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ENERGY REPORT VN 2016

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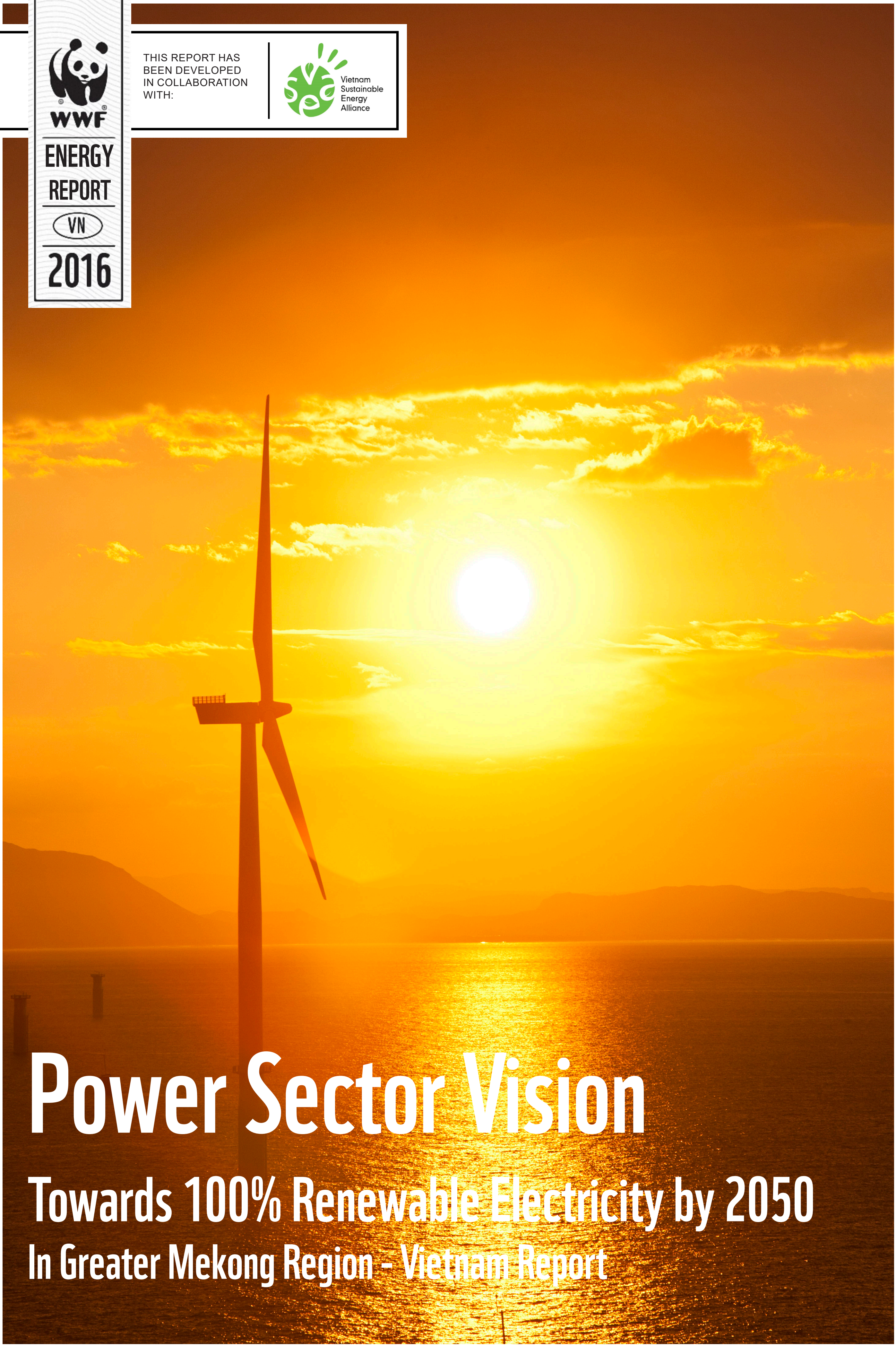

Power Sector Vision

Towards 100% Renewable Electricity by 2050

In Greater Mekong Region - Vietnam Report

SUMMARY

Although electricity from renewable resources, primarily from hydro energy, has been increasing in Vietnam in the last two decades, fossil fuel-based electricity still dominates the power generation system in the country. The share of power generation capacity from coal and gas was nearly 54% in 2015 . This share is expected to further increase in the coming years based on the official power development plan of Vietnam, despite Vietnamese fossil energy resources being scarce, with its oil and gas reserves likely to be depleted in the few decades to come . Hence, a necessary question is: could Vietnam be successful in achieving a low carbon power system and pursue a low carbon economy in the next few decades? Or will the country continue its dependence on fossil fuels?

The Intelligent Energy Systems Pty Ltd ("IES") and Mekong Economics ("MKE") were commissioned by WWF – Greater Mekong Programme Office ("WWF-GMPO") to undertake a project called "Power Sector Vision: Alternatives for power generation in the Greater Mekong Sub-region". This was to develop scenarios for the power sector of countries in the Greater Mekong Sub-region (GMS) that are in line with WWF's Global Energy Vision that outlines a 100% renewable energy supply by 2050. The objectives of WWF's energy vision are: (i) contribute to reduction of global greenhouse emissions (reduction by >80% based on1990 levels by 2050); (ii) reduce dependency on unsustainable hydro and nuclear power; (iii) enhance energy access; (iv) take advantage of new technologies and solutions; (v) enhance power sector planning frameworks: multi-stakeholder participatory process; and (vi) develop enhancements for energy policy frameworks.

The purpose of Power Sector Vision report is to provide detailed country-level descriptions of three scenarios for the power sector of the Socialist Republic of Viet Nam (Viet Nam):

- Business as Usual (BAU) power generation development path which is based on current power planning practices, current policy objectives.
- Sustainable Energy Sector (SES) scenario, where measures are taken to maximally deploy renewable energy and energy efficiency measures to achieve a near-100% renewable energy power sector; and
- Advanced Sustainable Energy Sector (ASES) scenario, which assumes a more rapid advancement and deployment of new and renewable technologies as compared to the SES.

The scenarios were based on public data, independent assessments of resource potentials, information obtained from published reports and power system modelling of the GMS region for the period 2015 to 2050.

The key findings of this study are:

- Domestic natural ressources in renewable energy have enough technical and economic potential to provide 52% by 2030 and 81% by 2050 of the electricity used in Vietnam under the SES scenario. This is three times what is the projected under the business as usual scenario.
- The cost of producing electricity from coal will increase, as the power plants will be more expensive and more coal will be imported.
- The cost of producing electricity from wind and solar will decrease, due to technology cost decline, learning by doing and economies of scale.
- The cost of producing electricity from renewables may be lower than the cost of producing from coal as early as 2022. Recent contract prices for wind and solar in first mover countries are now cheaper than coal.
- The scenario where 81% of electricity is produced from renewables in 2050 requires more CAPEX investment than the business as usual, coal-based scenario, $415 billion versus $341 billion. However, savings on fuel costs more than compensate for extra investment costs.
- Levelized cost of electricity (LCOE) is lower in SES compared to BAU; Energy security index is higher in SES compared to BAU
- The scenario where 81% of electricity is produced from renewables in 2050 has a lower total discounted system cost than the business as usual, coal-based scenario. Requirements to operate a power system using 81% renewable energy sources include: real-time monitoring and control of all elements in the system, near-real time and automated dispatch operations, and high quality forecasting systems for solar and wind energy
- Regional integration to optimize the use of renewable energy sources in the Greater Mekong could lower the cost of power in the region.The manufacture and construction of energy generation capacity creates more jobs in the renewable energy scenario than in the coal energy scenario.

Based on these findings, WWF Vietnam proposes recommendations to policy-makers of the country:

- Mandatory and enforced energy efficiency improving measures be taken for consumer goods, buildings, and industrial firms, starting with State Owned Entreprises
- The expansion of coal-fired power plants stops as early as possible
- The plans for nuclear power plants are cancelled and replaced by plans for renewable energy
- More support policies and incentives for renewable energy

[1] Electricity of Vietnam, "Vietam Electriciy Annual Report 2015", 2016.
[2] The Government of Vietnam, "The adjustments of 7th Vietnam Power Development Planning." 2016.
[3] H.A. Nguyen-Trinh, "The Prospective Evolution of the Vietnamese Power Sector_ The Vulnerability and Externality Analysis," in Sustainable Energy: Planning and Policies, Germany: Margraf Publishers, 2012, pp. 20–36.

WWF

WWF is one of the world's largest and most experienced independent conservation organisations, with over 5 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-government organizations and corporate clients.

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SummaryPartA:Vietnam

Disclaimers

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Part A was prepared by Vietnam Sustainable Energy Alliance (VSEA), leading by the Clean Energy and Sustainable Development lab (CleanED/USTH), as a technical summary of the full report.

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List of Acronyms

AD	Anaerobic Digestion
ADB	Asian Development Bank
AGL	Above Ground Level
ASEAN	Association of Southeast Asian Nations
ASES	Advanced Sustainable Energy Sector
BAU	Business As Usual
BCM / Bcm	Billion Cubic Metres
BNEF	Bloomberg New Energy Finance
BOT	Build-Own-Transfer
BP	British Petroleum
BST	Bulk Supply Tariff
BTU / Btu	British Thermal Unit
CAA	Commercial Arrangement Area
CAGR	Compound Annual Growth Rate
CAPEX	Capital Expenditure
CCGT	Combined Cycle Gas Turbine
CCS	Carbon Capture and Storage
CENER	National Renewable Energy Centre
CHP	Combined Heat and Power
CIEMOT	Centro de Investigaciones Energeticas Medioambientales y Tecnológicas
COD	Commercial Operations Date
CSP	Concentrated Solar Power
DNI	Direct Normal Irradiation
DR	Demand Response
DSM	Demand Side Management
DTU	Technical University of Denmark
EE	Energy Efficiency
EIA	Energy Information Administration
EPTC	Electric Power Trading Company
ERAV	Electricity Regulatory Authority of Viet Nam
EVN	Electricity of Viet Nam
FOB	Free on Board
FOM	Fixed Operating and Maintenance
GDE	General Directorate for Energy
GDP	Gross Domestic Product
GHI	Global Horizontal Irradiance
GMS	Greater Mekong Subregion
GT	Gas Turbine
HV	High Voltage
ICT	Information and Communication Technology
IDAE	Instituto para la Diversificación y Ahorro de la Energía
IEA	International Energy Agency
IES	Intelligent Energy Systems Pty Ltd
IPP	Independent Power Producer
IRENA	International Renewable Energy Agency
LCOE	Overall Levelised Cost of Electricity
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
MKE	Mekong Economics
MMCM	Million Cubic Metres
MOIT	Ministry of Industry and Trade
MOU	Memorandum of Understanding
MTPA	Million Tonnes Per Annum
MV	Medium Voltage
NASA	National Aeronautics and Space Administration (the United States)
NLDC	National Load Dispatch Centre
NPT	National Power Transmission Corporation
NPV	Net Present Value
NREL	National Renewable Energy Laboratory (the United States)
OECD	Organisation for Economic Co-operation and Development
OPEC	Organisation of the Petroleum Exporting Countries
OPEX	Operational Expenditure
PC	Power Corporation
PDP	Power Development Plan
PDR	People's Democratic Republic (of Laos)
PPA	Power Purchase Agreements
PRC	People's Republic of China
PV	Photovoltaic
PV Gas	Gas Trading Corporation under PVN
PV Power	Power Corporation under PVN
PVN	PetroVietnam - Viet Nam National Oil and Gas Group
RE	Renewable Energy
REVN	Renewable Energy of Viet Nam Joint Stock Company
ROR	Run of River
RPR	Reserves to Production Ratio
SB	Single Buyer
SCADA/EMS	Supervisory Control and Data Acquisition/Energy Management System
SES	Sustainable Energy Sector
SMO	System and Market Operator
ST	Steam Turbine
SWERA	Solar and Wind Energy Resource Assessment
SWH	Solar Water Heating
TCF / Tcf	Trillion Cubic Feet
TKV	Viet Nam National Coal and Mineral Industry Group
TNO	Transmission Network Operator
TOE	Tonne of Oil Equivalent
UN	United Nations
US	United States
USAID	United States Agency for International Development
USD	United States Dollar
VCGM	Viet Nam Competitive Generation Market
VINACOMIN	Viet Nam National Coal and Mineral Industry Group
VOM	Variable Operating and Maintenance
VWEM	Viet Nam Wholesale Electricity Market
WBG	World Bank Group
WEO	World Energy Outlook
WWF	World Wide Fund for Nature
WWF-GMPO	WWF – Greater Mekong Programme Office

Summary Part A: Vietnam

Foreword

In March 2016, the Government of Vietnam approved the adjustments of 7th Vietnam Power Development Planning (PDP7) for the period 2011 - 2020 with an outlook up to 2030. This official decision aims to reduce the demand for total electricity generation by about 20% and 18% by 2020 and 2030, respectively. As consequence, the total power installed capacity of Vietnam in the adjustment would reach only 60 GW by 2020 and 129.5 GW by 2030 as compared to 75 GW and 146.8 GW in the original PDP7. Compared to the previous version of the plan, this is a huge step forward by the Vietnamese Government towards climate change mitigation policies. However, this is not a comprehensive approach to energy transition: fossil fuel-based technologies will still heavily dominate the country's power sector. However, it does meet the ambitious CO2 reduction objectives of Vietnam at the COP 21 with coal consumption reduction of nearly 30%, changing from 76GW to 55GW, by 2030.

