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LONG-TERM GREENHOUSE GAS EMISSION MITIGATION OPPORTUNITIES AND DRIVERS IN VIET NAM

Meeting Paris Agreement Targets and Accelerating Progress towards the SDGs

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List of Acronyms

ADB	Asian Development Bank
BAU	Business-As-Asual
CCWG	Climate Change Working Group
CGE	Computational General Equilibrium
DARD	Department of Construction
DOIT	Department of Industry and Trade
DONRE	Department of Natural Resources and Environment
DOT	Department of Transportation
ECC	Energy Conservation Centre
EE	Energy Efficiency
EIA	Environmental Impact Assessment
ERAV	Electricity Regulatory Authority of Viet Nam
ESCOs	Energy Service Companies
EU	European Union
EVN	Electricity Viet Nam
FDI	Foreign Direct Investment
FiT	Feed-in-Tariff
GDP	Gross Domestic Product
GHG	Greenhouse gas
GIZ	Gesellschaft für Internationale Zusammenarbeit
GW	Giga Watt (1,000 MW or 1,000,000 kW)
JICA	Japanese International Cooperation Agency
kOE	kilograms of oil equivalent
kW	kilo Watt
kWh	kilo Watt hour
LCOE	levelized cost of energy (electricity)
LNG	liquified natural gas
LULUCF	Land Use, Land Use Change and Forestry
MARD	Ministry of Agriculture and Rural Development
MIC	Middle Income Country
MOC	Ministry of Construction
MOF	Ministry of Finance
MOIT	Ministry of Industry and Trade
MONRE	Ministry of Natural Resources and Environment
MOT	Ministry of Transport
MtCO2e	million tonnes of carbon dioxide equivalent
MPI	Ministry of Planning and Investment
MW	Mega Watt (1,000 kW)
MWh	Mega (million) Watt hour
NAMAs	Nationally Appropriate Mitigation Actions
NDC	Nationally Determined Contribution
ODA	Official Development Assistance
PDP7	Power Development Plan 7
PDP7-revised	Power Development Plan 7-revised
PDP8	Power Development Plan for the period 2021-2030 (and outlook to 2040)
PPA	Power Purchase Agreement
RE	Renewable Energy
REDS	Renewable Energy Development Strategy
RPS	Renewable Portfolio Standards
SDGs	Sustainable Development Goals
SMEs	Small and Medium Enterprises
SoEs	State owned Enterprises
solar PV	solar Photovoltaics
TWh	Tera Watt hour (one billion (109) kilo Watt hour)
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
VBF	Viet Nam Business Forum
VNEEP	Viet Nam Energy Efficiency Programme

Foreword

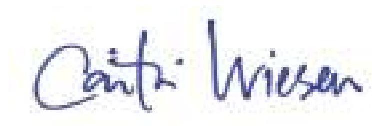
Climate change is one of the most pressing global challenges today. The United Nations Secretary-General's address to the General Assembly on 25 September 2018 urged all UN member states to approach their mitigation actions and commitments under the Paris Agreement with greater ambition and a sense of urgency. Climate action also presents a tremendous development opportunity, and if strategically managed, could add USD 26 trillion to the global economy and create 24 million new jobs worldwide by 2030.

Viet Nam is proactively implementing the Sustainable Development Goals and the Paris Climate Agreement and has committed to an 8% reduction in annual emissions with domestic means t by 2030 when compared to the business as usual scenario.

In this context, the UNDP discussion paper "Long-term Greenhouse Gas Emission Mitigation Opportunities and Drivers in Viet Nam: Meeting Paris Agreement Targets and Accelerating Progress towards the SDGs" shows that quality economic growth with ambitious and economically attractive climate change actions in Viet Nam is possible. The paper examines all major sources of greenhouse gas emission and opportunities for their reduction, with a special focus on the transition to high renewable energy penetration and energy efficiency that can improve Viet Nam's energy independence and shift Viet Nam to a low carbon development pathway.

The paper suggests that even if Gross Domestic Product (GDP) growth might be lower in the first few years compared to the business as usual scenario, a path to becoming free from fossil fuels by 2050 will increase GDP growth and provide social, environmental, and health benefits.

The intention of this paper is to contribute to making the case that clean, green investment decisions made today will have significant long-term benefits both in terms of greenhouse gas reduction as well as in economic growth. Reaping these opportunities will help lay the foundations for a green robust economy in Viet Nam where no one is left behind.



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Disclaimer: This policy paper has been prepared by Koos Neefjes (consultant) and was supervised by Akiko Fujii and Dao Xuan Lai (UNDP Viet Nam). The findings, interpretations and conclusions expressed are those of the author and do not necessarily reflect the views of the United National Development Programme in Viet Nam.

Summary of Conclusions and Recommendations

The following is a summary of conclusions and recommendations regarding long-term greenhouse gas emission mitigation opportunities and drivers in Viet Nam, so that it will grow sustainably while limiting GHG emissions to levels consistent with the Paris Agreement, and it will get multiple co-benefits that should also help achieving several of the SDGs.

1. Viet Nam's Nationally Determined Contribution (NDC) under the UNFCCC's Paris Agreement is commendable, but the world needs more ambition in greenhouse gas (GHG) emission reduction. Viet Nam is currently reviewing and revising its NDC, and it can increase its contribution. Increasing GHG emission reduction makes a larger contribution to achieving the international GHG emission reduction targets, can give Viet Nam immediate economic, social and environmental benefits, and will help it to achieve several SDGs.

2. Viet Nam can strengthen GHG emission reduction in all categories of emissions, including Land Use, Land Use Change & Forestry (LULUCF), agriculture, waste and industrial production, and especially in energy production and consumption. GHG emissions from energy production and consumption are the bulk of Viet Nam's current and future emissions, quadrupling between 2010 and 2030 in absolute total, and making up 86 percent of total net-emissions in 2030, according to the BAU scenario.

3. Macro-economic analysis shows that increasing GHG emission reduction ambitions beyond the current NDC will likely mean that Viet Nam's GDP will grow faster; generate new green and clean jobs; and increase various exports, because of technological modernisation and efficiencies. This requires Viet Nam to use opportunities and drivers for expanding RE deployment and increasing EE. The effects on inflation from an initial energy price increase are likely to be small, and energy prices are likely to be lower in the medium to longer term, compared to BAU. Energy transition will not only help to achieve high emissions reduction ambitions, but also minimise dependency on international fossil fuel markets and transport and increase national energy security.

4. Achieving the NDC targets or even higher emission reduction targets than the conditional 25 percent reduction from BAU by 2030, will require major investments, especially in the energy sector. Investment capital can be generated by the private sector. Vietnamese banks would be able to supply a large part of the required capital for EE investments. Foreign investment for RE is available, and improved regulations are needed to unlock this, e.g. by making power purchase agreements (PPAs) bankable. Any public investment still allocated to the energy sector should be used strategically, for example for improving electricity transmission and distribution systems.

5. The economic, social and environmental co-benefits of mitigation actions in the energy sector, as well as LULUCF, agriculture and waste, will very likely also support the achievement of several SDGs. Viet Nam can and should especially achieve the SDG7 targets by 2030 on access to energy for all; increased renewable energy deployment; and a doubling of the rate of energy efficiency. This will provide many related benefits such as a cleaner and healthier environment for people, e.g. because current plans for more coal-power plants could result in thousands of additional premature deaths per year by 2030 because of air pollution, which would be prevented.

6. Additional and expanded technologies for increasing carbon sequestration or reducing emissions from LULUCF, agriculture, and waste can be applied in financially attractive ways, and help increase emissions beyond the current NDC targets. The main driver to achieve this is technology. Many technologies in LULUCF, agriculture, and waste also provide environmental and social co-benefits.

