WWF

REPORT

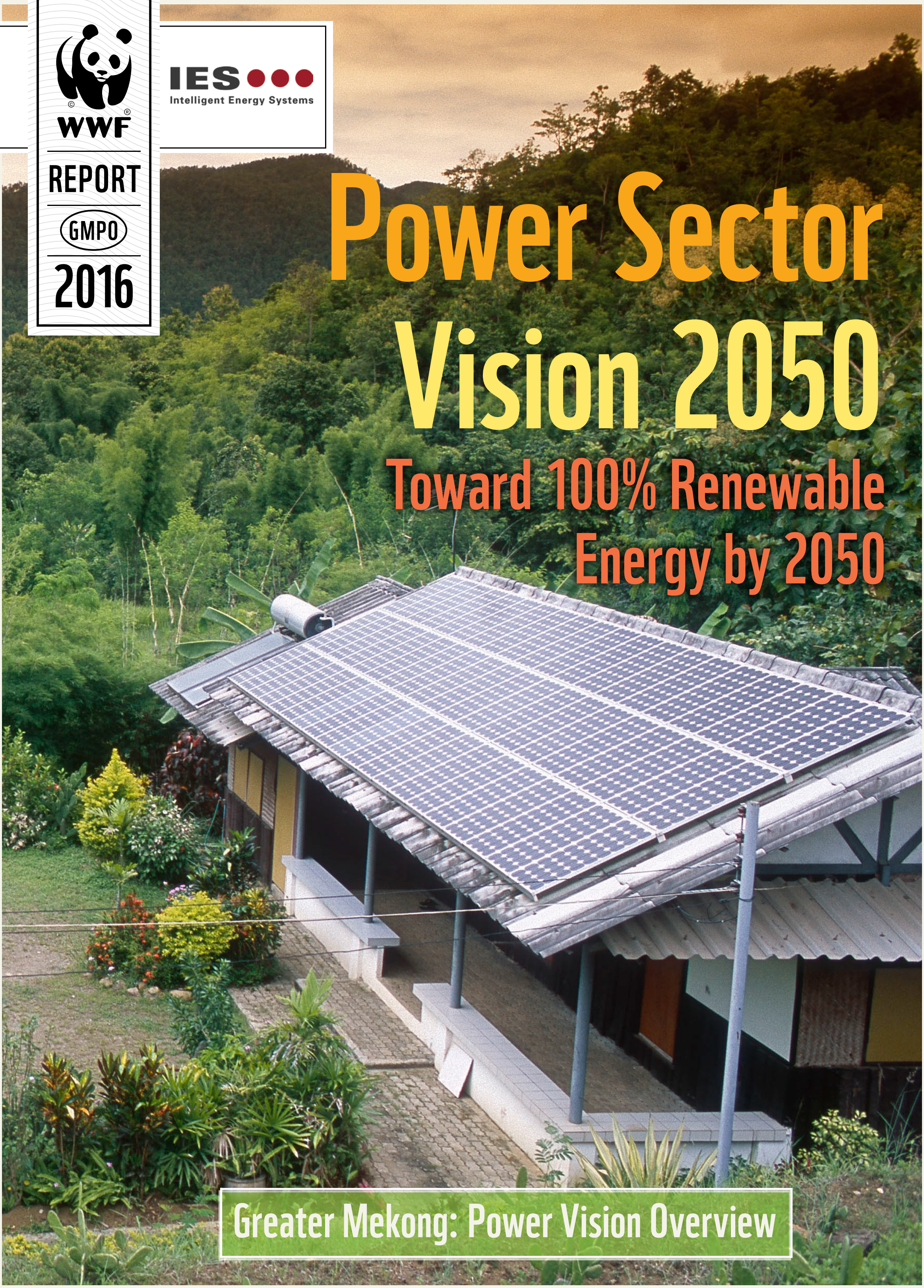
GMPO

2016

IES
Intelligent Energy Systems

Power Sector Vision 2050

Toward 100% Renewable Energy by 2050



Greater Mekong: Power Vision Overview

WWF
WWF is one of the world's largest and most experienced independent conservation organisations, with over five million supporters and a global network active in more than 100 countries.

WWF's mission is to stop the degradation of the planet's natural environment and to build a future in which humans live in harmony with nature, by conserving the world's biological diversity, ensuring that the use of renewable natural resources is sustainable, and promoting the reduction of pollution and wasteful consumption.

IES
Intelligent Energy Systems (IES) is an Australian consulting firm established in 1983 to provide advisory services and software solutions to organisations working in the energy industry. IES specialise in taking systematic approaches to solving problems in energy markets that require consideration of energy policy, legislation, economics, finance and engineering. IES has a proven track record in advising government departments, regulators, system and market operators, transmission companies, generators and retailers in the Asia Pacific region, including Australia, the Greater Mekong Sub-region, Philippines, Singapore and elsewhere.

MKE
Mekong Economics Ltd. (MKE) is a leading economic and socio-economic development and commercial consulting firm active in the Greater Mekong sub-region and Asia-Pacific region. MKE has over 20 years of experience in providing specialist services to international development agencies, non-governmental organizations and corporate clients.

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CONTENTS

PART 1 (WWF)

PART 2 (IES)

One regional report and five country reports

The Power Sector Vision has been sub-divided in different separate documents. There is a report for each of the countries and one regional report. The regional report presents a summary of the national reports, and discusses regional power sector topics such as grid interconnection.

Defining renewable energy, energy efficiency and sustainable energy

"**Renewable energy** is derived from natural processes that are replenished constantly. In its various forms, it derives directly or indirectly from the sun, or from heat generated deep within the earth. Included in the definition is energy generated from solar, wind, biomass, geothermal, hydropower and ocean resources, and biofuels and hydrogen derived from renewable resources" (IEA, n.d.).

"**Energy efficiency** is a way of managing and restraining the growth in energy consumption. Something is more energy efficient if it delivers more services for the same energy input, or the same services for less energy input." For instance, when a LED uses less energy than an incandescent bulb to produce the same amount of light, the LED is more energy efficient" (IEA, 2016).

"Renewable" does not necessarily mean "sustainable". The location, design, planning, development, construction and operation of power plants and their energy sources (e.g. biomass) will have a strong impact on the sustainability of the project. Special additional caution is recommended for hydro power and biomass projects, which can have severe social and environmental impacts.

Initiatives exist to improve the sustainability of these energy sources. Among those, the World Commission on Dams (WCD) has produced volumes of information on hydropower that remains relevant. -- Building on the WCD principles, the Hydropower Sustainability Assessment Protocol is a tool that promotes and guides more sustainable hydropower projects ; the Roundtable on Sustainable Biomaterials is an independent and global multi-stakeholder coalition which works to promote the sustainability of biomaterials. Their certification system is based on sustainability standards encompassing environmental, social and economic principles and criteria.

It is, however, important to remember that such sustainability schemes will not prevent all negative impacts. Seeking to maximise the use of lower impact renewables, such as wind, solar, or geothermal energy, and reducing usage through energy efficiency, remains a priority.

[1] http://www.hydrosustainability.org/

[2] http://rsb.org/

FOREWORD

Greater Mekong countries have a unique and timely opportunity to become leaders in clean, renewable electricity. Renewable energy sources such as sun, wind, water, geothermal, biomass, and ocean energy abound in the region.

Choices made in the coming months and years present opportunities for regional leaders to follow one of two paths: either leapfrog and embrace the best clean, renewable technologies now, or continue an overreliance on heavily polluting, high carbon fossil fuel power generation, non-sustainable hydropower projects or a dependence on risky and costly nuclear power.

Today, about 50 million people do not yet have access to reliable electricity in Myanmar, Cambodia and Laos (IEA, 2014). The region is mostly dependent on hydropower, gas, and coal. Each of the Mekong countries has a power development plan based mainly on large scale hydropower or coal power, or both. This report shows that another future is possible, where a diverse mix of renewable sources can meet nearly all of the region's electricity demand for all of its citizens by 2050.

By using this amount of renewable energy reasonably and tapping the region's large energy efficiency potential, it will be possible to significantly reduce the region's dependence on fossil fuels or future uranium imports; accelerate access to electricity for all; ensure stable electricity prices for decades to come; increase job creation; increase positive cooperation in the region to optimise electricity consumption and production; and reduce environmental and social impacts of traditional power generation. A sustainable, high renewable energy uptake approach can ensure electricity cost stability and maintain system security – that is, provide enough electricity at all times to make sure there's never a risk of the 'lights going out'.

In this context, with this report we aim to answer several key questions:

Can the Greater Mekong region (Vietnam, Thailand, Lao PDR, Myanmar and Cambodia) achieve a secure, sustainable power sector for all by 2050? Can there be a shift away from plans based mainly on polluting fossil fuels, nuclear power and large hydropower? Can the Greater Mekong develop an energy efficient power sector built around clean and inexhaustible renewable energy?

We hope that this report, and the accompanying country reports, will contribute to the debate about our future electricity mix. We strongly believe that renewable energy and energy efficiency will play a major role in our region in the coming years.

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A MOVE TOWARD MORE SUSTAINABLE ENERGY IS DESIRABLE

The Greater Mekong countries are going through a rapid transition, and this reflects in our power sector.

The current power mix in the Greater Mekong region is largely based on hydropower, coal, gas and oil, with more hydropower, coal and gas plants being planned. The Greater Mekong countries are going through a rapid transition, and this reflects in the power sector. Governments understandably seek to meet growing energy needs with low-cost investments, notwithstanding potential long term risks or environmental impacts. However, there are several reasons to gradually move away from fossil fuel technologies and to embrace renewable and more sustainable energy.

Hydro power can have severe social and environmental impacts

Whereas sustainable hydropower could potentially boost economies and help provide energy security, concerns have intensified over the potential cumulative impacts of the dozens of dams proposed for the Mekong region on the environment, fisheries, and people's livelihoods.

For instance, damming the Mekong:

- impacts the rivers natural hydrological flows, affecting other users of water resources and ecosystems;
- blocks fish migration up and down dams and reservoirs with negative consequences to wild fisheries and biodiversity conservation;
- blocks sediment and nutrient transfer, which causes river bed incision and associated lowering of water tables, subsidence of delta and coastal erosion as well as reduction of agriculture and aquaculture yields, increasing salt intrusion and affecting ecosystems and biodiversity conservation
- requires tens of thousands of people to relocate because their homes and land will be flooded
- impacts millions more through changes to water quality, access to the river, and other impacts during construction and operation.

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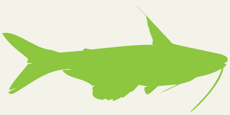
The Mekong fishery is valued at USD$17 billion per year, and provides jobs and food security for millions of people.



Hydropower dams threaten to block fish migration on the Mekong, endangering the world's most productive inland fishery

Each year, a large and diverse fish migration to upstream spawning grounds takes place along the Lower Mekong River. Up to 70 percent of commercial fish are long distance migratory species. If this fish migration is blocked by large infrastructure such as hydropower development, fish will not be able to reach spawning grounds.

The risk is that fish populations will fall and some species may vanish. The region's fisheries industry, integral to the livelihoods of 60 million people, may even collapse. "The combined effects of dams already built on tributaries and the loss of floodplains to agriculture is expected to reduce fish catch by 150,000 to 480,000 tonnes between 2000 and 2015" (ICEM, 2010). For the Lower Mekong alone the fisheries (both wild capture and aquaculture) have been valued at USD 17 billion per year (Mekong River Commission, 2015).

"Tributary dams alone are expected to reduce total fish stocks by 10 percent–26 percent by 2030 and dams proposed for the mainstream of the lower Mekong basin could cause a further 60 percent–70 percent loss of fish catch." (Orr et al., 2012)

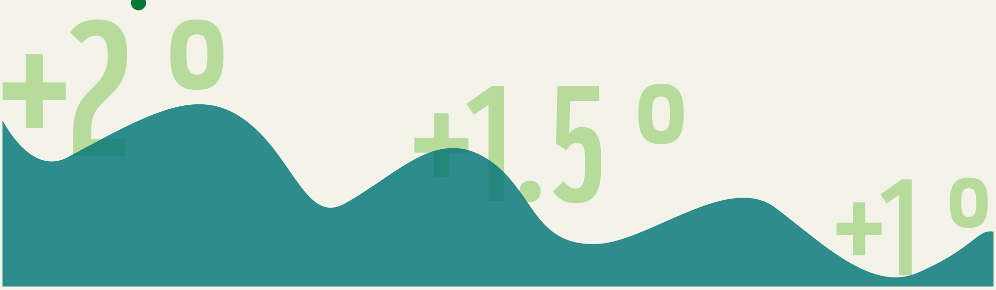
In other parts of the world, fish ladders and other engineering techniques have been employed to aid the migration of fish. These kinds of innovations are not suitable for the Lower Mekong River because of the diversity of species and sheer amount of migrating fish. Likewise, while yields from aquaculture are increasing, these cannot replace the region's wild fish stocks. There are no realistic alternatives to the river as a source of food security and livelihoods -to replace fish protein with domestic livestock protein would require up to 63 percent more pasture lands and up to 17 percent more water, exerting even more strain on forests and water resources.