The revised PDP mentions the deployment of renewable energy as a priority for the future of the national electricity mix. Targets are set at 6.5% of electricity production by 2020, 6.9% by 2025, and 10.7% by 2030. By using this amount of renewable energy reasonably and tapping the large energy efficiency potential, it will be possible to reduce significantly the nation's dependence on increasingly imported fossil fuel, accelerate access to electricity for all, ensure stable electricity prices for decades to come, increase green jobs creation, increase positive cooperation in the region to optimise electricity consumption and production, and reduce environmental and social impacts. 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 some key questions:

- Can Vietnam 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 hydro power?
- Can Vietnam develop an energy efficient power sector built around clean and inexhaustible renewable energy?

We hope that this report 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 Vietnam in the coming years.

Van Ngoc Thinh
Country Director
WWF-Vietnam

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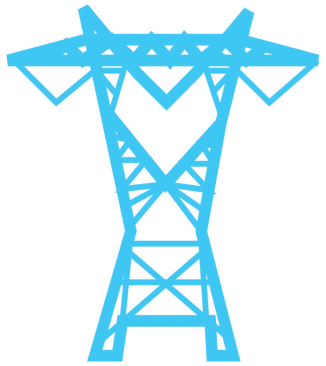
Wind Electricity - Bac Lieu

A MOVE TOWARD MORE SUSTAINABLE ENERGY PRODUCTION IS DESIRABLE



Vietnam is home to over 90 million inhabitants with a Gross Domestic Product (GPD) per capita of 2,052 US$ in 2014. Vietnam's GDP grew at an annual rate of 6.8 per cent between 1990 and 2013, and is projected by authorities to hover around 7% annually from 2016 to 2030 [(4)].

Status and trend of electricity consumption

Since the Reforms in 1986, domestic energy and electrical power consumption in Vietnam have been growing rapidly. Electricity is now available to almost all households, up from less than half in 1993. "By the end of 2014, 100% of the districts were connected to electricity; 99.6% of the communes with 98.2% of rural households were electrified"[(5)]. Over the past 10 years national energy demand has had a compound annual growth rate (CAGR) of 12.7% and for peak demand CAGR of 10.2%.

The increasing electricity demand is driven strongly by economic growth. Since the Reforms, Vietnam has developed quickly and got the status of middle income country by 2008. During the last two decades, economic growth rates have been in the 5% to 8% per year. The economic growth required a huge amount of energy because it is characterized by industrialization. In addition, the economic growth also increases the living standards which in turn, increases demand for electricity. For example, from 1995 to 2010 the per capita consumption rose during the same period from some 156 kWh to about 900 kWh. Coupled with population increase, industrialisation and urbanization drive the need for more energy and especially more electricity in the country. This fact is illustrated with an average annual growth rate of 5.7% between 1990 and 2012 for final energy consumption and of 14% annually for the electriciy use during the same period.

There are signs that economic growth in Vietnam will sustain its upward trajectory in the future. Despite the impacts of the Financial Crisis in 2008, the economic growth rates of Vietnam in the past 8 years were always higher than 5%. In 2015, the GDP growth rate reached the peak of the last five years at 6.68%.

Officially, in March 2016, the Government of Vietnam published the revised 7th Vietnam Power Development Plan for the period 2016 - 2020, with an outlook up to 2030 (The Government of Vietnam 2016). This official decision aims to ensure national energy security and meet the socio-economic development objectives of the country with an average GDP growth of about 7.0% during the period. This provides an evidence to believe that the electricity demand in Vietnam will grow at high rate in future. The projection for the total power installed capacity of Vietnam will be 60 GW by 2020 and 129.5 GW by 2030[(6)] .

Status and trend in power supply

Vietnam has experienced impressive results in power production. Starting from a production level of 14.3 TWh in 1995, the power sector of Vietnam has expanded at a rapid two-digit growth rate since. This continues today. According to EVN[(7)], "In 2014, total power system production and purchase in 2014 were recorded at 142 TWh, an increase of 10.76% compared with 2013; power sales reached 128 TWh which was 11.41% higher than 2013." In the same year, total installed capacity of the whole power system of Vietnam has reached above 34GW and the peak load was over 22 GW with variety of energy primary sources such as hydro power, coal-fired and oil-fired power, gas turbines, and wind power, etc. Vietnam currently ranks the 3rd in Southeast Asia and the 31st worldwide for scale of power generation sector. Total power system production in the same year were recorded at 142 TWh, increasing 10.8% as compared with 2013, which results in average electricity consumption per capita was over 1,400 kWh, equivalent to using 160W of power, 8 760 hours per year.

However, it should be noted that the power supply is subject to two major obstacles. The first is the seasonality of hydro inflows which for the smaller reservoirs affects availability of hydro generation during the dry season. The second is the transmission limits, particularly between south and central Viet Nam resulting in tight supply and demand within the south region.

In term of source composition, the power supply is dominated by large hydro, gas and coal. In 2014, the share of hydro accounted for 38% of power production, gas accounted for 30.9% and coal was for 25.6%. Other sources accounted for 5.5%. The imported source was also small in comparison to power production. The imports from China in the North were 3.61 Twh in comparison to more than 120 TWh of production in 2013.

(4) General Statistics Office of Vietnam, Annual Statistics Book 2015, 2016
(5) EVN, "Vietnam Electricity Annual Report 2015," Electricity of Vietnam Group, 2016
(6) The Government of Vietnam, "The adjustments of 7th Vietnam Power Development Planning." 2016
(7) EVN, "Vietnam Electricity Annual Report 2015," Electricity of Vietnam Group, 2015

Summary Part A: Vietnam

The trend of power resources, domestic and imported

Coal

The future of domestic coal as a power source is limited. The imported coal has potential to expand. However, there are signs that the expansion of coal is losing momentum.
The future of domestic coal as a power source is limited though estimates of reserve sizes suggest that further exploitation is possible. The reason is that the reserve of domestic coal located mainly around Quang Ninh while transmission system is under development. Domestic transportation networks (via sea or rail) for domestic coal have been contemplated, but with domestic coal prices for the electricity sector being regulated to come into line with international coal prices, the economics of such infrastructure investments against investment in facilities to import higher quality coal at locations along the coastline, make this unlikely. Meanwhile, imported coal from Indonesia and/or Australia has potential to expand.

However, there are signs that the expansion of coal is losing momentum. Prime Minister Nguyen Tan Dung announced in January 2016 his government's intention to "review development plans of all new coal plants and halt any new coal power development." More specifically, mid-January 2016, he signalled a reduced role for new coal fired power stations in the country's forthcoming power plans and an expanded role for renewable energy by stating [in Vietnamese]:
"There is a need to closely monitor environmental issues, especially in stringent monitoring of coal-fired power plants; to review development plan of all coal-fired power plants and halt any new coal power development; to begin replacing coal with natural gas; to responsibly implement all international commitments in cutting down GHG emissions; to accelerate investment in renewable energy, including building market mechanisms, encouraging policies and initiatives, and attract investment for solar and wind energy..."

Offshore natural gas reserves

Offshore natural gas is considered to be a longer-term option for development.

Viet Nam is estimated to have some 617 Bcm (21.8 Tcf) of proved reserves, or around 52% of the total proved natural gas reserves of the GMS. Further developments of Viet Nam's offshore gas reserves have been contemplated. In the south-west region, Offshore Blocks B, 52/97, 48/95, could support significant natural gas power generation projects in the south of Viet Nam, and in particular, top up gas to the Ca Mau complex and allow further development of the O Mon complex. PetroVietnam is currently working with recent joint venture partners Murphy Oil and ExxonMobil to develop these fields. In the north-east region, offshore oil and gas fields have been identified off the northeast coastline with extensive surveying and exploration still ongoing with significant investment in the infrastructure to support development of this field.

Liquefied Natural Gas (LNG)

The future of LNG is uncertain, at least in short-term. The most recent Gas Development Plan and Power Development Plans to have been approved by the government include plans for an LNG regasification terminal sited in the central province of Binh Thuan (near Ho Chi Minh City) with a capacity of 3 MTPA. However, the development of the LNG terminal has been delayed and it appears unlikely that an LNG import terminal would be in operation before 2020.

Nuclear Power

Nuclear power is risky for the environment and incurs high costs advancing technology. As part of a long-term energy security strategy Viet Nam has been enhancing their nuclear power knowledge and capability. Viet Nam has in place agreements with Russia and Japan to build nuclear power projects of 2400 MW and 2000 MW respectively[(8)]; both planned to be constructed in the Ninh Thuan province. Nuclear power features in Viet Nam's power development plans, although the dates of first generation from nuclear power remains uncertain with tightening safety requirements and unforeseen delays occurring in advancing the deployment of this technology in Viet Nam.

Large Hydro

Large hydro is not considered an option for additional future capacity, since Viet Nam has largely exploited all of the large scale hydro considered to be economically feasible. Around 38% of Viet Nam's electricity is currently generated by a range of large reservoirs and in some cases cascaded hydropower stations that are located throughout the country. The largest reservoirs, Hoa Binh and Son La, are located in the north west of the country, although there are significant storages located in the central and south regions as well.

(8) World Nuclear Association, www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/Vietnam, October 2015

Vietnam is able to gain the benefits of diversity in hydrological conditions across many separate river systems with notable diversity in inflows across north, central and south regions.

Small, mini, and micro hydro

There is potential to develop small, mini and micro hydro, but some projects have raised concerns due to environmental externalities.

Viet Nam has untapped small scale hydro potential. In recent years, there has been a lot of small hydropower development in Viet Nam with the number of projects going from about 141 in 2006 (167 MW) to about 156 (622 MW) by 2009, and some 226 projects (1635 MW) by 2014. Some 1943 MW of capacity is now under construction, and some 236 projects (with total capacity of 2019 MW) under study. However, concerns have been raised on small hydro projects in the country based on considerations of the low levels of efficiency achieved from some projects relative to the environmental externalities.

Onshore and offshore wind

Viet Nam is considered to have moderate to good onshore wind energy potential, with the best locations in Viet Nam recording good wind speeds throughout the year except for the months of April, May and September. Most of the onshore wind potential is along the country's south central and central coastal areas, and a number of locations in the mountainous areas in the central region. The greatest onshore wind potential that has been measured is in Binh Thuan province. A limited amount of data is reported in relation to offshore wind potential in Viet Nam, however, it appears that Viet Nam has potential for offshore wind with a little under half the sites having been tested being rated as "good" or better for offshore.

Solar Energy

Viet Nam is considered to have very high potential for the development of solar energy. A number of studies have been conducted to assess the potential[9]. They indicate a substantial potential for solar photovoltaic deployment throughout the country, with the greatest potential in the southeast, central highlands, Mekong River Delta, all coastal areas and the northeast. The study also concludes that there is substantial potential for concentrated solar power (CSP) based technologies, with the greatest potential in the central regions, highlands and southeast of Viet Nam.