7. Viet Nam currently lags behind many other countries in RE deployment. The main driver for energy transition will be financial because the investment costs of solar Photovoltaics (solar PV) and wind power have declined considerably and are expected to decline further. Solar PV and wind power technologies were developed with years of R&D and investments in other countries and now the economies of scale of manufacture and deployment can benefit countries like Viet Nam. The levelized costs of energy (LCOE) produced by solar PV and wind power has already become cheaper than coal-based power generation in some circumstances. If the environmental and social (health) externalities would be accounted for in the price of fossil fuelbased power, through for example taxation, solar PV and wind are already competitive in Viet Nam.

8. The LCOE of small scale (rooftop) solar PV available in the Vietnamese market can already off-set most electricity retail tariffs in Viet Nam. There is a need for further simplification and enforcement of regulation on net-metering, to encourage households and businesses to invest, benefit from lower expenditure, reduce demand from centralised power plants during peak hours, and reduce national emissions.

9. By some estimates, Viet Nam's power sector could become carbon neutral by 2050, with strongly improved EE and deployment of RE. This includes using the substantial potential of solar PV and wind power, which are currently estimated to be at least 85 GW and 21 GW installed capacity, respectively. This could deliver about as much power as current total installed capacity in Viet Nam can deliver. The potential may be even larger, because solar PV and wind power can be combined with other forms of land use, and off shore wind may expand beyond earlier estimated regions. There is also additional potential for biomass based power (that would e.g. reduce the need for landfilling waste) and other forms of clean power generation.

10. Viet Nam's EE per unit GDP is comparatively low. However, low cost improvements in EE are possible and will reduce expenditure of industries and consumers. In the first years of energy transition, energy prices may go up by a modest 15-20 percent, e.g. because of a carbon tax to account for external costs of fossil fuel use and elimination of all indirect support to fossil fuel consumption. Higher prices would be a primary driver for more investment in EE as well as RE. Measures to assist businesses to cope with higher prices and improve EE exist and can be improved. This will also affect low income groups, and mechanisms to assist them exist and can be modified, in particular progressive electricity retail pricing. Furthermore, in the medium to long term, improved EE, reduced importation of fuel, and lower RE costs will reduce the cost of electricity in Viet Nam.

11. Electrification of transport is gathering pace internationally, but Viet Nam has not yet addressed this opportunity in transport policies or the NDC. Its car park and bus fleets are expanding rapidly, which means a lock-in of at least 5-10 years of local pollution, but this could be partially avoided. In combination with RE generation, the batteries of vehicles can be charged during supply peaks of intermittent solar and wind power, creating a large "virtual" energy storage. As a result, national GHG emissions would be substantially mitigated when compared with the NDC targets.

1. Introduction

Viet Nam is a Middle Income Country (MIC) of about 93 million people (as of 2016), and an economy growing at more than 6 percent per year. Viet Nam is particularly vulnerable to the effects of climate change. Extreme weather events cause many casualties annually and suppress economic growth, and extremes are getting worse as a result of climate change. According to an indicator on human casualties and GDP losses from extreme weather events (Eckstein et al., 2017), Viet Nam ranks as 8th worst affected country globally over the period 1997 to 2016.

Global climate change is caused GHG emissions, and the world is on an emissions growth path that will likely lead to dangerous climate change (IPCC, 2014). The Paris Agreement under the United Nations Framework Convention on Climate Change (UNFCCC) agreed to limit average global warming to 2 degrees above pre-industrial temperatures and preferably no more than 1.5 degrees Celsius. But in 2016 we surpassed 1 degree Celsius levels and the joint "contributions" that Parties to the UNFCCC have made will likely lead to about 3 degrees warming. Indications are that maximum 2 degrees warming would be very difficult to achieve, and 1.5 degrees almost unrealistic. However, 1.5 degrees would significantly limit the effects of climate change, e.g. in terms of sea level rise, droughts and flood risks when compared to 2 degrees warming.

Depending on the scenario and target selected, the world must peak emissions by 2020 or 2025 and reduce net-emissions at increasing rates to the point of carbon neutrality and negative net emissions in the second half of the century. The gap between the emissions reductions necessary to achieve the Paris Agreement targets and the pledged NDCs "is alarmingly high", and "if the emissions gap is not closed by 2030, it is extremely unlikely that the goal of holding global warming to well below 2°C can still be reached" (UNEP, 2017).

Against this backdrop, Viet Nam's GHG emissions are growing at a very high rate. In its Nationally Determined Contribution (NDC) to the UNFCCC, Viet Nam has committed to reducing annual emissions with domestic means by 8 percent in 2030 when compared to the BAU scenario, or 25 percent on condition of international support (SR Viet Nam, 2015a). The Government of Viet Nam is currently reviewing the NDC and is considering adjusting the mitigation targets, which according to the Paris Agreement would signify an increase in ambition, not a decrease.

Even though historical emissions were the responsibility of developed countries, various estimates of permissible future emissions that would lead to 2 or 1.5 degrees maximum warming, show that developing countries like Viet Nam are already near or beyond a reasonable estimate of their per capita emissions "budget" too. This means that MICs, such as Viet Nam, should very soon stop increasing their emissions and set a target for national peaking of emissions, after which they would steadily reduce emissions in absolute terms, helping the world move towards net zero emissions.

This paper reviews official documents and research findings and examines how Viet Nam can grow sustainably while limiting GHG emissions to levels consistent with the Paris Agreement. It identifies opportunities and drivers for long-term greenhouse gas emission mitigation in Viet Nam with multiple co-benefits that should also help achieve several of the Sustainable Development Goals.

This paper covers all major sources of GHG emissions in Viet Nam (sections 2 and 3). Since future emissions growth as well as opportunities for reduction exist mainly in energy production and consumption, the focus of the paper is on the transition to high renewable energy penetration and high energy efficiency (sections 4 and 5). This is consistent with the messages from reports by the Intergovernmental Panel on Climate Change (IPCC), [1] that a strong reduction in energy demand and increase in renewable energy are critically important for the drastic reduction in GHG emissions that is required.

1 *Including the forthcoming "IPCC special report on the impacts of global warming of 1.5 °C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty." October 2018.*

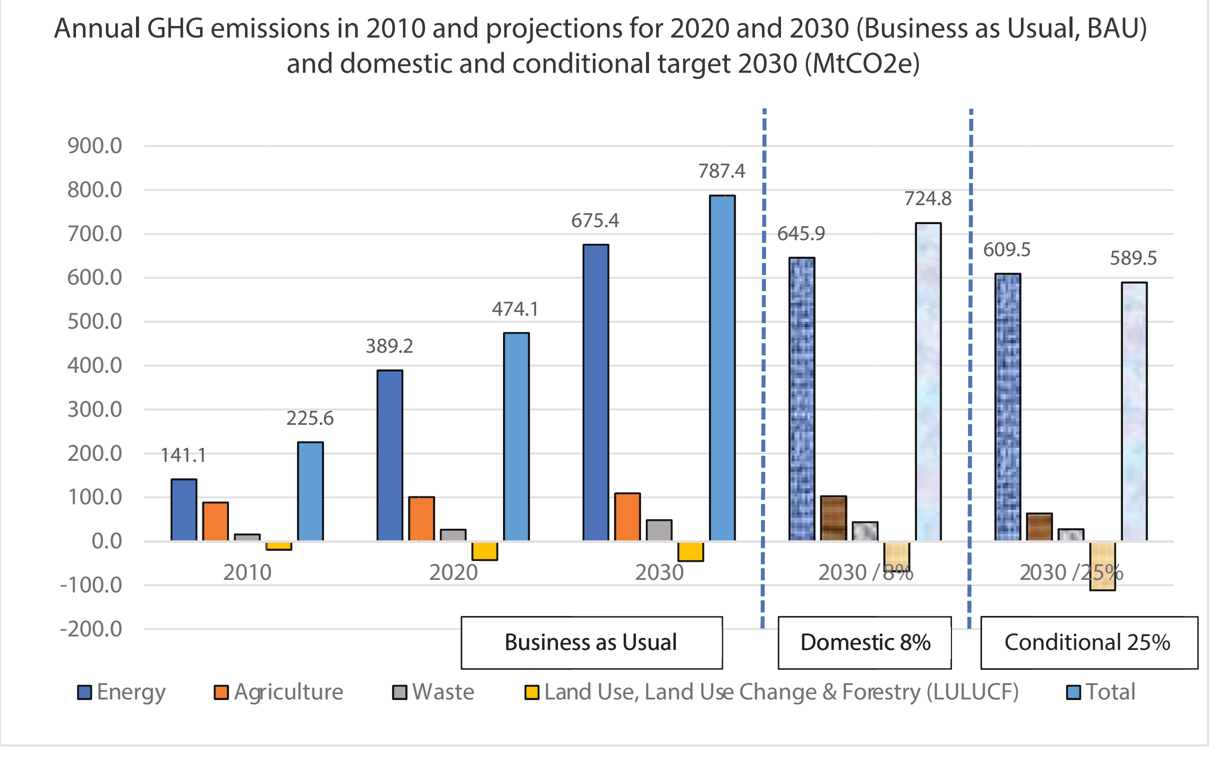
Following this introduction, Section 2 will show the importance of the energy sector for future emissions and emissions reduction. Section 3 will suggest that additional emissions reduction potential exists in the LULUCF, Agriculture and Waste sectors. Section 4 on energy supply focuses on solar and wind power, which have by far the biggest potential for future development, compared to other renewable energies. Section 5 shows that Viet Nam has considerable untapped potential for improving energy efficiencies, reducing energy demand and reducing GHG emissions from energy use. Section 6 discusses the macro-economic effects of Viet Nam's GHG emission mitigation targets in the current NDC, and also some effects of increased ambition in reducing emissions from energy production and consumption. Section 7 presents the positive effects on achieving several of the SGDs as a result of this. Conclusions and recommendations are summarised in section 7 of this paper.