Climate change is already a reality

Even if fossil fuel supplies were infinite, we would have another compelling reason to switch to renewable energy: climate change. For the Greater Mekong, climate change compounds existing and projected threats, affecting the region's people, biodiversity and natural resources. This is likely to have cascading effects: for example, water scarcity leading to reduced agricultural productivity, leading to food scarcity, unemployment and poverty. Among lower Mekong Basin countries, Laos and Cambodia are identified as the most vulnerable in part because of their limited capacity to cope with climate related risks (Yusuf and Francisco, 2009).

In all countries, climate change complicates existing problems. The city of Bangkok is sinking by 5-10 mm each year. Land subsidence and groundwater extraction combined with sea level rise could leave Bangkok under 50-100 cm of water by 2025 (UNEP 2009). Similarly the sinking and shrinking of large deltas of the Mekong and Ayeyarwaddy caused by the trapping effect of dams reservoirs, sand mining, unsustainable ground water extraction and destruction of the mangrove will be exacerbated by increased extreme weather events and sea level rise. Across the region, temperatures are rising and have risen by 0.5 to 1.5°C in the past 50 years. While rainy seasons may contract over parts of the region, overall rainfall is expected to rise. This means more intense rain events when they occur (WWF, 2009). To avoid even more devastating consequences, scientists and over 100 vulnerable countries agree that we must keep eventual global warming below 1.5°C compared to pre-Industrial temperatures (Tschakert, 2015). To have a chance of doing that, global greenhouse gas emissions need to start falling within the next five years, and we need to cut them by at least 80 percent globally by 2050 (from 1990 levels) – and even further beyond that date.

Curbing carbon emissions is critical to limit global warming and protect the Greater Mekong region from the worst effects of climate change



The global energy sector holds the key. It is responsible for around two thirds of global greenhouse gas emissions, an amount that is increasing at a faster rate than for any other sector. Coal is the most carbon-intensive fuel and the single largest source of global greenhouse gas emissions. Embracing renewable energy, along with ambitious energy-saving measures, is the best way to achieve the rapid emissions reductions we need.

Oil, gas and coal are unevenly spread in the region and their variable prices are difficult to predict

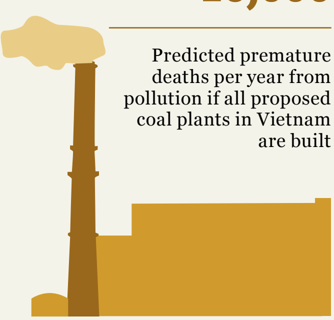
Supplies of oil and gas are set to decline while our energy demands continue to increase. It is clear that our reliance on fossil fuels cannot continue indefinitely. Some countries in the Mekong are already net fossil fuel importers (Laos, Cambodia, Thailand) while Viet Nam is expected to become a net energy importer by 2020 (APERC, 2012). Unpredictable and volatile prices make it difficult to foresee the financial viability of fossil fuel power plants over their lifetime, since they face competition of renewable energy plants with predictable and decreasing prices.

Fossil fuels also have impacts on the local communities and the broader environment

Take coal power plants: lifetime impacts of a typical 550-MW supercritical coal plant with pollution controls are not negligible. 150 million tonnes of CO_2; 470,000 tonnes of methane; 7800 kg of lead; 760 kg of mercury; 54,000 tonnes NO_x; 64,000 tonnes SO_x ; 12,000 tonnes particulates ; 4,000 tonnes of CO ; 15,000 kg of N_2O; 440,000 kg NH_3; 24,000 kg of SF_6; withdraws 420 million m^3 of water from mostly freshwater sources; consumes 220 million m^3 of water; discharges 206 million m^3 of wastewater back into rivers [3] (US Department of Energy, 2010; EndCoal.org, no date). The costs of externalities associated with coal-fired generation in the US have been estimated at around 18c per kilowatt hour (Epstein et al, 2011). A recent report (Koplitz et al., 2015) indicates that existing coal plants in Vietnam cause an estimated 4,300 premature deaths every year. If new projects under development are realised, this number could rise to 25,000 premature deaths per year.

25,000

Predicted premature deaths per year from pollution if all proposed coal plants in Vietnam are built



[3] A 0.70 plant capacity factor and a 50-year lifespan are assumed

One should also keep in mind that pollution control mechanisms on coal power plants increase the electricity costs: they can raise the cost of generation to 0.09 USD/kWh (Endcoal.org, no date), thereby making coal based electricity more expensive than many solar and wind parks.

50 million people have no access to reliable electricity in the Mekong region

This drastically reduces their chances of getting an education and earning a livelihood. Renewable energy sources offer the potential to quickly transform the quality of life and improve the economic prospects of millions. Typically, wind projects and especially solar photovoltaic require less time to build than fossil, large scale hydro or nuclear power plants. Building time can range from less than one month for a solar PV project of 1MW (Tritec Group, 2014) to 3-4 years for fossil fuel plants and much longer (minimum 6 years) for nuclear power plants (EIA, 2015). Solar and wind projects enable a fast ramp up of generation capacity; solar PV, wind and pico hydro are also more modular, enabling a large proportion of these people living in very remote areas to benefit from distributed electricity production. Nowadays, distributed solar PV can beat diesel generators economically (Bloomberg New Energy Finance, 2011) and is a viable technology, together with pico hydro power and biomass gasifiers.

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Renewable energy and off-grid solutions like solar lanterns can quickly bring electricity to remote areas

Nuclear plants are slow and very expensive to build, and even countries with extensive nuclear experience cannot guarantee against disasters with long-term health, environmental, and economic impacts

Nuclear is risky and nuclear waste will be dangerous for 10,000 years or longer

For some, nuclear power is seen to be a part of the solution to the energy crisis. It produces large-scale electricity with low carbon emissions – although mining and enriching uranium is very energy intensive.

But we cannot escape the reality that nuclear fission produces dangerous waste that remains highly toxic for thousands of years – and there is nowhere in the world where it can be safely stored. The United States alone has accumulated more than 50,000 tonnes of radioactive waste which it has not yet disposed of securely. According to the US Environmental Protection Agency (no date), it will be 10,000 years or even longer before it no longer poses a threat to public health.

Equally troubling, the materials and technology needed for nuclear energy can also be used to produce nuclear weapons. In a politically unstable world, spreading nuclear capability is a dangerous course to take, not least because every nuclear power station is a potential terrorist target.

History has shown that nuclear accidents do happen. The most famous are Three Mile Island (Unit 2 reactor, near Middletown, Pa., partially melted down in 1979), due to a combination of personnel error, design deficiencies, and component failures (United States Nuclear Regulatory Commission, 2014a); Chernobyl, Ukraine in 1986 (a surge of power during a reactor systems test destroyed Unit 4 of the nuclear power station) (United States Nuclear Regulatory Commission, 2014b); and Fukushima in 2011 where a tsunami hit the site's reactors (United States Nuclear Regulatory Commission, 2014c). These accidents, with the exception of Three Mile Island, resulted in significant health and environmental impacts.

OVER
$13.5 BILLION
SPENT BY JAPANESE GOVERNMENT ON FUKUSHIMA DISASTER CLEANUP

Such disasters also cause huge economic impacts that have to be met by government -- i.e. the taxpayers --since the responsible utilities, whether government owned or not, are unable to cover the expenses.

When all costs are taken into account, including decommissioning, nuclear power becomes an extremely expensive option, as is being illustrated by the current British project at Hinkley Point[4]. Nuclear power plants under construction (European Pressurised Reactors) in France and Finland have seen their projected costs soar and deadlines long since overrun. Construction began at Olkiluoto 3 in 2005, in Finland, and is not expected to be completed before 2018, nine years late. The estimated cost has risen from 3.6 billion USD to 9.5 billion USD. The company in charge of the project, Areva has already made provision for a 3.0 billion USD writedown on the project, with further losses expected; FTVO and Areva/Siemens are locked in a 10 billion USD legal battle over the cost overruns (Ecologist, 2015; New York Times, 2015). In Flamanville, France, the reactor was ordered in 2006 for a price of 3.7 billion USD and was expected to start generating electricity in 2012. Completion is now scheduled for 2018 and costs are assessed at 11.85 billion USD (Ecologist, 2015; Reuters, 2015a).

Before pouring billions into creating a new generation of nuclear power stations, we need to ask whether that money would be better invested in other, sustainable energy technologies. The cost overruns and accidents in countries with extensive experience in nuclear power should highlight the risk exposure of countries with little nuclear energy experience and low existing capacity to such risks.

Investment and jobs in the renewable sector are growing rapidly while renewable energy prices drop faster than predicted

Industrial growth, job creation and economic sense

Energy derived from the sun, the wind, the Earth’s heat, biomass, water and the sea has the potential to meet our electricity needs many times over (WWF, 2011), even allowing for fluctuations in supply and demand. We can also greatly reduce the amount of energy we need through simple measures like insulating buildings against heat or reusing and recycling materials. In this region, where energy demand is still expected to grow rapidly, energy efficiency has great potential to mitigate a significant share of this growth.

Around the world, people are taking steps in the right direction.

[4] The Government agreed to pay EDF a guaranteed a price of £92.50 per MWh over a 35-year period. The strike price is fully indexed to inflation through the Consumer Price Index. This is more expensive than several solar and wind projects already today.

In 2015, the world invested $329 billion in renewable energy, up by 4 percent compared to 2014 and this was higher than investment in conventional generation (Bloomberg, 2016b). In 2015, solar PV marked another record year for growth, with an estimated 57 GW installed for a total global capacity of about 234 GW (Bloomberg, 2016a). That is the equivalent of over one billion installed solar modules of 200W. The installed wind capacity has increased by 64GW to a total of 434GW by the end of 2015 (Bloomberg, 2016a). Last year, renewables were responsible for about 7.7 million jobs globally (IRENA, 2015a).

Solar photovoltaic (PV) power has seen its cost plunge, making the technology extremely competitive. The latest examples come from Dubai, where a 260 MW plant will sell solar electricity at 0.058 US dollar per kilowatt-hour (USD/kWh). This is due to learning curves and cost reductions across the supply chain, including PV cell costs (Figure 1).

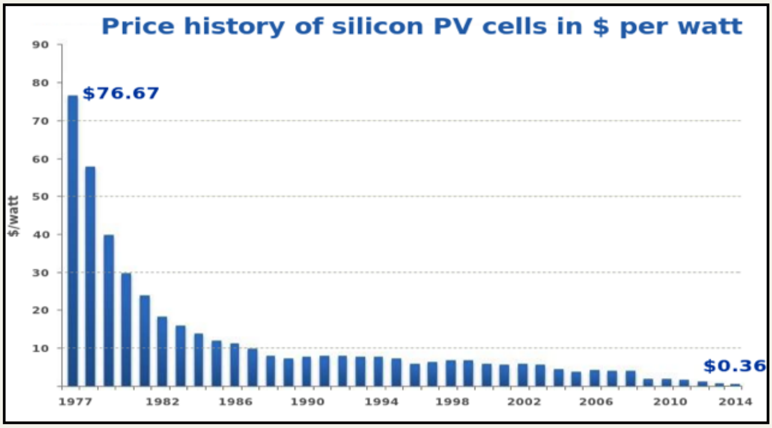


Figure 1. Price of silicon PV cells (Bloomberg New Energy Finance and pv.energytrend.com, no date)

More recently in Austin, Texas, project proposals were offering solar electricity at less than 0.04 USD/kWh with support from a federal income tax credit. These cost reductions have led Austin Energy to forecast that large scale solar PV prices may come down to below 0.02 USD/kWh in 2020 provided the income tax credit continues. Without the income tax credit, costs could still be lower than 0.04 USD/kWh (Figure 2).