Bio Generation (Biomass and biogas)

As an agricultural country, Viet Nam has significant potential for electricity generation from biomass and biogas sources.

Typical forms of biomass include wood and wood industry waste, crop waste and residues, animal waste, urban waste and other organic waste. Sustainable exploitation capacity of biomass for energy production in Viet Nam is estimated at about 150 million tons per year[10], with overall power generation potential of around 11-15 GW from biomass and 4-5 GW from biogas.

Geothermal

Presently there are no geothermal power plants in Viet Nam. The country's geothermal potential is limited, some 300 MW to 400 MW of resources have been identified to date.

Pumped storage hydro

Viet Nam does not presently have any pumped storage hydro plant in operation. However, feasibility studies show that pumped storage power plants are feasible, with the south and central regions offering the most favourable geographical conditions.

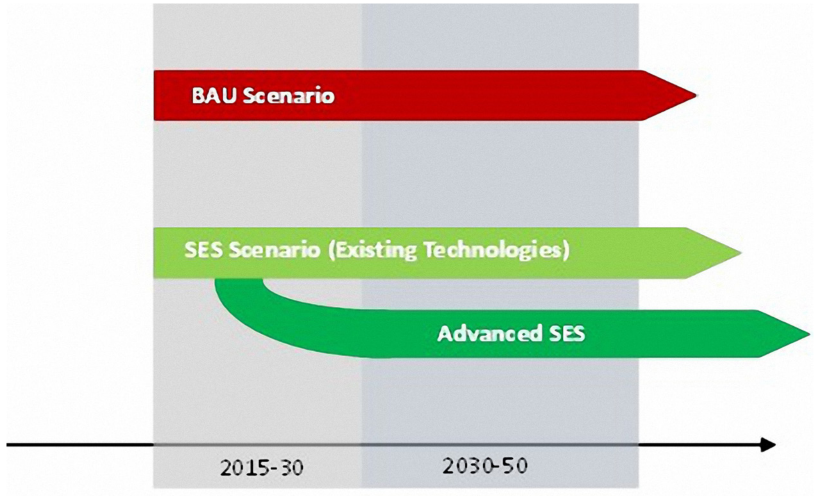
In summary, the current composition of Vietnam power supply cannot scale up proportionally to meet the future demand. Of the three major source of power supply, only gas has potential for future. Hydro and coal face capacity limitation and environment issues. Therefore, moving toward renewable energy such as solar, wind and biomass is desirable since they have huge domestic potential to expand in Vietnam.

Solar and wind are both intermittent energy sources. There is some natural seasonal diversification between resources: wind speeds tend to be high as the wet season ends, solar radiation tends to reach a peak as wind speeds become lower. In addition to the seasonal diversification among the solar, hydro and wind technologies; there is also diversification between the main regions of Viet Nam, which may alleviate the intermittency problem. The large share of hydro power is an asset to accommodate high levels of variable renewable energy in the network: dams store energy which can be dispatched rapidly when needed.

[9] MOIT (January 2015) Maps of Solar Resource and Potential in Vietnam, with Centro de Investigaciones Energeticas Medioambientales y Tecnológicas (CIEMOT), National Renewable Energy Centre (CENER) and Instituto para la Diversificación y Ahorro de la Energía (IDAE)
[10] http://ievn.com.vn/tin-tuc/Tong-quan-ve-hien-trang-va-xu-huong-cua-thi-truong-nang-luong-tai-tao-cua-Viet-Nam-5-999.aspx

THE THREE SCENARIOS (BAU, SES, AND ASES) IN A NUTSHELL

The three scenarios (BAU, SES & ASES) for VietNam Power Sector are conceptually illustrated in Figure 1.



The BAU scenario is characterised by electricity industry developments consistent with the current state of planning within Vietnam and reflective of growth rates in electricity demand consistent with an IES view of base development, existing renewable energy targets, where relevant, aspirational targets for electrification rates, and energy efficiency gains that are largely consistent with the policies seen in the country.

In contrast, the SES seeks to transition electricity demand towards the best practice benchmarks of other developed countries in terms of energy efficiency, maximise the renewable energy development, cease the development of fossil fuel resources, and make sustainable and prudent use of undeveloped conventional hydro resources. Where relevant, it leverages advances in off-grid technologies to provide access to electricity to remote communities. The SES takes advantage of existing, technically proven and commercially viable renewable energy technologies.

Finally the ASES describes how the power sector is able to transition rapidly towards a 100% renewable energy technology mix. That scenario assumes that renewable energy technology costs decline more rapidly compared to BAU and SES scenarios, consistent with their observed cost decline in the recent years. Table 1 presents a brief summary of the main differences between the three scenarios[11].

[11]For further details, please refer to the separate IES assumptions document.

Summary Part A: Vietnam

Table 1: Brief Summary of Differences between BAU, SES and ASES

Scenario	Demand	Supply
BAU	Demand is forecast to grow in line with historical electricity consumption trends and projected GDP growth rates in a way similar to what is often done in government plans. Electric vehicle uptake was assumed to reach 20% across all cars and motorcycles by 2050.	Generator new entry follows that of power development plans for the country including limited levels of renewable energy but not a maximal deployment of renewable entry.
SES	Assumes a transition towards energy efficiency benchmark for the industrial sector of Hong Kong[12] and of Singapore for the commercial sector by year 2050. For the residential sector, it was assumed that urban residential demand per electrified capita grows to 975 kWh pa by 2050, 40% less than in the BAU. Demand-response measures assumed to be phased in from 2021 with some 15% of demand being flexible[13] by 2050. Slower electrification rates for the national grids in Cambodia and Myanmar compared to the BAU, but deployment of off-grid solutions that achieve similar levels of electricity access. Mini-grids (off-grid networks) are assumed to connect to the national system in the longer-term. Electric vehicle uptake as per the BAU.	Assumes no further coal and gas new entry beyond what is already understood to be committed. A modest amount of large scale hydro (between 4,000 to 5,000 MW) was deployed in Lao PDR and Myanmar above and beyond what is understood to be committed hydro developments in these countries[14]. Supply was developed based on a least cost combination of renewable generation sources limited by estimates of potential rates of deployment and judgments in on when technologies would be feasible for implementation to deliver a power system with the same level of reliability as the BAU. Technologies used include: solar photovoltaics, biomass, biogas and municipal waste plants, CSP with storage, onshore and offshore wind, utility scale batteries, geothermal and ocean energy. Transmission limits between regions were upgraded as required to support power sector development in the Vietnam as an integrated whole, and the transmission plan allowed to be different compared to the transmission plan of the BAU.
ASES	The ASES demand assumptions are done as a sensitivity to the SES: An additional 10% energy efficiency applied to the SES demands (excluding transport). Flexible demand assumed to reach 25% by 2050. Uptake of electric vehicles doubled by 2050.	ASES supply assumptions were also implemented as a sensitivity to the SES, with the following main differences: Allow rates of renewable energy deployment to be more rapid compared to the BAU and SES. Technology cost reductions were accelerated for renewable energy technologies. Implement a more rapid programme of retirements for fossil fuel based power stations. Energy policy targets of70% renewable generation by 2030, 90% by 2040 and 100% by 2050 across the region are in place. Assume that technical / operational issues with power system operation and control for a very high level of renewable energy are addressed[15].

[12]Based on our analysis of comparators in Asia, Hong Kong had the lowest energy to GDP intensity for industrial sector while Singapore had the lowest for the commercial sector.
[13]Flexible demand is demand that can be rescheduled at short notice and would be implemented by a variety of smart grid and demand response technologies.
[14]This is important to all countries because the GMS is modelled as an interconnected region.
[15]In particular: (1) sufficient real-time monitoring for both supply and demand side of the industry, (2) appropriate forecasting for solar and wind and centralised real-time control systems in place to manage a more distributed supply side,

PROJECTED DEMAND GROWTH

Figure 2 shows Viet Nam's on-grid electricity demand (including transmission and distribution losses[16]) in the Business As Usual scenario. Viet Nam's electricity demand is forecast to increase at a rate of 5.1% pa over the 35-year period to 2050 with a slowdown in growth beyond 2040 as growth rates trend towards those of developed countries and population growth rates slow.

Figure 2: Viet Nam Projected Electricity Demand (2015-2050, BAU)

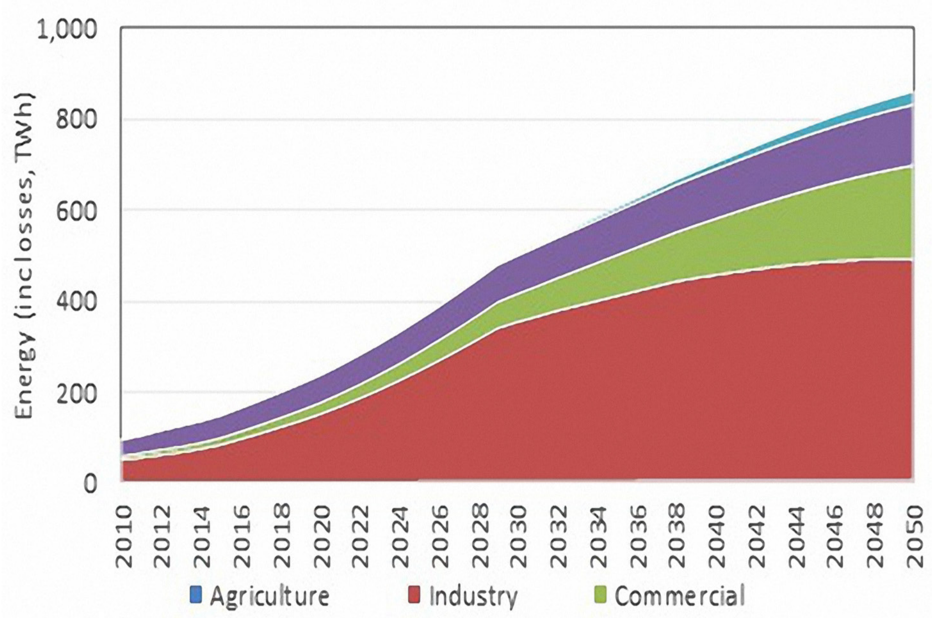
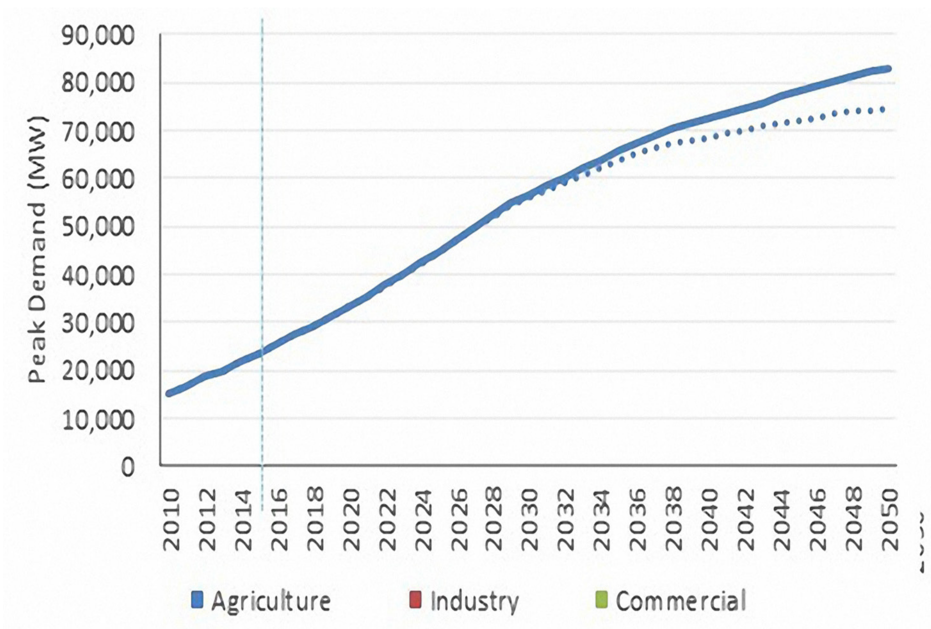


Figure 3 plots Viet Nam's forecast energy consumption from 2015 to 2050 with the BAU trajectory charted with a dashed line for comparison. The energy savings are due to allowing Viet Nam's energy demand to transition towards energy intensity benchmarks of comparable developed countries in Asia[17]. The SES demand grows at a slower rate of 4.0% pa over the period from 2015 to 2050.

