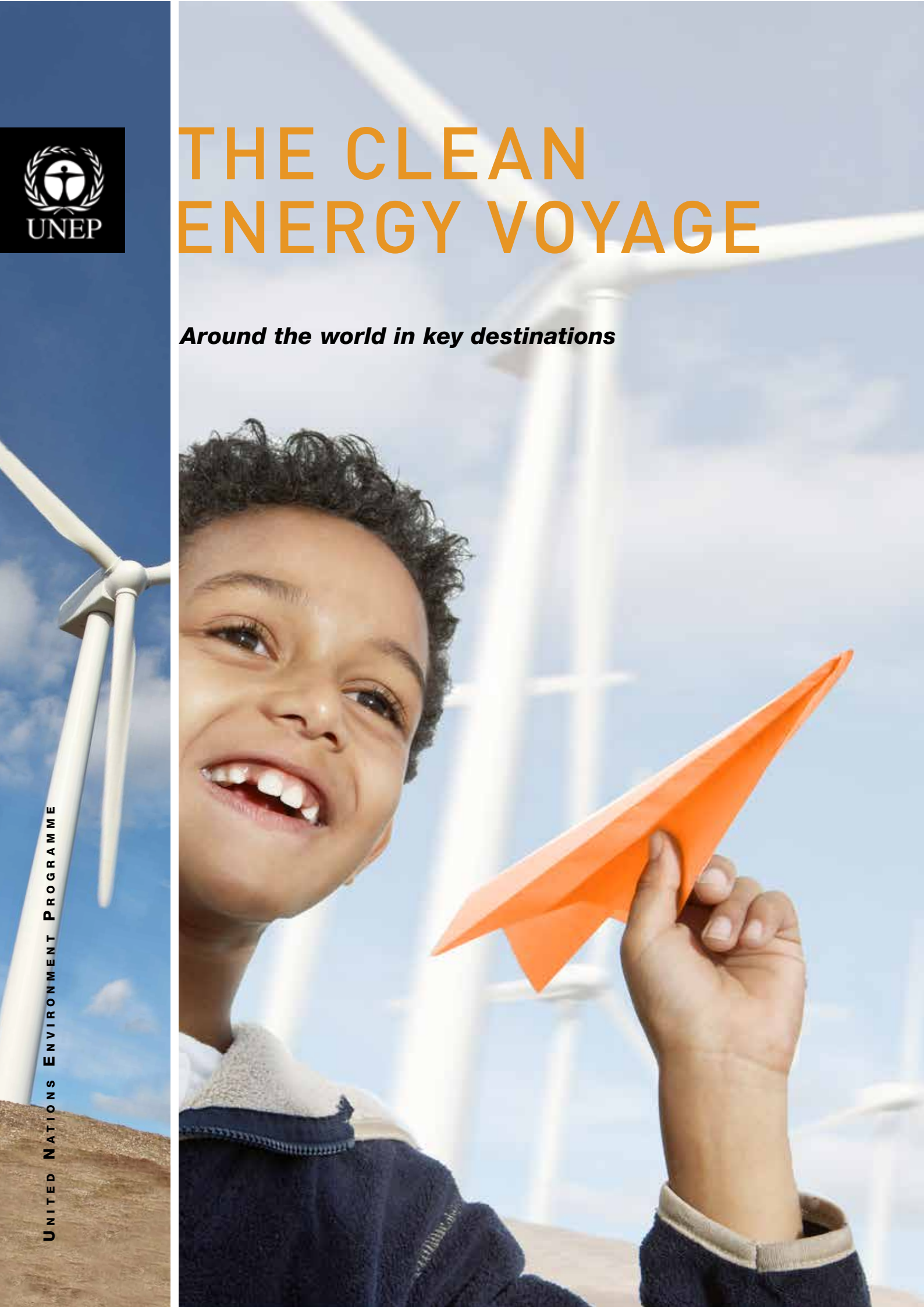
THE CLEAN ENERGY VOYAGE

Around the world in key destinations



UNEP

UNITED NATIONS ENVIRONMENT PROGRAMME

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THE CLEAN ENERGY VOYAGE

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THE CLEAN ENERGY VOYAGE

AROUND THE WORLD

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It always seems impossible until it's done.
Nelson Mandela

WHEN RENEWABLE ENERGY TECHNOLOGIES emerged from the lab to the marketplace, the refrain by many was they would not work. When they did work, they were often dismissed as too expensive or unrealistic on a large scale.

Yet, since 2000 when UNEP published *Natural Selection: Evolving Choices for Renewable Energy Technology and Policy*, renewable energy use has grown dramatically, costs have tumbled and largescale projects are up and running with many more in the "pipeline".

The latest assessment by the Frankfurt School of Finance and Management-UNEP Centre and Bloomberg New Energy Finance (BNEF) shows that since 2006, investments worth US$1.3 trillion have been made in the renewable energy sector. In 2012, total renewable power capacity worldwide exceeded 1,470 gigawatts (GW), up by 8.5 per cent from 2011.[1]

In just eight years since 2005, the number of countries with clean energy targets nearly tripled from 48 to 138, half of which are set by developing countries.[2]

Yet, myths and misunderstandings still abound. One of these asserts that renewable energy technologies are heavily subsidized. The truth, however, is quite different. Global data reveals that while clean energy received support totalling US$88 billion in 2011, fossil fuels in both developed and developing countries attracted global subsidies of US$523 billion in the same year.[3]

The fact is that renewable energy is no longer at the fringe, but rather plays a major role in powering the planet while generating decent jobs, combatting climate change, addressing poverty and assisting the transition to an inclusive green economy.

In this publication, UNEP would like to take the reader on a journey – a carbon emission-free virtual tour of some of the best illustrations of clean energy in all its forms, initiated by individuals and communities around the globe. Together, they are using their creativity, ingenuity, vision, as well as providing financial support, to provide clean energy in various forms. This exceptional tour is inherently limited, as positive developments continue to take place every day, which are beyond a single publication or snapshot in time.

The *Clean Energy Voyage* begins in the year 2000 and reaches its "destination" in 2030, the year chosen by the Secretary-General of the United Nations, Ban Ki-moon, to meet the objectives of the Sustainable Energy for All (SE4ALL) initiative.[4]

Together – from Kenya to the United States and Germany to the wind-swept plains of Mongolia and the rapidly emerging economy of China – these examples provide signposts for economies everywhere to imagine what is possible when they commit to a common goal.

Their experience demonstrates that our future and our energy system, in particular, is simply a matter of choice and policy shifts, rather than one of technological or financial constraints.

A global economy based increasingly on a shift to clean energy will require the combined dedication, skill and perseverance of individuals, communities and countries as a whole. It is happening, and now is the moment to accelerate and scale-up the extraordinary potential for a sustainable world that can support current and future generations.

UNEP is delighted to be a part of this clean energy story – not least because our new offices in Kenya generate electricity from a rooftop solar array and save enough energy from smart lighting systems and passive ventilation that we generate as much power as we consume.

Achim Steiner

UN Under-Secretary General and
Executive Director United Nations Environment Programme

YEAR 2000

Life can only be understood backwards, but it must be lived forward.

Soren Kierkegaard

As champagne corks popped to the flash of 10,000 lights around the Eiffel Tower at midnight, a new century took its first "breath". At the same time, many IT managers were holding their collective breath. Even after spending billions in upgrades, many were predicting the infamous Y2K bug would create international chaos.

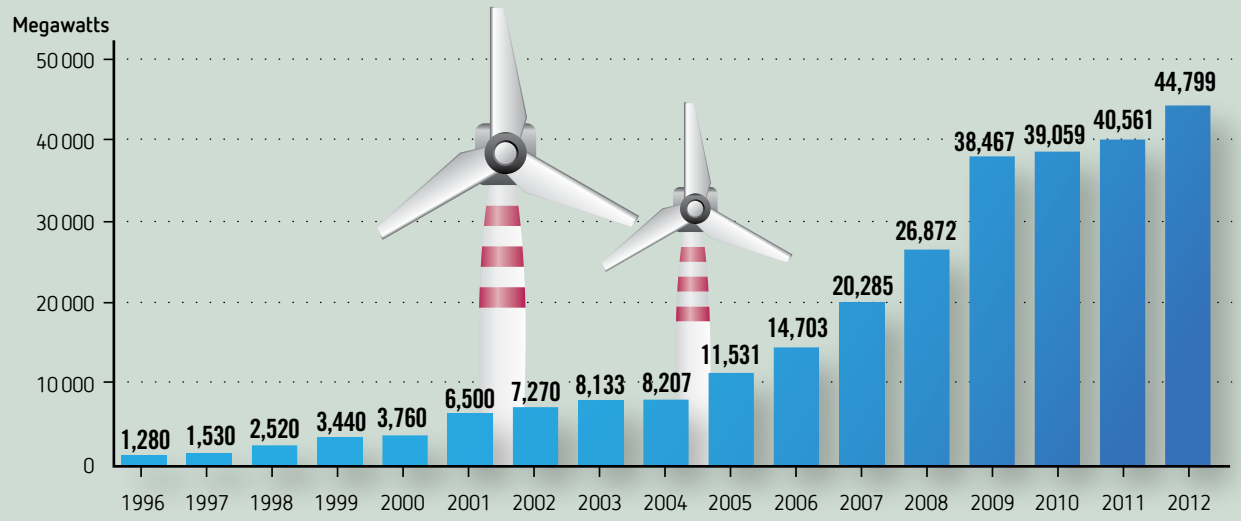
We were all wrong.

A few weeks later and less than a kilometre from the Eiffel Tower, officials at the International Energy Agency (IEA) were also making predictions about the clean energy industry. As with most of the conventional wisdom at the time, they said that by 2010, 34 GW of wind power would be installed across the globe. Across the Atlantic Ocean, the World Bank was predicting that China would have 9 GW of windpower installed by 2020 and only half a GW of solar PV.[5] **We were all wrong again.**

The total capacity of windpower installed globally reached 200 GW in 2010. In China, in 2012, the installed windpower and solar PV capacity reached 75 GW and 7 GW, respectively.[6]

The predictions were not just wrong, they were off by a factor of 10, or achieved a decade earlier than expected. Such is the history of energy predictions – it is full of wildly missed projections, often made by highly experienced experts equipped with statistical data spawned by computers and other resources.

Figure 1. Global annual installed wind capacity 1996 – 2012



Source: GWEC, *Global Wind Energy Outlook*, 2012

This is not to single out individual predictions – everyone got it wrong, even those who were very optimistic. The European Photovoltaic Industry Association, for example, forecasted in 2000 that 2 GW of PV will be installed by 2010, instead 40 GW were installed.

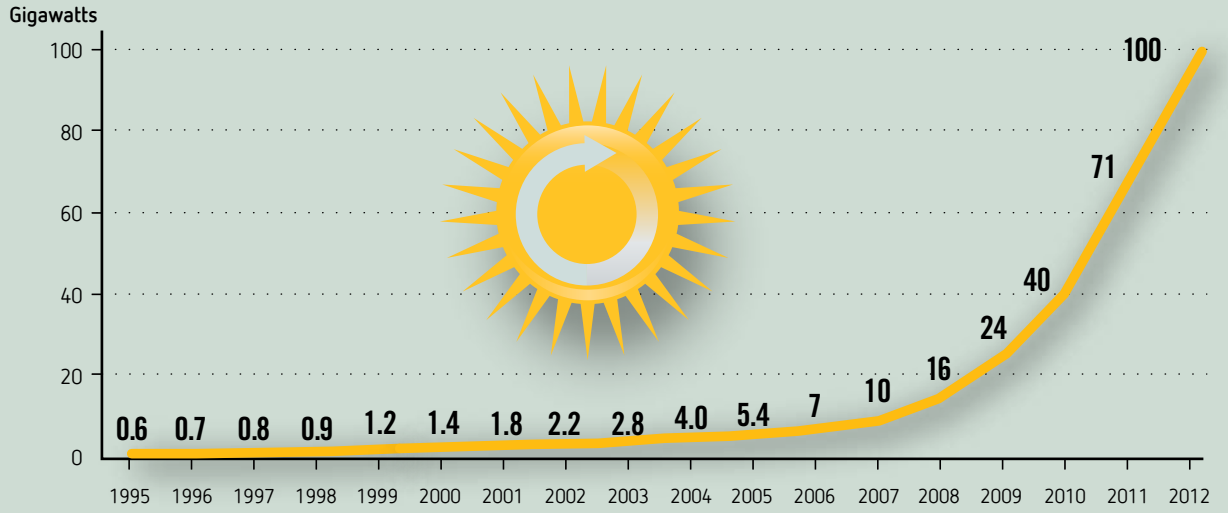
There could be many reasons why it is difficult to assess scenarios when it comes to the issue of clean energy.

The answer has many facets, but one key factor is the idea that "trend is not destiny". Assuming that the past will be the main driver for the future tends to confirm an existing bias and ignores a host of potential disruptive events that can dramatically change the course of a technology or policy.