2. Viet Nam's NDC:Greenhouse Gas Emission Reduction Targets

Viet Nam's NDC (SR Viet Nam, 2015a) has not set an expected year for peaking of national GHG emissions, but the impression from trends reported in 2015 are that this might be well beyond 2030. Figure 1 shows that in the BAU scenario, in which Viet Nam would not take deliberate action to mitigate emissions, the total annual emissions would almost quadruple in the period 2010-2030. With the domestically supported target of 8 percent reduction compared to BAU, it would still more than triple annual emissions, from 226 to 725 million tonne carbon dioxide equivalent (MtCO2e).

If the conditional target of 25 percent reduction compared to BAU would be achieved, the increase in total annual emissions between 2010 and 2030 is still more than 2.5 times. However, in this case the per capita emissions would remain lower in 2030 compared to the per capita emissions in e.g. the EU, Japan, Brazil or Indonesia (according to their NDCs) (CCWG, 2018a). And if the conditional scenario would be achieved, the rate of growth might have started to slow down and Viet Nam's emissions peaking in 2035 or 2040 would be imaginable. However, the Paris Agreement targets require more ambition from Viet Nam and nearly all other countries, as will be clear from the forthcoming IPCC Special Report on 1.5 degree Celsius Global Warming.

Figure 1 - GHG emissions in 2010 and projections for 2020 and 2030 (BAU) and targets 2030



Source: Data from SR Viet Nam (2015a) and MONRE (2015); figure after CCWG (2018a; 2018b).

Two aspects stand out in Figure 1: the very rapid increase and dominance of the energy sector in national emissions, and the large potential of the LULUCF sector for absorbing carbon dioxide, leading to carbon sequestration (negative net emissions). As part of the overall 8 and 25 percent targets, the rate of reduction compared to BAU in the energy sector is 4.4 percent in 2030 with domestic means, and the conditional rate is 9.8 percent annual emission reduction in 2030. The LULUCF sector's rate of net carbon sequestration compared to BAU in the LULUCF sector is 50 percent in 2030 with domestic means, and the conditional rate is 146 percent (MONRE, 2015; Neefjes, 2016; CCWG, 2018a).

The LULUCF potential for net carbon sequestration was thus considered to be very substantial, relative to other sectors, and the ongoing NDC review must show whether this was justified or not. Similarly, the NDC implies that, despite strong emissions growth in the energy sector, there would be very limited potential to reduce emissions compared to BAU. But that notion has been challenged since the NDC was issued in 2015: the mitigation potential in the energy sector might be substantial.

3. Opportunities for Additional Emissions Reduction in the LULUCF, Agriculture and Waste Sectors

The cost of GHG emissions reduction in the LULUCF, agriculture and waste sectors identified for the current NDC were quantified through different modelling approaches resulting in "abatement costs" of different technologies for reducing a tonne of carbon dioxide-equivalent (CO2e). These costs were estimated to be either negative, low or reasonable for several technologies and approaches, but higher for others, as shown in Table 1 (MONRE, 2015). This uses the technology codes in Table 1, where the codes are reproduced for readers who would like to review the details in MONRE, 2015.

Table 1 - LULUCF, Agriculture & Waste Technologies and Approaches (in Viet Nam's NDC, 2015)

LULUCF techniques with very low costs per tonne GHG emission mitigation:

- Protection of natural forest and coastal forest (F1, F2, F6)
- Natural forest regeneration (F4, F8)
- Natural forest and production forest regeneration (F9)

Additional LULUCF potential with slightly higher costs per tonne GHG mitigation:

- Plantation of coastal forest (F3, F7)
- Plantation of large timber production forest (F5)

Agriculture techniques with low costs per tonne GHG mitigation (but higher than LULUCF and Waste options):

- Integrated Crop Management (ICM) in rice and in upland crops (A5, A6)
- Improvement of livestock diets (A11)
- Improved irrigation for coffee (A14)
- Substitution of urea with ammonium sulphate fertiliser ($(NH_4)_2SO_4$) (A7)

Additional agriculture techniques with large potential but higher costs:

- Increased use of biogas (A1)
- Alternate wetting and drying, and improved rice cultivation (A3, A9)
- Re-use of upland agricultural residue (A8)
- Introduction of biochar (A4, A10)
- Improvement of quality and services available for aquaculture, such as inputs and foodstuff (A12)
- Improvement of technologies in aquaculture and waste treatment in aquaculture (A13)
- Improved technologies in food processing and waste treatment in agriculture, forestry and aquaculture (A15)

Waste treatment techniques with negative costs (=financial benefits) per tonne GHG emission mitigation:

- Organic fertiliser production (W1)
- Landfill gas recovery for electricity and heat generation (W2)
- Recycling of solid waste (W3)

Additional waste treatment techniques with substantial financial costs per tonne GHG emission mitigation:

- Anaerobic treatment of organic solid waste with methane recovery for power and heat generation (W4)

Based on: MONRE, 2015

The current NDC includes the application of all techniques and approaches in Table 1, but the costlier ones mainly under the conditional emission reduction target, meaning that international financial and technical support is expected. In formulating the NDC, the co-benefits of these techniques were not considered in financial analyses. However, many techniques provide co-benefits, such as higher production, better environmental quality or increased resilience. For example, household biogas saves women's time, improves the indoor air quality and outdoor environment, and delivers slurry for fertilizing gardens, compared to the baseline with scattered animal dung and the use of fuelwood for cooking. Mangrove forest along the coast protects people and assets from storm surges. Integrated Crop Management and Alternate Wetting and Drying increase crop yields and reduce the cost of inputs. Also "anaerobic treatment of organic solid waste with methane recovery" can strongly improve the local environmental quality by eliminating bad odours and treating waste water.

The ongoing NDC review will demonstrate the relative success of these techniques and possibly promote other techniques that could be applied in the period to 2030. It is also researching the (adaptation, social, economic, environmental) co-benefits of mitigation actions, and incorporating the co-benefits in decision making on the promotion of certain technologies and approaches. In fact, the co-benefits may be considerable and justify additional investments in several mitigation actions.