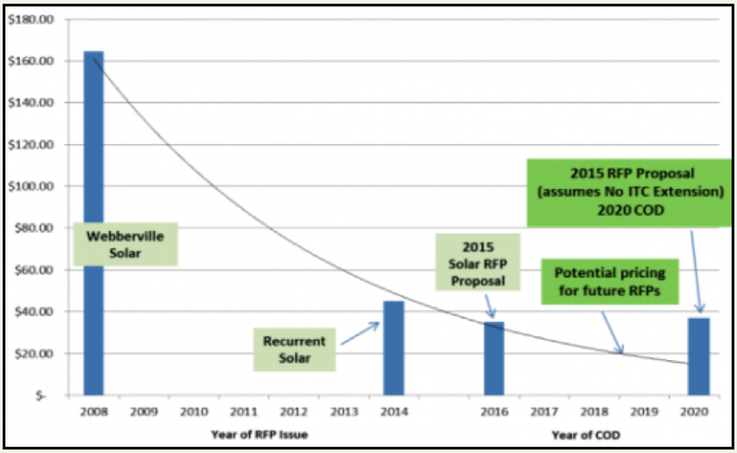


Figure 2. Projected solar PV cost in Austin, Texas (Clean Technica, 2015)

City Research (2015) summarises levelised cost of electricity (LCOE) of solar PV (today and what is expected in 2020 in Figure 3:

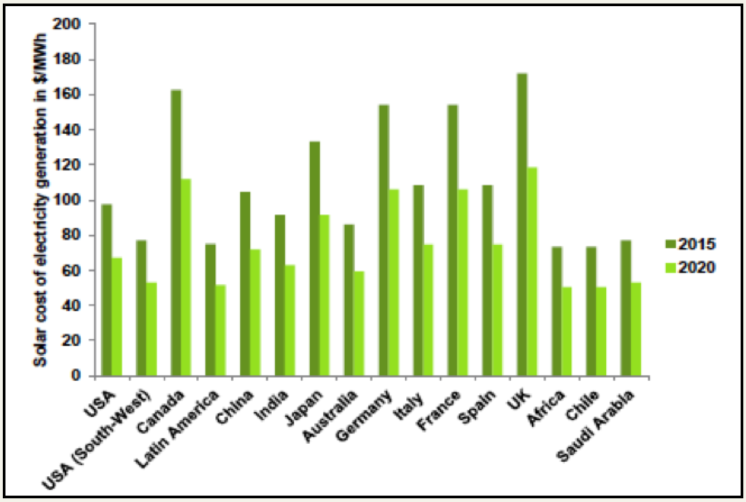


Figure 3. Projected solar PV cost in Austin, Texas (Clean Technica, 2015)

In the New Energy Outlook 2015 report, Bloomberg New Energy Finance said wind is already the cheapest new form of energy capacity in Europe, Australia and Brazil. By 2026, it will be the "least-cost option almost universally". In many countries, individual wind projects are consistently delivering electricity for

0.05 USD/kWh without financial support. These solar and wind costs compare to a range of USD 0.045 to 0.14/kWh or even higher for fossil-fuel power plants (IRENA, 2015b). In fact, this year in India, solar PV could be on par with coal, with major ramifications for coal projects such as those in the Galilee Basin[5]; Deutsche Bank researchers even expect that solar PV could represent 25 percent of total electric capacity in India by 2022 (Reneweconomy, 2015).

BATTERIES ARE TRANSFORMING RENEWABLE ENERGY POSSIBILITIES

Distributed electricity from renewables has also become more affordable: with decreasing solar PV prices and decreasing battery prices (Figure 4). Deutsche Bank recently called solar and batteries transformational (Reneweconomy, 2015), and a UBS study recently showed that solar and batteries are already cost effective in Australia (Reneweconomy, 2014). While currently very low fossil fuel prices may moderate some of these trends the direction is clear: increasingly, new investment will be in sustainable renewable generation rather than in fossil fuel generation.

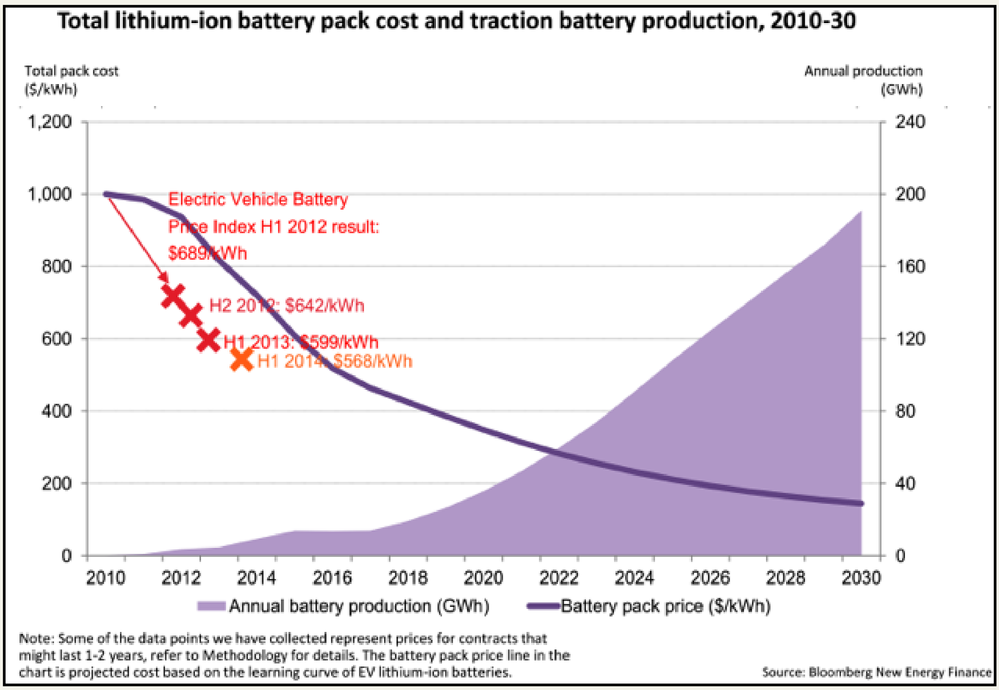


Figure 4, Battery costs (Bloomberg New Energy Finance, no date)

[5] Latest reports are that Adani, the Indian investor in Australia's huge Galilee Basin coalmine project, has put the project on hold due to current low commodity prices (Reneweconomy, 2016)

The Brazilian wind sector provides interesting insights on technology costs in countries starting recently with renewables: capacity auctions in 2009 resulted in projects selling wind energy at about 0.1 USD/kWh, but the price progressively decreased at each subsequent auction, to result in a price in 2011 of 0.07 USD/kWh and 0.052 USD/kWh in 2014 (ABEEólica, 2015).

Prices for wind and solar are quickly becoming competitive with fossil fuels around the world

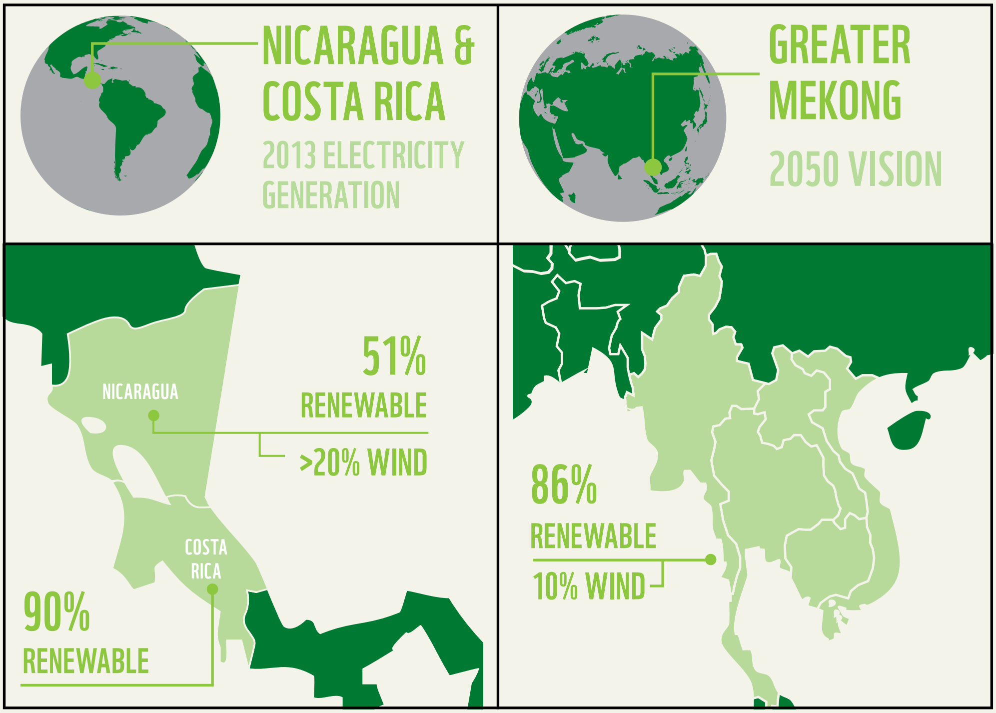
Projections show conclusively that within a few years, wind and solar electricity will be competing with fossil fuel power plants in the countries of the Mekong region (including coal) while providing price certainty for the next 20-25 years without causing pollution. These countries could join the group of countries that have chosen to modernise their power sector and use modern technologies rather than old fashioned polluting power plants. These quickly decreasing renewable energy prices also mean that any new long term power project based on coal, gas, large hydro or nuclear may be a stranded economic asset in the next 10 or 15 years. Several companies are realising this now and divesting from coal, gas, oil and nuclear.

Some countries are leading in renewable energy development (Table 1): Denmark is now producing 40 percent of its electricity needs with wind energy. Wind power also met more than 30 percent of electricity demand in Scotland and 20 percent in Nicaragua, Portugal, and Spain.

Table 1, Share of wind in electricity production

Country / Region	Share of wind in electricity production
Denmark	42%
Scotland	>30%
Nicaragua	>20%
Portugal	>20%
Spain	>20%

Solar PV reaches nearly 8 percent of the electricity supply in some European countries: 7.9 percent in Italy; 7.6 percent in Greece; 7 percent in Germany. It is not uncommon to see solar PV projects of over 200MW in countries like China or India. 100 percent renewable energy and electricity goals are being explored and deployed at the national level in countries such as Cabo Verde, Costa Rica, and Denmark (REN21, 2015).



Renewable energy generation in developing countries shows the Greater Mekong Power Sector Vision is technically feasible

Germany is an interesting case, with significant electricity production from solar PV, wind, biomass and hydropower. The following table summarises how the different technologies together contributed to 31 percent of the electricity production in the country during the first half of 2015 (Fraunhofer ISE, 2015).

Renewable electricity production in Germany (TWh) during the first half of 2015		
18.5	TWh	PV
40.5	TWh	Wind
23.4	TWh	Biomass
11.9	TWh	Hydro

There are several interesting developments supporting this energy transition in Germany. A significant change is the contribution from the public to this transition, as highlighted by the increasing amount of cooperatives active in the energy sector in Germany (Figure 5).

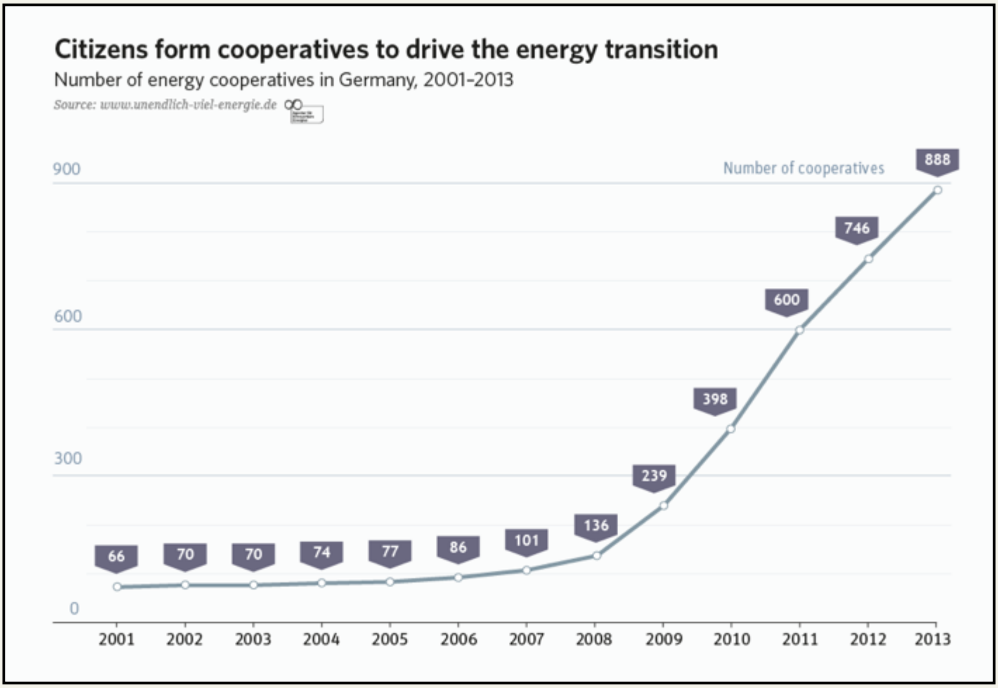
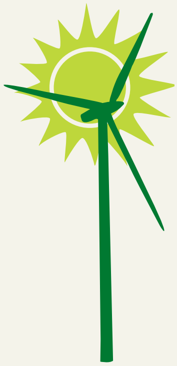


Figure 5. Renewable Energy Cooperatives (energytransition.de, 2014)

In parts of Asia, the renewable electricity sector is moving fast as well: China and Japan were the top two solar PV markets in 2014 in the world; the Philippines and Indonesia are the second and third largest geothermal power generators in the world, respectively; and South Korea leads in tidal barrage energy. China has installed over 80 percent the world's solar water heater (SWH) capacity in recent years and currently hosts around two thirds of the global total (REN21, 2015).

