation – efficiency and saving measures

Although several Norwegian companies in the clean and effective transportation sector have reached an advanced stage in their home market, very few have currently been observed to show interest or to be active in the Chinese market. Fewer than five Norwegian companies have been registered in this market sector in China. Although some of the companies have been operating in China for many years, they hold a very small market share. Others have only reached an early stage of market evaluation. The companies cover specific high-tech niche areas within this sector such as automatic tolling systems (ETC), and systems for NO_X emissions control for diesel vehicles, electricity powered vehicle and ICT-systems.

Interestingly, illustrating the dynamics of competition in this market sector, one of the historically best-established Norwegian companies in this field has chosen to withdraw from operations in China as strong competition from local companies was faced following the introduction of new standards in 2007.

With the implementation of new engine emission standards, Norwegian NO_X emission technology could be of interest to the Chinese market. The urgent need for better city planning is also a trigger point that can create opportunities for Norwegian information systems such as electronic road infrastructure planning. The signal from Norwegian companies in this sector is, however, that they observe high entry barriers to establishment in China, and will adopt a long-term strategy if they are going to be successful in this potentially large market.

TANDBERG

Norwegian videoconferencing company TANDBERG has been engaged in China for more than 10 years. The company staged a grand opening ceremony for its newly registered wholly foreign-owned enterprise in September 2007. Norwegian Prime Minister Jens Stoltenberg gave much needed publicity and high profiling of the company by his presence and speech. The re-make which incorporated the launch of new product improvements interlinked with a major company "re-launch" in March, stimulated a successful 70% market growth. TANDBERG now has 30 employees in China and over 100 companies as local customers, many of which are central and regional government authorities.

Tandberg's videoconferencing equipment can provide internal meeting efficiency and cost reduction achievements through reduced business travel. As an indirect result of the active usage of their system, it also has a positive effect on CO_2 emissions. China is an emerging market and TANDBERG faces the challenge of improving user awareness. With a large, young IT-competent population, video conferencing equipment may be easily adapted to Chinese tastes. Currently, this demographic cares about the environment, but finds it hard to identify means for becoming actively engaged in sustainability efforts.

Source: Innovation Norway 2008

3.2.5 The Clean Development Mechanism

China is proving an interesting country for investment in CDM projects and the purchasing of potential CERs at a reasonable rate. Norway alone will spend about €500 million in 2008 on CERs (and Emissions Reduction Units – ERU), and plans to contract some 30–35 million tons for delivery during 2008–2012. [157] A major part of this is expected to be purchased in China.

Several Norwegian companies have started engaging in this rapidly developing market as project developers, investors, advisors and facilitators, as well as project evaluators. Most of these companies are relatively newly established and generally small in size. They normally rely on a network of partners, as the market is complex and growing rapidly.

Det Norske Veritas (DNV) Passes Validation of Their 1000th CDM Project Worldwide

Within the field of environmental risk management, Det Norske Veritas (DNV) has been a pioneer in climate change activities since 1997 and has globally trained over 200 auditors in this field. In March 2004, DNV was the first Designated Operational Entity (DOE) accredited by UN (UNFCCC) for validation and verification across all major sectors of CDM projects. DNV has also co-developed the validation and verification manual that is generally recognised as the standard for this process. Worldwide DNV are leaders in the market segment of validating projects for CER quotas.

In 2004, DNV was one of the first companies in China to start validating CDM projects. DNV is now a market leader in the validation process and look to establish a strategy that gives them a stronger foothold in the annual verification process, where actual Certified Emission Reductions are measured and calculated based on company performance. DNV established an office in Shanghai in 1995 and their China operations were, in 2007, their largest unit outside of Norway. In 2007 the company had 750 employees in China spread among 36 offices. The company has three core focus areas: Maritime, Industry and Energy, with a 60-30-10% split in terms of people and activities.

Source: Innovation Norway 2008.

NEEC Facilitates Identification and Development of CDM Projects

Most of the projects identified through the Energy Management Program of NEEC are also suitable for sales of CO_2 quotas through the Clean Development Mechanism (CDM) to increase and/or realize the profitability of the projects. In 2007, six projects were identified through the Energy Management Program to PIN (Project Idea Note) level which is the first step towards reaching a certification for sale of CO_2 quotas.

	ENERGY MANAGEMENT PROGRAM 2007 - ENERGY EFFICIENCY & CDM PROJECTS IN CHINA				
No	Project owner / CDM partner	Type of project	Project development status	Saved t CO2 per year	CERs 2008 - 2012
1	ERDOS Phase 1	Heat recovery in the ferroy alloy industry	PIN submitted in October. Co-operation discussed in November and ongoing	440 000	1 320 000
2	ERDOS Phase 2	Heat recovery in the ferroy alloy industry	PIN submitted in October. Co-operation discussed in November and ongoing	350 000	1 050 000
3	Sinosteel Jilin Ferroalloys	Heat recovery in the ferroy alloy industry	PIN prepared in Dec 07 after discussion of co-operation in Nov 07	90 000	270 000
4	Sinosteel Liaoyang Ferroalloys	Heat recovery in the ferroy alloy industry	PIN prepared in Dec 07 after discussion of co-operation in Nov 07	26 000	78 000
5	Sanhe Green Hong Kong Ltd.	Straw Fired CHP 50 MW	Building permit granted in Sept 2007, Constr from April 2008 to autumn 2009	322 000	1 046 500
6	Qingdao Heat & Power Corp. Ltd.	Straw Fired CHP 24 MW	Building permit in 1Q 08, Constr from April 2008	154 560	618 240
	TOTAL			**1 382 560**	**4 382 740**

NEEC is now planning further development of potential energy efficiency projects in cooperation with project owners. These steps further the development of Project Design Documents (PDDs) and the certification of Certified Emission Reductions (CERs), preparing for the implementation of Energy Efficiency Measures.

Source: Innovation Norway 2008.

3.2.6 Air pollution

Air pollution and emission control has been a traditional focus area for Norwegian bilaterally-financed projects in China. Norwegian companies present in this field are mainly larger Norwegian international companies of which the majority have a well-established business in China. Their core business activity is not necessarily air filtration technology, but their type of business has meant that they also have had to build expertise in this area.

In terms of industrial emissions, foreign-owned production companies in China are facing increasingly stringent environment control standards in line with the increasing government pressure on local authorities to follow up and improve environmental standards. Norwegian companies have traditionally held a high standard, but are having to continue to improve the air filtration systems both for internal and external environments linked to their production sites. It is expected that the local national industry will also face the same stringent monitoring sometime in the future.