Some countries without major fossil fuel resources, such as Denmark, Japan and Brazil, decided early on to encourage renewable energy and energy efficiency as a hedge against volatile energy prices and availability. In Denmark, for example, farmer cooperatives were allowed to develop local wind resources in early 1980s and connect their new wind generators to the Danish power grid.[8]

This was the first step that led to a multibillion-dollar Danish wind energy industry today with global exports, a situation that is similar to Japan's solar PV industry. In the case of Brazil, the creation of its biofuel industry from sugar cane was born simply out of need. With limited funds to buy fossil fuels from other countries, Brazil concentrated on building what is now a

Figure 2. Solar PV Global Capacity 1995 – 2012



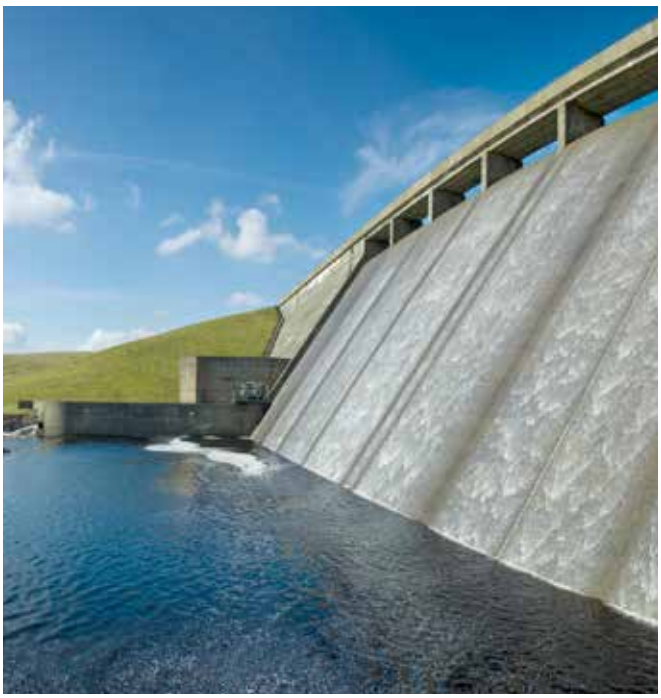
Source: REN21, *Renewables 2013 – Global Status Report*, 2013

booming industry, providing substantial employment and contributing a significant share of the country's economy.[9]

At the same time, in many parts of the world, other forces were driving the search for clean energy: energy insecurity, economic decline, unemployment, industrial growth, fossil fuel price volatility, limited access to rural energy, climate change, increasing momentum of sustainable environment aspirations and nuclear accidents. Collectively, they created a "perfect storm" of opportunity for clean energy development. Notwithstanding the hundreds of billions of dollars in subsidies to fossil fuel industries, the clean energy genie was well and truly liberated from the bottle of energy options.

History is often perfect when presented in hindsight but grappling with the future is always a much more challenging exercise, particularly when the rate of change accelerates. The most critical lesson from this slice of history is that the conventional, tried and profitable model can be turned on its head in a short period of time.

Factors, such as stable policies, introduction of innovative technologies and resulting cost reductions, have often driven stronger market uptake than anticipated.



PLANES, TRAINS AND AUTOMOBILES … AND SHIPS, TRAMS, BIKES AND FEET

A journey of thousand miles begins with a single step.

Lao-Tzu

The Clean Energy Voyage is simply not possible without sustainable mobility. As with ancient mariners, discovering a "new world" of opportunity depends significantly on the ability to navigate uncharted waters. For policymakers and companies alike, seamlessly stitching together the many modes of mobility presents some of the most challenging aspects of the voyage itself.

UNEP and sustainable transport[10]

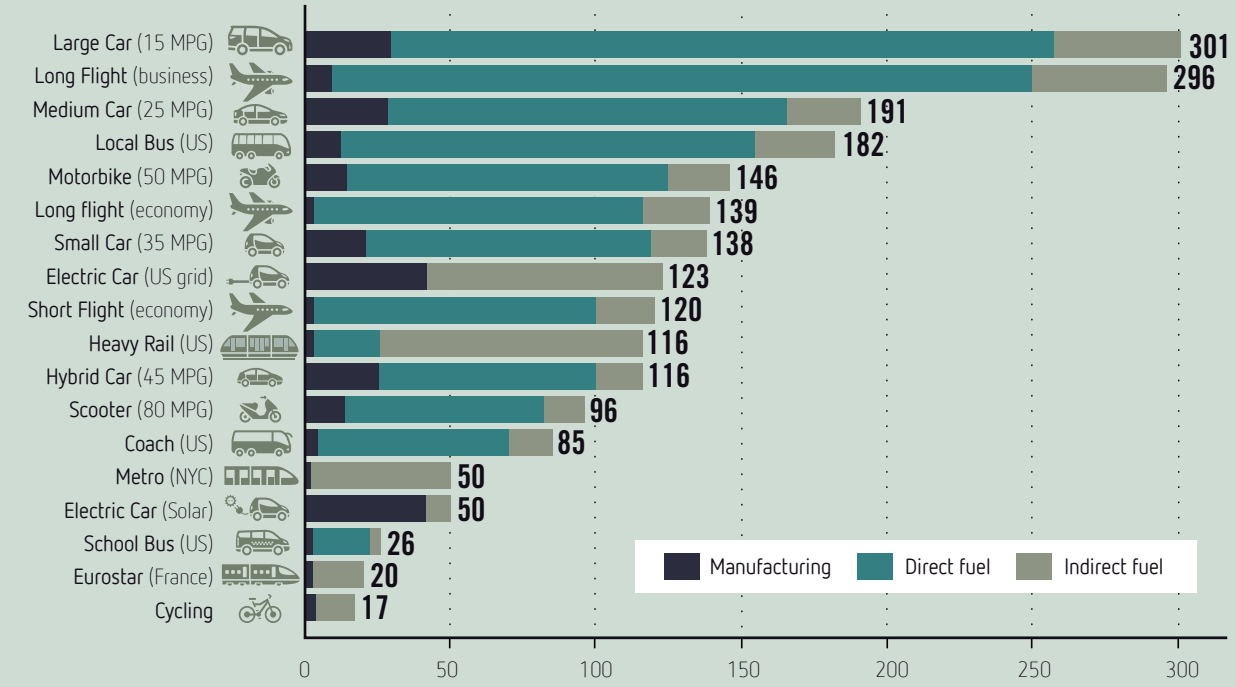
Today, the transport sector is responsible for approximately one-quarter of all energy related greenhouse gas (GHG) emissions. While governments are increasingly active with regards to air pollution and reducing the energy used by the transport sector, there is often a large gap between the technology available and best practice know-how, as well as the networks necessary to build consensus and transform the sector. UNEP addresses these gaps through the implementation of four global transport programmes that promote a paradigm shift towards a less car-intensive world and a substantial cleaning up of vehicles and fuels, especially in developing countries and those with economies in transition, which are grappling with air pollution and rising energy costs.

UNEP addresses fuel and vehicle related energy solutions through the ***Partnership for Clean Fuels and Vehicles (PCFV)*** *and the* ***Global Fuel Economy Initiative (GFEI).*** *The PCFV assists developing countries reduce vehicular air pollution through the promotion of lead-free, low-sulphur fuels to 50ppm and below, and cleaner vehicle standards and technologies. GFEI, which was launched in early 2009, aims to facilitate large reductions of GHG and oil use through improvements in automotive fuel economy in the face of rapidly growing car use worldwide. The GFEI partnership works towards the improvement of average fuel economy (reduction in fuel consumption per kilometre) of 50 per cent worldwide by 2050.*

Non-motorised transport and public transport

UNEP recognizes the benefits of 'mode shifting', which implies the change from private motor vehicle use to public transport and non-motorized transport (NMT), such as walking and bicycling, through better planning and infrastructure. Through its ***Share the Road*** *programme, UNEP also works to catalyse policies in government and donor agencies for systematic investments in walking and cycling road infrastructure, linked with public transport systems, such as Bus Rapid Transit (BRT) systems.*

Figure 3. The carbon intensity of travel



Sources: DEFRA, IEA, EPA, Chester & Horvath (http://shrinkthatfootprint.com)

One topic that has received much attention is biofuels. For the automobile industry in particular, biofuels are an attractive alternative to conventional fuels because they fit existing infrastructure. It is unlikely that enough biofuels can be produced sustainably to provide 100 per cent of transport needs. Consequently, some suggest using biofuels in those sectors that have few alternatives to fossil fuels, at least today. Even in the aviation sector some experts speak about biofuels being an "interim" solution that lasts 30-40 years. And biofuels will be able to meet a higher share, if overall demand for transportation fuel is reduced through modal shifts and efficiency measures.

Much has already been learned from a wave of first-generation biofuel technologies derived from sugar, soy and corn as raw materials. In 2012, ethanol, biodiesel and biomethane produced principally from these feedstocks provided three per cent of road transport fuels overall, although some countries and applications had much higher contributions. In 2010, for example, 13 per cent of Europe's 70,000 natural gas-operated public buses ran on biomethane.

■ *UNEP project*

Brazil and the United States accounted for 61 per cent and 25 per cent, respectively, of the global 83 billion litres of ethanol production, compared with 60 per cent and 30 per cent in 2010[11]. Brazil has used sugarcane to develop a substantial ethanol industry, while the United States relies on corn and is moving progressively to cellulosic materials.

Biodiesel production has been increasing, with production in 2012 reaching 22.5 billion litres. The United States is the global leader ahead of Germany, Brazil, Argentina and France. The dramatic increase in biodiesel production in the United States was due to a government mandate in mid-2010 that required refiners to blend 3.1 billion litres of biodiesel with diesel fuel in 2011 or face stiff daily fines.

Although production of first-generation biofuels continues and is increasing in some countries, a shift is under way to more advanced biofuels made from non-food crops, cellulosic material and waste. Given concerns and uncertainties about environmental and social impacts, there is considerable uncertainty about the long-term viability and stability of investments in advanced biofuel technologies, which has led many investors to withdraw from the market until sustainability issues are resolved.

With a world population expected to hit nine billion in the next 35 years, the question of biofuels quickly engulfs issues of land and water use, and to a lesser degree the type of feedstock. UNEP and others argue that in many developing countries – where under-investment in agriculture has led to low productivity – investment in biofuels can improve food production at the same time, thereby contributing to food security.

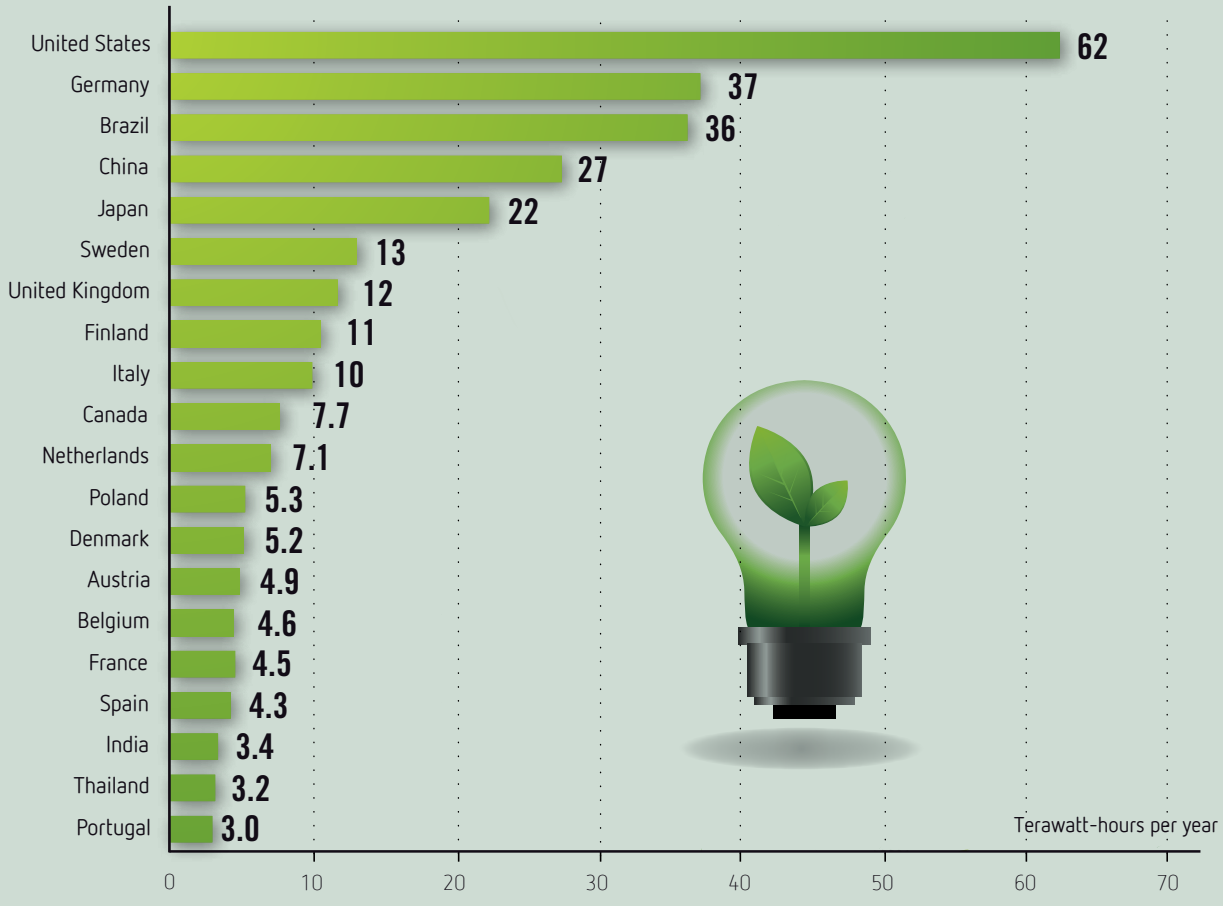
Advanced biofuel technologies now focus on agriculture and food wastes, farm forestry and woody residues, and non-food crops such as jatropha. Getting these technologies to the sweet spot of yield and profit, however, may require more than a focused R&D effort, as the Danish have shown in their town of Maabjerb.

In May 2013, the Maabjerg BioEnergy plant became the largest of its type in the world. The plant provides multiple pathways to convert large amounts of manure and industrial food waste into heat, electricity and various by-products that can be used in a range of sectors, including transport. In the sophisticated process, the Maabjerg BioEnergy plant also solves a number of environmental challenges by reducing phosphate, nitrogen and GHG emissions in the production and manufacturing process.

At full operation, the plant avoids 50,000 tonnes of CO_2 emissions from energy production and reduced emissions from farm animals – a measure encouraged by the Danish government's special charge on bovine flatulence. By addressing several challenges *at the same time*, the Danish example demonstrates to other biofuel developers a synergistic and profitable path for a food-energy system that is often unavailable when the focus is on a single production pathway.