But in the countries of the Mekong the pace of change is slow. Government subsidies and private investments in fossil fuels still vastly outweigh those in renewable energy and energy efficiency, even though the latter would give a far greater long-term return. Many building and factory designs follow old-fashioned, energy-inefficient designs locking in energy inefficiency such as air conditioning for decades to come. Lack of awareness, training, regulation, incentives, financial mechanisms for energy efficiency and renewables are stifling the much needed development of these industries.



RENEWABLE IS DOABLE

100% TECHNICALLY AND ECONOMICALLY FEASIBLE

100% possible

The Sustainable Energy Scenario (SES), which forms the second part of this report, is the most ambitious and detailed analysis of its kind to date in the region. It demonstrates that it is technically feasible to supply everyone in 2050 with the electricity they need, with nearly 90 percent of this coming from renewable sources. Hydro power with dams would not produce more than 11 per cent of the electricity needed, thereby keeping future hydro impacts in check. Such a scenario would reduce carbon emissions by about 85 percent compared to business as usual (BAU)[6]. In 2050, the remaining coal power plants in the scenario will be quite old, and it is quite possible to reach 100 percent renewable electricity shortly afterward, possibly by 2055. An Advanced Sustainable Energy Scenario (ASES), with more optimistic assumptions about renewable energy cost decreases and other technological advancements, produces a 100 percent renewable energy based power sector by 2050.

The SES and ASES scenarios have long term Levelized Costs of Electricity (LCOE) which are slightly lower than those under BAU. Moreover, the LCOE has been calculated based on generation CAPEX and OPEX solely and

BAU involves additional grid transmission and distribution costs. Also, externalities such as health impacts or social or environmental impacts have not been taken into account: research in six different locations in the US by Buonocore et al. (2015) shows health impacts alone can cost between $0.014 and $0.17/kWh.

The task ahead is, of course, raising major challenges.

However, the scenario IES has mapped out is practically possible. It is based only on the technologies the world already has at its disposal, and is realistic about the rate at which these can be brought up to scale. Although significant investment will be required, the economic outlay is reasonable. Cumulative investments in power plants and energy efficiency are about 25 percent higher in the Sustainable Energy Scenario (SES) than in the Business as Usual Scenario (BAU). However, cumulative

[6] Carbon emission reduction calculations have not taken into account dam emissions or biomass emissions, which can be significant depending on project design and management practices.

operating costs (including fuel costs) are much lower in the SES than in the BAU and in fact, the economy benefits economically from the energy transition. The savings in fuel due to energy efficiency and renewable energy are higher than the additional capital costs. Net year on year investments in the BAU represent 4.5 percent of GDP today, 6.5 percent of GDP in about 2025 and 5 percent in 2050. They start at the same level for SES, remain below 5.5 percent in 2025 and slightly less than 4 percent in 2050.

The SES accounts for projected increases in population and increased economic wealth – it does not demand radical changes to the way we live.

The scenarios detailed by IES for this report are not the only solution, nor are they intended to be a prescriptive plan. But in presenting the scenarios, we aim to show that a fully renewable energy future is not an unattainable utopia. It is technically and economically possible, and there are concrete steps we can take – starting right now – toward achieving it.

THE SUSTAINABLE ENERGY SCENARIO (SES)
SCENARIO IN A NUTSHELL

In 2050, electricity demand will have more than tripled in the Greater Mekong region. It is, however, about 30 percent lower than what would happen in BAU. While the population and economy continue to grow as predicted, ambitious energy-saving measures allow us to do more with less. Industry uses more recycled and energy-efficient materials, buildings are constructed or upgraded to need minimal energy for heating and cooling, and there is a shift to more efficient forms of transport.

A DIVERSE POWER MIX CREATES ENERGY AND ECONOMIC STABILITY

All people have access to electricity by 2030, through grid connected or off-grid solutions: in Myanmar and Cambodia, 70 percent of households are grid-connected by then and 30 percent are off-grid or connected to micro-grids. In the other countries, everybody is grid-connected. Wind, solar photovoltaic (PV), concentrating solar power (CSP), biomass, and to a lesser degree hydropower are the main sources of electricity. Some coal and gas power plants remain in the system (about 14 per cent). These are, by then, old plants that will be replaced a little later than 2050, unless economics dictate them to be mothballed before, due to their high electricity prices compared to other, renewable technologies.

Because supplies of wind and solar photovoltaic power vary, “smart” electricity grids have been developed to store and deliver energy more efficiently with pump and battery storage. About 40 percent of the electricity comes from variable sources (solar PV, wind, run of the river hydro) while the rest comes from less variable sources, such as biomass, CSP with storage, geothermal and hydropower dams. Seasonality still has an impact on the efficiency and availability of hydro and biomass.

Due to its environmental and social impacts, the contribution of hydropower is kept to a minimum. This means that minimal large hydro is added to the mix beyond what is already being built or in final development plans today. Micro-hydro is included in the run of the river plants, representing in total about four percent of the generation mix.

Solid biomass and biogas electricity are used carefully and provide about 19 percent of the total electricity mix. According to the Asian Development Bank (ADB 2015) and WWF’s calculations there are 130 million tonnes of agriculture residues and 24 million tonnes of dry matter from livestock available yearly for biomass and biogas production purposes. This potential is assumed to grow in line with agriculture growth projections. The SES scenario uses a maximum 75 percent of this potential each year until 2050. Around 2035, during the peak of biomass consumption in SES, an additional 12 million tonnes of biomass needs to be identified. This excess need goes down to nearly zero in 2050. In order to fulfil this additional need, it is expected that forestry residues become available, and that biomass that is used today for cooking is being freed up (within sustainable limits) for electricity production.

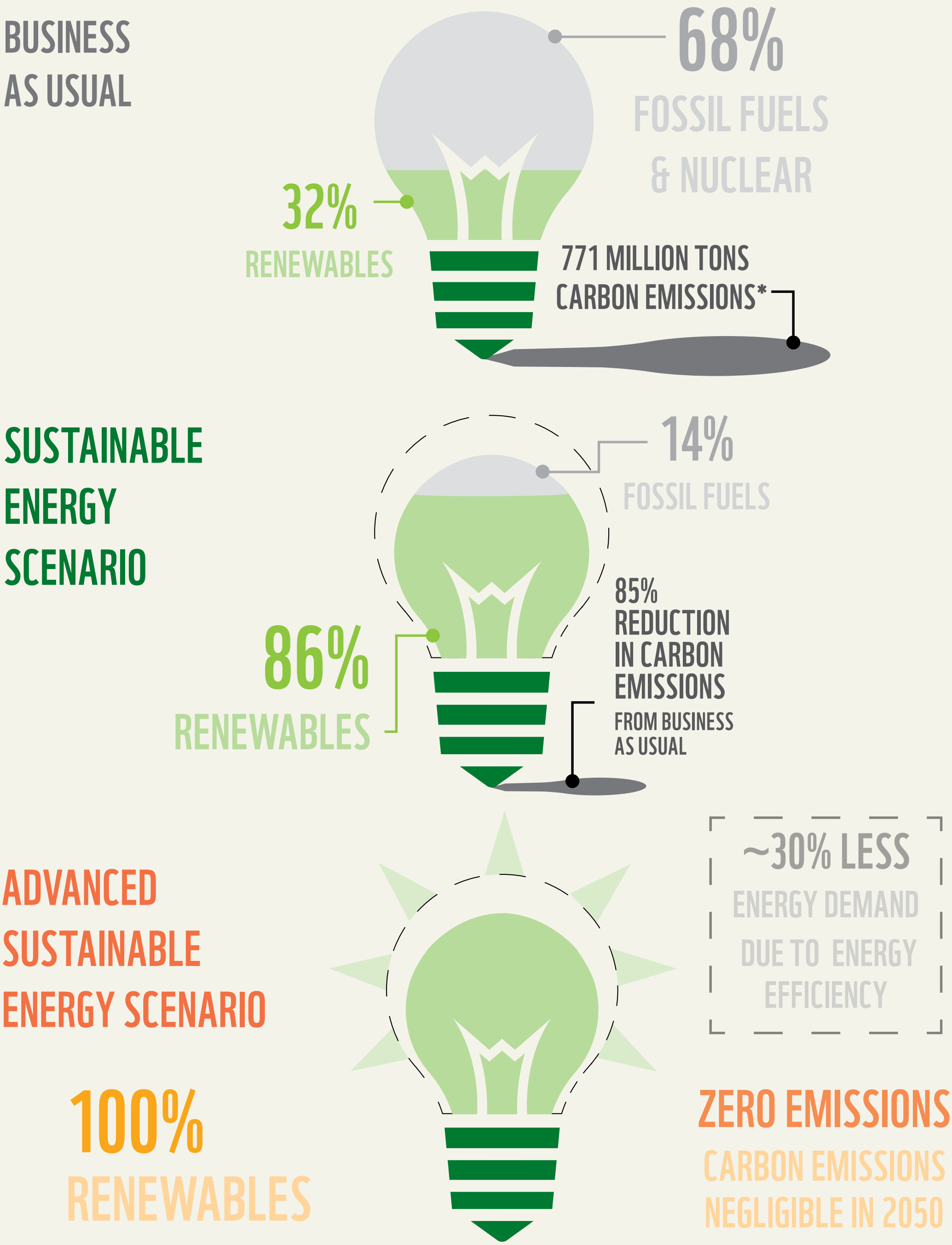
Human waste was not included in these calculations. In fact, human waste can be collected through sewage systems and can be used to produce biogas. In the Greater Mekong, we calculated human waste biogas could satisfy nearly half of all the scenario’s bioenergy needs, although estimates vary widely. It should be a priority to exploit this potential. If any additional bioenergy plantations are required, careful land-use planning and better international cooperation and governance are essential to ensure we do this without threatening food and water supplies or biodiversity, or increasing atmospheric carbon.

By 2050, we save nearly 40bn USD per year through energy efficiency and reduced fuel costs compared to a ‘business-as-usual’ scenario. But increases in capital expenditure are needed first – to install renewable energy-generating capacity, modernize electricity grids, transform goods and public transport and improve the energy efficiency of our existing buildings. Our investments pay off very quickly, as the savings outweigh the costs. If oil prices rise faster than predicted, and if we factor in the costs of climate change and the impact of fossil fuels on public health, the economic benefits would be much higher still.

THE ADVANCED SUSTAINABLE ENERGY SCENARIO (ASES) IN A NUTSHELL

The ASES would take more visionary leadership and a more aggressive energy transition , including decommissioning fossil fuel plants early

The ASES is based on bolder assumptions regarding technology cost decreases, energy efficiency, demand response, electrification of transport etc. As a result, the power sector becomes entirely fossil and nuclear free by 2050, reducing carbon emissions to virtually zero. Solar PV and wind power play a bigger role than in the SES, as well as battery storage, while ocean energy also enters the technology mix. Investments are slightly over 10 percent higher than in SES, but the fuel costs are reduced even further and there is no significant difference in annual net costs between the ASES and SES. While it is relatively obvious that solar and wind capital costs will decrease, it is more difficult to assess precisely how quickly. Predicting the cost of fossil fuels is also difficult. Having two scenarios, SES and ASES, to compare with BAU, enables us to better understand the implications of societal and technological choices. The SES will be discussed further below. The ASES is described in part 2 of this report.

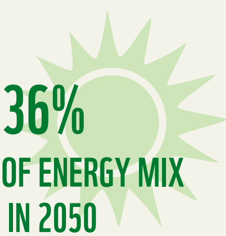


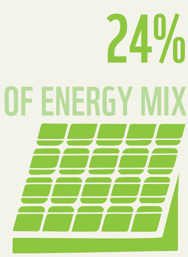
* measured in million metric tons of carbon dioxide equivalent

THE ENERGY MIX AND THE TECHNOLOGIES

At the moment, about 30 percent of the Greater Mekong's electricity comes from hydropower and 70 percent from fossil fuels (oil, gas and coal). Under the SES, fossil fuels are almost entirely phased out by 2050, to be replaced with a varied mix of renewable energy sources. However, not all renewable energy sources are sustainable. Without strict sustainability safeguards, hydropower and biomass can have significant environmental and social impacts. Even solar, wind and geothermal plants need to be properly planned to avoid impacts, but in general impacts are low. For these reasons, this scenario favours solar, wind and geothermal power whenever possible.