Elkem – Filtration Technology That Help Minimize Acid Rain Emissions

Elkem is one of Norway 's largest industrial companies, and one of the world's leading suppliers of metals and materials. Elkem has a well established micro silica business in China, where filtration technology captures and recycles harmful silica fumes. The company's efficient micro silica technology has been installed in over 85 factories in China, and provided Elkem with useful micro silica material that is sold, amongst others, to the concrete industry.


Effect of filtration technology installed at a ferrosilicon factory in Xibei, set up by Elkem and implemented by SINTEF, the largest independent research institution in Scandinavia. Photos and source: Elkem.

Although not yet introduced in China, Elkem possesses the technology to filtrate SO_2 with very effective results. The Norwegian invented scrubber ELSORB, which Elkem has installed in oil refineries, has the potential to remove as much as 99% of the sulphur dioxide from tail gas. The recovered sulphur becomes a commercial product which can be utilised as fertilizer or in the cellulose pulping industries. (Compared with other know technologies, employment of this technology is considerably cheaper according to Elkem.) Elkem also has a baghouse particle filtration system that is used for ash dust capture in electrochemical factories. Both these technologies can be transferred to coal fired power plants, which in China mostly are equipped with old filtration technology from the Soviet era.

To enter the Chinese market with these filtration technologies demands pilot studies to adjust technology to fit the coal combustion industry. Herein lies the risk of exposing patented technology. With no strict pollution standards that are reinforced in the coal combustion industry, the incentive in the market is currently not present. Elkem is hesitant to invest in selling this much-needed but expensive technology on a case-to-case basis when there is no official and nationally coordinated strategy for employment of such technology. Elkem also notes that it does not consider exposing patented technology a problem as long as they can get a big enough order to establish industrial production of filtration units in China. This would also provide a basis for China to develop a significant export industry in the field.

There are at least four main areas within air pollution where Norwegian companies can provide technologies and expertise: capture of SO_2, capture of NO_X gases, coal dust filtration, and the capture of CO_2. These are all major pollutants in China and strategic cooperation with Chinese authorities to establish pilot projects is emphasised by companies engaged in this industry sector as the key to success. Good market access can help to improve the prospect of substantial revenue potential, thereby minimizing the economic risk of a possible loss of patent.

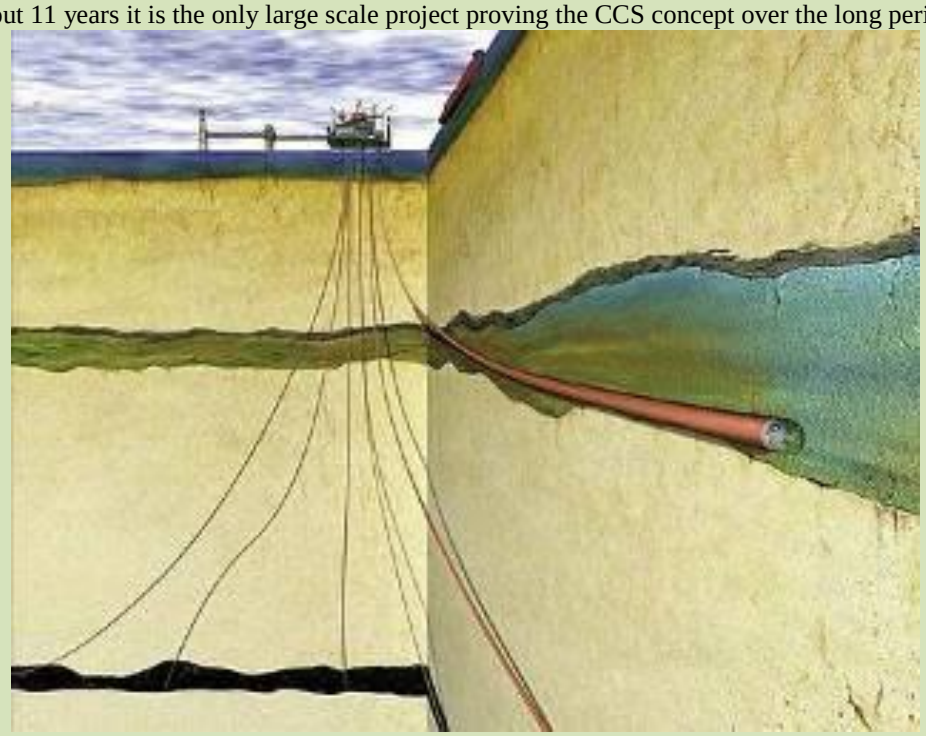
Carbon Capture and Storage (CCS) is a priority for the Norwegian government, yet the Chinese have so far not expressed much interest in pursuing cooperation with Norway in this field. At the meeting between Norwegian Minister of Environment and Development, Mr. Erik Solheim, and Minister Xie Zenhua of the NDRCD, June 2008, Minister Xie expressed the opinion that CCS is an immature technology whose implementation lies 15–20 years into

the future. Minister Xie also noted that China already has four or five pilot projects with other Western nations.[158]

Carbon Capture and Storage – one measure to combat climate change

StatoilHydro has more than 10 years of experience and mobilises significant human and financial resources for safe and sufficient industrial implementation of CCS technology within the full value chain, as well as for research and development in this field.

Introduction of a high CO_2 tax from the Norwegian government led to a pioneering and early development of the CCS technology and competence. The StatoilHydro-operated Sleipner West field is one of the largest gas producing fields on the Norwegian Continental Shelf. In order to meet commercial demands, 9 per cent content CO_2 in natural gas was to be reduced to less than 2.5 per cent. As a result, the world's first offshore carbon capture plant came into operation in 1996 along with its first carbon storage project in a geological formation. Annually approximately 1 million tons of CO_2 is stored in the underground, and operating for about 11 years it is the only large scale project proving the CCS concept over the long period of time.



CO2 injection

An important part of the Sleipner CO_2-injection project has been to verify that geological storage of CO_2 is a safe and reliable mitigation option. Since 1996 injection in Sleipner has contributed to learning and confidence building through a series of large EU-wide R&D programmes, focusing on storage monitoring. A key decision was to allow full openness regarding research results.

StatoilHydro has in recent years added two more CCS projects to its portfolio – the onshore In Salah project in Algeria and the offshore Snøhvit project in Norway. The Norwegian authorities have signed an agreement with StatoilHydro to finance a full scale CO_2-capture plant and associated pipeline and storage solution for the new power plant at Mongstad. Other CO_2 sources at the refinery may also be captured at this plant. The project is still on the drawing table. StatoilHydro is also involved in a project where CO_2 is planned to be captured from exhaust gas. The main objective for this project is to test, verify and qualify capture technologies capable of wide national and international deployment. By using this experience as a base, StatoilHydro now intends to generate significant business from CO_2 management.