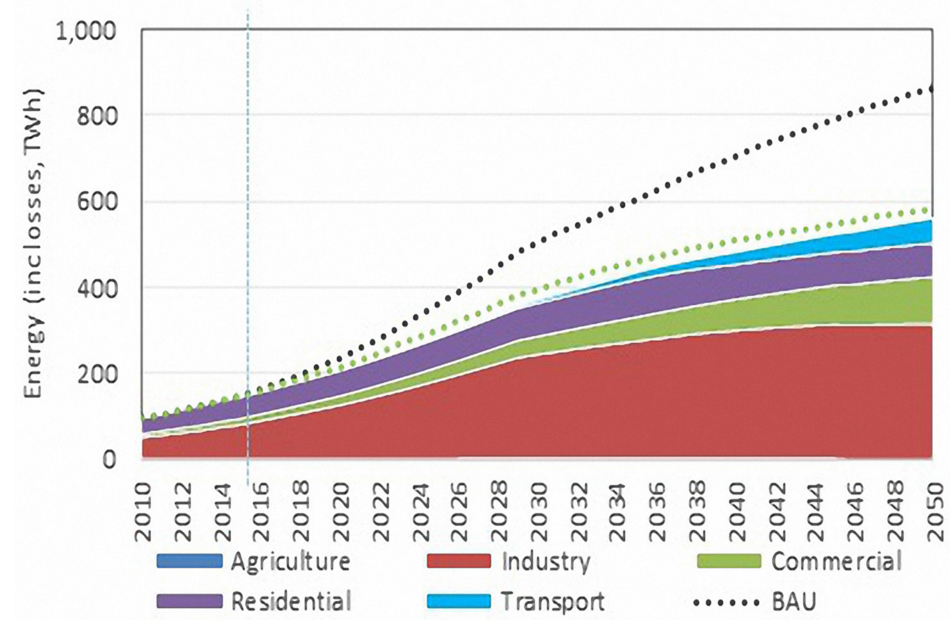
Figure 3: Viet Nam Projected Electricity Demand (2015-2050, SES)



storages and flexible demand resources, and (3) power systems designed to be able to manage voltage, frequency and stability issues that may arise from having a power system that is dominated an asynchronous technologies
[16]Note that unless otherwise stated, all other demand charts and statistics include transmission and distribution losses.
[17]Vietnam's industrial intensity was trended towards levels commensurate with South Korea (2014) by 2035 and allowed to decline at the same rate to 2050.

Figure 4 plots Viet Nam's forecast energy consumption from 2015 to 2050 with the BAU and SES energy trajectory charted with a dashed line for comparison. The ASES applies an additional 10% energy efficiency compared to SES. Electricity demand from the transport sector in the ASES is doubled compared to SES. It grows to 58 TWh, 10% of total electricity demand or 40% of all vehicles by 2050.

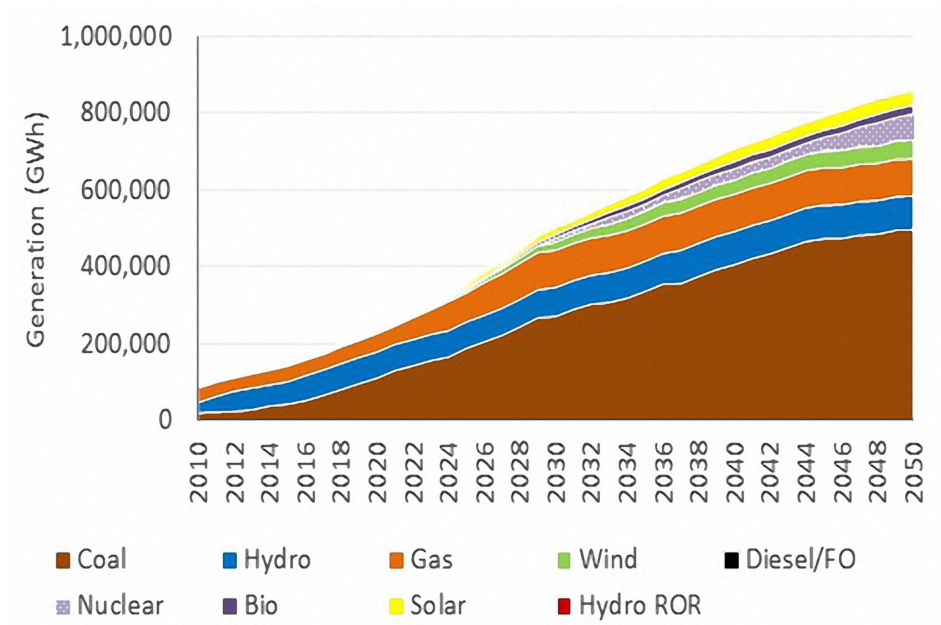
Figure 4: Viet Nam Projected Electricity Demand (2015-2050, ASES)



PROJECTED GENERATION MIX

Figure 5 plots the generation mix (on an as generated basis[18]) over time in the BAU case. Generation reflects additional generation required to export power to Cambodia from 2025 onwards. The most important problem identified in this scenario is that share of coal-based electricity generation will continuely increase over the planning period. This share is projected to reach more than 60% of the total electricity generation in Vietnam by 2050.

Figure 5: Viet Nam Generation Mix (BAU, GWh)



COMPARISONS AND ASSESSMENTS OF THE SCENARIOS

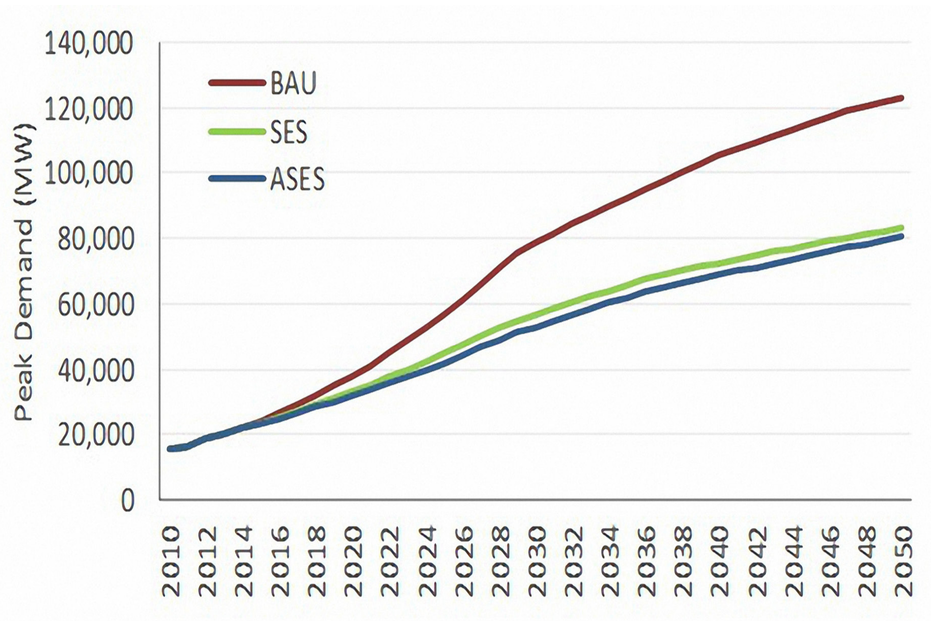
In order to understand the implications of the SES and ASES over the BAU, we have formulated a set of metrics to assist in their comparison. These are as follows:

- •Peak electricity demand per year
- •Energy intensity
- •Installed power capacity
- •Renewable energy percentage comparisons
- •Carbon emissions measures
- •Hydro power developments
- •A number of simple security of supply
- •Interregional power flows

ENERGY AND PEAK DEMAND

Figure 6 compares the total electricity consumption of the BAU, SES and ASES. As can be seen the energy consumption of the SES is lower than the BAU with the main driver being enhancements in energy efficiency in the SES. There is a similar situation for the ASES noting that electric vehicle uptake was doubled in the ASES.

Figure 6: Viet Nam Energy Demand Comparison

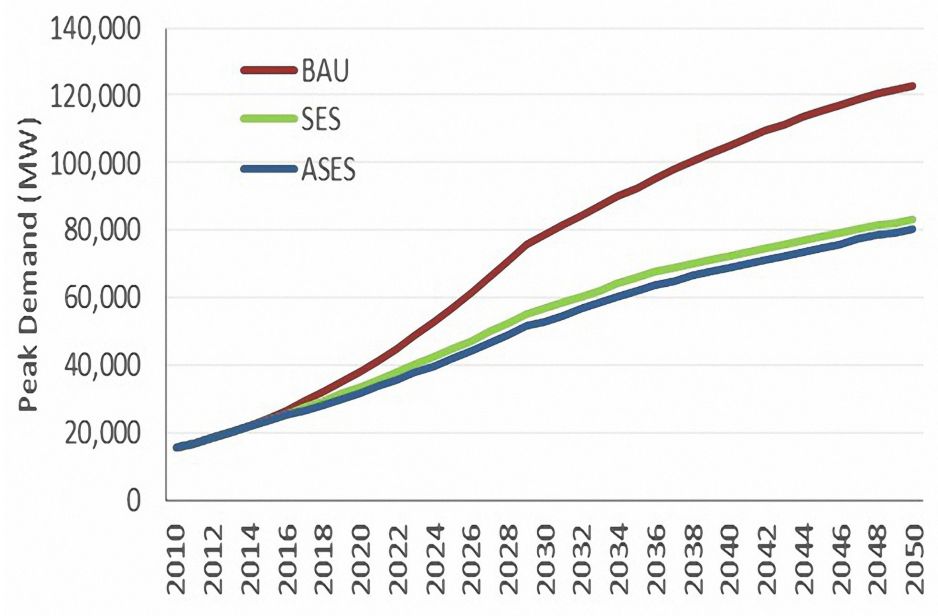


[18]Unless otherwise stated, all generation charts and statistics in this report are presented on an "as generated" basis, meaning that generation to cover generator's auxiliary consumption accounted for.

Summary Part A: Vietnam

Figure 7 compares peak load and shows the same relativities. This is attributable to improvements in load factor (reaching 80% by 2030 in SES and ASES). On top of this the SES and ASES have contributions from flexible and controllable demand that allows reductions in peak demand consumption included in the scenario as an assumption.

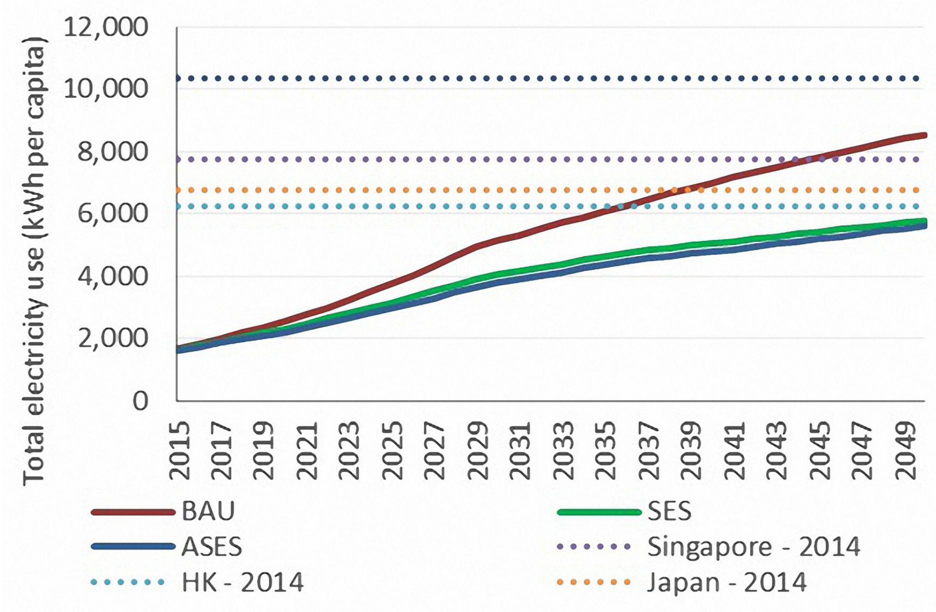
Figure 7: Viet Nam Peak Demand Comparison



ENERGY INTENSITY

Figure 8 plots the per capita electricity consumption per annum across the scenarios. In the BAU, per capita consumption levels increase at a rate of 4.8% to reach 8,500 kWhpa which is between Singapore and Taiwan's current levels. In the SES, it increases more slowly at 3.7% pa to reach 5,800 kWhpa and the ASES at 5,600 kWh by 2050. The SES and ASES assume higher energy efficiency savings keeping per capita consumption below Hong Kong's current levels. It should be noted that GDP growth assumptions remain constant across all scenarios with the difference in the ASES and SES being measures taken to improve energy efficiency.