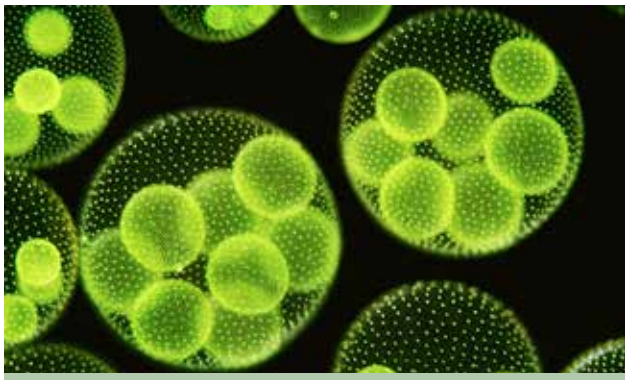
In Europe and elsewhere, however, some local feedstock supplies are failing to keep pace with the rapidly rising demand due to a lack of available land. This trend is driving both an increase

Figure 4. Bio-power generation of top 20 Countries, annual average 2010 – 2012



Source: REN21, *Renewables 2013 – Global Status Report*, 2013

in international trade in biomass and the creation of large feedstock plantations in regions with good growing conditions, such as tropical and sub-tropical regions. A growing number of large companies including utilities, energy and telecommunications companies are investing in biomass plantations across Africa, Asia, Eastern Europe and Latin America.



Where have all the algae gone?

The single cell organism responsible for "pond scum" may hold the promise for third-generation biofuels. Some of the current R&D recipes are elegant and mimic the Danish example of solving several problems at the same time: take CO_2 from the smokestack of a coal-fired power plant, mix it in a "bioreactor" with algae and water. Add sunlight and presto – biofuel! Environmental considerations still need to be assessed and addressed where these exist, however; a good example being the large land and water requirements for some production technologies. Still, airline companies have been trialling a mix of biodiesel made from oil extracted from algae in their jet engines with positive results (see below).

The current verdict: A potentially elegant destination in principle, but still too expensive.

The biofuel industry increasingly recognizes the seriousness of issues such as food security and biodiversity. Companies are seeking sustainability certification for market access or as part of their management of environmental and social risks. Some certification schemes are feedstock specific while others cover biofuels, bioenergy or biomaterials more broadly, such as the Roundtable for Sustainable Biomaterials[12]. The best of the schemes are developed in a transparent, multi-stakeholder process, which cover a range of environmental and social concerns, and require third-party auditing.

Solutions to these issues rely on a combined support at the policy and the project levels working together to minimize risk. UNEP is a partner in the Global Bioenergy Partnership, which has developed 24 sustainability indicators that help governments monitor and analyse the effects of bioenergy production, as well as the effectiveness of enacted policies.

Voulez-vous Vélib'?

The streets of Paris will never be the same after the introduction of a bicycle-sharing scheme. Since 2007, Parisians can rent one of 23,000 bicycles from 1,800 stations throughout the city (one every 300 metres in any direction) through a subscription service where the first 30 minutes of rental are free.

When he was first proposed the creation of a public bicycle-sharing system in 2007 to reduce traffic in the French capital, many Parisians laughed at their mayor, Bertrand Delanoë. After five years of operation, however, the largest system of its type in the world has transported 138 million people on 23,000 rental bicycles.

In 2013, Vélib' (a combination of "vélo", which means bicycle in colloquial French, and "liberté", or freedom) had 225,000 subscribers out of a total urban population of 2.3 million, and 31 communities on the outskirts of Paris, have joined Vélib, which serves as a model for other 34 French cities. Vélib' has also spurred development of similar initiatives in numerous cities around the world, from Barcelona to San Francisco and New York.

Vélib' has inspired Parisians to rediscover their passion for cycling to make 200,000 trips a day on privately owned bicycles. In total, the number of bicycles in Paris has increased 41 per cent since 2007. During the same period, motor vehicle traffic has decreased by 25 per cent.

The programme has been followed by the car-sharing scheme Autolib.[13]

Electricity as "fuel"

While the need for liquid fuels will remain for some time, there is seismic shift under way to substitute electrons for gasoline and diesel fuel. The rise of hybrid and electric vehicles continues, and with it new opportunities that seemed impossible a decade ago when the first hybrids were introduced to the market.

In some locations, electric transport is being tied directly to renewable electricity through specific projects and policies. Tesla Motors, for example, has recently demonstrated charging stations based on electricity generated from renewable energy sources that is free if the customer waits about 20 minutes to complete the fast charge, or pay a fee to swap their battery with a fully charged one in less than two minutes.

Electricity to power trains has a long history. One of Europe's largest electricity users, Germany's Deutsche Bahn, plans to increase the share of clean electricity to power its trains from 20 per cent in 2011 to 28 per cent in 2014.

Car love decreasing?

Today's 16 to 34-year-olds in the United States are not like their parents when it comes to the automobile. From 2001 to 2009, the average total annual distance travelled by this age group in cars decreased 23 per cent.[14] *This reduction has meant that by 2011, the average American was driving six per cent fewer kilometres per year than in 2004.*

Fuelled by social media and other new technologies, this decline was independent of employment status. The same youth group cycled 24 per cent more often, walked 16 per cent more frequently and travelled 40 per cent more kilometres by public transport. The percentage of young people without a driving licence rose from 21 to 26 per cent.

As with energy demand that is falling in many places, the shift away from motorized personal transport has financial and social implications for infrastructure planning, particularly where the past focus has been concentrated on roads.

Up in the air

Airlines around the world have shown growing interest and involvement in aviation biofuels as part of their effort to reduce fuel costs and GHG emissions. Several airlines are trialling biofuels, including Aeromexico, Finnair, KLM Royal Dutch Airlines, Lufthansa and Thai Airways.

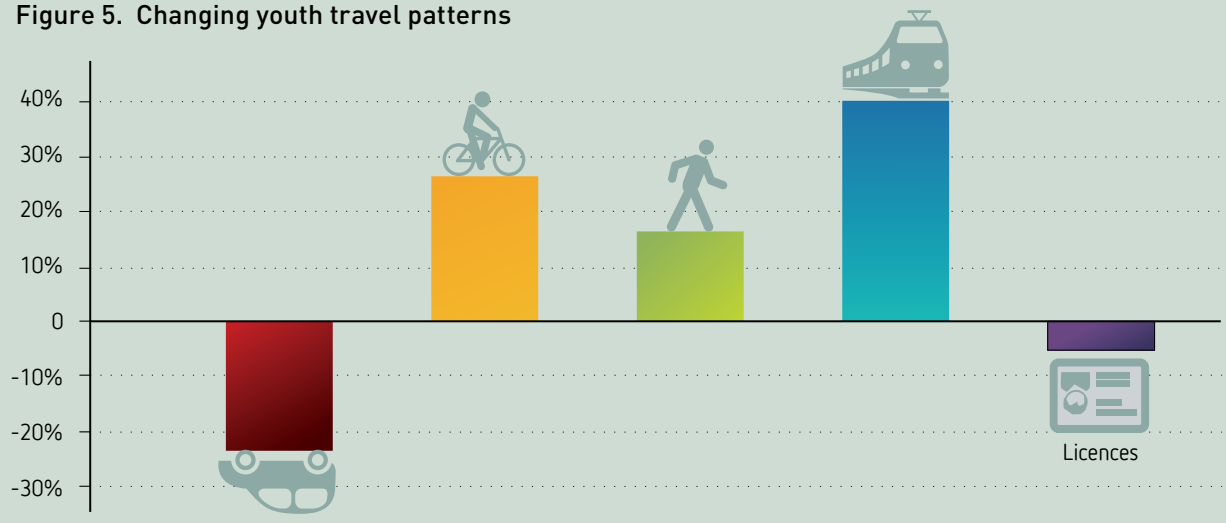
In May 2013, KLM Royal Dutch Airlines started weekly flights from New York's John F. Kennedy Airport to Amsterdam's Schiphol Airport using a sustainably produced biofuel. KLM believes this advancement demonstrates that sustainable biofuel in the airline industry is here to stay. Lufthansa, too, has run a number of commercial flights, using a 50 per cent biofuel mix in one engine with good results.

To be acceptable for commercial use, renewable jet fuel must be not only competitively priced compared with fossil fuel-based Jet-A, but also available in significant quantities as a "drop-in" replacement that meets the same exacting technical standards as conventional jet fuel. The fuel must also fulfil internationally recognized sustainability criteria that ensure land, water resources and biodiversity are not adversely affected during production, including reduction of overall carbon emissions over the fuel's lifecycle impacts.

In 2008, a group of interested airlines formed the Sustainable Aviation Fuel Users Group (SAFUG). The group was formed with support from NGOs such as the Natural Resources Defense Council and the Roundtable for Sustainable Biomaterials (RSB). Member airlines represent more than 15 per cent of the industry, and all member CEOs have signed a pledge to work on the development and use of sustainable biofuels for aviation.

It's clear that the *Clean Energy Voyage* will track closely to the course set to power our various modes of transport. In many ways, it is the most complex part of the voyage

Figure 5. Changing youth travel patterns



Source: www.reneweconomy.com.au

GIGIRI, KENYA

In the course of history, there comes a time when humanity is called to shift to a new level of consciousness, to reach a higher moral ground. A time when we have to shed our fear and give hope to each other. That time is now.

Wangari Maathai

We shall start The Clean Energy Voyage in Gigiri, a suburb of Nairobi, home to the headquarters of the United Nations Environment Programme and United Nations Human Settlements Programme (UN-HABITAT). The United Nations Office in Nairobi (UNON) is the latest example of a combined UN effort to "walk the talk" on reducing carbon emissions and promoting clean energy.

In Kenya, about **82%** of the population doesn't have access to modern energy services.

Kenya hopes to generate about **27%** of the country's electricity from geothermal sources by 2031.

Greening the blue

UNEP coordinated efforts across UN organizations to prepare the first GHG inventories in 2009, and to develop carbon emission reduction plans for each UN organization. Today, 63 organizations chronicle their GHG footprint.

In 2010, UNEP also launched the UN-wide campaign called "Greening the Blue" to highlight ways in which staff could facilitate measures to reduce their environmental footprint.

This building is beautiful, comfortable and efficient. But more than any of that, this building is a living model of our sustainable future.

Ban Ki-moon, Secretary General, United Nations

The new office facility combines a number of features to reduce energy demand, including efficient lighting, automatic controls and the use of natural light and ventilation. The building also supports the largest rooftop installation of solar PV in East Africa at the time of its construction – a 6,000 m^2 square metre solar array that generates as much electricity as its 1,200 occupants consume. In 2012, the solar electric system produced 714,000 kWh, which reduced the electricity bill of the new building by US$140,000.

UNEP's clean energy example highlights the importance of clean energy to the global building sector that is the single largest contributor to global GHG emissions. Buildings consume one-third of global energy to heat, cool and power offices and homes, a figure set to double by 2030 under a "business-as-usual" scenario. The use of clean energy in the design and construction of new buildings is one of the low-cost ways to combat climate change, while reducing electricity bills and dependence on fossil fuels.

UNEP's headquarters was designed to use one-half of the existing electricity consumption of comparable United Nations offices in Nairobi, but in a different way. Designers first determined the amount of energy they could "harvest" from the building and then used energy efficiency and other devices to reduce electricity demand and allow the building to service the overall energy needs of the occupants on an annual basis. The designers' objective was for the building to be energy neutral over the course of the year, rather than to be completely energy independent. Excess solar power that is not used can be used by other buildings in the compound. Any shortfall is met by the national power supply and standby generators when necessary.

When the building's solar power generation is insufficient, part of the grid power for the UNEP headquarters can be drawn from geothermal energy in the Rift Valley which has the potential to generate 10,000 megawatts (MW) and provide energy to up to 150 million households. However, only about 200 MW has been developed so far and mostly in Kenya. Part of the reason stems from the risks in geothermal development, particularly in the early stages where "dry holes" during the exploration phase can be costly. UNEP's African Rift Valley Geothermal Project (ARGeo) is

helping to reduce exploration risk, aiding expansion of this clean energy source.

The African Development Bank (AfDB) is now promoting a new model to fast-track geothermal development, using concessional finance for early stage and high-risk activities mainly related to drilling. The financing goes to a special purpose drilling company that assumes most of the drilling risk, which in turn paves the way for private investors to step in and develop the proven power resource.

Under this model, the AfDB, among other investors, has advanced about US$150 million of highly concessional finance to develop Kenya's 400 MW Menengai Project, which could eventually power 500,000 Kenyan households, 300,000 small businesses and other applications. Kenya aims to produce 27 per cent of its electricity from geothermal resources by 2031.

UNEP project

Shine the light

These projects will allow more Kenyans to access an electricity grid that currently reaches only 5 per cent of rural Kenyan households. Until it does, rural and unconnected Kenyans are increasingly working and studying by solar light. In the tea growing centre of Kericho, for example, sales of solar torches, task lights and room lights increased from 37,000 units in 2009 to more than 175,000 units in 2012, with growth expected to continue.

Part of this growth is due to a dramatic improvement of the quality of products, with more than 27 different models of solar lights meeting the Lighting Global Quality Standard[15] in 2012, compared with none in 2009. Another reason is the efforts of several organizations to promote solar lights, such as Lighting Africa and the One Acre Fund.[16] As a result, in addition to financial and health benefits as well as increased safety and productivity, there is evidence that children of farmers with solar lights study more hours each night and have better school performance.

Following their successful trial in 2010 the One Acre Fund marketed solar lights to all their Kenyan clients in 2011. More than 10,000 farmers opted to purchase a US$20 solar light package for general home lighting and cell phone charging. This gave farmers a substantial economic advantage, saving them an average of US$36 per year in kerosene for lamps, batteries for flashlights and phone charging costs, while allowing them to earn US$16 from neighbours to charge their cell phone batteries. In total, the solar light programme put US$178,000 back into communities in 2011.

With the increased availability of quality-assured solar lights, a market survey in the three Rift Valley towns – Kericho, Kapkugerwet (Brooke) and Talek – found a large number of solar lighting products with low or uncertain quality were still on the market. Such products risk a drop in consumer confidence, which can quickly erode an entire market and greatly weaken an entire region's clean energy sector. Improving the access to efficient and affordable solar LED lighting products one of the reasons UNEP supports the en.lighten Initiative[17] to accelerate a global market transformation to environmentally sustainable lighting technologies, such as solar lights. Solar lights are an important part of the *Clean Energy Voyage* and their growing use depends on continued monitoring and consumer education.