Norwegian companies generally emphasise that China can be a key market for future investment in the air purification sector although their current business activities in this field in China is of low to moderate importance in their overall business.

Bio-Powered CO2 Capture Technology
Aker Clean Carbon was awarded the 2008 prize for best new innovative and environmentally friendly technology at the Technoport Awards for its CO2 capture technology. The bio-powered capture technology is a further development of the company's amine-based post-combustion capture solution, which can be deployed on gas and coal-fired power stations, and other industrial sources.

The innovative technology uses an integrated bio-power station to produce the necessary steam and electricity to support the capture facility. In addition, the CO2 from the exhaust from both the gas and bio power stations are captured effectively. This solution captures more CO2 than what the gas power station produces (116 per cent) since it also capture CO2 from bio power that is climate neutral, and in this way contributes to reduce total harmful emissions. The technology is carbon negative, because it removes the CO2 from the natural carbon cycle.

A bio-powered plant can capture about 30 per cent more CO2 and produce about 20 per cent more electricity than a plant that uses conventional capture technology. The bio-facility is fuelled by biomass (chip or pellets) from wood, which means the natural forest growth can be deployed in an optimal way. The bio power station achieves an energy efficiency of about 90 per cent.

"A bio-powered carbon capture plant is an exciting solution, which could have a very positive impact on the environment. Some work still remains before the first bio powered capture plant is in operation, and this award inspires us to continue working hard to get to that point," says Oscar Graff, chief technology officer in Aker Clean Carbon.

Source: Press release from Aker Clean carbon, 22 October 2008.

3.2.7 Water management

Norway has a long history of being involved in water purification and treatment projects in China. The first Norwegian companies that entered this market area in the 1990s were based on mixed credit loans provided by the Norwegian government. Traditionally, Norwegian companies have been involved in the treatment of wastewater and sewage. Norwegian companies also offer unique Norwegian developed technologies that are linked to more niche areas such as desalination facilities and water saving sanitary solutions.

Currently, there are close to 15 Norwegian companies that are involved or are showing interest in the Chinese water purification field. A number of these are new entrants, suggesting there is an optimistic outlook for companies looking at possibilities in this market. A general characteristic for this market sector is that Norwegian companies are often SMEs, and recent new entrants are drawing on the benefit of being organised in a consortium.

A Norwegian Water Pilot Project in China - Consortium Model Offers a Win-win Scenario for Accessing Market Potential in the Water and Waste Water Sector

Improved water and waste water treatment solutions in China are badly needed, especially in many rural areas. Norwegian technology needs to adapt to the local environment and a pilot project is key to market entry.

NEEC is working in cooperation with Clean Water Norway (CWN), an association of approximately 20 water companies in Norway, on a water project in China. CWN comprises skill sets from consulting engineers, plant contractors and product specialists in the fields of water and wastewater treatment. A multi-client project is under planning and is expected to be initiated in China during 2009. The aim of the project is to develop a complete water and sanitation facility for a typical small town/village or new residential area in China, based on a complete package of Norwegian knowledge and technologies.

Through developing such a project it is believed that the results of the project can be disseminated to further projects, which might have a positive effect on the implementation and success rate of the introduction of Norwegian knowledge and technologies. Energy efficiency will quite likely play an important part in this project as water saving is also energy saving as well as cost saving. If a pilot project proves successful, Norwegian treatment technology and competence will have good prospects as long as the result proves

economically acceptable. Experiences from the already implemented energy management program will provide valuable input both for the development of the project as well as for creating possible synergies in project development.

Source: Innovation Norway 2008.

The Norwegian marine industry is known for its technology and sustainable fish farming facilities, which could be of benefit not only to the fish, but also to both China's lakes and seawaters. Current Norwegian activities mainly focus on aquaculture technology and river monitoring projects. In addition, there are several companies within the area of fish health and vaccination that have conducted market assessment studies and are considering the possibility of entering the Chinese market. Norwegian research institutes have also been engaged in the Chinese market. However, the current Chinese market is at an early stage of development in this respect and many challenges have to be overcome before successful business can be established. The Norwegian marine industry holds a strong technology advantage within the area of fish health and aquaculture technology that should be of major interest to China as it generates a better and more sustainable marine sector.

The majority of the Norwegian companies operating in this field emphasise that the Chinese market will become increasingly important for their business activities in the future. China has enormous potential for water purification technologies as well as water efficiency and management technologies. A key to market access is to identify project solutions that provide financial incentives to potential Chinese customers.

3.2.8 Maritime industry

The Norwegian maritime industry has a long history of association with China. With over 30 companies registered with offices in China, it is one of the most extensive Norwegian sectors within the country. The nature of the Norwegian maritime industry is mainly that of a supplier of components to the shipbuilding industry or as a transportation carrier with vessels that utilise Chinese ports. To a large extent, their activity does not impact mainland China's sustainable green economy, and worldwide only 2% of overall human emissions of CO_2 derive from shipping. However, there is an increasing focus in this industry on ensuring sustainable standards, with the Norwegian shipping industry at the forefront. Their efforts will also affect Chinese seawaters, shipbuilding, and port areas.

The International Maritime Organisation (IMO) sets the standards for this industry in areas such as treating ballast water to avoid uncontrolled transfer of marine organisms from one region to another; the use and emission level of environmentally-harmful greenhouse gases on ships; and encouraging focus on CO_2 emissions which are directly proportional to bunker consumption. Norwegian shipping companies have a strong commitment to high environmental standards in line with guidelines set by IMO.

Wallenius Wilhelmsen Logistics (WWL) Received Lloyds Green Shipping Award in December 2007
WWL has shown a strong commitment to being green. For example, it is WWL's tough, self-imposed environmental policy that has saved the world from 75,550 tons of sulphur dioxide emissions in a six year period between 2001 and 2006 - a 33.6 per cent reduction. Between 2000 and 2006, WWL also reduced the fuel consumption per transported unit by 11.5 per cent, thereby cutting emissions of carbon dioxide and nitrogen oxides, as well as sulphur oxide, into the atmosphere.

Their green concept vessel, E/S Orcelle, has heightened their focus on developing more sustainable energy sources. "We are already testing fuel cells and our next generation of Mark V ro-ro ships will use exhaust emissions to generate electrical power when vessels are at sea," said CEO Arild Iversen. "New vessels are also being fitted with the innovative PureBallast water treatment system."