Figure 8: VietNam Per Capita Consumption Comparison (kWhpa)



INSTALLED POWER CAPACITY

In the BAU Viet Nam is assumed to achieve 10% renewable energy in the generation mix by 2030 and this level is maintained with ongoing investment in renewable energy up to 2050. Solar consists of some 13% of total installed capacity by 2050. Wind and biomass generation developments occur in line with our understanding of government plans making contributions to the BAU's renewable energy target with some 19 GW and 3 GW of installed capacity by 2050 respectively.

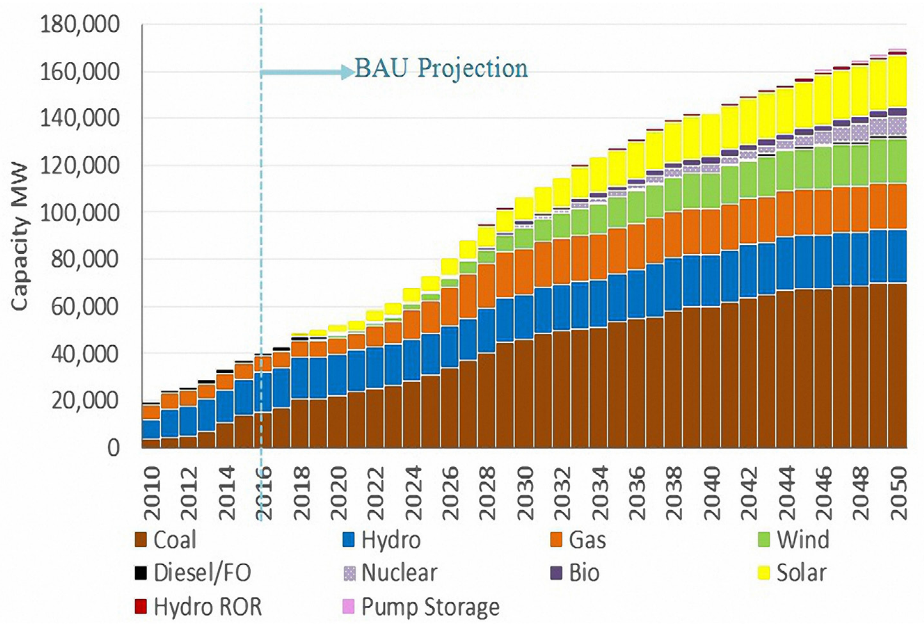


Figure 9: VietNam Installed Capacity (BAU, MW)

Figure 10 plots the installed capacity developments under the SES. Coal and gas fired-generation in the earlier years is very similar to the BAU due to committed projects. Over time, fossil fuel-based technologies drop off due to plant retirements and account for a combined total of 8% of total installed capacity by 2050 compared to 58% in 2015. Large-hydro penetration also decreases with planned large-scale hydro replaced with other renewable energy sources.

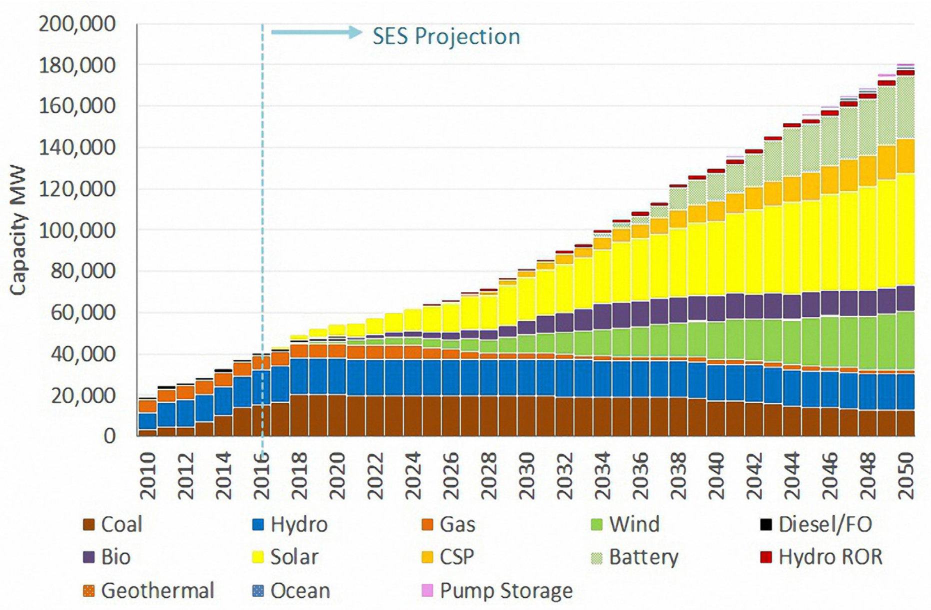


Figure 10: Viet Nam Installed Capacity by Type (SES, MW)

Figure 11 plots the installed capacity developments under the ASES. Committed and existing plants are assumed to come online as per the BAU but aren't replaced when retired. Existing thermal plant are retired early to meet the imposed renewable generation targets across the region. Renewable technologies ramp up much faster than in the SES to replace retirements of conventional generation technologies. By 2030 less than 25% of the installed capacity is based on fossil fuels; fossil fuels are entirely phased out by 2050.

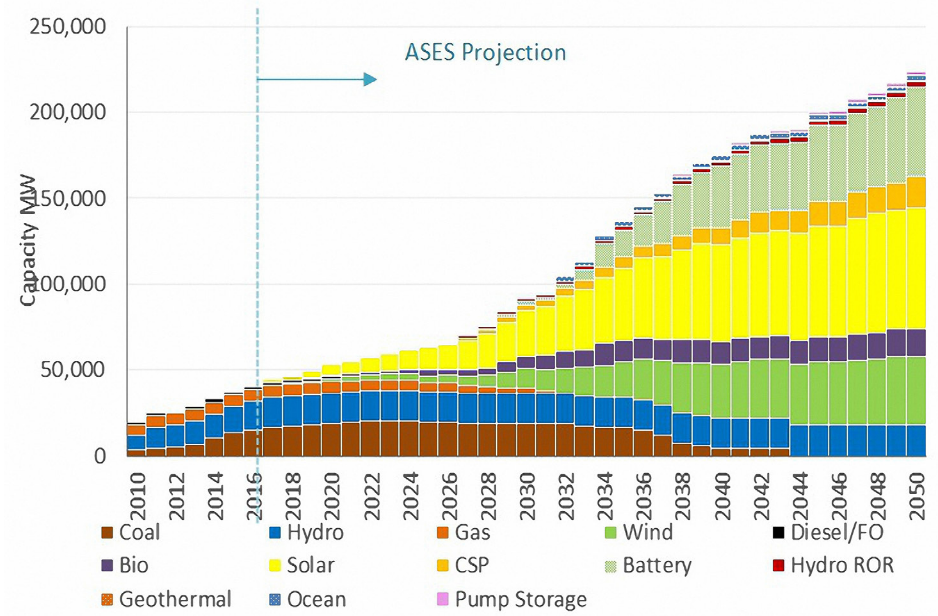


Figure 11: Viet Nam Installed Capacity by Type (ASES, MW)

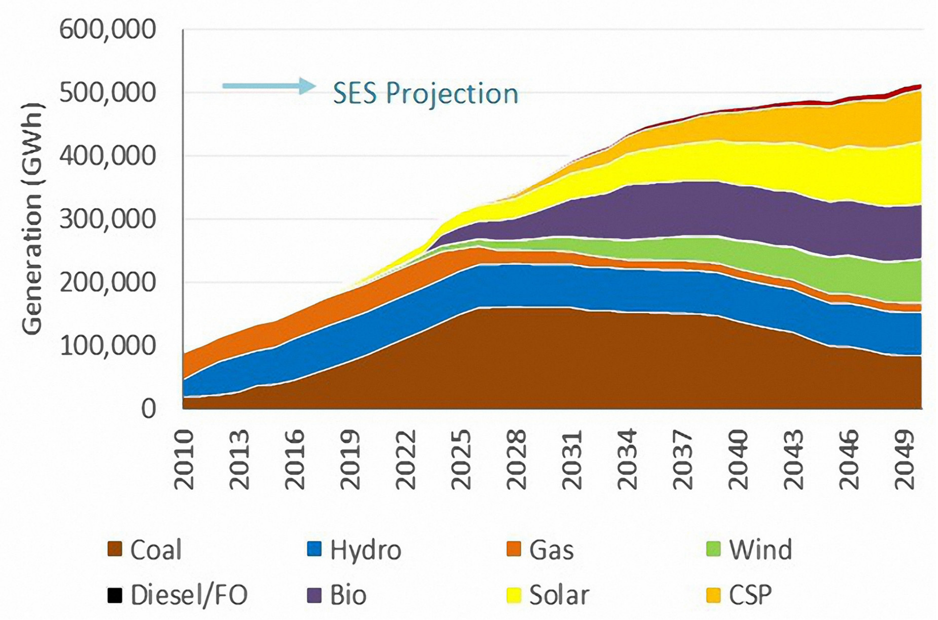
In SES, timing of renewable energy developments are based on the maturity of the technology and judgments of when it could be readily deployed in Viet Nam. Additional demand in the SES is predominantly met by renewables with 148 GW required to meet 2050 electricity demand from a small capacity base of large-scale and grid connected to some 54 GW of solar, CSP 17 GW, 12 GW of bioenergy and 28 GW of wind resources by 2050. Battery storage of 30 GW equivalent is also developed in conjunction with the significant solar PV capacity to support off-peak requirements. Small amounts of run-of-river hydro, ocean energy and geothermal are also developed in the later stages.

In ASES, by 2050 there is 68 GW of installed solar PV supported by 52 GW of battery storage (not including car batteries) capability mainly to defer generation for off-peak periods. Significant investment in offshore wind, bioenergy and CSP technologies occur to meet the rising demands, accounting for 5%, 7%, and 8%, respectively, of total installed capacity by 2050.

GENERATION MIX COMPARISON

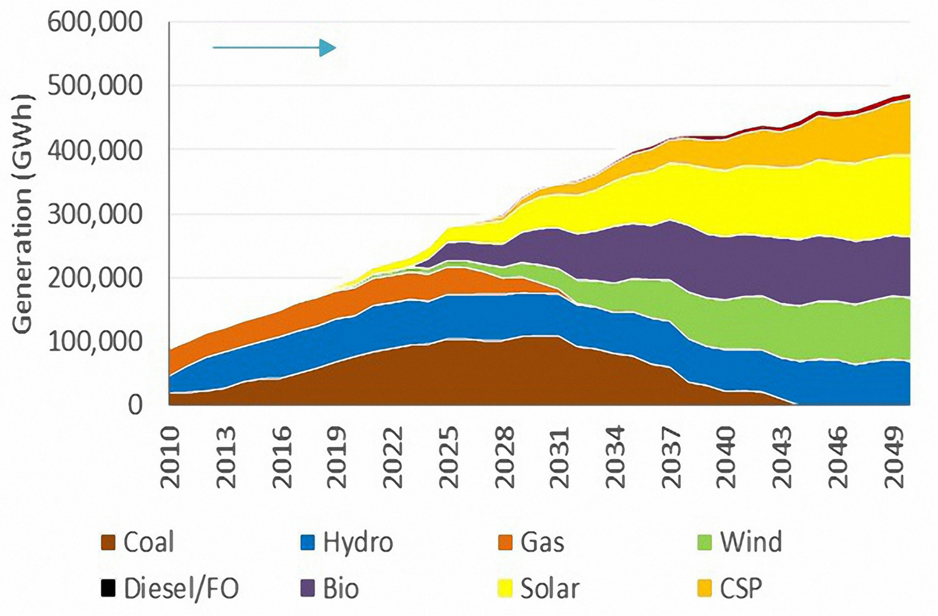
Grid generation is plotted in Figure 12[19]. Of the renewable technologies, by 2050, solar PV contributes the highest generation share (99 TWh) followed by CSP (82 TWh), bioenergy split between biomass and biogas (86 TWh), then onshore and offshore wind (69 TWh). Smaller contributions come from geothermal, ocean/marine energy and run-of-river hydro. By 2050 new renewable energy sources (excluding large-scale hydro) make up some 68% of the total generation requirement, or 81% including large-scale hydro.++

Figure 12: Viet Nam Generation Mix (SES, GWh)



ASES grid generation is plotted in Figure 13. Viet Nam's generation mix in the earlier years to 2020 is similar to the BAU case as committed new generation projects are commissioned and this has largely been kept the same. A notable difference is that there is an increase in wind and solar projects from 2016. Further non-renewable developments beyond 2019 cease; gas and coal-fired generation levels decline as units are retired while large-scale hydro generation continues at levels similar to current into the future, but the share of hydro generation decreases as there is no further large scale hydro development.