In fact, the techniques in Table 1, as well as some additional techniques and approaches on LULUCF, Agriculture and Waste, were already reviewed recently by a large pool of technical experts from Viet Nam and Japan (JICA & MONRE, 2017). They assessed the emissions mitigation potential and relative strengths of many techniques and approaches, also in terms of co-benefits. Examples from this review are listed in Table 2, which suggests that there is potential for more mitigation that is financially attractive and also offers co-benefits.

In conclusion, the potential benefits from additional mitigation efforts in the LULUCF, Agriculture and Waste sectors are currently being assessed as part of the NDC review. The already available data suggest that several techniques underlying the NDC targets can deliver more mitigation with limited additional costs, whereas several will deliver valuable co-benefits that justify additional investment.

Table 2 - Examples of LULUCF, Agriculture & Waste Technologies for Increased Mitigation (JICA & MONRE, 2017)

LULUCF:

- Protection of natural forest and coastal forest, as well as plantation of coastal forest (F1, F2, F3, F6, F7, F8), can be expanded / improved with additional forest fire control; insect and pest control; invasive species prevention; rehabilitation / forest enhancement; Sustainable Forest Management certification and development of development of non-timber forest products;
- Reducing Emissions from Forest Degradation and Deforestation (REDD) (agreed under the UNFCCC and already being applied in Viet Nam with international support) can lead to co-benefits such as reducing rural poverty, creating jobs and increasing incomes, reducing soil degradation, protecting water sources, resisting pests and diseases.

Agriculture:

- Introduction of biochar (A4, A10) at different scales may be relatively expensive but has major mitigation potential as well as substantial co-benefits to soil quality and productivity;
- Alternate Wetting and Drying (A3, A9) and Integrated Crop Management (ICM) in rice (A5) can increase emission reduction and co-benefits with High Efficiency Pumps and Solar Pump for drainage & irrigation.
- Improved technologies in food processing and waste treatment in agriculture, forestry and aquaculture (A15) should include High Efficiency Cooling for Chilling and Freezing Facilities in Cold Chain Process, which are available in the Vietnamese market and economically feasible.
- Fishing Vessel Structure and Planning/Methods can improve, e.g. with high efficiency diesel and gas engines for fishing vessels, and LED lighting for squid fishing.

Waste:

- There is additional scope for expansion of Organic Fertilizer Production (Composting) (W1);
- Landfill gas recovery for electricity and heat generation (W2) can increase in scale;
- Anaerobic treatment of organic solid waste (W4) can be expanded, using large available sources;
- Waste-to-Energy (WTE) has not yet been applied but has considerable potential, reducing the need for land filling.

Based on: JICA & MONRE, 2017. Note: technology codes are also used in MONRE, 2015.

4. Opportunities and Drivers for Additional Emissions Reduction with Renewable Energy

4.1 Energy Supply Technologies in Viet Nam's Nationally Determined Contribution

Table 3 shows that the annual emissions from energy production in Viet Nam's BAU scenario will increase from 41 percent of total energy emissions in 2010 to 68 percent.

Table 3 - GHG Emissions from the Energy Sector in 2010 and Projections for 2020 and 2030 (BAU)

GHG source categories	2010 ($MtCO_2e$)	2020 ($MtCO_2e$)	2030 ($MtCO_2e$)
1 Total Energy Emissions	**141.2**	**389.2**	**675.4**
1A Fuel combustion	**124.3**	**355.7**	**620.3**
1A1 Energy industries	41.1	171.3	404.4
1A2 Manufacturing industries & construction	38.1	69.3	92.5
1A3 Transport	31.8	87.9	87.9
1A4a Commercial/institutional	3.3	8.4	12.1
1A4b Residential	7.1	16.5	20.5
1A4c Agriculture/forestry/fishing	1.6	2.3	2.9
1B Fugitive emissions	**16.9**	**33.5**	**55.1**
1B1 Solid fuels	2.2	16.0	18.5
1B2 Natural oil and gas	14.7	17.5	36.6

Source: Table 3.5 in MONRE (2015); also in CCWG (2018a).

Notes: MtCO2e = million tonnes of carbon dioxide equivalent.

- Emissions from energy production are: category 1A1 on fuel use for power generation, and 1B on coal mining, gas and oil exploration. These make up 68% of total energy emissions in 2030, in the BAU.
- The categories 1A2, 1A3, 1A4 include GHG emissions from energy consumption, including all modes of transport and production by businesses, homes, offices, etc

Table 4 - Energy Production and Supply Technologies to Reduce GHG Emissions (in Viet Nam's NDC, 2015)

Low costs or even negative cost per tonne GHG emission mitigation:

- Solar water heaters (E4)
- Biomass power plants (E11, E15)
- Small hydropower plants (E12)

Moderate costs per tonne GHG emission mitigation:

- Substitution of ethanol for gasoline in transport (E7)
- Wind power plants by domestic funding (E13)
- Wind power plants by international support (E14)
- Biogas power plants (E15)
- Ultra-supercritical coal power plants (E16)

High costs per tonne GHG emission mitigation:

- Solar PV power plants (E17)

Based on: MONRE (2015), where the above technology codes are used.

The technologies underlying the commitments in the NDC for increasing renewable energy production and reducing emissions from thermal power plants are listed in Error! Reference source not found. (codes are used in MONRE, 2015). The abatement cost of reducing GHG emissions (per tonne CO2e) for different technologies in the production and supply of energy were identified for the NDC (MONRE, 2015). This shows that abatement costs are low or negative, moderate, or high, according to the model calculations made for the NDC targets. The more expensive technologies are mainly applied under the conditional emissions reduction target in Viet Nam's NDC.

These and other techniques for energy production were also reviewed in 2017 by technical experts on their mitigation potential, costs and other strengths (JICA & MONRE, 2017), with examples provided in Table 5.

Table 5 - Technology Options Energy Production and Supply (JICA & MONRE, 2017)

- Solar water heaters are already widely adopted and many types are on the market for further spread (E4);
- Production of ethanol and substitution for gasoline (E7) has met some hurdles. Currently a mix is available at the pumps for lower prices (=subsidies) but struggling to become popular.
- There is additional potential for the use of biomass in power plants (E11), including waste-to-energy, and for biogas power generation (E15) in e.g. mini-grids and linked to large farms, but potential for small hydro power plants (E12) is limited.
- Wind power plants (E13, E14) require an upgraded feed-in-tariff (which was issued in September 2018), investment costs continue to decline, and there is substantial physical potential (World Bank, 2014), so the potential for expansion beyond the 2015 target is possible.
- A solar Photovoltaic (PV) (E17) power generation feed-in-tariff has been regulated (2017), investment costs are declining rapidly, solar irradiation is good especially in the Centre and South of Viet Nam (AECID-MOIT, 2014), and investors are ready to invest, so expansion beyond the 2015 target is recommended.
- Several additional technologies could be financially attractive and reduce emissions. Regarding category 1A1 in Table 5, this could include technologies to increase the efficiency of power transmission and switching from coal power to natural gas powerplants, which is cheaper and cleaner than ultra-super critical coal power (E16). Regarding category 1B in Table 5, Flare Gas Recovery and Utilization for Process Heating in petroleum refineries is recommended.

Based on: JICA & MONRE (2017). Note: technology codes are also used in MONRE (2015).

Underlying the NDC targets, there were no actions for reducing emissions from coal mining, petroleum exploration and refining (category 1B in Table 3). However, according to JICA & MONRE (2017) some are financially promising and technically feasible (see Table 5). The ongoing NDC review will demonstrate the relative success of the techniques listed in Error! Reference source not found., and possibly promote additional ones for the period to 2030.