Source: Wallenius Wilelmsen Logistics

The transportation of LNG onboard vessels to end-users located outside the normal distribution grid is an interesting concept, providing them with a unique opportunity to switch to natural gas which has significantly lower emission levels than, for example, coal. Norwegian shipping companies pursue this type of transportation on Chinese rivers.

The Norwegian maritime equipment industry has a long-term presence in China within areas such as environmentally friendly coatings and sanitary systems. More recently, Norwegian shipbuilding skills in terms of engineering capacity, have been established to facilitate strategic cooperation with well known Chinese shipyards or workshops to manufacture FPSO, drilling vessels, semi-submersibles, subsea equipment and topside modules to serve its international and local clients.

3.2.9 Solid waste management

In the field of solid waste management, only two Norwegian companies have been registered. However, only one is presently active in China. The attractiveness of the solid waste management field in China is strongly linked to the economic benefits generated by the demand for recycled products. In the case of PV slurry, where Norwegian technology has made a breakthrough, the rising solar manufacturing industry stimulates a growing demand in the market. Also, China is a key world centre for Solar PV manufacturing industry, which means that recycling takes place close to market.

Metallkraft Sets up Recycling of Silicone Slurry for Solar Wafer Production in Yangzhou

The rapid rise of the solar industry has put pressure on the supply of raw materials. The wafer cutting process, a crucial step in the production of solar panels, requires large amounts of cutting slurry. The slurry is quickly polluted during the cutting process by silicon shavings, metal particles from the saw wires, and water. The large amount of exhausted slurry that must be disposed of in an environmentally friendly way has been a headache for an industry that has environmental concern as its main guideline.

Metallkraft has a patented technology ensuring that the spent slurry is effectively recycled and that all pollutants are turned into commercially viable products. The recycled slurry fully retains its cutting abilities, at a fraction of the cost of fresh slurry. There is also a dry mix of undersized silicon carbide and metal particles which cannot be used as recycled slurry, leading to its use in the ceramics and metallurgical industries. Alternatively, it can be processed further into solar grade silicon and SiC melts. The result is 100% recycling without the addition of any chemicals. The process was developed by Dr Knut Henriksen, former Research Director at Elkem, and founder of the company.

Their first large-scale production site is now being set up in Yangzhou, providing a close location to their key customer, Jiangsu Shunda. The facility is expected to be ready for test production towards the end of 2008 and will be officially opened in early 2009 with an initial capacity of 20 000 tonnes/year from two production lines. The factory has a total capacity of 80 000 tonnes/year, which should be achieved by 2010 providing an estimated turnover of US$160 million. The company aims to have a world market share of 20% and plans to have three operational factories by 2012.

Source: Innovation Norway 2008.

3.3 Barriers for Norwegian EGS exports to China

Norwegian companies consider the Chinese market for green products and services to have relatively high entry barriers. This leads to a challenging market environment where additional resources are required to ensure successful market entry. These barriers increase the likely risk of successful entry and may also prolong the market entry process.

Interestingly, Norwegian companies that are well established in China do not consider these barriers to be any lower than the significance rated by companies that are new entrants. This

emphasises that barriers in the Chinese market for green products and services will continue to affect and involve every-day business activities as companies become well established in this market.

As seen in Figure 10 below, the entry barriers are generally considered to be of moderate to high significance by 74% of the respondents.[159] During the coming years the barrier level is expected to decrease somewhat, mainly driven by a positive development in general market attitude as the green topic gains increasing focus from a top-down government approach. However, the pressure from international competition is expected to present an increasing challenge, and many companies stress the importance of early market entry in order to gain a good market position.

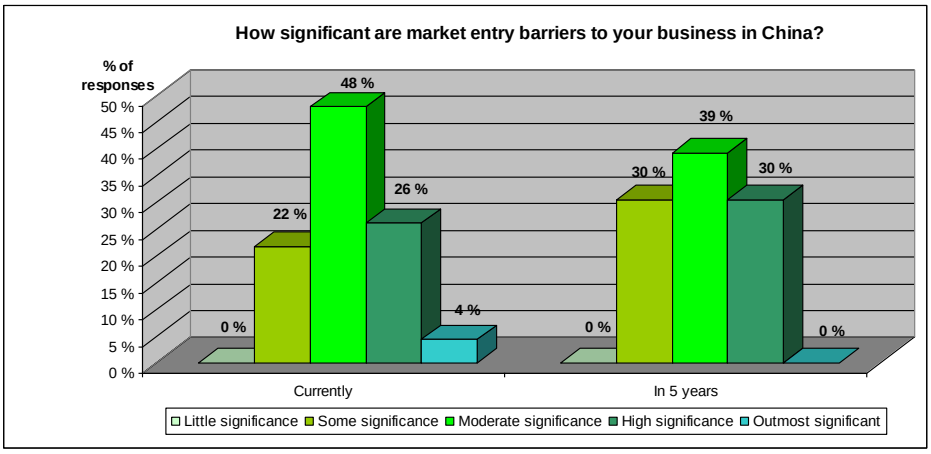


Figure 10: Market Entry Barriers in China / Norwegian Clean Tech Companies.
Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

The European Commission funded a study in 2007 that analysed the opportunities and challenges of EU–China trade relations.[160] Figure 11 shows that the companies in the European environmental technology and service industry considered current market barriers to be of a higher significance than emphasised by Norwegian companies. Although these two studies cannot be directly compared, the companies seem to be more in alignment when rating the level of market entry barriers in five years time.

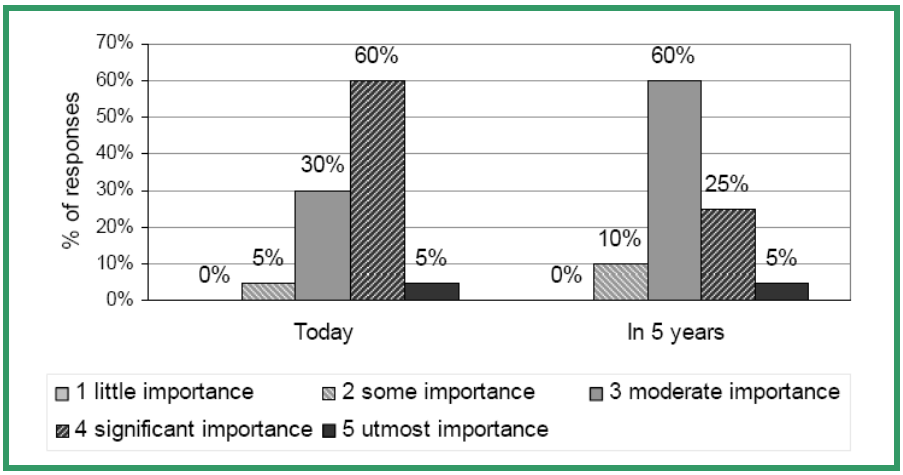


Figure 11: Market Access and Other Commercial Practice Problems in China (EU companies)

The most frequently mentioned market barriers are illustrated in Figure 12 below.[161] The research shows that these barriers are not specific to stage of market entry nor are they unique to specific market sectors, but relevant across all industrial sectors.