Figure 13: Viet Nam Generation Mix (ASES, GWh)



[19] Battery storage is not included as they are generation neutral (before efficiency losses).

Of the renewable technologies, by 2050, solar contributes the highest generation share (128 TWh) with 71 GW of installed capacity at 25% followed by wind at 20% then bio-energy and CSP at 19% and 17% respectively. By 2050 new renewable energy sources (excluding large-scale hydro) make up some 86% of the total generation requirement or 100% if large-scale hydro generation is included.

Figure 14 and Figure 15 show the renewable capacity and generation mix between the three scenarios. Renewables (including large-scale hydro) reach 41% in the BAU which is equivalent to a 24% generation mix compared to the capacity reaching 90% in the SES contributing 73%. The ASES has renewables (including large-scale hydro) accounting for 100% of total capacity and generation by 2050.

Figure 14: Viet Nam Renewable Installed Capacity Mix

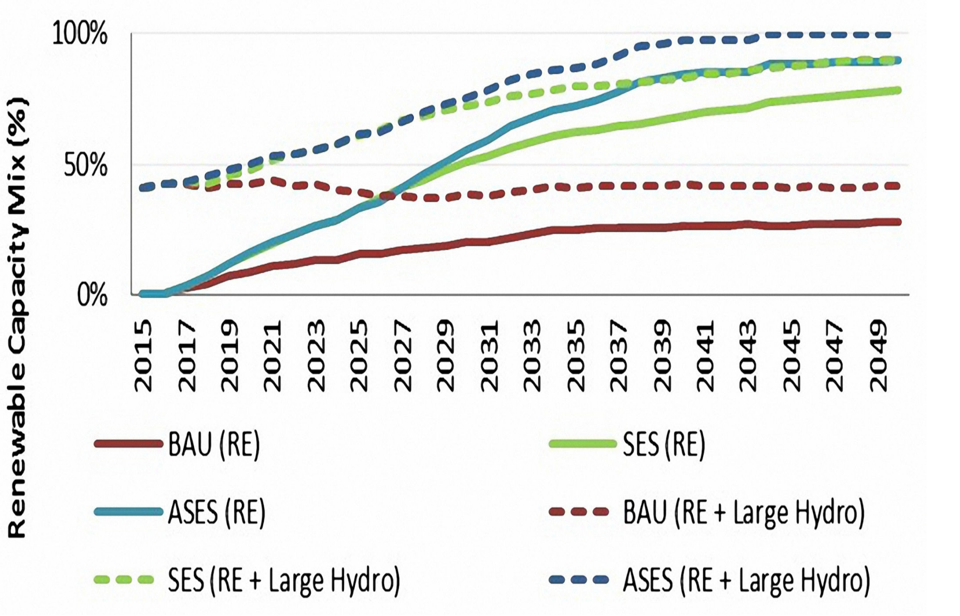
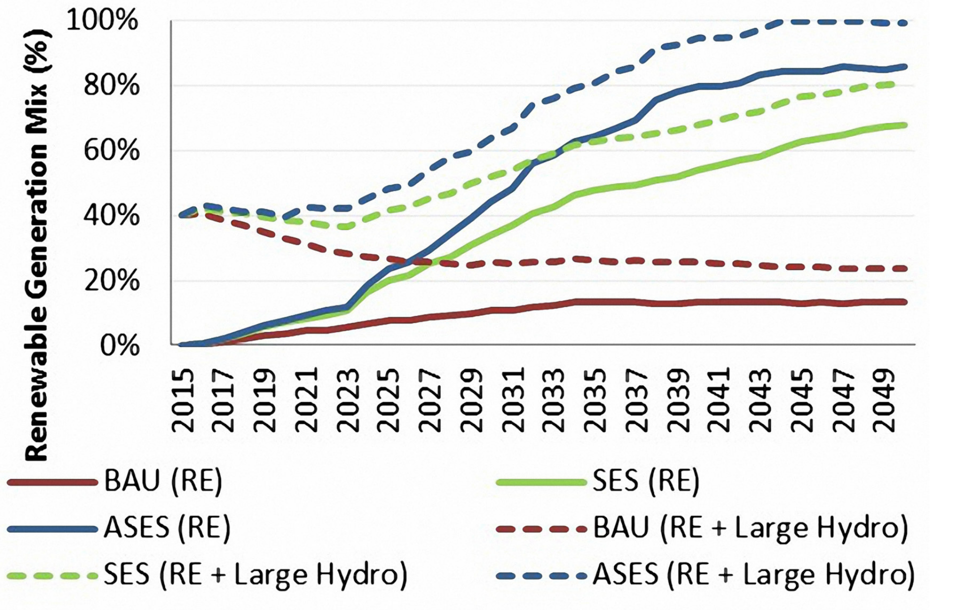


Figure 15: Viet Nam Renewable Generation Mix Comparison



CARBON EMISSIONS

Figure 16 and Figure 17 show the carbon intensity of Viet Nam's power system and the total per annum carbon emissions respectively. The carbon intensity increases in the early periods as committed coal enters the system. The SES trajectory then trends towards 0.15t-CO2e/MWh and the BAU ranges between 0.5 - 0.6t-CO2e/MWh beyond 2025. In terms of total carbon emissions, the shift towards the SES and ASES saves up to 383 and 461 mt-CO2e, respectively, or the equivalent of 82% and 100% savings respectively against the BAU as a baseline. The BAU emissions level continues to peak as a result of increasing demands and the reliance on coal.

Figure 16: Viet Nam Carbon Intensity Comparison

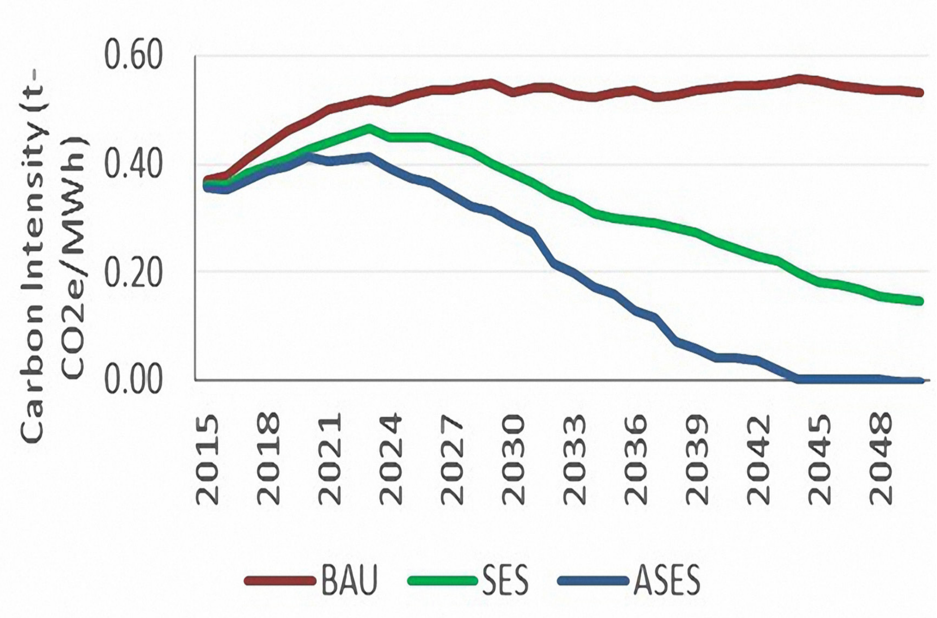
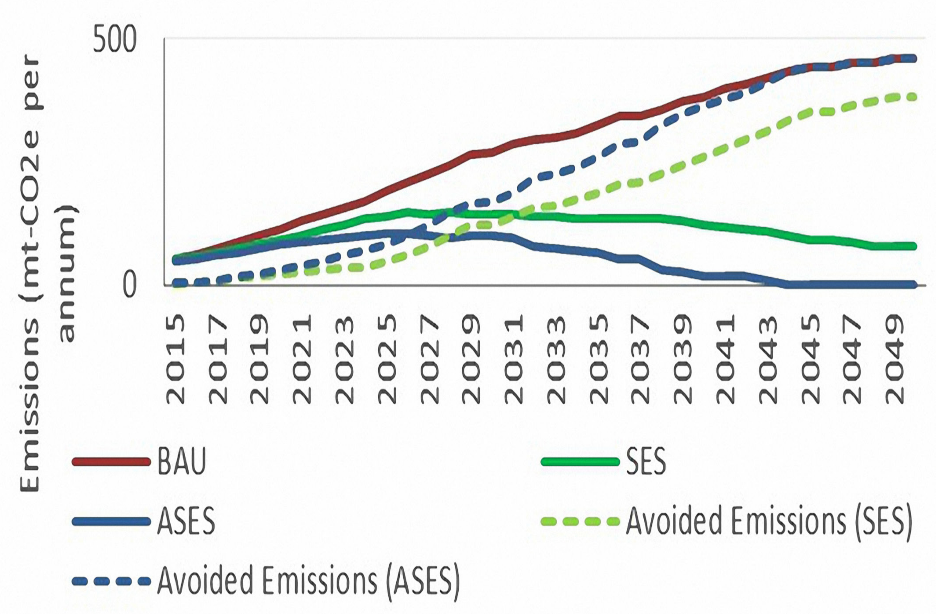


Figure 17: Viet Nam Carbon Emissions Comparison



MACRO SECURITY OF SUPPLY INDICATORS

For households and firms, security of energy supply means reliability. It is achieved by having a reserve margin in the power production system. For a country, national security of supply means energy independance. It is achieved by relying on domestic rather than imported energy sources.

Figure 18 plots the energy reserve margin calculated as the difference between the maximum annual production from all plants accounting for energy limits and the annual electricity demands. For electricity importing countries like Viet Nam, gross import limits have also been included. The figure below shows similar energy reserve margins with the SES and ASES having slightly lower margins around 2030 as gas and coal plants retire.

Figure 18: Viet Nam Security of Supply Measure: Energy Reserve

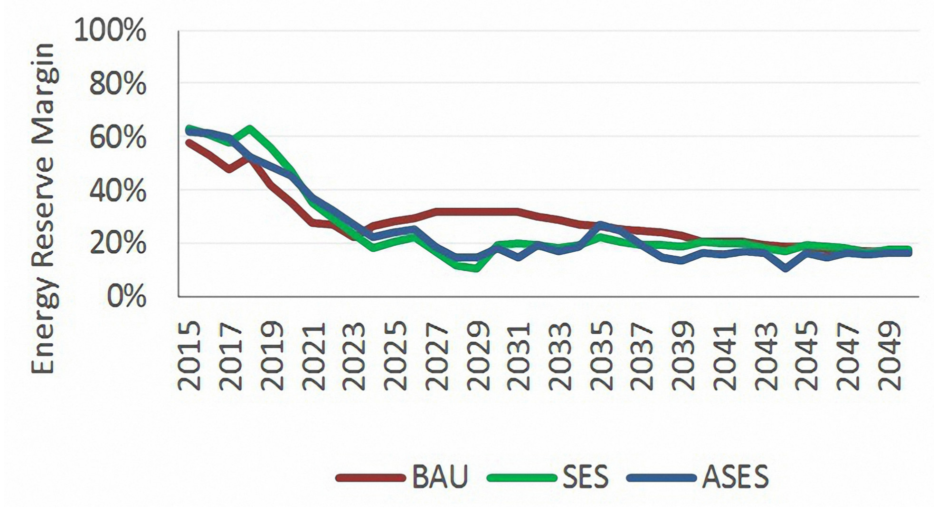


Figure 19 and Figure 20 show two simple national securities of supply measures.