Better heat, better breathing

Kenya is a country whose rural communities also rely heavily on biomass cookstoves. Improving this device can have a large and beneficial range of impacts: reduction of fuel wood consumption and pressure on local forests, as well as fuel costs for households, and decrease in smoke and fumes that cause respiratory diseases. With the UN Foundation and other agencies, UNEP has been working for more than a decade to improve the use of efficient cookstoves and gas through its partners, such as the African Rural Energy Enterprise Development Programme[18] (AREED) and the Global Alliance for Clean Cookstoves[19]. One AREED project in Ghana has already supplied more than 50,000 homes with cleaner, more efficient cookstoves, while the Global Alliance pursues its ambitious but achievable goal to foster the adoption of clean cookstoves and fuels in 100 million households by 2020.

The *Clean Energy Voyage* in Kenya is a postcard from the heart of what is possible. In a region where human civilization is thought to have been shaped, East Africa's energy sector is creating a compelling path that other countries can follow.

GERMANY

Our dependence on fossil fuels amounts to global pyromania, and the only fire extinguisher we have at our disposal is renewable energy.

Hermann Scheer

Visitors to Germany can explore the Black Forest, tour medieval castles and sample some uber delicious Bratwurst during Oktoberfest. But Germany offers something more tantalizing and unmatched by any other destination – the greatest installed capacity of solar PV in the world.

Germany's expanding renewable power industry will account for over **0.5 Million** jobs by 2030, an increase of more than a third from current levels.

On 25 May 2012, Germany reached a power production peak of **22 GWh,** enough to meet half of national electricity demand at that time.

The distinctive success of the German solar PV industry can be measured on 15 April 2013, when the country's 1.3 million solar power systems set a new domestic and world record of 22.68 GWh just after noon (see Figure 6). The 167 GWh of solar electricity covered more than 12 per cent of the total German electricity consumption on this typical Monday in April.[20]

The German transition to a clean energy economy, or *Energiewende*, has been developed through an overarching national policy to shift from a focus on energy demand to a focus on energy supply, and a shift from centralized to distributed generation and efficiency.

The *Energiewende* has driven a series of steady and carefully targeted policies that had an impact on solar PV installed capacity which, in March 2012, reached 32 GW from a mere 6 GW in 2008. This increase helped Germany double the renewable share of its total electricity consumption in the past six years to 23 per cent in 2012. With forecasts to double again by 2025, such progress would be well ahead of the country's 50 per cent target for 2030, and which is nearing the official goal of 65 per cent in 2040 and 80 per cent in 2050.

The policy has significantly affected overall energy supplies. In the period 1990-2011, when Germany began the first phase of its transition to clean energy, coal-fired power generation fell 14 per cent and nuclear power generation 30 per cent, while renewable power generation grew by 614 per cent. In 2010, four German states generated almost 50 per cent of their electricity from windpower. During spring of 2012, 50 per cent of the country's electricity was generated from renewable at one point of time, nearing Spain's 54 per cent peak record set in April 2012.

German energy productivity advanced across all sectors to the point where Germany is becoming the world's most energy-efficient country. Since 1990, the base year for Kyoto Protocol's carbon accounting (and also the year Germany reunified), the country's weather-adjusted primary energy use fell 11 per cent and carbon emissions dropped 25.5 per cent, while real GDP rose 37 per cent.

Although Germans have travelled much further down the clean energy road, particularly with solar PV, it has not been without hitting a few potholes. As the industry matures, normal trade "bumps" have arisen over rules governing imports and exports that are believed to be contrary to previous agreements. These unfavourable and hopefully temporary setbacks highlight the important international issues that will arise as the clean energy sector progresses.

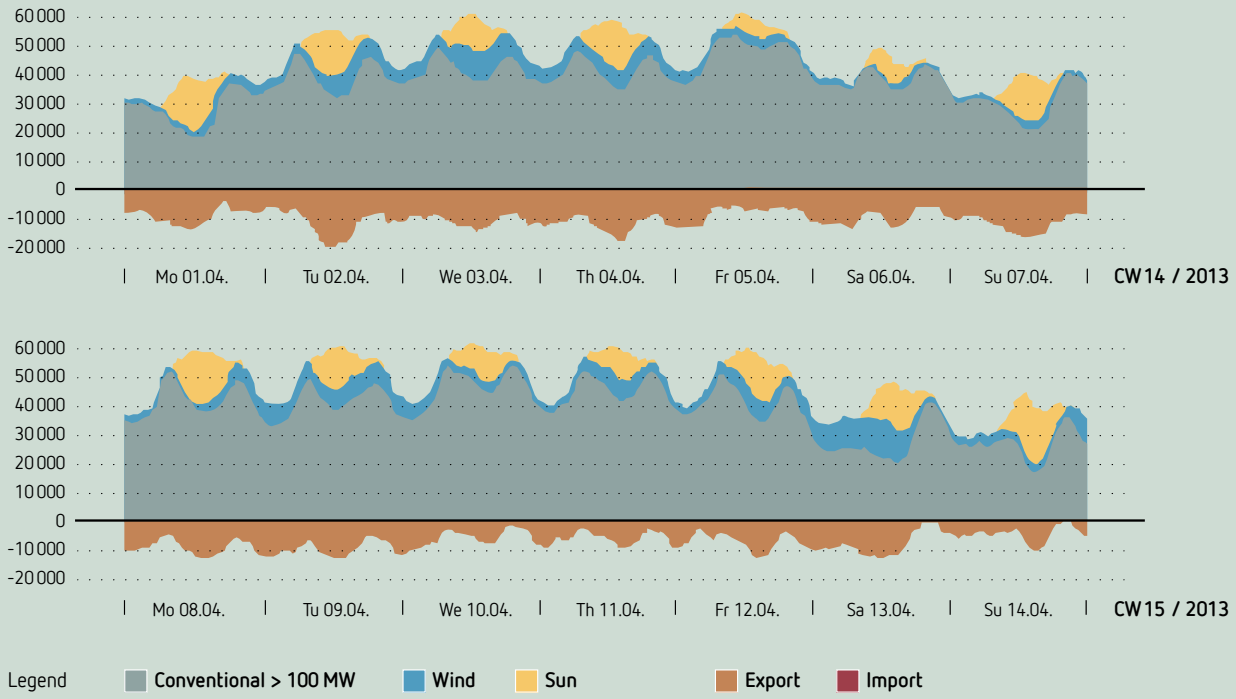
More opportunities and benefits

The German states and municipalities understand the economic importance of clean energy. The sector has already produced more than 378,000 jobs, particularly after the 2008 global financial crisis when employment in the sector grew by 10 per cent.[21]

Their renewable energy capacity helped German communities avoid a bill of €6 billion for energy imports in 2011, which enabled more investment in local development. German municipalities can also expect at least €1.2 billion a year in tax revenue from the use of renewable energy by 2020.[22]

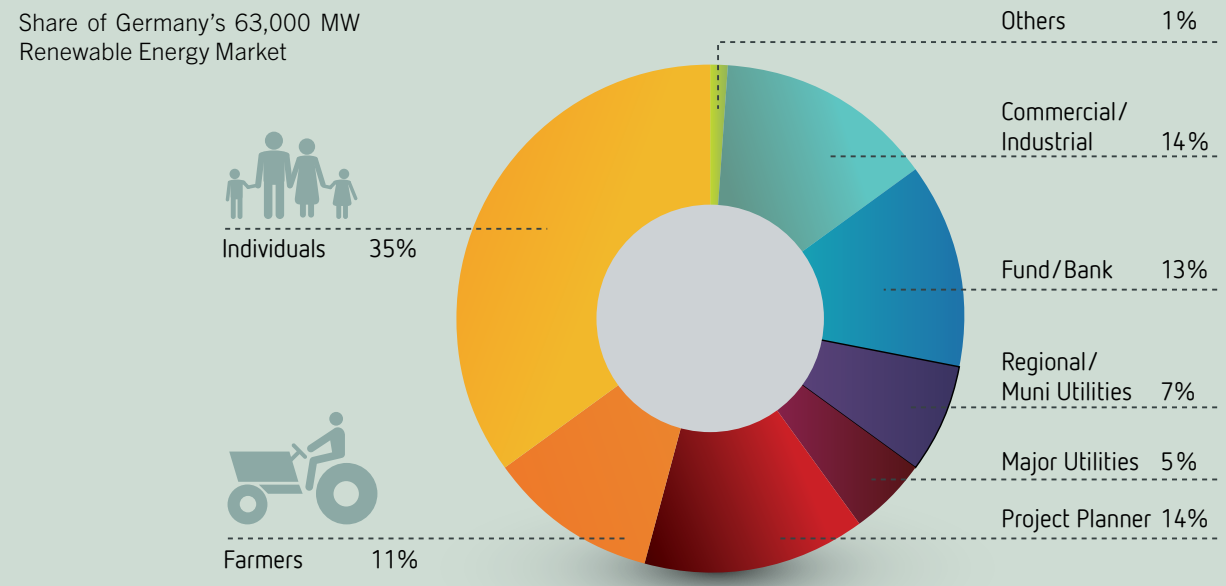
Germans have also been quick to take the new market signal to their financial hearts. More than 80,000 citizens now hold shares in collectively run systems for the generation of electricity and

Figure 6. Solar PV record output in Germany



Source: Fraunhofer ISE (www.ise.fraunhofer.de)

Figure 7. German ownership share of renewable energy assets



Source: German Renewable Energies Agency Information Platform (http://www.unendlich-viel-energie.de/en)

heat from renewable energy sources, and more than 50 per cent of the shares are owned by individuals (see Figure 6). More than 500 energy co-operatives created in recent years have already invested a total of €800 million in renewable energy sources.

In 2013, Germany also created a novel plan to let citizens invest in transmission lines. The concept allows up to 15 per cent community ownership, with a guaranteed return of 5 per cent for local investors. Such a move could save billions and smooth the transition to smart grids by helping overcome opposition to new transmission lines. In the United States, high-voltage transmission lines are typically built by large companies that receive a regulated return of more than 10 per cent. The Edison Electric Institute estimates that US utilities and transmission companies will spend US$66 billion (€50 billion) on new transmission infrastructure between 2011 and 2015, with the entire cost borne by customers. According to the German concept, American electricity customers could save US$500 million a year.

Getting policy right

Two key policies cemented Germany's rapid advance leading to the Renewable Energy Act in 2000: (i) a fixed 20-year power purchase contract (feed-in tariff) offered to most renewable energy sources, such as rooftop solar PV, with priority access to the grid, and (ii) a stipulation that such power purchases not draw on Germany's public purse.

The second policy is critical and often debated: utilities are required to pay the feed-in tariff for each renewable energy

Taking Feldheim

The small rural town of Feldheim lies in the gently rolling countryside of Brandenburg, southwest of Berlin. In 2008, the town was able to produce 100 per cent of its energy through wind power and a biogas plant. It also decided to build its own new smart grid, which was completed in October 2010 with each villager contributing €3,000. Now the citizens of Feldheim pay about 31 per cent less for electricity and 10 per cent less for heating. The project has created about 30 jobs in Feldheim.

The town also generated something else – international interest. The mix of energy efficiency and renewable energy attracted 3,000 visitors in 2011 from Australia, Canada, Iran, Iraq, Japan, North Korea, South Korea and South America.

source fed into the grid by any producer, and recover those payments via a renewable energy surcharge. The 2012 surcharge cost the average German three-person household about €10 each month – about 3 per cent of a typical household's total energy costs, or 0.3 per cent of its total expenditures.[23]

These costs, however, must be balanced against the benefits. Renewable energy directly reduces several costs, such as the wholesale electricity price and carbon price. Germany's electric bills, for example, rose more slowly during the period 2000 – 2012 than the price of heating oil and gasoline.

If, as predicted, renewable energy and energy efficiency costs continue to decrease, and the cost of fossil fuels increases, the surcharge should turn into a large public dividend that could total more than a trillion dollars during the period 2030-2050. To date, this shift from investment to return is outpacing expectations.

In early 2013, the successful German feed-in tariff fell below €0.12/ kWh (US$0.15/kWh) for small solar PV systems, and continues to fall each month in line with a stable policy that dovetails well with more liberalized power markets in Europe, the phase-out of German coal subsidies, and the declining costs of energy from renewable energy resources.[24]

The German *Energiewende* demonstrates clearly that a heavily industrialized market economy can make the energy transition to a self-financing combination of efficiency and renewable energy.

The Germans are now exporting their solutions beyond their borders. In May 2013, the German state of Rhineland-Palatinate agreed to support Cape Verde in the conversion of its energy system to allow the country to become one of the first to use solar and wind power to meet 100 per cent of its energy needs by 2020.

Berlin and Munich aim for the future

Munich plans by 2025 to meet all its electricity demand from 100 per cent renewable power using a mix of hydro, solar PV, geothermal, biomass, biofuels and efficiency. The city's plan will incorporate solar PV farms in the German states of Saxony and Bavaria, as well as in the wind farms in the North Sea.

In Berlin, a petition signed by more than 250,000 Berliners has put ownership of the city's distribution network at the ballot box. Berliners want to significantly increase the amount of renewable energy in their energy mix, which is currently less than 2 per cent of the total electricity supply.

CAPE VERDE AND OTHERS, TOWARDS A *CLUB 100*

Islands provide replicable models for many more communities isolated by water, desert or just distance from the grid.

Jose Maria Figueres

Miles away from Germany, the islands of the Cape Verde archipelago are also taking on the challenge of renewable energy. A clean energy revolution began in 2010 with the construction of two large solar parks and the Cabeolica [25] wind farm project, the first large scale wind project in Africa and the first renewable energy public private partnership in sub-Saharan Africa.

Cape Verde aims a share of 100% of energy from renewable by

2020

Close to **80%** of the world's energy supply could be met by renewable by mid- century with the right enabling public policies.

In 2012, while you were probably going about your business, a village in Cape Verde's westernmost island called Monte Trigo[26] experienced its first 24 hours of electricity thanks to an off-grid solar energy project demonstrating that rural electrification is feasible. And in 2013, Cape Verde decided to go 100 per cent renewable by 2020.

But just like Cape Verde, many other islands are on the same track. Halfway between Hawaii and New Zealand, an exotic and tropical group of three atolls known as Tokelau[27] seems like an idyllic holiday destination that guarantees a real adventure – it's a two-day journey by boat just to get there. But before celebrating your arrival with a cool drink, there is something every visitor should know: the 12 km^2 small island state is on the treacherous frontline of climate change; enduring extreme weather, storm surges, droughts, coral-bleaching and salt intrusion into their limited groundwater.