Interestingly, when comparing these results with those of the EU study, Norwegian companies identify local favouritism as a much stronger market barrier than European-based companies.[162] Comparing the two studies, IPR infringement stands out as a stronger obstacle for EU companies than for Norwegian companies. This probably reflects differences in the two sample groups, as the participating Norwegian companies generally have a much shorter history of business activity in China than companies in the EU study. The threat of IPR infringement is also related to the nature of business activities and degree of involved technology transfer to China. It underlines the importance of including the issue of IPR in the early strategic planning process. Norwegian companies often express a pragmatic attitude acknowledging that their small size has to accommodate for the possibility of generic copying through continuous technological development.

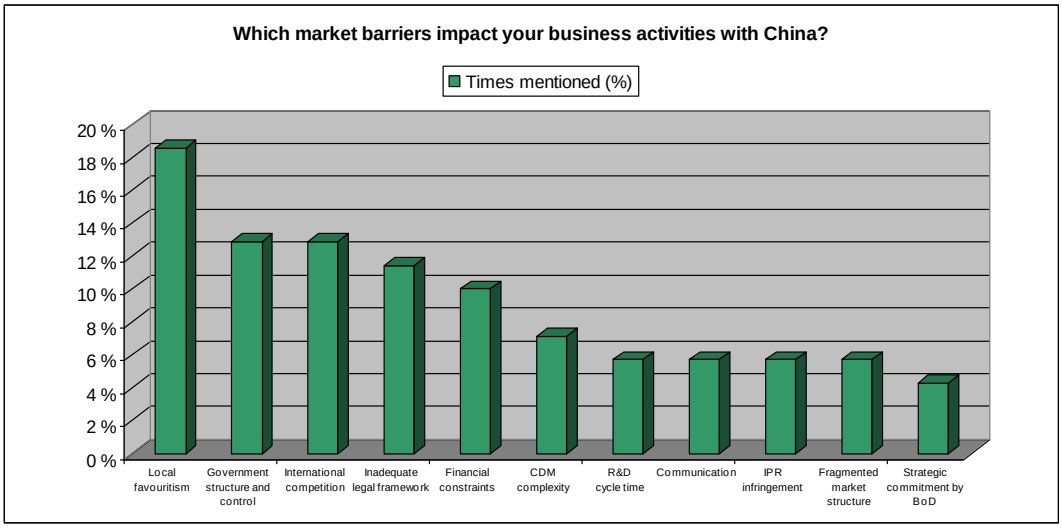


Figure 12: Market Barriers and Their Considered Impact for Norwegian Business Activities in China. Reinvang & Tønjum: "Prepared to Ride the Green Dragon?", WWF 2008.

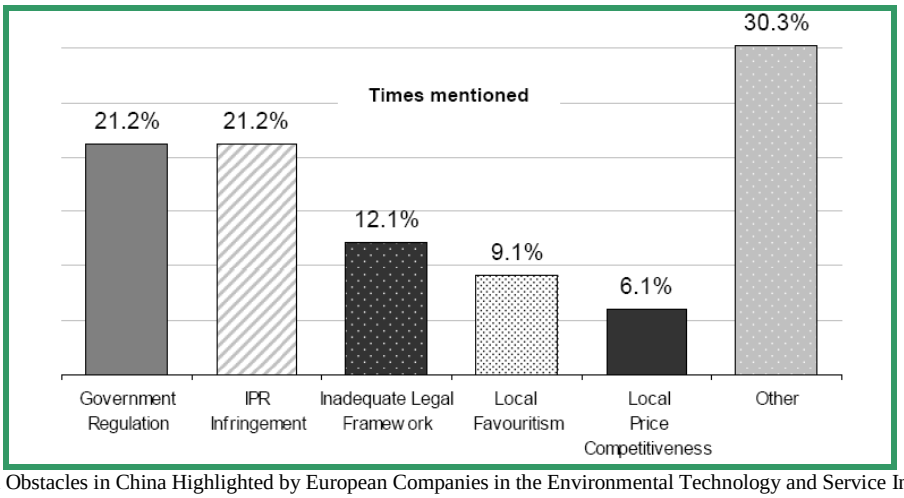


Figure 13: Market Obstacles in China Highlighted by European Companies in the Environmental Technology and Service Industry, 2007.

Local favouritism limits environmental benefit of best practice

Throughout the market for green products and services there are repeated examples of Norwegian companies being surpassed by local competition, although the chosen technology is of a lower environmental standard. In certain fields the officially defined standard has been placed at a level that allows local companies to compete, although this is at a lower level than Western best practice. The focus on low-cost, low-tech solutions challenges Norwegian companies which, to a large extent, offer high quality long-term solutions. Foreign companies are also known to face more stringent controls than their local counterparts, leaving an imprint of unfair/discriminatory treatment in favour of local business.

Government structure weak on securing continuity and facilitating easy market access

Within the market for green products and services, the public sector is potentially a major customer. The government also plays an important role in providing environmental standards as well as licensing agreements to foreign companies in order for them to be allowed to operate as a business. Norwegian businesses operating in China emphasise the need to work very closely and continuously with government officials in order to achieve results during their office term. Official employees tend to change jobs every 2 to 3 years without much overlap. This lack of continuity creates turbulence and delays that makes it more challenging to compete. This is also amplified by the lack of well-defined environmental standards and incentives that are followed through on a regional level. When it comes to licensing new products, product class may have to be established. This can be time-consuming, especially if the case has to be evaluated and presented to several parties over a period of time.

Inadequate legal system creates unpredictable business framework

The Chinese legal system is considered by many respondents to have a large number of grey areas that can run in a foreign company's disfavour. Concern is also raised regarding law enforcement–which is arguably weak, especially in relation to local business environments. The law is also under constant development which means that it sometimes changes rapidly, creating instability in the operating environment. This can have implications for the budget process and its quality of accuracy, for example, or for the operating process thereby delaying activities as new regulations have to be complied with.