It is important to note that the technical potential of some RE technologies is considerable in Viet Nam, and less for others. Small-scale hydropower is considered green or renewable (unlike large-scale hydropower), but future development potential is limited. There is some potential for the use of biomass, including various wastes, but that potential is also limited. The technical potential for solar PV can be estimated at around 85 giga Watt (GW) (AECID-MOIT, 2014). However, ADB (2015) and GreenID (2018) give lower and higher estimates respectively, as such estimates are strongly dependent on assumptions about areas that can technically be developed. The potential for onshore and off shore wind power in Viet Nam has been estimated by different analysts to range from 21 GW to 27 GW (GreenID, 2018; ADB, 2015; AWS Truepower, 2011; World Bank, 2014). [2] However, wind power generation potential is strongly dependent on how much

2 Estimate based on AECID (2014) which lists solar PV technical potential production of all provinces, totalling 109 TWh/year. This would require an installed capacity of about 85 GW on the assumption of average daily production of 3.5 kWh per kWp installed capacity.

off shore wind would be developed. By comparison, current total installed power production capacity in Viet Nam is about 43 GW and the PDP7-revised projection for 2030 is to have in total 129.5 GW installed.[3]

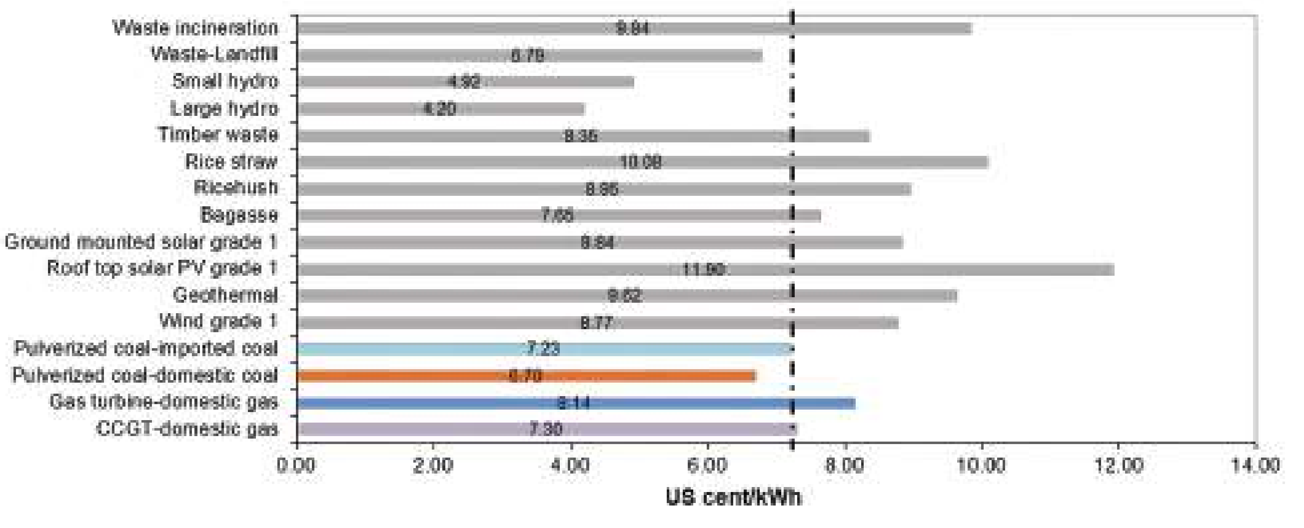
4.2 Declining Renewable Energy Costs

The most important global trend over the past years and into the foreseeable future is the decreasing cost of renewable energy (REN21, 2018a). Solar PV has become much cheaper in the three years since the formulation of the NDC, and the costs of wind power, including large-scale off shore wind power are declining too.

GreenID (2018) analysed the levelized costs of energy /electricity (LCOE) of all sorts of power technologies under Vietnamese conditions in different years.[4]

Figure 2 gives their LCOE estimates for 2017, based on technology and price assumptions for that year as deemed applicable in Viet Nam. This included estimates for renewable energy costs under the Vietnamese conditions: solar PV LCOE of 8.84 USD cents per kilo Watt hour (kWh) (= USD 88.4 per mega Watt hour (MWh)) and wind power LCOE of 8.77 USD cents/kWh (= USD 87.7 per MWh).

Figure 2 - Levelized Cost Of Energy (LCOE) of key technologies in 2017 in Viet Nam



Source: GreenID (2018)

These are comparatively conservative estimates of RE costs, which are justified for 2017 because RE regulations, capacities and markets are not fully developed yet in Viet Nam. However, elsewhere much lower commercial prices have already been reached in 2017 according to analysis by different international organisations (IRENA, 2018; IEA, 2016; REN21, 2018a):

> "Solar PV tenders resulted in record-low bids in a number of countries. In Germany, for example, winning bids were on average nearly 50% lower than those over the last two years, to below EUR 50 per megawatt-hour (MWh) (USD 60 per MWh). In the United States, the country's least expensive ever solar power purchase agreement was awarded for a 150 megawatt (MW) project in Texas, with prices potentially as low as USD 21 per MWh.
>
> In markets as diverse as Canada, India, Mexico and Morocco, the prices bid for onshore wind power came down to about USD 30 per MWh. A Mexican tender late in the year [2017] saw prices below USD 20 per MWh – a world record low and down 40-50% relative to Mexico's tenders in 2016. Germany also saw a national record low of EUR 38 per MWh (around USD 45 per MWh)." (REN21, 2018b, p.10).

3 *How installed capacity (in e.g. MW) translates into annual production (in e.g. MWh/day) depends on the capacity factor, which is lower for e.g. solar PV and higher for e.g. coal thermal power.*

4 *LCOE is the cost of production of a unit of energy (in this case electricity) over the lifetime of a power source, based on the present value of investment, fuel supply, operation & maintenance. Compared to coal, diesel or gas power plants, solar PV and wind power plants tend to have higher capital investment costs, a lower "capacity factor" (the hours per day or year of actual power production), but they have no fuel supply costs.*

In 2017, the LCOE of power from imported coal was estimated at 7.23 USD cents/kWh for Viet Nam (= USD 72.3 per MWh), a cost level shown with a dotted line in Figure 2. In 2017, the proportion of low-efficiency and relatively cheap "sub-critical" coal-thermal generation technology was much higher than "super-critical" technology (more efficient and expensive). The "ultra-super-critical" technology (yet more efficient and expensive) was not yet applied anywhere in the country. Only the LCOEs of domestic coal power, hydropower and waste-landfill (methane) power were estimated to be cheaper than power from imported coal. Various biomass options, solar PV and wind power were all estimated to be somewhat more expensive, and (small scale) rooftop solar PV the most expensive of all.

All LCOEs in Figure 2 are at the power plant gate and do not include the cost of transmission (including supporting infrastructure, operation, maintenance and power losses) that should be added to reach the full costs. This may be estimated at 8 percent on average, which should be applied to all technologies except rooftop solar PV. In 2017, the average retail price was 7.6 USD cents/kWh. This means that small and large hydro in Viet Nam's power mix are cross-subsidising nearly all other forms of power generation, including some low-efficiency and polluting coal power and all gas power. In addition, indirect subsidies to fossil fuel consumption also persist and actually reduce the costs of fossil fuel consumption, such as public investment in transport infrastructure that is used for fuel supply (UNDP-Viet Nam, 2012; 2014; 2016; 2017).