Tokelau may be the first of many such islands to slip beneath rising seas in the coming decades, but not before showing the

world how to join the upcoming *Club 100*, an increasingly non-exclusive group of countries, regions and cities providing 100 per cent of their energy from clean energy sources. Tokelau is a strong candidate of the club, having worked diligently to replace diesel-only energy systems with a system that relies on solar power with back-up power from generators fired by biofuel made from local coconut oil. Tokelau is now home to the largest stand-alone solar system in the world – a 1 MW solar-battery system that provides 100 per cent of the electricity for its 1,500 citizens.

The people of Tokelau cannot change the course of the climate crisis alone, but they do inspire by example and remind other countries of the direct and enduring consequences from burning fossil fuels. They are leading by example and showing other countries how to move rapidly and globally to an economy based on 100 per cent renewable energy.

Club 100 is not a new development. At the end of the 20th century, almost everyone thought the idea behind it was as mythical and ephemeral as the lost continent of Atlantis. It's just not possible, experts said, that a region or a city could provide all of its energy from renewable energy sources, notably because "fossil fuels will provide the majority of the energy for our societies well into the future".

A funny thing happened on the way to the future, though.

Even vocal advocates of clean energy have been surprised by the rapid rate that reality has overtaken their expansive imaginations. Increasingly, countries and regions are leapfrogging renewable energy targets and moving toward full 100 per cent integration of renewable energy into their electricity and energy supplies. Some are moving even further, suggesting 150 per cent, or even 300 per cent renewable electricity generation, to meet not only electricity needs of households and commerce, but also for applications such as electric transport.

Membership of *Club 100* could grow rapidly, with many medium-size cities aiming to transition to various forms of "100 per cent" in the coming decades. Larger cities with populations over 1 million are also working towards "100 per cent" or "near-100 per cent" goals. These include Fredrickshavn (Denmark), Moura (Portugal), Malmö (Sweden), and San Francisco (United States), which intend to join by 2020, and Copenhagen (Denmark), Hamburg and Munich (Germany), Gothenburg (Sweden), Rizhao (China) and Sydney (Australia), which all intend to join between 2025 and 2050.

While some cities have set explicit 100 per cent renewable energy visions, others have instead established carbon-neutral or fossilfuel-free goals that imply moving towards 100 per cent renewable energy. In Sweden, Växjö aims to be fossil-fuel-free by 2030, and Gothenburg and Stockholm aim for the same by 2050.

ECOWAS Regional Centre for Renewable Energy and Energy Efficiency (ECREEE):

The ECREEE secretariat is based in Cape Verde, Praia and was established in November 2009 by the ECOWAS Commission with support of the Austrian and Spanish Governments and technical assistance of UNIDO. ECREEE's key objective is to support the development of renewable energy and energy efficiency markets in West Africa by supporting various activities to mitigate existing barriers. ECREEE activities include policy development and quality assurance, capacity building, the design and implementation of tailored financing mechanisms and appraisal tools, awareness raising and the implementation of demonstration projects with potential for regional scaling-up.

Large cities transitioning to completely decentralized energy systems are starting with smaller neighbourhoods and districts. Local authorities can advance the integration of renewable energy into districts within the larger city environment. Such districts allow for an incremental scale-up of renewable energy, while helping local authorities develop their own "best practices", encourage business engagement and innovations, and gain public interest and acceptance. In addition, several cities have planned or designated zero-emissions districts, including Vancouver (Canada), Copenhagen (Denmark), Helsinki (Finland), Hamburg and Munich (Germany), Rotterdam (the Netherlands), Stockholm and Malmö (Sweden), and London (United Kingdom).

National and local governments also plan a number of 100 per cent renewable energy cities to be constructed "from the ground up." These include Masdar City in the United Arab Emirates, PlanIT Valley in Portugal, Songdo in South Korea, and Tianjin Eco City in China. These cities will have populations that range from the thousands to the hundreds of thousands of inhabitants.

In Germany alone, more than 130 regions and municipalities have set themselves the target of providing 100 per cent of their

energy supply with renewable energy in the medium- to long-term (see Destination Germany).

The move to *Club 100* has been so strong that several organizations are now tracking progress towards 100 per cent clean energy, including Go100 per cent.org[28] and renewables100.org[29].

Pioneering clean energy

Half a world away from Tokelau, and in a much colder climate, another island state demonstrates what can be done when a country puts its mind to eliminating fossil fuels by using abundant local renewable resources to create an economy based on clean energy.

Iceland is often cited for its 100 per cent use of renewable energy to generate electricity, but only two generations ago the country of 300,000 people used coal and oil to heat and power homes and fuel their fishing fleet and vehicles. As a nation just south of the Arctic Circle, Iceland's older residents can easily remember when coal smoke, not steam from the island's famed fumaroles, shrouded the capital.

In the early 1900s, however, farmers began constructing small hydropower plants and piping hot water from geothermal pools to heat homes, farms and greenhouses. Several decades later, in the 1970s, geothermal energy was first used for heat and power applications.

Today, Iceland generates 100 per cent of its electricity from renewable energy: 75 per cent from large hydro, and 25 per cent from geothermal. Equally significant, Iceland provides 87 per cent of its demand for hot water and heat with geothermal energy, primarily through extensive district heating systems. Together, hydro and geothermal sources provide 81 per cent of Iceland's primary energy needs for electricity, heat and transportation. In the process, Iceland has become a leader in geothermal development and exports its technical expertise worldwide.

Iceland has also been able to use its local renewable energy resources to provide electricity at highly favourable prices to three large aluminium smelters. These smelters together consume almost 80 per cent of Iceland's electricity generation at a time when electricity prices around the world are rising. It must be noted, however, that locating energy intensive industries where abundant renewable energy is available avoids the generation of 'dirty' electricity such as coal, to manufacture aluminium which would have otherwise been processed anyway elsewhere to meet global demand.

Due to its low-cost green electricity and reliable transmission system, Iceland is also attracting new industries, including those in the knowledge economy. The business of IT industry server farms is thriving because of Iceland's location between Europe and North America, and because the country's electricity is green and 50 per cent less expensive than in Western Europe. It is, therefore, a great opportunity for Iceland to pursue its economic growth and reduce its carbon emissions at the same time.

In March 2013, Denmark's wind turbines generated more than 100 per cent of the electricity for the Scandinavian country's six million citizens. In the previous year, wind energy provided nearly 30 per cent of Danish electricity, with biomass contributing another 14 per cent. Together, these renewable energy resources put the country well on target to reach 33 per cent in national energy mix by 2020.[30] *"I think it's doable, I think it's necessary, and it's also good for the economy," said Martin Lidegaard, Danish Energy Minister in 2012.*

Potential members of the upcoming *Club 100*

A number of regions and cities are gearing to join Club 100. In Austria, the state of Upper Austria (Oberösterreich) has set a target of 100 per cent renewable energy sources for heating and electricity by 2030, while Scotland has targeted a 100 per cent renewable energy electricity supply by 2020, mostly from wind energy.

Across the Atlantic, several cities in the United States are planning to join the club. After a tornado levelled their city in 2007, the citizens of Greensburg (Kansas) decided to do things differently and rebuild with 100 per cent renewable energy.

When visitors cross the Golden Gate Bridge to San Francisco, they are entering a city working to turn its dream of 100 per cent renewable energy into reality. The city has already achieved the Kyoto Protocol target of reducing GHG emissions to 7 per cent below 1990 levels. Aggressive energy efficiency programmes have reduced municipal, commercial and residential energy use by 45 MW – enough to power more than 45,000 households. Throughout the city, more than 15 MW of solar PV have been installed, as well as 3.5 MW of biogas cogeneration at the city's wastewater treatment plants.

All public transportation in San Francisco run on electricity or biodiesel. The city is replacing 17,600 older streetlights with energy-efficient LED lights to reduce energy use by 5.7 million kWh per year. Virtually the entire municipal electricity load, about one-fifth of the total electricity needed in the city, is met with carbon-neutral hydropower.

The pending HomeStar energy efficiency incentive program by the U.S. Government, coupled with the city's Energy Watch and Zero Energy Homes programmes, are expected to dramatically reduce residential energy consumption. The city's 10-year GoSolarSF solar incentive programme is further expected to triple the current amount of solar PV installed citywide by 2017.

And the private sector?

It's not only cities and regions that are joining the club. Private companies and organizations are also finding substantial benefits from using 100 per cent renewable energy in their operations. The US retailer Walmart is moving to join Club 100 with a 600 per cent expansion of the company's use of renewable energy over 2010 levels, while simultaneously reducing the energy intensity of its buildings by 20 per cent compared with 2010 levels.

The company maintains 150 solar installations in seven countries. In California alone, 75 per cent of facilities use some form of renewable energy. Walmart's six-fold increase in renewable energy projects would eliminate the need for roughly two US fossil fuel power plants and generate more than US$1 billion annually in energy savings once fully implemented.

> *More than ever, we know that our goal to be supplied 100 per cent by renewable energy is the right goal and that marrying up renewables with energy efficiency is especially powerful … The math adds up pretty quickly – when we use less energy that's less energy we have to buy, and that means less waste and more savings. These new commitments will make us a stronger business, and they're great for our communities and the environment.*
>
> Mike Duke, CEO of Walmart

Google also plans to join the club. The company has invested more than US$1 billion in wind and solar projects that generate 2 GW of clean electricity, enough to provide 30 per cent of the company's current electricity needs. Google pays more for this clean energy than conventional power from the grid, but expects its long-term pricing contracts for renewable energy will eventually be cheaper as conventional power becomes more expensive over time.

As a destination, *Club 100* is increasingly a "must go to" place for individuals, companies and communities on the Clean Energy Voyage.

So, relax for a moment (there are other destinations) and take in the view of both the present and future. It's superb.

CHINA

As many know, the Chinese expression for "crisis" consists of two characters side by side. The first is the symbol for "danger", the second the symbol for "opportunity".

Al Gore

On the lush green fields of Inner Mongolia, sturdy horses graze at the foot of hundreds of wind turbines with 40-metre blades spinning above them in a stiff, constant wind. It is just the latest juxtaposition of the modern and traditional in a rapidly developing economy. At the end of 2012, China had more than 60 GW of wind power capacity – the highest of any single country and representing one-fourth of the world's total capacity.

In 2012, China was responsible for almost **one-fifth** of total global renewable energy investment.

In 2010, the renewable energy sector contributed to the nation's GDP by US$ 63 billion and created about **4.35** millions jobs.

China is on target to reach 200 GW by 2020, which would surpass the 120 GW target set in 2008 under the Government's "Three Gorges of the Sky" project. Reaching this goal would give China an installed wind power capacity 18 times higher than the figure predicted in 2000.

Speeding up

Several thousand kilometres away, travellers can board a maglev train from Shanghai's airport and speed 50 km to the city centre in just seven minutes. Some of the electricity for the high-speed train comes from clean power generated by solar cells, wind turbines and other equipment made by a hundreds of local companies.

Almost as rapidly as its trains, China has become the number one destination for clean energy in the world. Some may have more advanced technology sectors, but no other country has developed more total renewable energy capacity than China more quickly, and impressively. In 2012, China was once again the dominant country for investment in renewable energy, with investment rising by 22 per cent from 2011 to US$67 billion.

China's largest renewable energy capacity comes from hydro power, with an already 212 GW installed base and a target to reach around 325 GW by 2015. 65 per cent of the world's 200 million solar water heaters[31] are installed in China. This represented 170 million square meters of solar water heaters in 2010, and a policy target was set to reach 300 million by 2020.

China's bioenergy efforts are also noteworthy. In 2011, it produced 2.3 billion litres of biofuels, mostly ethanol. Policy targets of 10 million tonnes of ethanol (12.6 billion litres) and 2 million tonnes of biodiesel (2.3 billion litres) exist for 2020. In 2011, the country had 4 GW of biomass power and a policy target of 30 GW by 2020.

It is with solar PV, however, that China may have made its most significant impact. Chinese manufacturers produce 70 per cent of the world's solar PV modules, with 90 per cent of the 20 GW production in 2011 exported. These exports earned companies nearly US$2 billion in 2011 from the United States and US$40 billion from the eurozone, where 60 per cent of China's solar productions were installed.

Although slow to develop, the domestic market is now starting to expand rapidly as exports drop to 70 per cent of production, due in large part to lower European feed-in tariffs and new tariffs on Chinese solar panel imports, as well as a more supportive domestic policy environment. At the end of 2012, China had nearly 5 GW of solar PV installed domestically, up from less than one GW in 2010. Domestic installations were 10 per cent of the total PV market for 2012 when China overtook Japan as Asia's largest solar PV market.

The rapid market change is reflected in China's renewable energy targets. The first target for solar PV in 2007 was 1.8 GW by 2020, which was later increased to 5 GW and then 20 GW. The government's Golden Sun programme, which was launched in 2009, approved projects totalling 1.7 GW in 2013, up from the 1 GW originally planned. In 2012, China announced that the target would be 50 GW by 2020 [32], and there are some experts who believe that figure could be double that amount, or more.

In its 12th Five-Year Plan, China has set an overall renewable energy target of 9.5 per cent of the overall energy consumption in the country by 2015. Of the 90 GW of electric capacity newly installed during 2012, renewable energy accounted for more than one-third, and non-hydro renewable energy capacity was more than one-fifth. This figure could rise substantially after China decided to cap GHG emissions in 2013.

UNEP, China launch Global Efficient Lighting Centre

Efforts by developing countries to transition rapidly to energy efficient lighting received a significant boost with the 2012 opening of the Global Efficient Lighting Centre – UNEP Collaborating Centre for Energy Efficient Lighting (GELC), in Beijing, China.

Launched by the UN Environment Programme (UNEP) and the National Lighting Test Centre, GELC assists developing and emerging countries in the establishment or strengthening of national and regional lighting testing laboratories. Projects undertaken by GELC include lamp quality testing conducted with countries participating in UNEP's en.lighten initiative. Understanding how lighting products perform and how to measure their performance builds capacity for measurement, verification and enforcement programs in developing countries.