Market attractiveness engages strong international competition

The market for green products and services is receiving increased international attention as the Chinese government places stronger focus on developing a sustainable future economy. This competition aids in raising awareness on quality, which leads to an advantage for Norwegian companies. However, it means that many large players with strong financial backing are competing in this market, presenting a barrier to Norwegian companies which are relatively small in comparison to their foreign counterparts. In addition, the companies are also often small in comparison to the jobs at hand. Very few SMEs can take on a turnkey responsibility often demanded by China's growing cities or customers such as the paper industry, steel industry and so forth. The OECD offer to China in the Clean Tech sector also needs to be more focused on Chinese demand rather than focusing on what the companies can supply today as separate entities. Norwegian SMEs are trying to counter their disadvantages by working together in a consortium. The synergies generated through cooperation and also the ability to generate interest in the market can serve as a good basis for further business development.

Market entry requires strong financial backing

Considering the complexities and challenges of the Chinese market to a foreign company introducing new green products and services, a need may be seen in having a proven pilot project locally to obtain local acceptance, considering the time to market is often from three to five years. This requires a high level of investment before a healthy cash flow can be expected.

Norwegian companies within the fields identified in this report are largely SMEs. Currently, they report three main sources of capital: private investors and equity funds; Innovation Norway's investment company, "Statens Investeringsselskap AS"; and public funding available through the systems of NORAD, which work under Official Development Assistance (ODA) regulations. The latter sources are most frequently used in the early stages of market assessment, and this report also reflects a high level of activity at this stage of market entry.

In order for there to be a viable business case, the challenge is to bridge the early market entry stage of feasibility studies with the later stages of business establishment and sales generation. The complexities of the Chinese market and the long time frequently necessary to achieve positive return on investment (ROI) means that the transfer of much-needed technology is limited by a lack of financial support. When looking at other OECD countries, their financial funding for cooperation with China tends to include a larger percentage of funding that is not ODA-tied – something which provides more opportunities to promote commercial cooperation. It is also helpful to create forums for Clean Tech companies and private investors to meet in order to attract capital into the sector. The Norwegian government can ensure that such a forum exists, following for example the model of SWENTEC in Sweden.

It appears that Norwegian companies have a very national approach to raising capital. In addition to national sources, Norwegian companies could look at the big investments being planned through World Bank, the European Bank of Reconstruction and Development and others, and consider bidding for implementing parts of such projects.

Complexity of CDM curtails Norwegian companies engagement

The CDM was developed to encourage investment and transfer of technology that would help to reduce greenhouse gas emissions in developing countries worldwide. The prospect of additional income from the sale of CER quotas makes projects more attractive and practical from a financial point of view.

Only 10 per cent of the respondents in this market study have considered using the CDM process to partly finance their environmental projects in China. Many companies are deterred from considering supporting a project with this additional income due to the complexity of attaining approval to CER quotas. In several cases their projects are on too small a scale for this process to be viable. Secondly, an approved methodology relevant to their technology field might not be available, requiring additional efforts in the PDD process. Third, the required cooperation with a Chinese partner adds risk and uncertainty in relation to control both of the project and the income from CER quotas.

The first Norwegian company to bring a Chinese CDM qualifying project through to filing with the national approval authorities took place in March 2008. The first CDM-approved projects in China entered the pipeline in 2005, illustrating how Norwegian engagement in this process linked with China has been very low.

Traditional Norwegian R&D cycle limits speed to market

The Chinese market for green products and services requires new technologies. China has a very fast development cycle, and tends to bring products and technologies to market at an earlier stage of the development cycle than is the norm in the Norwegian research environment. For a product or technology to receive customer interest, it has to prove itself in the Chinese market. This sets a challenge for traditional R&D and the accepted quality standard prior to introducing a new product or concept to the market. For a pilot project in the Chinese marketplace to catapult its company's market presence demands that the company both invest more resources and identify cooperative partners at an earlier stage of the R&D cycle than what traditionally is the norm.

Language barriers remain a challenge for good communication

Although not a unique when working in China, the language barrier is more profound than encountered in many other countries around the world. The language barrier remains high, especially when working in rural China where many of the green products and services projects are located. Translation services are often at a non-optimal level of quality leading to misunderstanding and misinterpretation. Mandarin has a structurally very different way of expression and argumentation that is also embedded in Chinese culture, something which means that even good English can be misunderstood. This complicates good liaison building and can create areas of conflict and delays in project developments.

Threat of IPR infringement requires rapid market access to reach critical mass

The risk of IPR infringement is high in China even with approved Chinese patents, and this has kept many companies from entering the market as they are concerned about exposing their technology. For Norwegian companies, it remains a challenge to attain a good market presence quickly in order to secure a good sales level and acceptable ROI. Several companies have expressed a willingness to take this risk of patent infringement if they can see a good route to rapid market penetration.

Young fragmented market demands efforts in education to stimulate investment in green products and services

When looking at the area of green products and services in China, it becomes apparent this is still a young market. During the last few years, increased emphasis by the government on this issue has resulted in raising awareness levels. Among others factors, environmental accidents have also played an important part in engaging the population. In March 2008, it was announced that SEPA will be promoted to Ministry of Environmental Protection (MEP). This should assist in making the issue of sustainable development highly visible on the political agenda and make the development of environmental protection rules less dependent on approval by other ministries which focus on economic growth.

Norwegian board of directors hesitant to engage in sustainable development in China

Several larger Norwegian companies have shown hesitation about entering the Chinese market for green products and services. They may already have technology available that can clearly benefit the Chinese market, but choose to either keep the technology national or to establish their international activities in other world markets. This is a result of the high entry

barriers outlined by this report, which means that some companies consider it more viable to achieve a more successful market entry with higher ROI in other geographical areas that provide better stability and lower operational risk. Many companies do not proceed past the stage of market assessment, and there are several cases of Norwegian companies having broken operational ties with China.

Improved incentives by the Norwegian government and increased facilitation of engagement by Norwegian branch organizations would most likely improve engagement by Norwegian companies in the EGS markets in China.

3.4 Conclusions

Norway is a nation with leading environmental standards and an advanced energy-industrial complex, which provides a solid base for developing and profiting from a strong Clean Tech sector. Norway has a number of small and medium sized enterprises (SMEs) with leading pollution control technology where the demand is immense in China. In renewable energy, Norway has world leading commercial groups in hydropower and solar energy. Norway is also leading in innovation concerning carbon capture and storage, deep sea off-shore wind development, and early-stage solutions such as harnessing the energy from freshwater meeting salt water ('salt-power'). A strong Clean Tech engagement with China is envisaged in the Norwegian government's recent China Strategy.