The percentage generated using domestic fuel sources starts above 95% and declines over time to around 51% by 2050 in the BAU. The decline is driven by the increasing coal and uranium requirements that need to be imported. The security level in the SES and ASES case remains relatively high with the trend declining slightly in the first 15 years due to committed coal projects and settles around 85-90% from 2030 onwards. Although the ASES reaches 100% renewable generation, Viet Nam relies on imported electricity to satisfy up to 15% of its electricity requirements by 2050.

Figure 19: Viet Nam Security of Supply Measure: Percentage of Electricity Generated by Domestic Resources

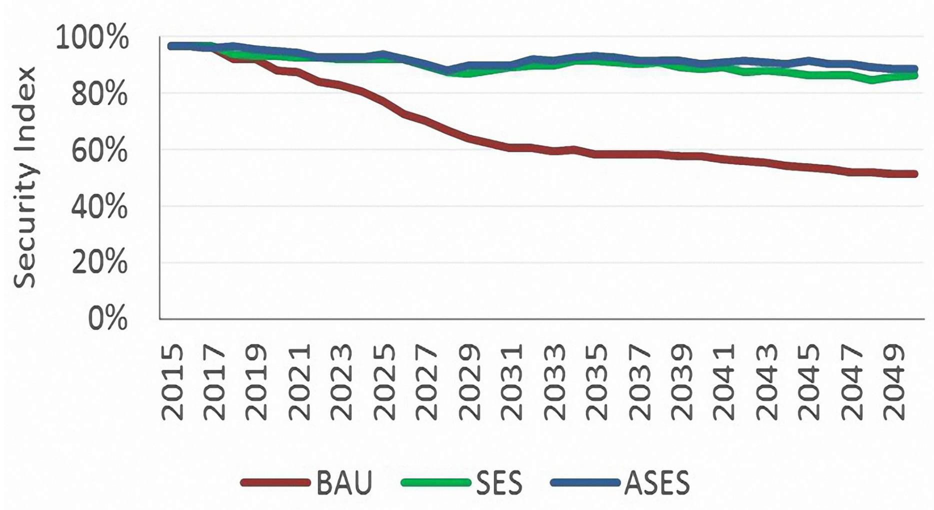


Figure 20 plots the highest share of generation from a particular fuel source. In the BAU, the dominance is held by large-scale hydro initially then becomes coal-fired focused through the rest of the horizon. In the SES and ASES, it is dominated by hydro then coal in the short-medium term, and then solar PV by the end of 2050.

Figure 20: Viet Nam Security of Supply Measure: Maximum Dominance of a Technology in Generation Mix

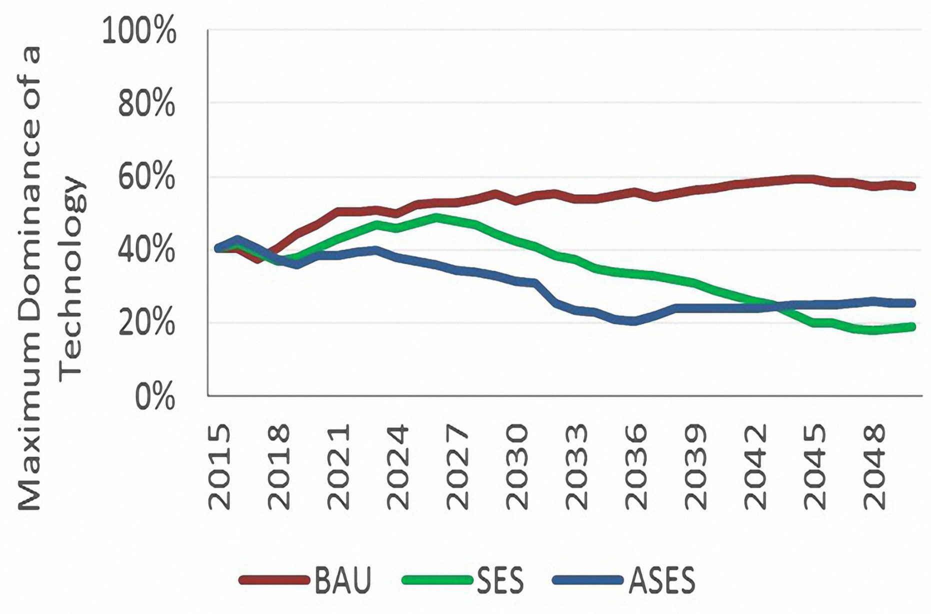
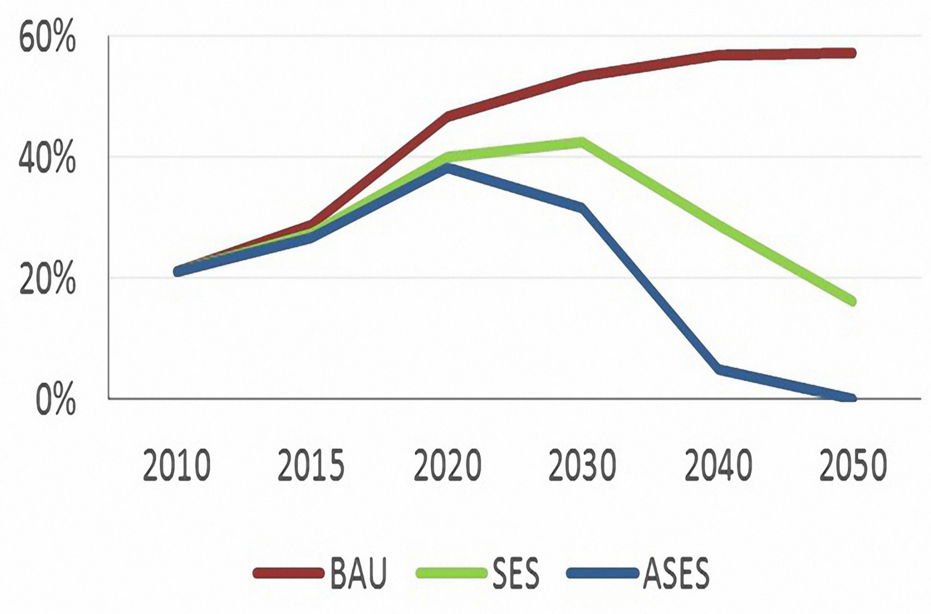


Figure 21 plots the dependence on coal in all scenarios. The coal share increases past 50% under the BAU case indicating higher reliance on imported fuel inputs whereas the SES and ASES decline from 2020 as no further coal projects come online, and older plants are replaced with renewable technologies towards 2050

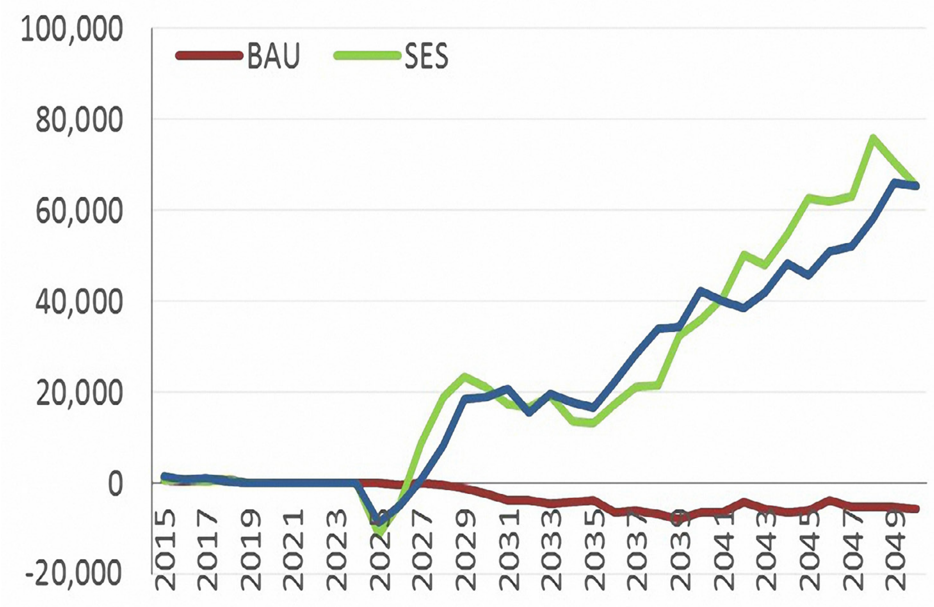
Figure 21: Viet Nam Security of Supply Measure: Coal Share



INTERREGIONAL POWER FLOWS

Figure 22 compares the net flows in and out of Viet Nam. The BAU has flows going out into Cambodia and up to 75,000 GWh of net imports in the SES and ASES primarily from Lao PDR to support ongoing demand growth as conventional generation technologies are retired. Imports account for approximately 15% of Viet Nam's total power requirements in the SES and ASES by 2050.

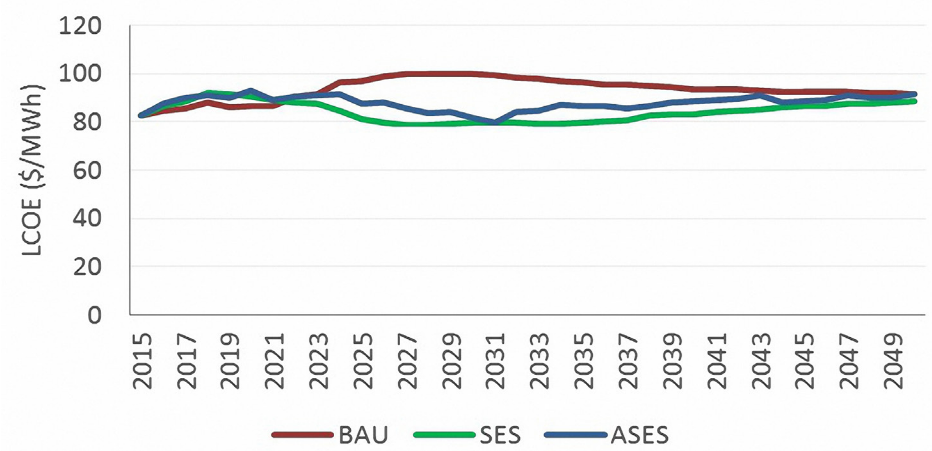
Figure 22: Viet Nam Imports (positive) and Exports (negative) (GWh)



OVERALL LEVELISED COST OF ELECTRICITY (LCOE)

The comparison of the LCOE (only includes generation costs) is shown in Figure 20. The LCOE for the BAU starts to increase initially as a result of increasing fuel costs returning to long-term averages then steadily declines to $91/MWh as coal and gas costs stay flat and lower cost renewable generation is added into the capacity mix

Figure 23: Viet Nam LCOE for Generation



The ASES and SES initially decline then rise from around 2030 onwards driven by more investment in higher cost renewable technologies and battery storage which increases the overall LCOE. The ASES LCOE experiences a step up in costs from 2030 primarily driven by ocean/marine energy developments. By 2050 the SES and ASES reaches $89/MWh and $91/MWh respectively. This LCOE analysis does not include the cost of externalities[20].