International support

China's success in the clean energy sector is due in large part to the combined efforts of the national government, supplemented with support from international organizations. Many efforts begun before 2000 are now bearing significant results. Certification, for example, is a fundamental and often costly step for industry development, particularly if products need to meet stringent export standards.

In 1999, the Renewable Energy Development Programme, which was funded by the World Bank and the Global Environment Facility (GEF), helped to establish and develop the China General Certification Centre. With a team of more than 40 members, the Centre is able to certify wind turbines, solar electric products and solar water heaters.

The Programme also stimulated market demand, helping more than 400 000 Inner Mongolian yak-herding families access cleaner solar lighting.

A similar programme, the US$100 million China Renewable Energy Scale-up Programme – or CRESP – also helped to further develop China's renewable energy sector by developing more effective clean energy policies and laws, as well as improving the renewable energy industry supply chain, including production, manufacturing, standardization and certification.

China's rapidly evolving renewable energy sector demonstrates what can be achieved in a short time when national resources and international support are concentrated on an ambitious goal. It's definitely an essential destination of the *Clean Energy Voyage.*

UNEP project

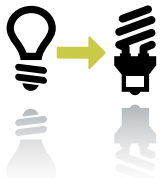
WALL STREET BAZAAR

My greatest challenge has been to change the mindset of people. Mindsets play strange tricks on us. We see things the way our minds have instructed our eyes to see.

Muhammad Yunus

The Big Apple's famous street is the world capital of money, and an essential destination for entrepreneurs on the Clean Energy Voyage. Between the opening and closing bells of the hallowed New York Stock Exchange, the new entrants must vie for space among mature stocks comprising the Dow. All are vying for cash that is the lifeblood of any industry and critically important for new industries. In the recent past, it has not been an easy "climate" for clean energy.

Investing **US$ 170 billion** annually in energy efficiency worldwide could generate savings of up to **US$ 900** billion per year.



Replacing all inefficient lightning worldwide would save countries almost **US$ 110 billion** annually and reduce global electricity consumption by 5%.

Over the past decade, however, that attitude has almost been entirely turned on its head. When investors began to perceive a new crop of renewable energy investments as no more risky than other standard forms of infrastructure, the clean energy sector in 2011 received more than US$279 billion of investment, up from US$40 billion in 2004. In that year and for the first time, investment in clean energy power plants surpassed that of conventional fossil fuels.

Investment in renewable power and fuels (including small hydroelectric projects) in 2012 was US$244 billion, down 12 per cent from the previous year's record figure, but still 8 per cent up from 2010. The reasons are complex, and they relate to finance sector regulations forcing banks to reduce long-term lending, and renewable energy stocks under-performing due to maturing solar and wind sectors where temporary over-capacity has driven profits down. Lower prices for equipment, however, meant that more capacity was installed in 2012 than in 2011.

The trends were not all down, nonetheless. The highlight of 2012 was a further shift in activity from developed to developing economies where investment increased 19 per cent to a record US$112 billion.

In the European Union, investments in renewable energy accounted for more than 71 per cent of total electric capacity additions in 2011, bringing renewable energy's share of total electric capacity to 31 per cent (see Figure 5). Solar PV alone represented almost 47 per cent of new installed capacity.

The reasons for this dramatic growth fit squarely on the shoulders of supportive policy that created positive market signals for investors. These included renewable energy targets, feed-in tariffs, grid access policies and a fluctuating carbon price. Another market signal is government-supported research and development (R&D), which has led to dramatically lower costs for clean energy technology. As seen with the drop in investment between 2011 and 2012, changing policy signals can greatly affect the investment climate for the clean energy sector.

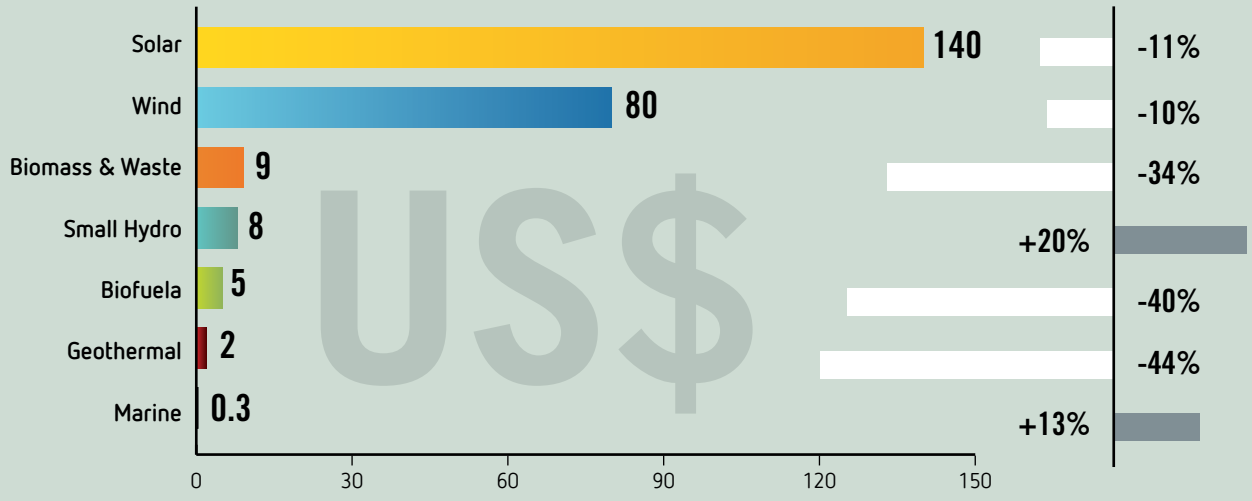
UNEP's initiatives to drive clean energy investments

In the early 1990s, UNEP began working with the finance sector to increase the engagement of the financial community in the clean energy and other sectors. The UNEP Finance Initiative[34] (UNEP FI) is a global partnership with more than 200 institutions, including banks, insurers and fund managers.

In 2011, the Frankfurt School UNEP Collaborating Centre for Climate and Sustainable Energy Finance[35] was established as a joint venture with the German Government. UNEP's Seed Capital Assistance Facility[36] (SCAF) is designed to support clean energy entrepreneurs at the earliest "seed" stage of a project. The Seed Capital Assistance facility operates as a Public Private Partnership, working with commercial investors to help them develop and finance early stage investments in a wide range of developing countries.

With this support, for example, the Evolution One Fund, Africa's first clean tech fund, made an initial US$680,000 seed investment to prepare a 80 MW wind farm in South Africa that has since mobilized US$138 million in construction finance. In Tanzania, SCAF support has helped the fund make a US$300,000 seed investment in a 10 MW small hydro plant that will help the country overcome its current power deficit and dramatically reduce emergency diesel generation that costs US$0.40-US$0.50 per kWh to operate. In total, the SCAF partner funds aim to finance more than US$2 billion of clean energy infrastructure in the developing world, including US$30 million at the early seed stage.

Figure 8. Global new investment in renewable energy by sector, 2012 and growth on 2011, $BN



Source: Bloomberg New Energy Finance, 2012.

UNEP project

One of the newest investment trends is an increasing focus on new markets. As more developing countries join the 118 countries already supporting clean energy policies, investment in these countries is now nearly half the total. Furthermore, the fastest growth is now occurring outside previous hotspots such as China, particularly in Africa where investment quadrupled in the past four years to US$12 billion annually. In 2012, a number of significant projects occurred in Africa, including two of the 10 largest deals globally.

This investment is being encouraged by a number of international finance initiatives. The Climate Investment Funds[33], for example, are using US$2.3 billion of direct finance to leverage more than US$19 billion to develop clean technology, such as the Ouarzazate solar project as part of the Middle East and North Africa (MENA) cooperation (see Destination: Maghreb).

A different "class" of traveller

As the clean energy sector matures, new financing models are starting to emerge. Pension funds and large institutional investors looking for stable, safe and long-term options can see the benefits of clean energy investments. They are looking closely at project ratings, feed-in tariff validity periods, project design lifetimes, construction performance risk and the variability of renewable energy resources.

One option being explored by utilities and pension funds is a joint-ownership model where a utility finances and builds a project with short-term funds and then sells a share of the project to pension funds. Dong Energy is one utility that has piloted this approach with 49 per cent pension-fund ownership.

Going offshore

In May 2013, Dong Energy finished erecting the last wind turbine at the 400 MW Anholt offshore windfarm in Denmark[37] that now supplies clean power to 400,000 households, which is equal to 4 per cent of Danish electricity demand. Ownership of the project is split between Dong Energy and two pension funds: Pension Danmark, a customer-owned labour market pension fund covering 600,000 individuals employed in 22,000 companies within the private and public sector; and PKA, the largest administration company for occupational pension funds administrating eight occupational pension funds with a total of 245,000 members, 90 per cent of whom are women.

A new financial destination – Main street

In January of 2013, a US-based company called Mosaic was looking for US$313,000 to fund four renewable energy investments. When Mosaic [38] posted these investments online – offering a 4.5 per cent return to investors who could participate with loans as small as US$25 – the company's co-founder, Billy Parish, thought it would take a month to raise the cash.

Within 24 hours, 435 people had invested and the projects were sold out. The company had spent just US$1,000 on marketing and in the next three months raised US$1.1 million for a dozen solar projects. Now, the company is connecting with other solar developers to identify new projects for financing. More than 10,000 people have already registered to invest.

Normally the domain of much larger transactions, Wall Street has been joined by a viral, Internet-enabled process called "crowd funding". Mosaic is just one of several new companies looking for finance from the Main Street crowd.

Some mainstream investors have also seen the opportunity. Warren Buffett's MidAmerican Energy Holdings Company's US$850 million bond for the Topaz Solar Farm in California was the first time a public bond offering for a US solar PV project had been deemed "investment grade." The offering was oversubscribed by more than US$400 million and the company has now launched a second round to raise potentially US$1.25 billion more.

The increasingly inclusive club

As investment expands in different ways from Wall Street to Main Street, bankers and financiers are not the only ones who have seen their previously exclusive services bypassed. Energy utilities are also feeling the effects of new market entrants and new funding models.

Reactions have been mixed, although it is clear that many executives in the power sector are struggling to understand the new and evolving models of distributed generation with its powerful nexus of continuing decreasing costs for clean energy that will eventually cross the holy grail of "grid parity". Passing this point will encourage a raft of customer decisions to become more efficient or add an on-site renewable energy generation system. These decisions will directly and indirectly affect a utility's bottom line.

In the United States, for example, First Solar signed an agreement with the El Paso Electric Company in 2013 to sell solar electricity for less than half the cost of power generated from typical coal plants. In Australia, the cost of electricity from solar PV is estimated at less than half the cost of buying it from the grid (see Destination Australia).

Utilities are also coming to grips with the new reality that electricity demand forecasts may be wrong, and in some cases, very wrong. They then face a triple threat: other technologies delivering the same energy service at a lower cost "without the wire" (grid); falling demand as a result of efficiency measures, and a decreasing price for their product as more and more clean energy is delivered to the grid at lower prices.

In this new distributed model, planning for load growth is also highly compressed and less risky than the multi-year planning for

conventional power plants. Multi-megawatt solar PV plants, for example, are now built in eight to 10 weeks, while wind projects take six to nine months. New entrants that can operate at this pace have an advantage in the evolving market.

Modular approach

In less than a decade, installations of utility-scale solar PV plants have increased from 10 MW to nearly 600 MW (see Antelope Valley solar farm[39] in California). Companies are developing standard "power blocks" of several megawatts that can be individually financed and simply repeated over and over to meet the specifications of a particular plant. Such a modular approach has helped achieve a 50 per cent reduction in balance-of-system costs in just two years.[40] Companies are starting to compete in a market "sweet spot" of 10 MW to 50 MW installations in places such as California, where 97 per cent of new electricity generation capacity into the state's grid in the second half of 2013 – nearly 1,600 MW – will be from solar projects.[41] This decentralized and modular nature of renewable energy completely changes the way energy infrastructure can be planned and developed, particularly in regions such as sub-Saharan Africa, where power infrastructure needs are greatest.

Utilities are also dealing with solar leases and other forms of consumer finance that are making substantial inroads into their customer base. Some solar leases have a zero upfront cost, where customers simply allow a PV array to be placed on their roof from which they purchase cheaper electricity. In 2012, for example, third-party-owned solar capacity represented 74 per cent of California's home solar market.[42] Much of that market's growth comes from low- and median-income areas where the benefits of solar can be accessed with a zero upfront cost lease.

Community-owned power assets, including transmission and distribution, are also rising in popularity (see Destination Germany). If this weren't enough, new energy storage technologies at the start of their development curves are further disrupting the centralized electricity model. Advanced batteries, fuel cells, flywheels, pumped storage and other technologies will increasingly combine with renewable energy to produce a system that can provide electricity and heat on demand and at any scale. This will soon end the myth that renewable energy cannot provide power when it is needed.

And if more and more people decide they can get an electricity service "without the wire" from a grid network – as they do with their mobile communication service – utilities will have to transform themselves or be increasingly spurned by a financially fickle Wall Street.

At that point, they may well wonder, "for whom the closing bell tolls".

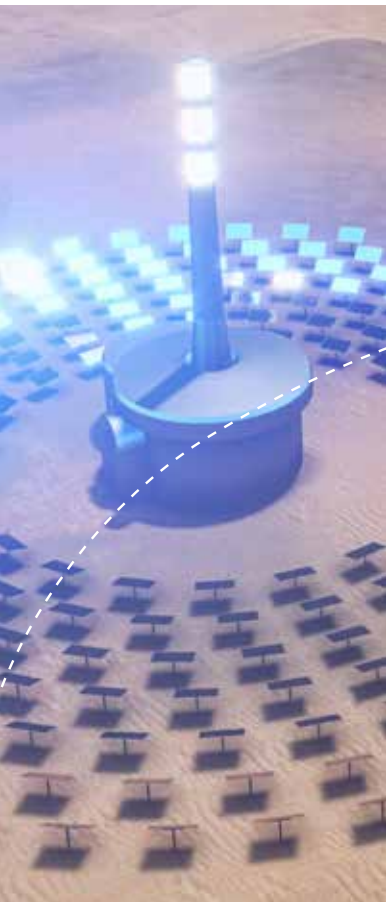
Green Climate Fund Readiness Programme

Developing countries will soon have at their disposal a significant new form of finance to help them respond to the challenges of climate change following the approval of the Governing Instrument of the Green Climate Funds (GCF) at the United Nations Climate Change Conference in Durban in 2011.