However, this study shows that PM Stoltenberg's vision and the aims of the China Strategy have not been followed up so far with concrete instruments and initiatives. Norway is not currently exploring "every technological and business opportunity that promotes change". Rather, in spite of the significant potential Norway is lagging behind other European countries regarding Clean Tech export and promoting commercial cooperation with China.

Norway generally lags behind its peers in terms of Clean Tech exports. In 2005, Norway's export of Clean Tech is estimated at €0.8 billion, merely 12% of Danish exports the same year (€6.7 billion) and 28.5% of Swedish exports (€2.8 billion). In contrast to Denmark and Sweden – where governments have consciously promoted development of the sector – Norwegian government institutions currently do not even provide statistics on status and development of the Clean Tech sector.

Studies also show that Norwegian companies have worse conditions than its European peers in developing the Clean Tech export sector towards emerging economies such as China. Norwegian companies receive less government support for feasibility studies regarding market entry potential in developing markets compared with companies of other European countries. Norway only provides Official Development Assistance funds for cooperation with China and – unlike other countries – also own funds aimed at promoting commercial cooperation. Finally, Norwegian companies are barred from making use of EU financial mechanisms promoting commercial engagement with China as Norway is not a EU-member and has not established similar mechanisms for Norwegian companies.

The survey of Norwegian EGS companies in this report shows that none of the major Norwegian commercial stakeholders regarding low carbon development – for example StatoilHydro's renewable energy division, solar company REC, and hydropower company SN Power (owned by Statkraft) – are currently engaged in China. This reflects significant challenges related to the Chinese market compared with other investment options. First, the

large scale hydro market is not open to foreign companies such as SN Power (but the rapidly developing small hydropower sector is). However, the non-involvement of the most important Norwegian commercial EGS stakeholders shows that even though the government has emphasized bilateral cooperation with China on environmental issues for more than a decade, frameworks are not in place leading to engagement of the most important Norwegian commercial stakeholders and their substantial financial, technological and human resources.

The fact that the Norwegian government is a majority owner in several of the most relevant large Norwegian companies (e.g. StatoilHydro and Statkraft), makes the contrast between political goals and lack of large company engagement even starker. The recent launch of a "Nordic Climate Cluster" of 16 large Norwegian and Swedish companies aiming to provide low-carbon solutions in the global market provides an interesting platform for the Norwegian government to engage with in the future when working to implement its China Strategy.

The current Norwegian commercial engagement in China is fragmented and dominated by small and medium-sized enterprises (SMEs). Only in one field ("energy efficiency") do the companies currently involved in China report that the engagement is "significant" for the company. This reflects the situation whereby most Norwegian companies are relatively new to the emerging Chinese market and that China has not yet become established as a key market. This also indicates that Norwegian companies are still in a vulnerable start-up phase and that the next five years will be crucial for consolidating and developing further the Norwegian SME engagement. In this context, the Norwegian SME consortium NEEC appears innovative and constitutes a basis to build on and possibly expand to include other Nordic/European SMEs.

Finally, Norway has a significant impact on the Chinese market through its $394 (€249) billion sovereign wealth fund (SWF) 'the Government Pension Fund' (GPF), which is based on petroleum revenues and is the second largest SWF in the world. The Norwegian SWF does not apply positive screening ('best-in-class') by sector in its investment portfolio something which contributes to develop best practises, and GPF has not set up any thematic fund targeting investments in Clean Tech or the wider EGS sector in spite of the documented financial viability of such targeting. (In contrast, the China Investment Corporation SWF recently announced that it will target investments in environmentally-friendly technologies.)

At end of 2007 the Norwegian SWF's holdings in China (mainland) in the energy sector comprised ten companies which are strongly engaged in coal power production or extraction. In addition there were investments in three oil or gas companies. There were no investments in renewable energy companies. Out of the 122 Chinese companies the Norway's SWF invested in, only one is easily identifiable as a Clean Tech company.

This implies that the Norwegian SWF investments in China (mainland) in 2007 generally supported unsustainable development trends which contribute to severe detrimental environmental impacts, thereby violating the spirit of the funds ethical guidelines. The fund's investment practises in China in 2007 also ran counter to the Norwegian government's China Strategy where it aims "to integrate environmental, climate change and sustainable development concerns into all Norwegian efforts vis-à-vis China." Moreover, the opportunities to target and profit from investments in the Chinese Clean tech sector were not actively explored. Targeted investments in the Chinese Clean Tech sector would also help develop the sector to the benefit of Norwegian and other international solution providers.

3.5 Recommendations

Given the urgency of the climate change and sustainable development challenge and the significant market opportunities in the EGS sector, WWF recommends all countries and stakeholders with human and financial resources in the field to engage strongly with China in the areas where they are leading. Strategic Clean Tech engagement with China and other developing nations should be part of a new "Green Deal", where major investments in application and further development of clean technologies stimulate renewed global growth while pushing the transition towards a more sustainable and low carbon economy forward.

Within such a perspective, the following recommendations are provided for Norway as an example of a country with human and financial resources to invest in a global sustainable development through EGS engagement with China.

In order to contribute to equitable sustainable development, Norway first of all needs to make a transition to a development model compatible with and supportive of global sustainable development. The Norwegian government should heed Chinese PM Wen Jiabao's recent call to developed countries to "alter their unsustainable lifestyle" and do more to help developing nations adapt to climate change.[163]

In order to position themselves strategically, Norwegian companies with relevant solutions need to increasingly embrace and invest in the opportunities provided by emerging markets in a global economy making a gradual transition towards a more equitable and green economy of the 21st Century by:

- increasingly include global perspectives for the EGS sector in business strategies and development, such as China's fast-pace growth in the EGS sector, low cost and rapid production capacity, possibilities for large scale pilot projects and potential role as technology and innovation hub in years to come,
- applying and investing in long-term strategies for developing and profiting from emerging markets such as China, thereby benefiting from first-mover advantage,
- focusing more on innovation and tailoring solutions to demand rather than export of existing solutions that often does not effectively match developing countries' needs,
- encouraging SMEs in particular to actively explore and realize potential for creating consortiums and common platforms in order to scale-up and become relevant in a global market.