The SES takes into account each resource's potential although it limits the use of dams and biomass due to the potential negative impacts of those technologies, and due to the need to keep biomass for other purposes. The scenario takes into account GDP growth rates, and other constraints and opportunities such as availability of grids, variability of wind and solar sources and economic aspects. Technological breakthroughs, market forces and geographic location will all influence the way renewable energies develop and are deployed, so the final energy breakdown could well look very different.





Solar energy

The sun provides an unlimited supply of energy that we can use to generate electricity and heat. At the moment, solar energy technology contributes very little of the total electricity supply in the Mekong region, but this proportion can grow fast. In the SES, solar energy supplies around 36 percent of our total electricity by 2050.

Solar energy provides light, heat and electricity. **Photovoltaic (PV) cells,** which convert sunlight directly into electricity, can be integrated into devices (solar-powered calculators have been around since the 1970s) or buildings, or installed on exposed areas such as roofs. Solar PV can be grid-connected, but can also generate power in rural areas, islands and other remote "off-grid" locations. In the SES, solar PV would contribute about 24 percent of all electricity needs in the Greater Mekong region. We estimate that this would require less than 0.1 percent of the region's total land mass[8]. Since many of these solar modules will be installed on existing buildings, the additional land need for solar PV is even lower.

Concentrating solar power (CSP) uses mirrors or lenses to focus the sun's rays onto a small area – for example to heat water, which can be used to generate electricity via a steam turbine or for direct heat. The same principle can be used on a small scale to cook food or boil water. **Solar thermal collectors,** which absorb heat from the sun, already provide hot water to thousands of households in the region and enable households to reduce their electricity or gas bills.

One obvious challenge in adopting high levels of solar power in the generation mix is that supply varies. Photovoltaic cells don't function after dark – although most electricity is consumed in daylight hours – and are less effective on cloudy days. Solar electricity can be combined with other renewable electricity sources, however, to reduce the impacts of this variability. Moreover, energy storage is improving: CSP systems that can store energy in the form of heat (which can then be used to generate electricity) for up to 15 hours exist (CSP Today, no date) . In the SES, CSP would contribute about 13 percent of all electricity needs in the Greater Mekong region.[9]

Wind energy

Wind power currently supplies a tiny share of the electricity in the region, while high shares of wind power are possible. In Denmark, wind already accounts for 42 percent of the country's electricity production. In Jutland and on Funen, two Danish regions, wind power supplied more electricity than the total region's consumption during 1,460 hours of the year (ENERGINET.DK, 2016). Offshore wind power, also possible in the region, is less variable, and turbines can be bigger. In the SES, wind could meet 14 percent of the region's electricity needs by 2050. However, the total potential is much larger in the region, especially if offshore wind is taken into account.

[8] Assumptions: Maximum irradiance 1000W/sqm; 15% module efficiency; 20% derating for roads, shadow reduction, service stations etc.

[9] The 20 megawatt GemaSolar power tower in Spain designed by SENER has 15 hours of full-load storage.

Although wind farms take up large areas and have a visible effect on the landscape, their environmental impact is minimal if they are planned sensitively. When turbines are sited on farmland, almost all of the land can still be used for grazing or crops. Unlike fossil fuel and nuclear power plants, wind farms don't need any water for cooling. Offshore wind developments need to be sensitively planned to minimise the impact on marine life and birds, and more research is needed in this area. Floating turbines, which would have less impact on the seabed and could be sited in deep water, are under development already. Two pilot projects are planned, in Scotland (30MW) and Portugal (25MW) (Reuters, 2015b).

<1%

OF ENERGY MIX IN 2050

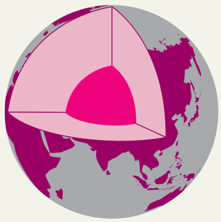
Wave and tidal power installations could affect the local marine environment, as well as maritime industries such as shipping and fishing and coastal communities. It is critical that appropriate sites are selected and technologies developed that minimize any negative impacts.

Ocean power

The motion of the ocean, through waves, tides and currents, salinity and thermal gradients, provides a potentially vast and reliable source of energy – but there are significant challenges in converting it into electricity. These are relatively new technologies, although tidal plants have been operating since the 70s, like the La Rance 240MW plant in France. More recently, the 254MW Sihwa Lake Tidal Power Station was commissioned in South Korea. Costs are still quite high with an LCOE for tidal systems between $32USDc/kWh and $37USDc/kWh and for wave between $41USDc/kWh and $52USDc/kWh at a 12 percent discount rate (SI Ocean, 2013).

Myanmar has areas with some of the largest tidal ranges in Southeast Asia which are suitable for economic electricity generation (United Kingdom Hydrography Office, 2011). Large amplitude tidal ranges are associated with strong tidal currents, such as those on the Yangon river (Myanmar Ministry of Transport, 2013). The country would also have 5-10 kW/m annual mean exploitable wave energy resource (Reguedo, 2011). Vietnam has total exploitable tidal energy of 1,753 GWh/year for a 5.5 GW exploitable capacity (Pham, 2013). However, there is currently little data available to calculate the real potential for these technologies in the Greater Mekong region.

Recognising this constraint, the SES assumes that ocean power accounts for less than 1 percent of the region's electricity supply by 2050.



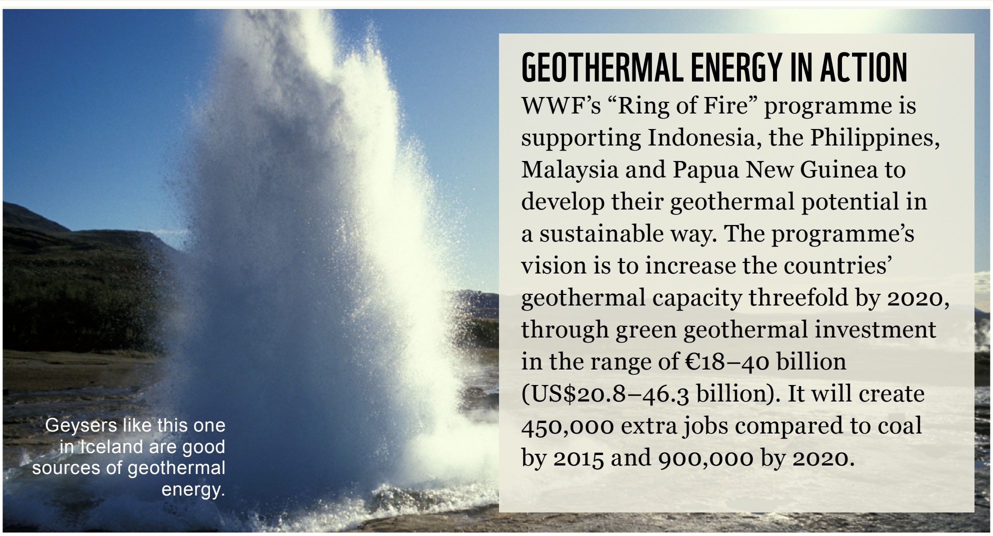
1%

OF ENERGY MIX IN 2050

Geothermal energy

The ancient Romans used the heat from beneath the Earth's crust to heat buildings and water, but only relatively recently have we begun to rediscover its potential. When temperatures are high enough, geothermal energy can be used to generate electricity and local heating, including high-temperature heat for industrial processes. Unlike wind or solar power, which vary with the weather, geothermal energy provides a constant supply of electricity. Iceland already gets a quarter of its electricity and almost all of its heating from its molten "basement." In the Philippines, geothermal plants generate 14 percent of total electricity (Bertani, 2015). In the Greater Mekong region, the SES suggests just under one percent of electricity production by 2050 could be generated by geothermal.

Exploiting geothermal resources will undoubtedly affect the land and the people who live in the surrounding areas. Geothermal steam or hot water used for generating electricity contains toxic compounds, but "closed loop" systems can prevent these from escaping. If sites are well chosen and systems are in place to control emissions, they have little negative environmental impact. In fact, because geothermal plants need healthy water catchment areas, they may actually strengthen efforts to conserve surrounding ecosystems[10].



Geysers like this one in Iceland are good sources of geothermal energy.

GEOTHERMAL ENERGY IN ACTION

WWF's "Ring of Fire" programme is supporting Indonesia, the Philippines, Malaysia and Papua New Guinea to develop their geothermal potential in a sustainable way. The programme's vision is to increase the countries' geothermal capacity threefold by 2020, through green geothermal investment in the range of €18–40 billion (US$20.8–46.3 billion). It will create 450,000 extra jobs compared to coal by 2015 and 900,000 by 2020.

[10] See for instance Geothermal Projects in National Parks in the Philippines: The Case of the Mt. Apo Geothermal Project (Dolor, 2006)

11%
OF ENERGY MIX IN 2050

Hydropower

Hydropower is currently the region's largest renewable power source, providing 30 percent of all electricity. Large-scale hydropower dams store water in a reservoir behind a dam, then regulate the flow according to electricity demand. Hydropower can provide a relatively reliable source of power on demand, helping to balance intermittent sources like wind and solar PV. In fact, solar PV and wind can also help balance the variability of hydro, since its output is reduced during the dry season, while solar output increases during the dry season.

However, with the exception of pico or micro-hydropower, **hydropower can have severe environmental and social impacts.** By changing water flows downstream, dams threaten freshwater ecosystems and the livelihoods of millions of people who depend on fisheries, wetlands, and regular deposits of sediment for agriculture. They fragment habitats and cut fish off from their spawning grounds. Creating reservoirs means flooding large areas of land: 40–80 million people worldwide have been displaced as a result of hydroelectric schemes (International Rivers, 2008). **The fact that current hydropower projects are included in the SES does not mean that WWF or its partners condone any specific existing dam.** But since they have been built, they are part of the suggested power mix in the SES. It may well be that some of those dams will be decommissioned early to make way for more sustainable solutions.

The SES reflects these concerns by reducing the increase in hydropower compared to current business as usual plans. Hydropower dams would provide 11 per cent of our electricity in the region in 2050, representing an increase in capacity of 7.5 GW compared to today. 11 GW of hydro run-of-the-river[11] schemes are included as well. New hydropower schemes would need to respect stringent environmental sustainability and human rights criteria, and minimize any negative impacts on river flows and freshwater habitats. A separate report (Grill and Lehner, 2016) presents an analysis of the indicators 'degree of hydrological flow regulation' and 'degree of river fragmentation' caused by hydro dam scenarios.

[11] Hydro without dams or reservoirs

28%
OF ENERGY MIX

Bioenergy
Energy from biomass – materials derived from living or recently living organisms, such as plant materials or animal waste – comes from a large range of sources and is used in many different ways. Wood and charcoal have traditionally provided the main source of fuel for cooking and heating for millions of people in the Mekong region. Agricultural waste such as rice husk has been used for energy purposes, for instance in briquettes or pellets to replace charcoal, or in biogasifiers to produce electricity. More recently, biofuels have begun to replace some fossil fuels in vehicles.

In principle, biomass is a renewable resource – it's possible to grow new plants to replace the ones we use. Greenhouse gas emissions are lower than from fossil fuels, provided there is enough regrowth to absorb the carbon dioxide released and good management practices are applied. Bioenergy also has potential to provide sustainable livelihoods for millions of people. However, if produced unsustainably, its environmental and social impacts can be devastating. We need comprehensive policies to ensure bioenergy is produced to the highest standards.

The SES favours alternative non-biomass renewable electricity resources wherever possible, as bioenergy competes with several other energy and non-energy uses: examples include liquid biofuels for aviation, shipping and long-haul trucking; charcoal for cooking; and some industrial processes, such as steel manufacturing. In the Greater Mekong, the SES suggests that 19 percent of electricity would come from biomass and biogas in 2050.

A significant proportion of the biomass electricity needs in the SES is derived from products that sometimes go to waste. These include some plant residues from agriculture and food processing; sawdust and residues from forestry and wood processing; manure; and municipal waste. Using these resources up to a sustainable level has other environmental benefits – cutting methane emissions and water pollution from animal slurry or reducing the need for landfills. But part of these residues need to be left in the field for nutrient recycling. In fact, the biomass needed to fulfil the electricity needs outlined in the SES would amount to 154 million tonnes, agriculture residues and livestock waste combined. This represents a maximum 75 percent of the total amount of agriculture residues and livestock waste available each year. An additional 12 million tonnes would come from forestry residues, dedicated biomass plantations or biomass that is freed up through reduction of wood needs for cooking in the region.