UNEP, in collaboration with the United Nations Development Programme and the World Resources Institute, is setting up a GCF Readiness Programme to assist countries to prepare to access and manage GCF funding both institutionally and in terms of private-sector engagement. By offering results-oriented support for climate finance readiness, the Programme will help strengthen national institutional frameworks in the target countries, help to identify climate change activities with high funding priority for the countries and facilitate increased investment of the private sector in climate-relevant areas. This will accelerate the implementation and replication of successful climate change mitigation, REDD+ and adaptation efforts, and thereby allow countries to increase their resilience to climate change and to advance in their transition towards low-carbon socio-economic development. In addition, feeding back lessons learned at the country level to the GFC Board will help the GFC design its operations in ways that reflect the needs of developing countries.

This project is part of the International Climate Initiative and funded by The Federal Ministry for the Environment, Nature Conservation and Nuclear Safety. For more information, visit: www.international-climate-initiative.com

UNEP project



MAGHREB

I'd put my money on the sun and solar energy. What a source of power!
I hope we don't have to wait until oil and coal run out before we tackle that.

Thomas Edison

From Casablanca to the Kasbah, North Africa's Maghreb region is fast becoming a primary destination for clean energy. Famous for being Europe's winter escape station, the sun-drenched region now boasts one of the most ambitious solar projects in the world.

In the MENA (Middle East and North Africa) investment topped US$2.9 billion in 2012, up 40% from 2011 and **+650%** from 2004.

In Morocco, US$ 9 billion will be invested to build 2 GW of solar power by 2020. Enough to supply **40%** of the nation's electricity needs.

Morocco – All aboard the solar express

After taking the train to Marrakech, clean energy voyagers to Morocco who travel a bit further can visit Ouarzazate, home to the first phase of what will eventually be one of the largest projects of its type. Under Morocco's national solar plan, construction began in May 2013 on the first 500 MW of concentrating solar power (CSP).

When completed in 2016, the 3,000-hectare power plant will meet the electricity needs of Ouarzazate's 1.5 million residents. Morocco expects to build five new solar plants by the end of the decade with a combined production capacity of 2,000 MW at an estimated cost of US$9 billion.

The project is underwritten by a number of financial institutions, including the World Bank, AfDB, European Investment Bank, KfW (Germany) and the Agence Française de Développement (French Development Agency). Additional support is provided by the Climate Investment Funds.

This international finance has been a critical factor to reduce project risk and enhance financial viability by reducing the cost of investment and hence the cost of electricity. Morocco is aiming to become a world-class renewable energy producer, and is exploring the opportunity to export clean electricity to neighbouring Europe.

With planned windpower projects, Morocco's efforts could produce 42 per cent of the country's electricity from clean energy sources in 2020. Reaching this goal would be a significant achievement for a country that currently imports 96 per cent of its energy – the largest importer of energy in the North African region – and a signal to the region that clean energy is a mainstream destination.

Hot times in Tunisia

The clean energy traveller looking for a hot shower in Tunisia may well look up to the roof and a solar water heater that captures the country's abundant solar resource. As in many parts of the world, however, the purchase price for a solar water heater can be many times the total monthly earnings of most households.

This high upfront cost presents a significant financial barrier for many families, even though a solar water heater can pay for itself in as little as four years. Despite this short payback time, loans are often difficult to procure because banks are reluctant to lend for what they see is an unfamiliar clean energy technology. Households also tend to favour gas-fired units that are heavily subsidized.

To address this barrier, UNEP initiated the Mediterranean Investment Facility[43] (MIF) for renewable energy and energy efficiency technologies in Tunisia, Montenegro, Morocco and Egypt. The MIF helps local governments and financial institutions offer two key incentives: an interest rate reduction and a guarantee for commercial loans.

The Facility also helps banks or other financial institutions evaluate small and medium-scale investments, provide training and create specialized credit facilities and clean energy funds. It stands out as an example of how international and local public support addressed critical demand-side barriers that were preventing the widespread use of solar water heating. Through MIF, the initial US$2.2 million funding from the Italian Ministry for Environment, Land and Sea has leveraged a total investment of more than US$200 million.[44]

MIF offers five-year loans for residential solar water heaters with repayments made through a customer's monthly electricity

bill. The credit mechanism also includes a 20 per cent subsidy of the total initial cost, which makes solar water heaters cost competitive with LPG. MIF also provided loans with discounted interest rates, which were phased out after 18 months as the sector developed.

One of the key factors that stimulated the market for solar water heating was the involvement of the national utility, STEG[45], as a channel for credit recovery through a customer's electricity bill. The initial average bank consumer loan had an interest rate of 12 to 13 per cent. With STEG's involvement in recovering loan payments through the electricity bill, banks lowered interest rates by five to six per cent because the loan risk had drastically decreased. After a few months of operation, the financial support mechanism led to a policy change as well, with the Tunisian Government making the 20 per cent capital cost subsidy legally permanent.

The Facility has also tackled supply-side barriers through certification and supplier accreditation schemes, as well as a comprehensive communications campaign to promote and strengthen the demand for solar water heaters.

Mediterranean Investment Facility by the numbers

- *500,000 m^2 of solar collectors installed in 166,000 systems in 2005-2012*
- *47,000 tonnes of fossil fuels savings (oil equivalent) and US$15 million of avoided expenditures from LPG savings in 2005-2010*
- *Number of qualified solar installers increased from 100 in 2002 to 1,200 in 2010, while solar water heating suppliers increased from 8 in 2002 to 50 in 2010*
- *In 2005-2010, the industry turnover was about US$120 million, which included US$107 million of manufacturing activity*
- *Since the Facility began, about 3,000 new direct jobs and up to 7,000 indirect jobs have been created in the solar water heating sector*

Based on experience in the residential sector, the Mediterranean Investment Facility has also developed similar financial mechanisms and policies that extend to the commercial and industrial markets that include hotels and other service industries, as well as mechanisms for photovoltaic technology and the industrial solar water heating markets in Tunisia.

The program has been replicated beyond Tunisia's borders. In Montenegro, which has the highest level of sunlight in Europe, UNEP is also developing a joint program with the government to build a sustainable, long-term residential solar water heater market by financing low-interest loans and subsidizing capital costs. In Egypt, for example, UNEP has developed EGYSOL, a public-private partnership to promote solar water heating in the service and tourism sectors of the Red Sea and South Sinai.

AUSTRALIA

It is very unlikely that new coal-fired power stations will be built in Australia. They are just too expensive now, compared with renewables.

Bloomberg New Energy Finance

Nicknamed "the sunburnt country", Australia is an iconic destination in the Clean Energy Voyage. The sun is literally rising on the rapid transformation of Australia's electricity market that was formerly supplied principally by coal-fired generators.

In 2012,
14 times
more solar photovoltaic panels were installed than in 2007.

Global photovoltaic capacity has been increasing at an average annual growth rate of more than **40%** since 2000.

In April 2013, the one-millionth solar PV system was connected to Australia's national grid. This made one in every 10 Australian homes a "micro-power station", generating clean electricity to power homes and businesses, and even exporting clean electricity to power their neighbours. Per capita, Australia has even more solar power from solar PV than Germany.

Less than 20 years earlier, however, there was none. Such is this growth rate that if AU$1,000 was invested at the same time and grew at the same rate as solar installations, the investor would now be a billionaire.

The first residential solar PV system connected to an Australian electricity grid was the Solar One Project in July of 1994 on Queensland's appropriately named Sunshine Coast. Solar One used the combination of solar water heating, gas cooking, energy efficient appliances and a 1.4 kW solar array to generate more power than the home consumed, while demonstrating the technical means to connect thousands of micro power stations to grids throughout the vast Australian continent.

The 2.5 GW exponential growth of the sector – a compound annual rate of 100 per cent – was brought about by the "perfect storm" of government policy, rising power prices and the rapid technical advance of solar PV manufacturing, particularly in China.

This rapid advance, aided in large part by Australian photovoltaic research and supported by the national government, fits the classic technology development model where PV costs declined by an average of 6 per cent for each doubling of manufacturing capacity.

The solar PV array on Solar One cost the equivalent of AU$25 per watt installed, while the one-millionth solar PV system cost just AU$2 per watt installed, which challenges Germany for the title of cheapest price for installed PV in the world. Since 2011 alone, the cost of solar PV in Australia dropped by 29 per cent.[46] By contrast, the cost of energy from new fossil-fuelled plants continues to rise.

So, how did it happen?

In 2007, the Australian Government offered homeowners a AU$8,000 rebate to install solar PV at a time when a 1.5 kW solar array cost almost AU$16,000. At the same time, the government legislated a 2 per cent renewable energy target for the retail electricity sector. Some states began offering feed-in tariffs, including an AU$0.44 per kWh feed-in tariff in the solar rich state of Queensland. Concurrently, China's solar PV manufacturing sector was in full expansion and started to supply the Australian market with less expensive solar panels.

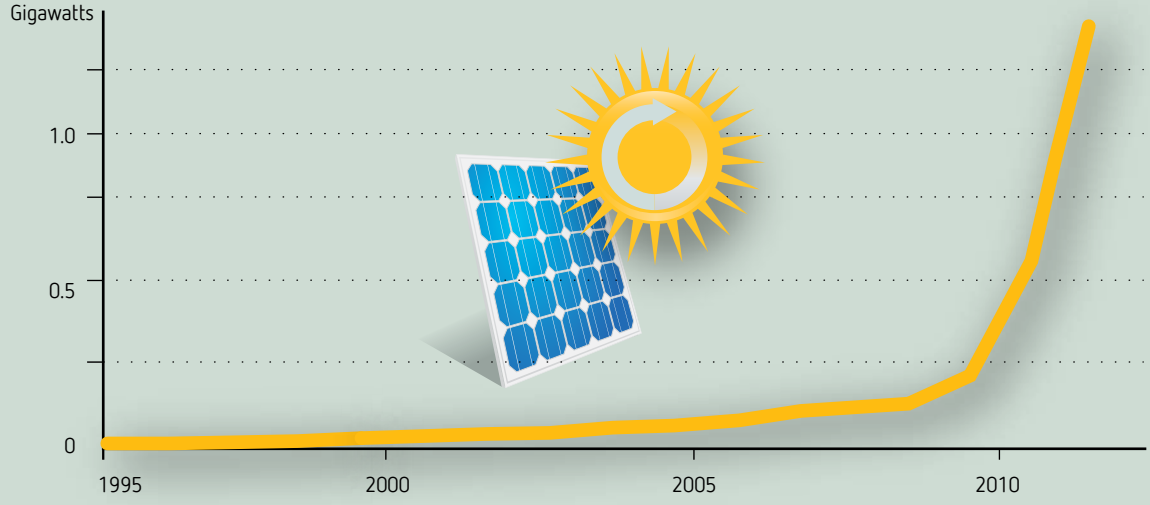
Prices began to tumble as the industry focused on smaller, 1.5 kW systems. Soon, such a system could be bought for a net cost of just AU$2,000 after the rebate, which offered a simple payback of five to six years for a system that would last for more than 20 years. Power prices also started to rise rapidly as utilities spent billions upgrading transmission lines to handle an increasing daytime peak load, mainly to meet the demands of air-conditioning.

As more people started to install solar systems as a hedge against rising prices, prices dropped even further, allowing some companies to offer a system at zero cost after the rebate. A newly elected Australian Government then elevated the renewable energy target to 20 per cent by 2020, and created a market for tradable renewable energy certificates. More quickly than anyone imagined, the solar industry boomed.

This boom caught the state and federal governments by surprise and forced them to quickly eliminate or greatly reduce feed-in tariffs and rebates. This substantially dampened the rate of solar installations, but not before Australia added 2 GW of solar PV from 2010 to 2012 – more than 90 per cent in the residential market.

Although dampened, solar PV installations are set to rise substantially and could reach 10 GW by 2017, according to some estimates. The market is being driven by an average retail electricity price of AU$0.27 cents/kWh that continues to increase; a substantial solar resource in most areas of the country; and an emissions trading scheme. Consequently, Australia has

Figure 9. Solar PV installed capacity in Australia



Source: DataMarket (http://data.is/naKtrl)

joined Germany as one of the first regions to experience "grid parity" for solar PV at the retail level.

While Australian homeowners have been happy to install solar PV and watch their electricity bills decline, the nation's electricity distributors and retailers have had a more difficult time adjusting to the new reality of declining electricity demand from the growth in solar PV and energy efficiency. With revenues declining, electricity distributors and retailers initially found little value from this new distributed capacity. Politicians were pressured by those without solar PV to reduce support, even though in one analysis, solar PV installed in Queensland was found to actually save households without solar installations AU$56 per year.[47]

Attitudes, however, are changing. After one particularly high temperature period, one utility executive said that the 500 MW of rooftop solar in his distribution network were "... making a big difference in reducing the peak demand", which is the most expensive power to generate in Australia.

The Australian story illuminates the disruptive nature of solar PV and other renewable energy technologies, and the role that government policies can play to encourage – or discourage – clean energy development. It is a case study of how quickly the energy landscape can change when solid market signals are applied.

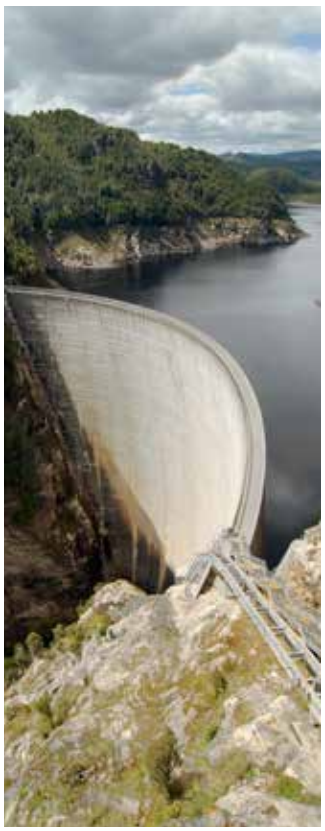
Nevertheless, Australia's market development is not a textbook case of getting it right, but rather a cautionary tale of boom and bust that can be exacerbated by rapidly changing incentives and penalties to competing fossil fuel interests that fall well short of a "level playing field" where all technologies compete fairly. Australian subsidies to fossil fuels are still about AU$7 to 10 billion per year compared with about AU$1 billion for renewable energy and energy efficiency.