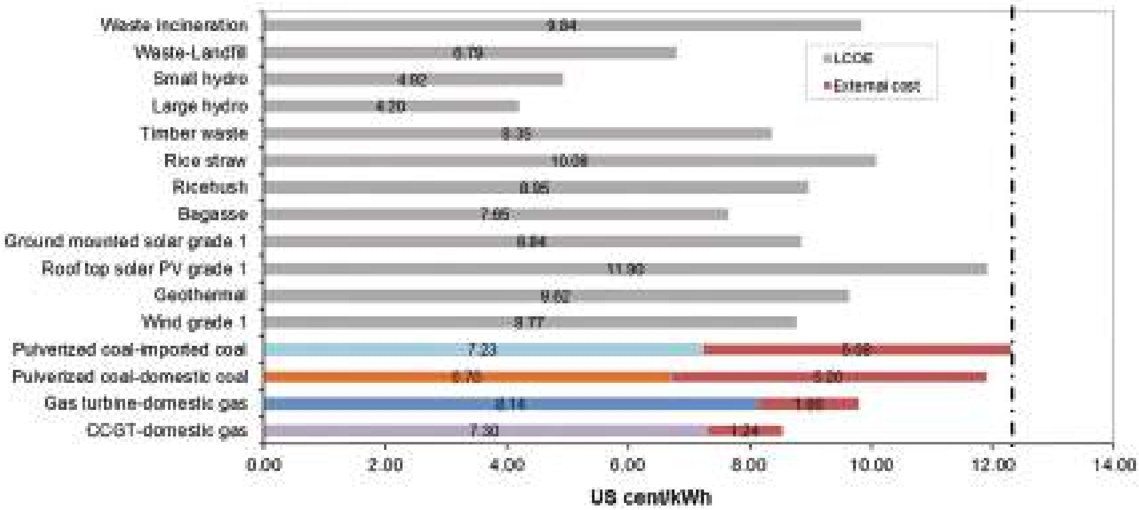
Viet Nam has several policies in place, including the Renewable Energy Development Strategy issued in late 2015 (SR Viet Nam, 2015b), and support policies with feed-in-tariffs (FiTs) for different renewable energies. FiTs are the price at which the off-taker must buy RE from the plant owner for the economic lifetime of projects of 20 years. The FiT for solar PV is 9.5 USD cents/kWh and applies to projects that must be connected and operating by 30 June 2019 (SR Viet Nam, 2017). The revised FiT for onshore wind power is 8.5 USD cents/kWh and for off-shore wind power the FiT was set at 9.8 USD cents/kWh, which must be operating before 1 November 2021 (SR Viet Nam, 2018). Viet Nam has similar support policies for biomass based power generation.

4.3 The Real Costs of Fossil Fuel Power

GreenID (2018) shows that without internalising external costs, solar and wind power will be competitive by 2025 or sooner. But internalisation of external costs of energy production will make RE more competitive, to the point that premium FiTs for RE are no longer needed. GreenID (2018) asserts that renewable energy can already compete with coal and also gas power if the environmental, social, health and livelihood costs are internalised in the price. This is illustrated by calculations of the LCOEs in Figure 3. It stresses that externalised costs are "costs that citizens and government are actually bearing, while investors are not paying for it" (GreenID, 2018, p.4).

Fossil fuel based power would be made more expensive by phasing out all indirect support and by "internalising" costs to the environment, health and livelihoods. External costs can be internalised through fees, taxes or for example carbon-cap-and-trade systems. It would make the fossil fuel based part of the power mix more expensive and provides an upward pressure on the retail price. It means that the full cost of electricity would shift to companies and electricity consumers, and no longer depend partially on the State and tax payers. It would also increase the RE share, which is at the moment more expensive than the lowest cost fossil fuel generated power, but becomes relatively more economical. These measures will initially make the total power mix more expensive. However, RE will continue to become cheaper, as has happened in other countries, at a rate that will depend on capacity development and mechanisms such as the auctioning of concessions to build RE plants. Further reduction in the costs of RE and a larger RE share will then reduce the overall power mix cost.

Figure 3 - LCOEs in 2017 in Viet Nam, including external costs of fossil fuel generation technologies



Source: GreenID (2018)

4.4 Key PolicyDrivers for Increased Renewable Energy

The current average electricity retail price is regulated by the Government but power is produced by different sources, which means that there is a mechanism of cross-subsidies from cheap to more expensive sources of electricity. [5] Viet Nam is implementing a programme of power sector reform over a period of about two decades, in which the first stage of competitive wholesale markets has been reached for some of the power producers (Neefjes and Dang Thi Thu Hoai, 2017). Retail markets would, according to current estimates, be made competitive in 2024. [6] The expectation is that fully functioning wholesale and retail markets will increase efficiencies and lead to affordable prices. But reform is complex.

Wholesale markets must respect existing fixed prices for certain power sources, including the already awarded FiTs for a period of 20 years from the start of connection/operation, after which the wholesale markets will determine their price. Another complication is that most of the cheap hydro-power sources cannot be used purely on commercial terms because water must sometimes also be used to combat drought that is affecting agriculture.

Currently, and expectedly for some more years, the retail prices are regulated and "cost based," and not determined by the markets. They are (on average) low by international comparison, for example because they are subject to low rates of taxation. They are also differentiated, per category of consumer / client (the latter means that rooftop solar PV system could offset some of the higher tariffs – see below). Also, the five distribution companies that are coming out of Electricity Viet Nam (EVN) (in Hanoi, Ho Chi Minh City and the North, Centre and South of Viet Nam) have different revenue profiles. In competitive retail markets, supply to remote areas with low income households, small enterprises and high distribution infrastructure costs per customer must not result in higher tariffs compared to the richer urban areas, according to Viet Nam's social-economic policies.

There is no clarity yet on how power sector reform will enable the increase of RE power generation. Proposals to ensure that power sector reform also leads to increased RE deployment, include the following (Neefjes, 2017): (a) a carbon price on the use of coal and gas; (b) "renewable portfolio standards" (RPS) that force large power generation companies to gradually increase renewable energy in their generation portfolio (RPS are mentioned in the Renewable Energy Development Strategy (REDS): SR Viet Nam 2015b); (c) auctioning of

5 *The average retail price is currently set by the Government and could be increased by EVN in small steps. Through regulated formula the average price determines all retail tariffs, for different categories of customers.*

6 *Once competitive retail markets are matured in Viet Nam, currently scheduled for 2024, Government and EVN regulation of the average price and also the pricing structure will change.*

licences for building renewable power plants in certain locations against the lowest long term tariffs (which is being researched and maybe piloted for wind and solar in Viet Nam, with international support); and (d) "net metering" of electricity production by rooftop solar PV systems on homes and businesses.

"Net-metering" allows residential and commercial customers to generate their own electricity from solar PV to feed electricity they do not use back into the grid. This features in the REDS and the solar PV regulation (SR Viet Nam, 2015b, 2017) and has started to be applied at a small scale. This may cover on-site demand during sunny hours, send excess power into the grid (with the purchase of excess power for the same FiT of 9.35 USD cents/kWh that applies to solar PV farms, according to SR Viet Nam, 2017), and draw from the grid when there is no sun. Based on current solar PV system costs on the Vietnamese market, this can already offset some of the retail tariffs in Viet Nam, making it financially attractive to some consumers. However, application of net-metering is administratively not yet sufficiently simple, and not yet applied by all branches of EVN (GreenID, 2018; UNDP-Viet Nam 2016).

4.5 Planning for Renewable Energy Development

A key feature of wind and solar PV electricity generation is that it is more "distributed" and less concentrated in a small number of very large power plants compared to thermal power plants. In particular, rooftop solar PV can be located almost anywhere and be connected to low voltage distribution networks. Medium sized plants can be connected to the 110 and 220 kV transmission lines that cross every province in Viet Nam. Large plants require connection to 220 or the 500 kV transmission lines. Distribution of wind power and solar PV capacity across the national grid means that production "evens out" (if wind is weak or the sky is cloudy in one part, it may be different in another).

To optimise the use of wind and solar resources, data on their potential are needed. The need for connection to transmission and distribution infrastructure must also be considered in land use planning. Power development planning is the responsibility of the Ministry of Industry and Trade (MOIT) and land use planning of the Ministry of Natural Resources and Environment (MONRE), and their affiliated provincial departments (DOITs and DONREs) who must coordinate. But land is scarce, especially in the lowlands of Viet Nam. Opportunities for combined land use can be generated from collaboration in sectoral and integrated spatial planning with the Ministry of Construction (MOC) and provincial Departments of Construction (DOCs), which are responsible for urban development, the Ministry of Transport and provincial Departments of Transportation (DOTs), and the Ministry of Agriculture and Rural Development (MARD) and provincial Departments of Agriculture and Rural Development (DARDs).