A possible long-term alternative source of high-density fuel is algae. Algae can be grown in vats of saltwater or wastewater on land not suitable for agriculture. Large-scale cultivation of algae for biofuel is currently in development. Algae have not been included in this study due to lack of data. However, they may well contribute to the future energy mix. In WWF's global energy study, "The Energy Report" (WWF, 2011), algae were contributing slightly less than 20 percent of the total biomass used in the energy sector.

CHALLENGES AND RECOMMENDATIONS

The IES analysis shows that the region can technically meet its electricity needs from renewable sources by 2050. But it throws up some challenges – and not just technical ones. The social, environmental, economic and political issues this report raises are equally important.

On the technical side, several key factors will enable the region to meet its energy needs from renewable sources. We need to **rationalise demand** by improving energy efficiency, and by reducing wasteful use of energy. Because electricity and heat are the forms of energy most readily generated by renewables, we need to **maximize the use of electricity and direct heat and minimise the use of liquid and solid fuels,** with improvements to electricity grids[12] to support this. We need to optimise the use of resources at a regional level and exchange electricity. And with current technological developments, we should seriously consider distributed electricity systems at a significant level.

A sustainable energy future must be an **equitable** one. Its impact on people and nature will greatly depend on the way we use our **land, seas and water resources**.

Moving to a renewable future will mean rethinking our current **finance** systems. It will also require **innovation**.

Local, national and regional governance will need to be greatly strengthened to secure an equitable energy future. We need **regional cooperation and collaboration**.

These challenges are outlined on the following pages. In this regional version, high level recommendations are provided. Country specific recommendations can be found in the country reports.

[12] whether at the large scale, small scale (micro-grids) or meso-grid level (DNV-GL, 2014)

Energy Conservation

How can we do more while using less energy?

Under the SES, regional electricity demand in 2050 is 30 percent lower than the "business as usual" scenario. It still represents three times the current consumption. These improvements come from using energy as efficiently as possible. We assume that, over the next 20 to 35 years, Mekong countries will reach an energy efficiency level similar to South Korea, Hong Kong, Japan, or Singapore, depending on the country and economic sector. In fact, it may well be that we still overestimate future electricity demand in our scenarios, since new more energy efficient technologies will become available over time.

Energy conservation is one of the prerequisites of a future powered by renewables – we will not be able to meet the needs of our people if we continue to use it as wastefully as we do today. It's the single most important element in the SES.

In every sector, solutions already exist that can deliver the massive energy savings we need. The challenge is to roll them out as soon as possible. But the challenge is not only about technologies being available. It is also to ensure energy is used wisely. For example, in the Mekong region, air conditioning is often programmed at very low temperatures, even 16^{0} Celsius, overlooking elementary and very low energy measures to protect rooms from heat (shades, insulation, adequate ventilation and air circulation etc.).

In manufacturing, using recycled materials greatly reduces energy consumption. For example, making new products from recovered aluminium instead of primary aluminium cuts total energy use by more than two-thirds. Stocks of materials that take a lot of energy to produce, such as glass, steel and aluminium, have grown over the past decades, making recycling and reusing materials increasingly viable. Finding alternatives to materials that take the most energy to produce, such as cement and steel, will mean further energy savings.

Product design also has considerable implications for energy use. Making cars with lighter (although not weaker) frames, for example, reduces both the need for energy-intensive steel in manufacturing and their fuel consumption. Electric vehicles are inherently more energy efficient than vehicles with internal combustion engines, even if the electricity comes from combustion-based power plants. The efficiency of energy-hungry appliances like fridges, washing machines and ovens is improving all the time. Considering life cycle costs, and avoiding "disposable manufacturing strategies" for goods is critical. Policy rulings on energy efficiency standards for goods will have enormous impacts given recent improvements in appliance technology.

The world already has the architectural and construction expertise to create buildings that require almost no conventional energy for day-lighting, heating or cooling, through airtight construction, heat pumps and sunlight. With built-in energy generation systems, such as solar PV, they can even produce more energy than they use.

At the same time, we need to radically improve the energy efficiency of our existing buildings. We could reduce heating and cooling needs by insulating walls, roofs and ground floors, replacing old windows and installing ventilation systems. Local solar thermal systems and heat pumps would fulfil the remaining heating, cooling and hot water needs. Lighting efficiency is an obvious example of quick efficiency gains (Figure 6).

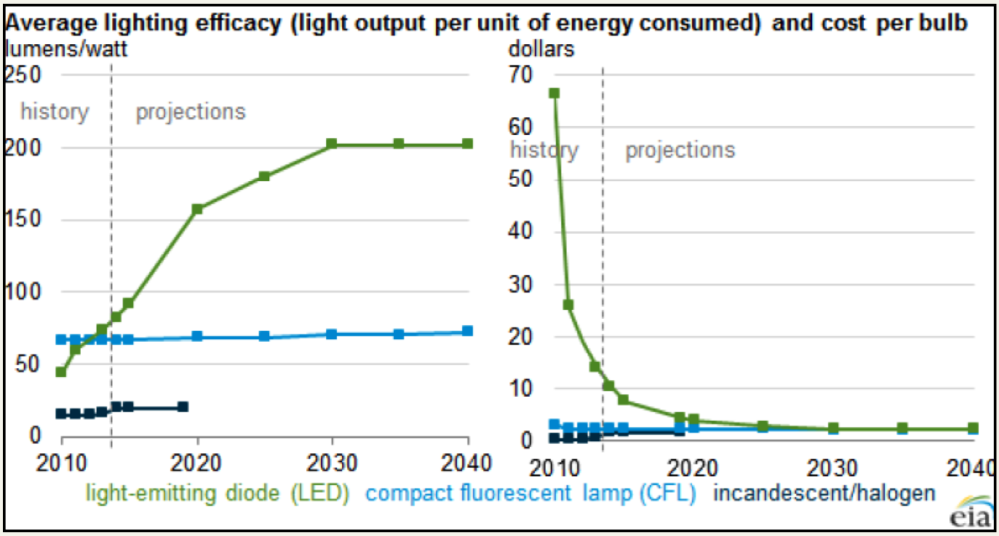


Figure 6. Lighting efficiency (EIA, 2014)

The transport sector could transition quickly toward reliance on electricity, with significant supply and storage implications for the electricity sector. While the further development of trains, preferably electric, is a necessity, auto transport is about to be transformed through technology and social change. Several manufacturers are selling or actively developing electric models, including less conventional companies such as Google and allegedly Apple. Toyota has recently announced that their fleet would emit nearly zero carbon by 2050 (BBC, 2015) and Volkswagen has made similar announcements after the emissions scandal that hit the car manufacturer recently. This can not only change the way we use and power our cars, but it also represents a huge opportunity to store electricity and affect grids and home electricity systems. At the same time, new car sharing and personal mobility initiatives like Uber combine the use of smart phones, electronic payment and cars to provide alternative modes of transportation. If this is combined with driverless cars such as the ones being developed currently by various companies, it means that owning a car in the city may one day be a thing of the past.

The more energy we save, the easier the task of moving to a renewable energy future will become. It's one area where everyone can play a part.

What now?

- We must introduce legally binding minimum efficiency standards for all products that consume energy, including buildings, along the lines of the Japanese "Top Runner" scheme and the European EcoDesign requirements. Governments, companies and experts will need to agree on the standards, which should be monitored and strengthened over time.
- Energy conservation should be built into every stage of product design. Wherever possible we should use energy-efficient, highly-durable and recyclable materials. Alternatives to materials like cement, steel and plastic that take a lot of energy to produce should be a focus for research and development. We should adopt a "cradle to cradle" design philosophy, where all of a product's components can be reused or recycled once it reaches the end of its life.

» For the rural cooking energy sector, which in countries like Myanmar and Cambodia still rely heavily on solid fuels, management of wood dryness and fuel stove efficiency will remain important for perhaps 20-25 years. Solid fuel storage, management and stove efficiency remain only partially addressed. Scenarios using electric cooking as a replacement of wood as a renewable, sustainable cooking fuel need further evaluation and review in light of the overall planning decisions.

» We need strict energy-efficiency criteria for all new buildings, aiming toward near-zero energy use, equivalent to "Passive House" standards. Retrofitting rates must increase fast to improve the energy efficiency of existing buildings. Governments must provide legislation and incentives to enable this.

» Substantial investment is needed in public transport to provide convenient and affordable energy-efficient alternatives to private cars. We particularly need to improve rail infrastructure: high-speed electric trains, powered by electricity from renewable sources, should replace air travel over distances of 1000 km or less, and a greater proportion of freight should be delivered by rail. In cities, car sharing systems should become the norm. Smart applications enable us to do this comfortably and efficiently today.

» In the industry sector, mandatory periodical energy audits for establishments consuming over 300 tonnes of oil equivalent (toe) per year; technical assistance in examining energy efficiency measures at the level of industrial processes and installations (boilers, compressed air engines, cold production, etc.); prior consultation obligation (evaluation of the project's energy efficiency by an approved certified party) for new industrial projects consuming more than 600 toe a year are measures that can help improve energy efficiency.

» Individuals, businesses, communities and nations all need to be more aware of the energy they use, and try to save energy wherever possible. Driving more slowly and smoothly, buying energy-efficient appliances and switching them off when not in use, turning down heating and air conditioning, and increased reusing and recycling are just some ways to make a contribution. Education should start at the school level and through media. The negawatt approach provides a good example of how to systematically approach energy efficiency.

» Consumers and retailers can put pressure on manufacturers to be more energy efficient through their buying choices. WWF has helped to develop www.topten.info, an online search tool that identifies the most energy-efficient appliances on the market in several countries. Discerning buyers can compare energy-efficiency ratings for a growing number of items, including cars and vans, household appliances, office equipment, lighting, water heaters and air conditioning.

THE NEGAWATT APPROACH

Definition: negawatts represent non-consumed energy thanks to a more efficient and waste-conscious use of energy.

Concept: consuming better instead of producing more.

Benefits: Breaking with the practice of risks and inequality means a fourfold or fivefold reduction in our greenhouse gas emissions, eliminating our waste and accelerating our transition to energy efficiency and renewable energy.

This common sense approach facilitates the discovery of a new, hidden but huge resource. It gives priority to reducing our energy needs, without affecting quality of life or economic growth.

The "production" potential of negawatts is higher than half of the current world production of energy with currently available and reliable solutions offering numerous related benefits: absence of pollution, creation of jobs, decentralisation, responsibility, solidarity, peace, etc.

The "NegaWatt approach" can be broken down into 3 phases:

1. cutting energy waste at all levels of organisation in our society and in our individual behaviour to eliminate careless and expensive waste;

2. improving the energy efficiency of our buildings, means of transport and all the equipment that we use in order to reduce losses, make better use of energy and increase possibilities;

3. finally, production using renewable energy sources, which have low impact on our environment. (Association Negawatt, no date)

Renewables, electrification, grids and storage

Renwable sources could provide unlimited power, but how do we switch onto them?

The SES depends heavily on increasingly using electrical power, instead of solid, gaseous and liquid fuels. Using more renewable electricity presents several challenges. Firstly, of course, we need to generate it. That will mean massively increasing our capacity for producing power from the renewable resources with the least environmental impact – through wind, solar, biomass and geothermal power technologies in particular. We will need to combine large-scale renewable power plants with distributed power systems, using for instance solar PV connected to the grid, or offgrid, or as part of small and meso-grids.

We are going to need investment to extend and modernize electricity grids to cope with increased loads and different energy sources. We need to transmit power efficiently from onshore and offshore wind turbines, solar parks, biomass plants or remote geothermal plants to factories and urban centres – while minimizing the impact of new power lines or subterranean cables. Efficient regional networks will also help to balance variable renewable sources from different regions. In fact, electricity exchange of this kind is already happening: Norway stores excess Danish wind power production in its dams during windy periods, and exports electricity to Denmark during less windy days.

Capacity markets and demand response also help to improve the efficiency of the power sector (see private sector section).

While solar and wind have the potential to supply an effectively unlimited amount of power, this is constrained by the capacity of electricity grids to deliver it. Our existing grid infrastructure can only manage a limited amount of these variable, supply-driven sources. Grids, whether at large, regional or local scale, need to keep electrical voltage and frequency steady to avoid dangerous power surges, and they need the capacity to meet peaks in demand. Today, we keep some power stations, notably coal and hydropower, working around the clock to provide a permanent supply of electricity (or "base load"). These power stations cannot simply be switched off when renewable energy supplies are high, meaning energy can go to waste.