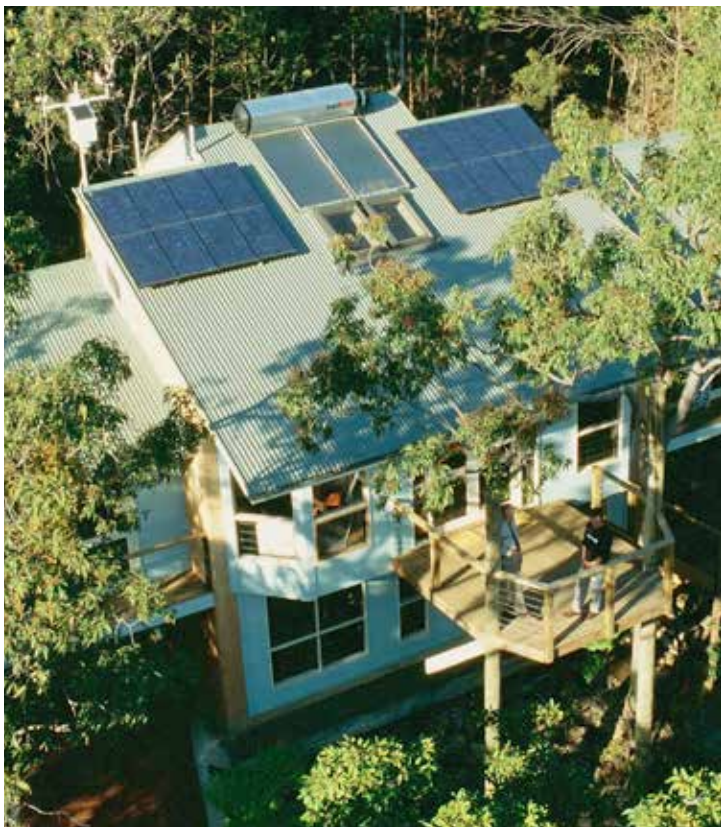
In spite of this, the Australian experience shows how strong public support creates positive market signals, amplifying the effect of declining costs to foster the transition to a clean energy economy.

When asked if their country can move quickly towards a clean energy economy, Australians increasingly use a favourite expression: "No worries mate."

And elsewhere? Applying the UNEP FIT report in the Republic of Trinidad & Tobago

In order to respond to energy challenges, countries have multiplied recourse to renewable energy policy making. The most prevalent national renewable energy policy in the world is the feed in tariff (FIT). As of early 2011, 50 countries had some form of FIT in place, with more than half of these being in developing countries. In 2012, UNEP published a report entitled, Feed-in Tariffs as a Policy Instrument for Promoting Renewable Energies and Green Economies in developing countries. The UNEP report is intended to serve as a guide for policy makers in developing countries to make informed policy decisions about the "whether", "when" and "how" of FITs and to support nationally appropriate policy measures to scale up renewable energy. Using this toolkit, UNEP provided technical assistance to support the Ministry of Energy and Energy Affairs of the Republic of Trinidad and Tobago to develop FIT policy and legal instruments.





■ *UNEP project*

YEAR 2030

I ask all of us here, if not us, then who? If not now, then when?

Naderev "Yeb" Saño

One of the main messages from the past development of clean energy is that "trend is not destiny". Estimates for the installation of renewable energy capacity can be highly unpredictable. This publication, however, is more focused on the question of what could be, and, at what cost.

In their analysis, the International Renewable Energy Agency shows clearly the dramatic decline in renewable energy costs over the past decade.[48] What if these current trends continue? In such a scenario, the cost of renewable energy technologies continues to decrease, the cost of fossil fuel and nuclear continues to increase, and energy efficiency becomes a compelling economic imperative.

Under these assumptions, it's clear from a range of studies and examples in these pages that in 2030, many communities, regions and even countries could obtain 100 per cent of energy or electricity from renewable energy and energy efficiency. If the trends accelerate, this list will grow; if trends slow down, it will be less.

One of the more interesting and inexpensive ways to test these trends, at least in the electricity sector, is to run hour-by-hour computer simulations using a range of renewable energy and energy-efficiency options. Such simulations have been performed for at least eight countries and regions.

In Australia, an analysis using thousands of hourly simulations of supply and demand data from the National Electricity Market found that in 2030, 100 per cent of electricity demand could be provided by a mix of wind and moderate amounts of solar PV and CSP.

The total annual cost, including capital, operation and maintenance, of this least-cost mix is estimated at AU$7 to 10 billion a year higher than an "efficient" fossil fuel scenario that emits substantially more GHG emissions. Australians could, however, pay for the extra cost of a 100 per cent renewable energy power sector by simply removing the estimated AU$10 billion they currently pay each year in subsidies to fossil fuels industries.

Australia's National Electricity Market Operator also concluded that there were "no fundamental limits to 100 per cent renewables" by 2030, with the additional cost to Australians as little as AU$0.66 per kWh.[49] That study did not, however, account for improving energy efficiency, health and other economic benefits from renewable energy, and even minimal improvements in technologies such as solar PV.

The Australian studies highlight two important elements in the move to pay for a clean energy economy: the need to shift subsidies from existing fossil fuel industries, and the possible rapid energy efficiency gains that could provide up to one-third of power requirements by 2030.

In 2012, for example, the IEA estimated that by 2050, the world needs to spend an extra US$36 trillion on energy systems to meet its scenario that limits global warming to 2°C. The IEA, however, also points out that this figure will be more than offset by the US$100 trillion in savings that can be gained through the reduced use of fossil fuels.

The IEA has also noted that the world needed to spend US$5 trillion by 2020[50] (over and above business-as-usual spending of US$19 trillion) to prevent global warming of 2°C, but this could be paid for by cutting fossil fuel subsidies.

Similar studies from the United States and Europe burst the myth that renewable energy cannot supply baseload electricity demand that, for example, coal currently provides for Australia and nuclear for France. The mix of renewable energy systems in the Australian computer models easily supply baseload demand, although there are no baseload power stations.

The IEA and other expert groups see a future energy system characterized by greater diversity of technologies and fuels, more renewable energy and increased complexity across the entire infrastructure. The standard will be energy as a service, rather than simply as a commodity.

To address climate change and energy security, however, the global economy will need more than 100 per cent renewable energy in the power sector. Increasing energy efficiency and demand management will also be needed to curtail the growth of energy demand.

One thing is clear: the new energy system will look for complementary resources and needs across different sectors: electric vehicles that link the transport sector to the power sector, increased use of electricity and cogeneration in heating; the use of thermal and other forms of energy storage to balance variable renewable generation; more sophisticated demand responses; and using hydrogen as an energy carrier for heating, power generation and transportation. This will also require experts from other areas such as demand management, efficiency, information technology and systems management.

One of the most significant goals for 2030 is universal access to modern energy services – one of three integrated goals under the United Nations Secretary General's Sustainable Energy for All (SE4ALL) initiative. Success on this initiative will provide electricity to 1.3 billion additional people – one in five globally. Success would also provide modern energy services to twice that number – the nearly 40 per cent of the world's population

Table 1. Global renewable power capacity by 2030 in recent scenarios

	Hydro	Wind	SolarPV	CSP	Biomass	Geothermal	Ocean
	GW						
Actual 2006 Capacity for Comparison	–	74	8	0.4	45	9.5	0.3
Actual 2011 Capacity for Camparison	970	238	70	1.8	72	11	0.5
IEA WEO (2012) "New Policies"	1 580	920	490	40	210	40	10
IEA WEO (2012) "450"	1 740	1 340	720	110	260	50	10
IEA ETP (2012) "2D2"	1 640	1 400	700	140	340	50	20
BNEF GREMO (20111)	–	1 350	1 200		260	30	–
IEA RETD (2010) "ACES"	1 300	2 700	1 000	120	340	–	–
Greenpeace (2012)	1 350	2 900	1 750	700	60	170	180

Notes: CSP stands for solar thermal power. Figures for 2030 are rounded to nearest 10 GW or 50 GW from original sources. Hydropower figure for 2011 excludes pure pumped hydro capacity; a comparable figure for 2006 is not available, see REN21 (2012), notes to Table R2, and note on hydropower on page 168.

Source: REN21, *2013 Renewables Global Futures Report*, 2013

who rely on wood, coal, charcoal or animal waste for heating and cooking. Toxic smoke from burning mostly low-quality biomass energy resources causes lung disease and kills more than two million people a year, most of them women and children.

Without access to modern energy, it is also not possible to achieve the United Nations Millennium Development Goals to reduce poverty, improve the health of women and children or broaden the reach of education.

Another objective is the doubling of renewable energy from the current 18 per cent of global energy in 2012, which means a tripling of modern renewable energy sources if the share of traditional biomass remains constant.

Reaching these objectives – from energy access to high rates of energy efficiency and renewable energy – is without doubt technically feasible. In most cases, they are already cost-effective and many more would be if current subsidies to fossil fuels are removed or redirected.

There is an unstoppable momentum that will, at its minimum, create an energy landscape in 2030 that is vastly different from today. The question of whether we have an entire global economy powered by clean energy is now a question of when, not if.

Clearly, though, sooner is better – and cheaper – than later.

A traveller's note

Where there is a will, there is a way.

Imagination, said Albert Einstein, is more important than knowledge.

He was right. After the first decade of the 21st century, it's clear that we have enough knowledge to solve pressing challenges, particularly climate change and energy access.

The Clean Energy Voyage shows that many communities have used that knowledge to imagine a sustainable energy future, and then take that journey of discovery. They have encountered many challenges but also discovered solutions that were easier – and cheaper – than previously thought. Communities around the globe are hungry for the best ideas that deliver modern services without the huge environmental burden of our past and present fossil-fuelled economy.

In the many projects facilitated by UNEP to improve energy access, develop and finance clean energy, and promote sustainable transport, it's clear that even small amounts of clean energy can create a huge improvement in health, education and economic opportunity.

Global energy use is expected to grow by 36 per cent by 2035 – with non-OECD countries accounting for almost all of the increase – and based on current trends, 1.2 billion people, or 15 per cent of the world's population, will still lack access in 2030.[51] Therefore, we cannot afford business-as-usual.

With timely and focused policies, both energy, poverty and climate mitigation could be realistically addressed through the three targets of the SE4ALL initiative: (i) ensure universal access to modern energy services; (ii) double global rate of improvement of energy efficiency; and (iii) double the share of renewable energy in the overall global energy mix.[52]

The technical potential of renewable energy technologies vastly exceeds current global energy demand, yet more than 97 per cent of this potential is still to be tapped.[53] It must be noted that many of the pre-2004 scenario projections on levels of renewables for 2020 were already exceeded in 2010. What does this all mean? Can we realistically aim for the IPCC's most ambitious target of 77 per cent share of renewables by 2050? Or should the real question be: Do we want to?

This Clean Energy Voyage over time and across continents tells us one thing: we can certainly afford to be more ambitious. Market and business trends confirm that the transition has begun.

The power of the Clean Energy Voyage is simply that it is an idea whose time has come, and there are no reasons for delay.

It's time to imagine a Club 100 with every community and nation as members, and knowing it's only as distant a destination in time as we choose it to be.

Our children and grandchildren may very well wonder why we didn't go there sooner.

NOTES

1 Frankfurt School-UNEP Centre/BNEF, 2013; *Global Trends in Renewable Energy Investment*, 2013.

2 REN21, *Renewables 2013 – Global Status Report*, 2013.

3 OECD/IEA, *World Energy Outlook*, 2012.

4 The three objectives by 2030 include doubling both the global rate of energy efficiency improvement as well as the share of renewable energy in the energy mix from 2010 levels, while ensuring universal access to modern energy services. For further information, please visit www.sustainableenergyforall.org

5 REN21, *Renewables 2013 – Global Status Report*, 2013.

6 Ibid.

7 Ibid.

8 http://www.irena.org/DocumentDownloads/Publications/IRENA_GWEC_WindReport_Denmark.pdf

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25 EU Press Release: http://europa.eu/rapid/press-release_BEI-10-166_en.htm

26 http://www.worldfutureenergysummit.com/Portal/news/3/1/2013/switching-on-the-light-as-13-billion-people-live-without-electricity.aspx

27 http://www.tokelau.org.nz/

28 http://www.100-ee-kongress.de/english-information/

29 http://www.renewables100.org/

30 http://marokko.um.dk/~/media/Marokko/Documents/Other/GBEnergistrategi2050sammenfatning.pdf

31 REN21, *Renewables 2013 – Global Status Report*, 2013.

32 Ibid.

33 www.climateinvestmentfunds.org/cif/

34 http://www.unepfi.org/

35 http://fs-unep-centre.org/

36 http://www.unep.org/climatechange/finance/SeedCapital/SCAF/tabid/29555/Default.aspx

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LIST OF ACRONYMS

AfDB	African Development Bank
AREED	African Rural Energy Enterprise Development Programme
BNEF	Bloomberg New Energy Finance
CSP	Concentrating solar thermal power
EGYSOL	Italian Ministry of the Environment, UNEP and the Egyptian Authority for Renewable Energy Project for the Promotion of Solar Thermal Power in Egypt
GDP	Gross domestic product
GEF	Global Environment Facility
GW	Gigawatt
GWh	Gigawatt hours
IEA	International Energy Agency
kW	Kilowatt
kWh	Kilowatt hour
LED	Light emitting diode
LPG	Liquefied petroleum gas
MW	Megawatt
PV	Photovoltaic
R&D	Research and development
SCAF	Seed Capital Assistance Facility
SE4ALL	Sustainable Energy for All initiative
STEG	Société tunisienne de l'électricité et du gaz

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The Clean Energy Voyage explores the rapid progress with clean energy technologies, policies and projects over the past decade, and explodes the many myths about the potential for a global economy powered by clean energy.

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