Combined land use is already being promoted, for example by the Board of Directors of EVN which issued a resolution on this in 2016. This is recommending that solar power should be developed on sites of existing power plants with transmission lines and other infrastructure and capacities, such as hydro-power reservoirs with floating solar PV panels (Neefjes and Dang Thi Thu Hoai, 2017). Many options exist in other countries of integrated solar and wind farms, and combinations of RE with crop / vegetable farming, livestock, and aquaculture; industrial parks and harbours; tourist resorts; and waste landfills. There are no obvious reasons why these cannot be developed in Viet Nam as well. Biomass-to-energy, including incineration of municipal waste through collaboration between power producers and waste management companies, might guarantee a steady supply of waste to power plants (JICA & MONRE, 2017), and reduce the size of landfills near urban centres.

Viet Nam's MOIT has started to formulate the Power Development Plan for the period 2021-2030 (and outlook to 2040) (aka "PDP8"). This is an opportunity for raising the share of RE in the power mix. PDP8 will include a list of new power plants, which could include solar PV and wind parks, that were not yet considered in PDP7-revised (EAG and EU, 2018). PDP8 can also provide guidance for combined land use in the case of solar PV and wind, including the above-mentioned options, and guidance on investment modalities and regulations such as auctioning and RPS (see section 4.4).

4.6 Public Investment and ODA as Drivers for Renewable Energy Investment

One the most commonly perceived barriers to RE deployment in Viet Nam is the intermittency of solar PV and wind power leading to unreliability and instability of the grid. However, based on experiences in other countries, this has also been debunked as myth (RLS, 2016; GreenID, 2016). The intermittency challenge can be met by good management of power demand and supply, which must always be balanced, distributed generation capacity, and additional power storage.

For example, Germany's System Average Interruption Duration Index (SAIDI) was halved between 2006 and 2015 when its RE capacity increased from 12 to 35 percent of total power grid capacity, implying that power distribution has become more reliable, not less (RLS, 2016). Countries with similar or lower quality national transmission and distribution infrastructure compared to Viet Nam, have already included more solar PV and wind power capacity. Experts estimate that Viet Nam could include about 10 percent RE in its power mix without major investments in its transmission and distribution infrastructure, which is currently planned to happen well after 2030.[7]

The distributed nature of RE systems reduces inherent intermittency and can result in a major share of wind power in the "base load" of a power supply system, which is often reserved for e.g. coal thermal power plants that take time (and costs) to start up (RLS, 2016). Interruption of supply can be reduced e.g. if battery banks are included in small-scale (household, business) systems as back-up. At the large scale, power systems can increase storage capacity with technologies that can respond to peak demand, e.g. "pumped storage" hydropower (reservoirs that are filled when solar PV and wind power supply are too high). In fact, Viet Nam's power development plan already includes pumped storage (SR Viet Nam, 2016), but investment is not yet taking place.

"Smart grid" technology can improve demand and supply management. Large energy users like aluminium smelting plants can receive price signals automatically, and increase consumption when supply is high and price is low, and vice versa. Supply of wind and solar PV power can be predicted from good use of weather forecasts, even in intervals of just 15 minutes, enabling optimal demand-supply management.

The Government no longer supports investments by energy State owned Enterprises (SoEs) in power generation and no longer provides guarantees for loans from Official Development Assistance (ODA) lenders to SoEs. The limited available public infrastructure investment capital (including ODA) that might still go to the energy sector must (thus) be used strategically. [8] Any public investment capital still available might be applied to areas where private investment is less likely, and to improve the conditions for attracting private (foreign, domestic) capital. For example, it could be focused on management quality (smart grid / dispatch management improvement), transmission and distribution infrastructure, and power storage capacities such as pumped storage.

4.7 Private Investments in Renewable Energy Development

The Government of Viet Nam has capped public sector debt. Foreign and domestic private capital will have to become the primary or even sole source of investment in future power production capacity. UNDP-Viet Nam (2018a) found that, between 2011 and 2015, the private sector had spent USD 3.40 billion on RE projects, mainly in small-scale hydropower and also wind power and solar water heaters. This includes a large share of international private finance. UNDP-Viet Nam (2018b) reviewed (foreign) private investor interest and suggests that "at least USD 10 billion" foreign capital is immediately available "to support Viet Nam's transition to cleaner energy and energy saving," "if barriers are removed." According to existing plans, more would be needed for RE in particular, but the study found that external private capital can be mobilized.

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7 SR Viet Nam (2016) gives for 2030 a planned 10.7 percent of total electricity production from RE. This includes small hydro and biomass based electricity, and solar PV and wind would still be well below 10 percent.

8 The Government agreed to cap national debt which has resulted in a strong push to reduce public investment into several sectors, especially sectors where private sector capital could be mobilized such as energy supply.

However, in the absence of government guarantees to risks associated with energy SoEs, foreign private investors are perceiving the investment risks in e.g. power plants to be high. The FiTs have been criticised, and the standardised Power Purchase Agreements contain legal weaknesses, leading to "low bankability" of the PPA. In 2017, a solar PV FiT was issued that generated considerable investor interest, and the revised FiT for wind power is higher than previously, which changes risk perceptions at least somewhat. But perceived high risk makes international capital comparatively expensive, or inaccessible. Foreign investors may sometimes be able to reduce their risks through loan guarantees from their home-State, but that is rare. Several call for international arbitration in case of disputes.

Risks are perceived differently by international and national financiers / investors. National banks are still unfamiliar with solar and wind power but have experience lending to energy projects of national SoEs and do not perceive major credit risks or off take risks. But the perception of international investors is that energy SoEs are a risk as recipients of loans for investment (a typical question: can and will they repay, on time?), and specifically EVN as the off taker is treated with caution (can and will they pay for all electricity produced, on time?) (UNDP-Viet Nam, 2018b; EuroCham, 2016).

There are also risks related to the opaque permitting and land acquisition processes, and experiences of corruption that make the early project development stage expensive (EuroCham, 2016; UNDP-Viet Nam, 2018b). Before completion of construction of a power plant, or even at the outset of construction, investors must have agreed a PPA and a Connection Agreement, which must be enforceable. Power off-take must take place according to these agreements, and payments must be made by the "single buyer", EVN (although in coming years there will be multiple buyers, as the competitive retail market will develop). Investment risks also include timely connection of RE power plants to the grid (delays are costly for investors), and full off-take of the power produced (EVN may have reasons for not taking all the power produced, despite a PPA that says all will be bought). Investment risks are also related to FiT regulations (e.g.: will the FiTs remain as agreed after signing PPAs, for the full period of 20 years, or could they be changed?). And investors have called for a pricing roadmap and predictability of FiTs (e.g.: the current solar PV and wind power FiTs will only apply if plants are connected to the grid and producing by specific dates, but what if construction is delayed and the deadline is not met, what will the FiT then be?) (VBF, 2016).

Many of these risks can be reduced with more advanced and in-depth RE regulation based on international experience, including the standard PPA and arbitration processes. Financial risks are also decreasing with higher solar PV and wind FiTs, as well as other measures. Some developed country governments are interested in pooling funds to create joint international guarantees that could cover several of the risks. Large private sector players may also add funds to such guarantees. For e.g. power transmission and storage facilities blended finance deals are being explored, with ODA loans and grants combined with private sector investments. Private sector investors in power plants will normally be made responsible for their connection to the grid. In the case of large-scale RE farms, they may also reduce off-take risks by investing in some grid extension.

An international shift in risk perception stems from the Paris Agreement and may benefit Viet Nam. Pension funds and insurers take a long-term view when investing their funds as they have medium and long-term payment obligations, and investments in oil industry and coal mining present medium and long-term risks as demand will reduce. Pension funds and insurers (and others in the international financial markets) are looking to divest from these companies and invest in green and clean projects, including power generation. Furthermore, some petroleum companies with capital have engineering capacities and have started to invest in (off shore) wind parks. IT companies have large electricity needs for their data centres and have started to set goals of reducing their emissions and producing and/or buying RE (solar PV and wind in particular). Additional international players in different sectors in Viet Nam could thus imply new and greater opportunities for private investment in RE in Viet Nam.