The SES estimates that networks could accommodate at least 40 percent of total electricity from variable sources over the coming decades through improvements in technology and grid management. The other 60 percent would come from less variable sources: biomass, CSP with storage, hydropower and a small amount of geothermal electricity and ocean power. Some of the most important solutions to manage the grid include demand-response measures; pumped storage in hydropower dams; battery storage; hydrogen; heating storage (e.g. CSP with molten salt) and cooling storage (e.g. ice storage for cooling processes).

The combination of large ("super") and "smart" grids holds the key. Power companies and consumers will get information on energy supply, and price, to help manage demand. Put simply, it will be cheaper to run your washing machine when the wind is blowing or the sun is shining. Households, offices or factories would program smart meters to operate certain appliances or processes automatically when power supplies are plentiful. We could also take advantage of times when supply outstrips demand to charge car batteries and to generate hydrogen fuel.

Distributed or centralised electricity production?
In countries like Laos, and especially Cambodia and Myanmar, a large portion of the population is not yet connected to the main grid. Sometimes, there is no centralised grid but rather a series of unconnected regional grids. Discussions are taking place globally and in the region around the optimal way to supply electricity to consumers, whether large or small. With rapidly decreasing solar and battery costs, it is no longer clearcut that extending a centralised grid will be more cost-effective than investing in a mixture of renewable generation sources offgrid, with storage, either standalone or as part of micro, mini and meso-grids. Lithium-ion storage median price is forecast to decline by 47 percent in the next five years based on a survey of industry experts (Rocky Mountain Institute, 2016). What's more, batteries will not be dedicated to a single use. One can easily imagine that electric car batteries can also be connected to a household's grid, and in that way contribute to distributed storage and grid management.

It is also no longer clearcut that substantial electricity offtake and higher levels of utility (higher power needs) will only be possible through a centralised grid. Solar home systems will become more sophisticated and capable in combination with deep efficiency, and allow for more comfort (e.g. with DC televisions, small efficient fridges etc). Micro and mini-grids will also improve, enabling large, industrial and small consumers to connect to distributed power solutions. These new types of grids can also be planned in a way that will allow formation of larger grids over time, should this become desirable. Micro and mini-grids could be connected up over the years, creating meso-grids which would complement existing national grid infrastructure but at lower cost than significant new investment in high voltage transmission infrastructure. Such an approach enables a more rapid satisfaction of local electricity needs, while avoiding the development of a full electricity grid at the national level from the outset.

With increasing capabilities for distributed renewable generation, and the possibility that battery based solar becomes cheaper than the grid in coming years to decades, it would be prudent to consider all options and not focus solely on a centralised grid, which is investment heavy, shows little flexibility over time and locks in investment for the next half century, regardless of its use over time. It is useful to keep in mind that, in some countries like Australia, there is already an economic case in some locations to disconnect from the grid and use solar plus storage.

The electricity networks that power our world represent one of the great engineering feats of the 20th century. The work we need to do to modernize them or to replace them over the coming decades will be one of the great feats of the 21st.

What now?

» Large-scale and distributed renewable power generation needs to be built urgently, to forestall overinvestment in a new generation of costly and ultimately unsustainable fossil fuel power plants, mega dams and grid infrastructure that could lock in a high emissions intensity economy over decades.

» A regulatory framework for renewable energy is required. This framework should include a system to award licences for RE projects, national grid connection rules and a tariff system. Such a tariff system can be inspired by several existing schemes around the world, such as feed-in tariffs, net metering, auctioning, reverse auctioning etc., bearing in mind that some schemes are more adapted for large scale production and some are more appropriate for distributed systems.

» Planning of renewable energy zones helps the private sector access land for projects. The governments can also announce plans for future grid connections for RE projects, and let companies apply for grid capacity. The new grid connections can then be planned based on firm grid capacity demand, thereby ensuring sufficient grid capacity and optimal grid connection use.

» An institutional framework should provide an arbitration mechanism between the national operator and private operators in case of a dispute, especially in the case of disagreements regarding the interpretation and application of regulations.

» Electrification plans should not automatically consider central grid expansion as the best solution. Distributed solutions, which can be built rapidly and respond in a modular way to growing demand, can be more cost effective.

» Countries need to work together to extend electricity networks to bring power from centres of production to centres of consumption as efficiently as possible. International networks will help meet demand by balancing variable power sources (such as solar PV and wind), supported by constant sources (geothermal, stored CSP, hydro, biomass).

» We need urgent investment into smart grids to help manage energy demand and allow for a significantly higher proportion of electricity to come from variable and decentralized sources. This will help energy companies to balance supply and demand more efficiently, and enable consumers to make more informed choices about their electricity use.

» By 2050, all cars, vans and trains globally should run on electricity. We need legislation, investment and incentives to encourage manufacturers and consumers to switch to electric cars. Improvements in battery technology could even allow us to run electric trucks, and possibly even ships. This is a long-term aim, but research and development is needed now.

Electricity exchange between countries and power sector strategies

Various countries in the Mekong region consider electricity an export product. Laos exports a large part of its hydropower production to Thailand. Myanmar is considered as having an important potential for exports as well.

Cross-border electricity exchanges between countries should therefore be encouraged as long as they do not have negative social, economic and environmental impacts. They allow integration of more variable power in the grids. Solar, wind and hydropower can be combined and used to take advantage of diversity in demand and supply conditions over a larger area. Hydro can offer pumped storage during sunny or windy days in parts of the Mekong, and this reserve hydro capacity can then be used during rainy and windless days. This can happen on various time frames, from an hourly basis, to a seasonal basis.

By 2025, large solar and wind farms will compete at prices which are likely to be lower than the production cost of large hydro or coal power plants. This means that countries that were importing hydro or coal power might look to renegotiate or even not renew their PPAs, since they would produce more solar or wind electricity at home or would be able to sign PPAs with wind or solar parks that would be cheaper than the hydro or coal PPAs. It will therefore be important to consider very carefully the construction of large coal or hydro power plants with payback periods of over 10 years.

This would lead to risk of stranded assets in the region: diesel, hydro, gas or coal power plants where the break-even has not yet happened but the assets are priced out of the market. This is already happening to some extent with a series of gas and coal power plants in Europe. Countries that are planning their power sector on the basis of coal and/or large scale hydro might see their electricity markets becoming more expensive than other countries, losing out in terms of competitiveness and environmental reputation. This should be kept in mind when developing the grid, preparing master plans and power sector strategies.

What now?

- A careful assessment of the financial viability of electricity export strategies based on various power sector scenarios of the exporting and importing countries would help mitigate a part of the stranded asset risk

» A diversification of power plant technologies, integrating more wind and solar technologies in the mix, would reduce the technology risk by providing more complementarity between the technologies (it does not help to offer only hydropower production to the regional mix during the dry season)

» A regional discussion between grid operators based on credible projections regarding different renewable energy technologies would help identify where grid improvements are necessary to optimise electricity exchange between countries

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Land use

We need large areas of land to meet our energy needs. What can we do to limit the impact on people and nature?

Sustainability means living within the capacity of humanity's one and only planet and the limited amount of land and sea available, without jeopardising the ability of future generations to do the same. We need space for buildings and infrastructure, land to grow food and fibres and raise livestock, forests for timber and paper, seas for food and leisure. More importantly, we need to leave space for nature – and not just because the millions of other species that inhabit our planet are important in themselves. We need healthy ecosystems to supply our natural resources, provide clean air and water, regulate our climate, pollinate our crops, keep our soils and seas productive, prevent flooding, and much more. The way we use our land and sea and planning for this is key to securing a renewable energy future, and perhaps some of the hardest challenges we face.

Over the coming decades, we will need to develop an extensive renewable energy infrastructure, and it will be essential that we put the right technologies in the right places. Solar farms, for example, can make use of unproductive areas and roofs of existing buildings or parking areas in urban areas. Geothermal fields are often found in unspoilt areas, so we need to choose sites carefully to minimize their environmental and social impact, and make sure surrounding areas are well protected. We need to assess all new hydropower plants especially rigorously, and choose sites for offshore wind and ocean power carefully to minimize the impact on marine life. We also need to carefully plan the routes of the long-distance, high-voltage power lines and undersea cables we will need to transmit electricity from new production centres. Regarding bioenergy production, we need to consider the rights of local communities, including indigenous people, the movements of migratory species, the effect on water supplies, the type of infrastructure and governance systems in place, and a host of other constraints. All energy projects need to reflect community Free Prior and Informed Consent (FPIC).

What now?

» All large-scale energy infrastructure developments must satisfy independent, in-depth social and environmental impact assessments. They should also meet – or exceed – the best social and environmental management practices and performance standards. The Gold Standard for best practice in projects delivering carbon credits provides a good example. For hydropower, WWF has participated in the development of the International Hydropower Association Sustainability Guidelines.

» We need to carefully analyze, country by country, what land and water is available for bioenergy, taking social, environmental and economic issues into account. An important future source of biomass could come from the biomass currently used for fuel wood and charcoal. If we accept that everybody should have access to electricity by 2030, in accordance with the UN Sustainable Energy for All target, then it is not impossible to imagine that, by 2050, a much smaller percentage of people in the Greater Mekong region will depend on biomass for cooking. A sustainable part of this biomass could be used for other purposes, such as electricity production.

» Forestry companies, governments and conservationists need to identify areas of idle land (forests that have been cleared already but are no longer in use) where it may be possible to increase yields of biomass with the least impact on biodiversity. Southeast Asia is one of the regions with most potential. WWF is supporting the Responsible

Cultivation Area concept, which aims to identify land where production could expand without unacceptable biodiversity, carbon or social impacts. We are also helping to identify areas that should be maintained as natural ecosytems and primarily managed for conservation purposes through schemes such as the High Conservation Value Framework.

» Large-scale bioenergy production has to be based on binding sustainability criteria, with strong legal controls – binding legislation and strict enforcement – at national and international levels. Voluntary standards and certification schemes, along the lines of the Forest Stewardship Council, the Roundtable on Sustainable Biomaterials and Bonsucro, also have a role to play.

» As individuals, we need to make more considered choices about the food we eat, the transport we use and other lifestyle factors that influence global land use. Plant based diets require much less land than meat based diets. Public policy should help to guide these choices.

Finance

Renewable energy makes long-term economic sense, but how do we raise the capital needed?

Energy efficiency and renewable energy share a similar financial barrier. Upfront investments in capital are most often higher than less efficient or non renewable technologies. This higher capital cost is compensated by energy savings in the case of energy efficiency and by lower operating costs in the case of renewable energy that does not require raw energy sources[13]. This is confirmed by the SES, where the yearly net costs very quickly become lower than the BAU yearly net costs. The investment pays off handsomely over time. By 2050, we will be saving nearly $40 bn USD every year, according to the SES compared to a business-as-usual scenario. And that's purely the financial savings that come from reduced operating costs. It doesn't take account of the costs we could incur from climate change– up to one-fifth of global GDP, according to the Stern Review (Stern, 2007) – if we don't radically reduce our greenhouse gas emissions by moving to a renewable energy supply. Nor does it include the added value of the millions of jobs created or the health and social benefits, such as better air quality and more leisure time.

[13] Biomass is an exception

But we will need to invest significant capital before we start seeing these returns. Large sums will be needed to install renewable energy-generating capacity on a massive scale, to modernize electricity grids, transform public transport infrastructure and improve the energy efficiency of our existing buildings. Upfront costs are likely to be higher than for a conventional power sector, but there will be international sources of support for opting for a greener development pathway. Climate finance can leverage private sector investment to achieve significant (sustainable) renewable energy investment if there are quality projects which meet International Finance Institutions' governance requirements. In particular, the Green Climate Fund "is a global initiative to respond to climate change by investing in low-emission and climate-resilient development. It was established by 194 governments to limit or reduce greenhouse gas emissions in developing countries, and to help adapt vulnerable societies to the unavoidable impacts of climate change. Given the urgency and seriousness of the challenge, the Fund is mandated to make an ambitious contribution to the united global response to climate change" (United Nations, 2016). The fund will offer a wide variety of financial products to support, amongst others, renewable energy and energy efficiency projects.

Net expenditure will need to continue to grow until 2050 to around $120 bn USD a year but will not rise above 5.5 percent of the Greater Mekong region's GDP. This remains lower than the net cost of the BAU scenario, which peaks at 6.5 percent of GDP. At the same time, energy savings and reduced fuel costs mean operating expenditure will soon start to fall. The savings outweigh the costs very quickly after a few years, depending on the country.