Figure 24: Difference in Capex, Opex and Energy Efficiency Costs (SES and BAU)

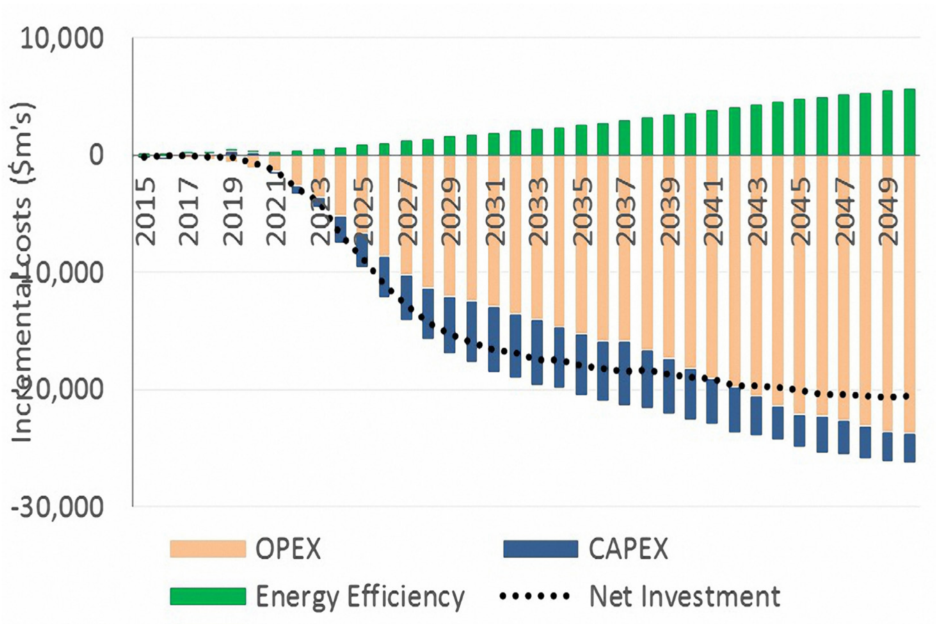
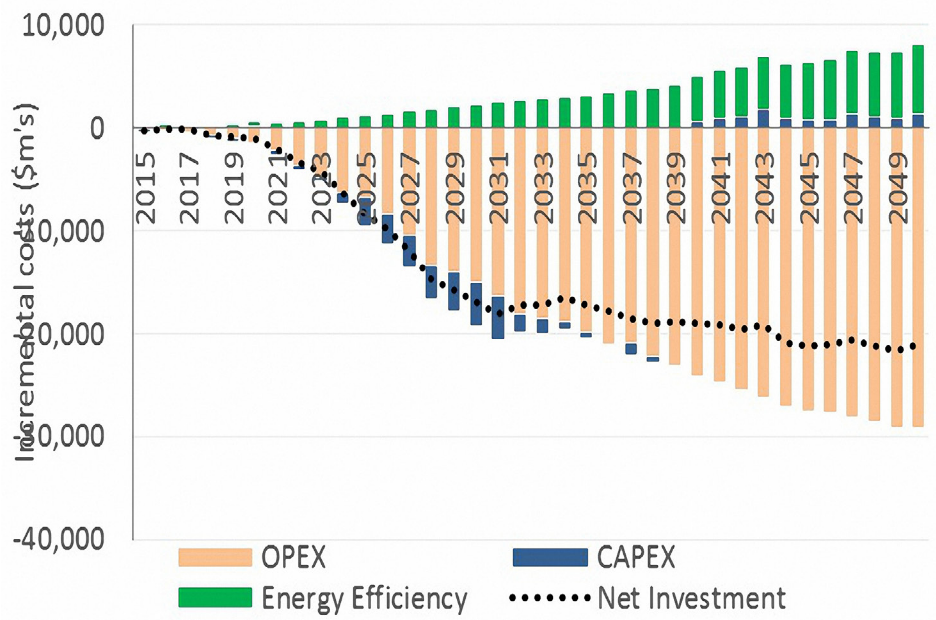


Figure 24 and Figure 25 plot the difference in amortised capex, opex and energy efficiency costs between the SES and BAU, and ASES and BAU respectively. The costs have also been adjusted for exports and imports. Positive amounts represent an additional investment required in either the SES/ ASES and negative amounts correspond to cost savings

The ASES follows similar trends to the SES with the noticeable difference of capex savings from 2030 onwards attributable to the replacement of retiring conventional plant with renewable technologies even with the assumed acceleration of capital cost drops. By 2050 the savings amount to $21 billion a year.

Figure 25: Difference in Capex, Opex and Energy Efficiency Costs (ASES and BAU)



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[20] A detailed study on the cost of externalities is presented in the following reference: Buonocore, J., Luckow, P., Norris, G., Spengler, J., Biewald, B., Fisher, J., and Levy, J. (2016) 'Health and climate benefits of different energy-efficiency and renewable energy choices', Nature Climate Change, 6, pp. 100–105.

CHALLENGES AND POLICY RECOMMENDATIONS

The results from the three scenarios show that Vietnam 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.

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/barriers are outlined on the following pages. Additional high level recommendations can be found in the next part.

BARRIERS TO DEVELOPMENT OF RENEWABLE ENERGY IN VIET NAM[21]:

Policy and institutional barriers include:

- Absence of clearly defined national strategies and legally bound targets for renewable energy, lack of a uniform legal framework with high level legislations such as a law or a degree to stipulate and mandate strong mechanisms for development of renewable energy;
- Absence of a state-level focal point organisation dedicated to managing the renewable energy area (currently the RE is overseen by a department within the GDE but there have been suggestions for establishing a national committee for renewable energy[22]).

Technical barriers:

- Overall knowledge on renewable energy technology in the country remains limited;
- Absence of training organisations and facility leading to a lack of qualified experts and skilled technicians;
- Viet Nam does not have sufficient trade companies who can supply renewable energy equipment and related services. Most of renewable energy technologies are imported with limited after installation service;
- Absence of adequate and reliable technical data / measurements as regards renewable energy potentials; and
- Lack of design and operational and safety standards.

Economic and financial barriers:

- Lack of adequate incentive mechanisms for development of renewable energy sources and lack of financial support mechanisms in place for some forms of renewable energy: solar and geothermal for example;
- High investment costs and high electricity production cost, which is partly due to the limitations in access to appropriate technology and skilled manpower plus the economy of scale factor;
- Difficulty in accessing financial sources for renewables energy projects which are highly capital intensive;
- Significant subsidies for conventional electricity discouraging investments into renewable energy.

[21] This information in this section is based on various reports including: IE Study on Renewable Energy Development in Viet Nam (2009) and the USAID-sponsored study on Off-Grid Opportunities and Challenges in Viet Nam (2014).
[22] http://nangluongvietnam.vn/news/vn/du-bao-kien-nghi/kien-nghi-thanh-lap-uy-ban-quoc-gia-ve-nang-luong-tai-tao-viet-nam.html

Barriers for specific renewable energy technologies:

- *Small hydro power:* for Off-grid generators: Cheap and low quality technology imported from China is still dominating in the off-grid remote mountainous areas in Viet Nam. This course of development is regarded unsustainable as the site installations usually lack of proper operator training, lack of manuals translated into Vietnamese and poor commissioning procedures. Grid-connected plants: concerns related to the unpredictable movements in the administered avoided cost tariff prices over the economic life of the project.
- *Wind power:* issues include: (1) lack of experience and technology that have been tested under Viet Nam's particular conditions (high risk of typhoon, high humidity, etc.), (2) absence of management and business models for successful O&M of a wind farm, even for small wind farms suitable for application to Viet Nam's offshore Islands (where wind-diesel hybrids represent an important option to lower the costs of traditional diesel generation), (3) some of the provinces with good wind potentials such as Binh Tuan and Ninh Thuan are also rich in minerals which creates a conflict in land use (wind parks vs. mines).
- *Solar power:* (1) a particular policy and legal framework to support solar power installations (e.g. feed-in tariff) is yet to be developed in Viet Nam, (2) local producers of solar equipment and appliances have difficulties competing in quality with imported panels and side equipment from Europe and China, and the equipment failure rate is high, and therefore the trust in local equipment is low, (3) there are no standards reported for solar technologies; performance standards, equipment certification and codes of practice for quality control need to be developed and accepted; lack of incentives for the establishment and adherence to such technical standards.
- *Biomass:* (1) Most of the technologies are imported without consulting and technical services for biomass power technologies, especially maintenance and repair services after installation. (2) Locations of the residues are scattered throughout the country. For example, rice is not always processed in a central, large scale, location so the residues are normally spread over a large area especially in the remote areas.
- *Biogas:* Electricity production from biogas has faced very specific technology barriers, in particular, fragmented and artisan production of spare parts and instruments which means the quality and compatibility of the equipment and spare parts replaced as the technology is not standardised.

Barriers related to energy efficiency include:

- *Information barrier*: Energy users remain unaware of potential energy savings and their financial benefit, and how to attain them.
- *Expertise barrier*: Appropriate expertise to advise clients on energy savings options and conduct energy audits is not readily available locally.
- *Energy Pricing Barrier*: Higher and cost reflective energy prices are an exceptionally powerful force to attract attention to energy efficiency and to increase incentives for action. In Viet Nam, prices paid for energy are low relative to those in most other countries. Despite frequent increases, the actual level of electricity tariffs has not risen in real terms over the past decade.

Other factors that impede the development of renewable energy and application of energy efficiency measures in Viet Nam might include:

- Lack of social acceptance and support for clean energy.
- Low awareness among customers and in wider communities about the benefits from renewable energy and energy savings, and about environmental damage costs resulting from use of fossil fuels; and
- Lack of educational and information strategies and plans.

RECOMMENDATIONS

The following are key recommendations to reduce the barriers and "enable" the SES and ASES:

Energy conservation

How can we do more while using less energy?

- Introduce legally binding minimum efficiency standards for all products that consume energy, Governments, companies and experts will need to agree on the standards, which should be monitored and strengthened over time.
- Strict energy-efficiency criteria for all new buildings, aiming toward near-zero energy use. 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.
- In the industry sector, mandatory periodical energy audits for establishments consuming over 300 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).
- Individuals, businesses, communities and nations all need to be more aware of the energy they use, and try to save energy wherever possible. 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.

Renewables, electrification, grids and storage

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

- Large-scale as well as distributed renewable power generation needs to be built urgently. Utilities need to use smart grid technologies to open up access to renewable energy projects.
- An improved regulatory framework for renewable energy is required. This framework should include a system to award licences for RE projects, encourage distributed systems, national grid connection rules and a tariff system. The tariff system needs to be dynamic and be adjusted to cost reductions of renewables, so that it is not too low to encourage new installations, but at the same time, not too high to avoid an excessive financial burden on the consumers or the government.
- The data on the existing grid capacity and grid management should be accessible to all stakeholders. The governments should also announce plans for future grid connections for RE projects, and let companies apply for grid capacity.
- Planning of renewable energy zones with extensive stakeholder participation helps the private sector access suitable land for projects.
- An institutional framework should provide an arbitral 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, biogas).
- We need urgent adequate 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.
- National renewable energy and energy efficiency targets should be articulated at provincial and local level, to increase ownership and participation.

Electricity exchange between countries and power sector strategies

- 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.

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?

- All large-scale energy infrastructure developments must satisfy independent, in-depth social and environmental impact assessments. For hydropower, WWF has participated in the development of the International Hydropower Association Sustainability Guidelines.
- We need to carefully analyze what land and water is available for bioenergy, taking social, environmental and economic issues into account.
- 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.
- 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.

Finance

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

- 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.

- Global climate negotiations have provided finance and technology opportunities. It is now up to the governments, the private sector and other organisations in Vietnam to prepare plans and claim a substantial part of this financial support.
- 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.

Innovation

What advances will make our renewable energy vision a reality?

- 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.
- 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

- Provide the right enabling framework for companies to invest in renewable energy and energy efficiency
- Ensure a sustainable electricity grid mix to attract companies that are serious about their environmental performance and worried about unstable electricity prices.

CONCLUSIONS

COP21, in December 2015, in Paris confirmed the global willingness to avoid 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 hydro power outstrips environmentally and economically sustainable 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, how 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 Vietnam 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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VIETNAM'S POWER SECTOR by 2050 in numbers

100%

renewable energy technology mix

100%

of CO_2 emissions reduction

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33%

of electricity needs reduced by using energy efficiently

43%

electricity generation from solar energy

Why we are here

To stop the degradation of the planet's natural environment and to build a future which humans live in harmony with nature

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