Given Norway's expertise in pollution control and renewable energy, the Norwegian government should invest ambitiously in development of the national EGS sector in order to reduce CO_2 emissions and enable Norway to become a global solution provider, by *inter alia*:

- monitoring the development of the national Clean Tech sector and providing strategic support while learning from the experience of, for example, Denmark and Sweden,
- initiating a dialogue with the Clean Tech sector, investors and large businesses in need of Clean Tech infrastructure in overseas investments in order to frame a large Clean Tech sector push including removing legislative and regulation barriers,
- formulating procurement policies and large scale government projects with EGS tenders,
- launching Clean Tech R&D programs with business participation and establish innovation competitions and tenders,
- investing ambitiously in a transition from fossil fuel energy provider to renewable energy provider drawing on its advanced hydropower sector and with carbon capture and storage as well as deep sea off-shore wind development as locomotives of innovation.

The Norwegian government should also engage relevant companies in a dialog on a stimulus package to promote global low-carbon development through ambitious private-public partnerships (PPP) in selected fields, *inter alia* by:

- actively following up Hu Jintao's recommendation to "strengthen [Sino-Nordic] cooperation in new energy and environmental protection, especially in raising energy efficiency in the construction sector and in hybrid energy and clean energy development",[164]
- making use of its position as majority owner of major Norwegian energy companies to ensure that business strategies and investments contribute in addressing the global climate challenge while securing return on investment for shareholders,
- taking the initiative to engage Norwegian large companies with low carbon solutions and innovation potential in the Chinese market in order to establish a bridge and also entry points for SME innovative companies,
- exploring possibilities for Sino-Norwegian PPP where Norwegian companies have significant potential for contributing to large-scale implementation of low carbon technologies such as hydropower, CCS, PV-industry and off-shore wind. Given the currently limited Chinese interest in cooperation on CCS and the closed large-scale hydropower sector, offshore wind (and PV) emerges as an interesting new field of exploration.

The Norwegian government should also support Norwegian SME export of EGS and provide incentives for transfer of technology, by *inter alia*:

- actively following up Hu Jintao's recommendation to "encourage [Sino-Nordic] technological cooperation between our small and medium sized enterprises, set up platforms for them to increase business contacts and encourage them to share distribution channels and jointly develop products",[165]
- bringing support mechanisms and incentives for the sector on a par with other OECD countries and launch further initiatives to make Norway a leader in the field, especially in providing frameworks and incentives for export to and cooperation with developing countries where the needs are largest and markets less mature,
- providing relevant financial programme information from international financial institutions, nation states and unions (EU) in a condensed format to the Norwegian Clean Tech sector.

The Norwegian government should also aim at setting new standards for Free Trade Agreements in current negotiations with China, by:

- applying documented best practice for integration of environmental concerns and stimulating cooperation and innovation in the EGS sector,
- providing incentives for increased employment of (often advanced) Norwegian EGS solutions in China and (often low-cost) Chinese EGS solutions in Norway,
- taking the initiative to jointly develop a model methodology for measuring the carbon footprint and environmental cost of bilateral trade. It should also include mechanisms allowing corresponding money flows to be invested in reducing environmental impact.

Finally, the Norwegian government should make Norway's SWF a financially-sound driver for global low carbon development, by:

- introducing positive filtration by sector thereby supporting best in class companies,

- developing instruments ensuring that Norway strategically invests in the transition to a more low carbon economy in China and other emerging economies through "best-in class" screening and separate Clean Tech investment funds.

For a more detailed description of WWF's recommendations for the coming revision of the ethical guidelines of the Norwegian SWF, see Wong, K. et al: *Fund Management in the 21st Century: The Role of Sovereign Wealth Funds in Promoting a Low Carbon Future*, WWF & Innovest 2008.

Abbreviations and acronyms. Glossary

¥ Chinese Yuan (RMB)

BB Bulletin Board

CAPS Controlled Air Pyrolysis System
CCICED China Council for International Cooperation on Environment and Development
CCP Chinese Communist Party
CCS Carbon Capture and Storage
CDM Clean Development Mechanism
CEO Chief Executive Officer
CER Certified Emission Reduction
CNOOC China National Offshore Oil Corporation
CO_2 Carbon Dioxide
COD Chemical Oxygen Demand
CWN Clean Water Norway

DNA Designated National Authority
DNV Det Norske Veritas
DOE Designated Operational Entity

EGS Environmental Goods and Services
ESCO Energy Service Company
ETC Electronic Toll Collection
EU European Union

FPSO Floating Production Storage and Offloading
FTA Free Trade Agreement

GDP Gross Domestic Product
GW Gigawatts
GWh Gigawatt hours
GWp Gigawatt peak

HFC hydrofluorocarbons

ICT Information and Communication Technologies
IGCC Integrated Gasification Combined Cycle
IMO International Maritime Organization
IPR Intellectual Property Right

kCER 1 kCER = 1000 CER (Certified Emmission Reduction)

Kgoe/t Kilogram of Oil Efficiency Per Tonne
kW Kilowatts
kWh Kilowatt hours
kWp Kilowatt peak

LEED Leadership in Energy and Environmental Design

M Million
m^2 square metres
MoE Ministry of Environment
MOFCOM Ministry of Commerce of the People's Republic of China
MoU Memorandum of Understanding
MW Megawatts
MWh/t Megawatt hour per tonne
MWp Megawatt peak

NASD National Association of Securities Dealers
NDRC National Development and Reform Commission
NEEC Norwegian Environment and Energy Consortium
NEPA National Environmental Protection Agency
NHO Næringslivets Hovedorganisasjon
NILU Norsk Institutt for Luftforskning
NIVA Norsk Institutt for Vann og Avløp
N_2O Nitrous Oxide
NO_X Nitrogen Oxides
NOK Norwegian Kroner
NORAD Norwegian Agency for Development Cooperation
NPC National People's Congress
NTNU Norway University of Science and Technology
NVE Norges vassdrags- og energidirektorat

ODA Official Development Assistance
OECD Organization for Economic Co-operation
OTC Over The Counter

PDD Project Design Document
PFC Perfluorocarbons
PIN Project Idea Note
PV Photovoltaic

QBtu Quadrillion British Thermal Units

R & D Research and Develpoment

REC Renewable Energy Corp
¥ Renminbi
ROI Return on Investment

SEK Swedish Kroner
SEPA State Environment Protection Administration
SFT Statens Forurensningstilsyn
SHP Small Hydro Power
SiC Silicon
SINTEF Scandinavias largest independent research institution
SME Small-to-medium Enterprise
SO_2 Sulfur Dioxide
SOA State Ocean Administration of China
SWF Sovereign Wealth Fund

TSP Total Suspended Particulate

UN United Nations
UNFCCC United Nations Framework Convention on Climate Change
US United States of America
US$ United States Dollars

VAT Value Added Tax
VOC Volatile Organic Compounds

WWL Wallenius Wilhelmsen Logistics

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