Unfortunately, our current financial system is not suited to taking the long view. Investors expect a return within a couple of years. New power developments cannot be left entirely to the free market as long as it is sometimes cheaper to build a coal or gas power station than a wind farm or solar array, especially in terms of capital expenditure (CAPEX). We need new financing models, such as public-private partnerships with shared risks, to encourage long-term investment in renewables and energy efficiency. Legislation and stable political frameworks will also help to stimulate investment.

This need for upfront capital is not only a problem for governments and utilities but also for households wanting to invest in solar technologies. Attracting local and foreign investors and lenders to the renewable energy and energy efficiency markets requires stable and ambitious policies creating an enabling framework. It has been demonstrated in several countries, for instance Tunisia, Bangladesh, Germany or the US, that this enabling environment can start a very rapid development of renewables and efficiency. At the household level, very often solar is already economically interesting, but some financial barriers are making it difficult to act. Some creative programmes have been very successful in other countries and could be adapted to the country needs. In Tunisia, PROSOL is a savvy mix of government subsidies and bank loans that enable middle-class citizens to invest in solar thermal or PV (Climate Policy Initiative, 2012); Mosaic is crowdsourcing investors who invest in solar PV on other people's roofs in the US (Mosaic, 2015); Solease is leasing solar PV on people's roofs in Europe (Climate-KIC, 2015). Grameen Shakti provides soft loans for solar home systems in Bangladesh (Grameen Shakti, 2009).

But this support for renewable energy needs to be compared with direct and indirect subsidies for electricity and fossil fuels. These subsidies provide affordable fuel and electricity for people and industry but are weighing heavily on countries' budgets. Reducing these subsidies for electricity while maintaining some social tariffs would reduce the burden on public budgets and higher electricity prices would make energy efficiency and renewable energy financially more attractive. Subsidies to the fossil fuel sector could be redirected to renewable energy and energy efficiency programme, providing long term benefits for the countries' people and industries.

While many governments are cutting public spending, investing in renewable energy could help stimulate economic growth, creating many "green collar" jobs. Today, 7.7 million jobs have been created in the renewable energy industry (IRENA, 2015a). Energy efficiency savings, especially in industry, can also help spur economic competitiveness and innovation.

The economic arguments in favour of moving toward a fully renewable energy supply are persuasive. When we also take into account the environmental and social costs and benefits, the case is unbeatable. Subsidies for fossil fuel options should be revised and positive investment for long-term sustainable options should receive more incentives for establishment. The challenge now is to overcome the clamour for short-term profits and recognize the long-term opportunities.

What now?

» We urgently need to create a level playing field for sustainable renewable energy and energy efficiency – or, better, one tilted in its favour to reflect the potential long-term benefits. Feed-in tariffs, net metering, renewable electricity auctions and reverse auctions should be extended. We need to end direct and hidden subsidies to the fossil fuel sector, but without increasing energy prices for the poorest.

» Increasing taxes on products and cars that use more energy will help to steer demand toward more efficient alternatives. VAT and import taxes should be waived for sustainable energy technologies.

» We need ambitious cap-and-trade or carbon tax regimes, nationally and internationally, that cover all large polluters, such as coal-fired power stations and energy-intensive industries. Setting a high price on carbon will help to encourage investment in renewable energy and energy efficiency, as well as reducing emissions.

» Global climate negotiations have provided finance and technology opportunities to help developing countries build their capacity for generating renewable energy and improve energy efficiency. It is now up to the governments, the private sector and other organisations in the Greater Mekong region to prepare plans and claim a substantial part of this financial support.

» People should install any effective micro-generation and energy-efficiency measures they can afford in their own home, business or community, assuming these make environmental and economic sense. Governments, energy companies and entrepreneurs can encourage this. Banks can offer low interest rates for energy efficiency and renewable energy projects, backed by international support mechanisms for instance.

» Investors should divest from fossil fuel and nuclear firms, and buy shares in renewable energy and efficiency-related companies. Anyone with savings can help to tip the balance by choosing banks, pension providers or trust funds that favour renewables.

» Politicians need to clearly support renewable energy and energy efficiency, and create supportive legislation to build investor confidence. Political parties need to reassure investors that broad energy policies will survive a change of government. National legislation needs to overcome the bias toward the energy status quo, through measures such as legally binding energy-efficiency standards.

» Energy service companies could have access to lines of credit to make energy efficiency investments (so called third-party financing) in the industrial, buildings and service sectors. They are remunerated on the basis of the savings achieved. The ESCOs can also offer energy performance contracts (EPCs).

Innovation

What advances will make our renewable energy a reality?

The power sector scenario mapped out in the second part of this report is ambitious – but it is grounded firmly in what exists today. Only technologies and processes that are already proven are included. These are sure to be refined and improved in the years ahead, but the report is cautious in estimating their growth potential. This means we have an opportunity to improve on the SES – to increase from about 90 percent to 100 percent renewable electricity, and to reduce the need for hydropower and biomass as this puts pressure on food and water supplies, communities and the natural world.

After 2030 smart energy grids that are capable of managing demand and accommodating a much larger proportion of variable electricity have a vital role to play, and will be an important area for R&D. Already mobile technology offers more immediate feedback possibilities for transmission efficiency monitoring. Smart appliances that respond to varying electricity supplies will complement this.

Improving ways of storing electricity generated by wind and solar is another important focus. Several solutions are already in use. Solar power can be stored as heat or cold. Lower cost storage options, at a home, business or basin basis are rapidly becoming available. This presents another challenge to the “spinning reserve” models that underpinned previous generation planning.

Technology has provided us many more options – we need to seriously consider how best to use them.

Hydrogen could also have a major role to play in industry and transport. Hydrogen is the ultimate renewable fuel: the raw material is water, and water vapour is the only emission. It produces energy either through direct combustion or in fuel cells, and is easily produced through electrolysis, which can be powered by renewable electricity at times of high supply or low demand. However, major challenges remain in storing and transporting it. Intensive R&D into hydrogen could have a major impact on the future energy balance.

According to the SES, the region will still need to burn a small amount of coal and gas in 2050 (about 14 percent of total energy supply). This share of fossil fuels might disappear before 2050, due to lack of economic competitiveness, or shortly after 2050, due to aging equipment.

Technology moves fast. Just 50 years after the Wright Brothers made their first flight, jet planes were carrying passengers from London to Johannesburg. Tim Berners-Lee wrote the first World Wide Web page in 1991: there are now over 3 billion web users and an immeasurable number of web pages. Tablets have already overtaken the sales of laptop computers in the incredibly short space of 6 years. Given the right political and economic support, human ingenuity will allow us to realize our vision of a 100 percent renewable electricity supply by 2050. This is also why we developed a third scenario: the advanced sustainable energy scenario (ASES). With this scenario we try to understand what would happen if these technology improvements happen more rapidly than expected.

What now?

» We need to radically increase investments in researching, developing and commercializing technologies that will enable the world to move toward a 100 percent renewable energy supply. These include energy-efficient materials, design and production processes, electric transport, renewable energy generation, smart grids and alternative fuels

» At the same time, we should stop pursuing ideas that will lock the world into an unsustainable energy supply, particularly techniques for extracting unconventional fossil fuels.

» National policies for renewable energy innovations are often fragmented or simply non-existent. Governments need to introduce supportive policies, in close collaboration with representatives from industry and finance.

» We need to educate, train and support the scientists, engineers and other skilled workers who will invent, design, build and maintain our new energy infrastructure. We also need to support entrepreneurs and innovative companies with ideas to help us move toward a renewable energy future.

The Role of the Private Sector

Companies are interested in electricity supply security. A power cut represents an economic loss. Analyses from blackouts in the United States show that a 30-minute power cut results in an average loss of $15,709 USD for medium and large industrial companies, and nearly $94,000 USD for an eight hour interruption. Even short blackouts – which occur several times a year in the US – add up to an annual estimated economic loss of between $104 USD and $164 billion USD (Allianz, no date). Renewable energy systems and energy efficiency or demand side management can provide energy security to companies, by helping them to satisfy their power needs in a hybrid way – combining on-grid and distributed solutions.

Companies are interested in stable electricity prices. Power purchase agreements (PPAs) with wind power plants or solar parks guarantee stable prices for the next 20 to 25 years, since these electricity plants do not depend on raw material prices, unlike diesel, coal or gas power plants. Several companies, including IKEA, Google, Apple and Coca Cola are heavily investing in renewable energy, be it through PPAs or their own renewable energy infrastructure.

Companies are also concerned about their reputation. Most famous companies want to operate in a clean way. This includes the sourcing of electricity. Several companies have made commitments to source 100 percent of their energy from renewables. These include Adobe, Alstria, Autodesk, Aviva, Biogen, BMW Group, BROAD Group, BT Group, Coca-Cola Enterprises, Commerzbank, DSM, Elion Resources Group, Elopak, Formula E, Givaudan, Goldman Sachs, Google, H&M, IKEA Group, Infosys, ING, International Flavors & Fragrances Inc.(IFF), J. Safra Sarasin, Johnson & Johnson, Kingspan, KPN, La Poste, Land Securities, Marks & Spencer, Mars Incorporated, Microsoft, Nestlé, Nike, Inc., Nordea Bank AB, Novo Nordisk, Pearson PLC, Philips, Procter & Gamble, Proximus, RELX Group, Salesforce, SAP, SGS, Starbucks, Steelcase, Swiss Post, Swiss Re, UBS, Unilever, Vaisala, Voya Financial, Walmart and YOOX Group (The Climate Group, 2016). Some companies have already started relocating in order to have access to clean, renewable electricity sources. Countries that offer clean electricity available on the grid, or that provide the right enabling framework for companies to invest in renewable energy and energy efficiency, will attract these companies.

Some companies have already started relocating in order to have access to clean, renewable electricity sources. Countries that offer clean electricity available on the grid, or that provide the right enabling framework for companies to invest in renewable energy and energy efficiency, will attract companies.

Companies may also be interested in providing flexibility to the grid operators. Every electricity consumer can agree to give up some of his or her power access at specified times in order to provide flexibility to power companies and grid operators. A surge in demand can then be mitigated by curtailing some consumers rather than calling upon additional power plants, usually called “spinning reserve.” Aggregators can form the interim party between consumers and the grid operators or power companies. In other words, the capacity market will provide an insurance policy against the possibility of blackouts by providing financial incentives to ensure we have enough reliable electricity capacity to meet demand.

In the United States, in 2012, businesses and homeowners earned over $2 billion USD in direct revenues from demand response measures; 29.5GW of capacity was made available by these players to the electricity market to provide more flexibility to the grid, lowering the number of peaking plants and increasing efficiency (Smart Energy Demand Coalition, no date).

What now?

» We need to provide the right enabling framework for companies to invest in renewable energy and energy efficiency: in the Greater Mekong, most of the time policies are lacking and several barriers prevent companies from investing in renewable energy and energy efficiency

» We should provide the right framework for the organisation of capacity markets. Here are some recommendations taken from the Department of Energy and Climate Change, United Kingdom (2012). "Forecast of future peak demand will be made; the total amount of capacity needed to ensure security of supply will be contracted through a competitive central auction a number of years ahead; providers of capacity successful in the auction will enter into capacity agreements, committing to provide electricity when needed in the delivery year (in return for a steady capacity payment) or face penalties; providers of capacity able to enter the auction will include existing providers and new providers, to incentivise extra investment now and in the future and to incentivise good repair and maintenance practices; and the costs of the capacity payments will be shared between electricity suppliers in the delivery year."

» We also need to ensure a sustainable electricity grid mix to attract companies that are serious about their environmental performance and worried about unstable electricity prices.

WHERE DOES THIS TAKE US?

The December 2015 United Nations Climate Change Conference in Paris, or COP21, re-confirmed the global appetite for avoiding addressing catastrophic climate change. That the world faces an energy crisis is beyond doubt. A lack of access to energy is one of the main causes of poverty. There's a pressing need to secure a sustainable energy supply as demand for fossil fuels and hydropower outstrips environmentally and economically sustainable power supply.

We – individuals, communities, businesses, investors, politicians – must act immediately, and boldly. Half-hearted solutions are not enough. We must aim for a fully renewable and sustainable energy supply as a matter of urgency.

It is possible. The second part of this report lays out, in unprecedented detail, one way that we can do this. It isn't the definitive solution, and it isn't perfect: as we've seen, it raises many challenges and difficult questions. The modelling shows that solutions are at hand. The scenarios are presented to catalyze debate and to spur the region to action.

We now need to respond to the issues it raises. We need to take it further. But most of all, we need to act on it – each and every one of us. **Starting today.**

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100% RENEWABLE ENERGY

By 2050 under the Advanced Sustainable Energy Scenario

80 - 100%

Reduction in carbon emissions by 2050

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