5. Opportunities and Drivers for Additional Emissions Reduction with Energy Efficiency

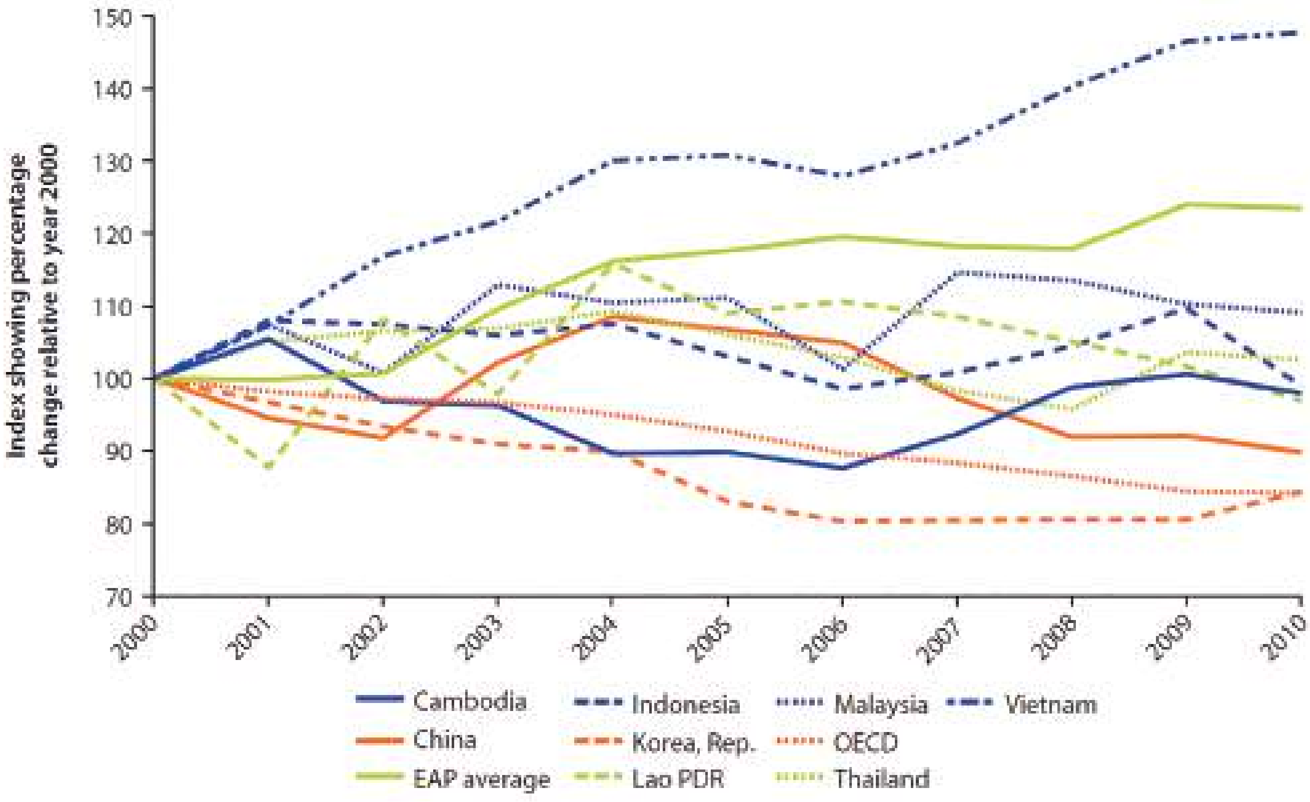
5.1 Energy Demand and Efficiencies

As shown in Table 3, energy consumption in industry, transport, and buildings (commercial and institutional buildings, the residential and agricultural buildings) all show high projected growth rates to 2030 (categories 1A2, 1A3, and 1A4a,b,c in Table 3). The totals and growth rates in emissions from energy consumption in industry and transport stand out.[9]

Between 2000 and 2010 Viet Nam's industrial, as well as transport, emissions increased, and total emissions per unit GDP increased, which is shown by the index in Figure 4 (see Table 3 for 2010 data). Viet Nam's increase in emissions intensity (emissions per unit GDP) were increasing over this period, whereas it stayed roughly the same or even decreased in other countries.

9 Viet Nam did not report and target reduced emissions from industrial processes (non-energy) but this is expected to be included in its revised NDC.

Figure 4 - Change in CO2 Emissions per unit GDP in Viet Nam Compared to other Nations and Regions



Source: Audinet et al. (2016), p.5

Notes: Data from World Development Indicators.

On the y axis, the year 2000 = 100. EAP = East Asia and the Pacific; GDP = gross domestic product; OECD = Organisation for Economic Co-operation and Development; PDR = People's Democratic Republic.

Viet Nam's energy intensity also did not compare well with the rest of the world. Viet Nam's energy use in kilograms of oil equivalent (kOE) per USD1,000 of GDP was 237 kg in 2013 when the world average was 208 kg (in constant 2005 USD). In the same year, electricity intensity in kWh per USD of GDP was 1.4, whereas the world average was 0.8. Data also show that energy efficiency of the economy was at that time improving, but that improvements were small (UNDP-Viet Nam, 2014, using World Development Indicators, 2013).

Viet Nam set a target for 2011-2020 to reduce the intensity of greenhouse gas emissions by 8-10 percent as compared to 2010, and energy consumption per unit of GDP by 1-1.5 percent per year (SR Viet Nam, 2012). As part of the unconditional 8 percent emissions reduction compared to BAU in the NDC (SR Viet Nam, 2015), it committed to 20 percent reduction of emission intensity per unit of GDP compared to the 2010 levels. The latter would thus show a clear negative trend that would signify some decarbonisation of the economy as well as improvement in energy efficiency. The ongoing NDC review will show whether this is being achieved.

The PDP7-revised was revised in 2016 (SR Viet Nam, 2016). This included a revision of the projected growth in power demand, resulting in lower figures of projected supply in 2020 and 2030. The mix in 2020, 2025, 2030 was also adjusted to include relatively more RE. But the increase in RE power was modest and the 2030 projections in PDP7-revised still signify about half of all power to come from thermal coal plants in 2030.

The electricity demand projections in PDP7-revised also remained very high, and above the rate of projected GDP growth over the same period. This means that the electricity sector grows consumption faster than GDP according to the plan and will contribute to increased energy intensity (less energy efficiency). Because the share of coal and gas in the mix is increasing at the same time, as per PDP7-revised, the carbon intensity of the overall economy is more likely to increase rather than decrease, instead of decoupling economic growth from energy consumption (growth).

Discussing the demand growth projections in the context of the formulation of PDP8 for the period 2021-2030 (and outlook to 2040), senior officials recognised that further adjustment of demand projection is needed, and energy efficiencies must improve. They also recognised the importance, as well as opportunity for raising the share of RE in the power mix (EAG and EU, 2018).

5.2 Energy Efficiency Technologies in the NDC

Comparatively low EE and high CO2 intensity in the present situation, and according to current power demand projections also in future (SR Viet Nam, 2016), suggests a significant potential for improvement of EE, reducing energy demand and limiting emissions growth. The technologies that shaped the commitments in the NDC for improving EE, reducing energy demand, and reducing emissions are listed in Table 6 (MONRE, 2015).

The technologies listed in Table 6 were all judged to be negative or low cost, meaning that they should be implementable with minimal external support, or even lead to profits of entrepreneurs. They were also reviewed by JICA & MONRE (2017) as summarised in Table 7. This shows that several technologies have penetrated the market, meaning that they are being taken up by private enterprises and households, and are already contributing to improved energy efficiencies. Some technologies are not yet being taken up to the extent that may have been hoped for. Additional technologies were also mentioned in that review, that are promising for the period to 2030 in terms of volume and financially.

In particular, the high energy consuming industries must adopt energy efficiency measures with priority, such as steel and aluminium, cement, pulp and paper, beverage and fertilizer industries. For example, regarding steel in-depth analysis of options has already been done (AFD-MOIT, 2014). Aided by international projects, Nationally Appropriate Mitigation Actions (NAMAs) have been formulated to improve energy efficiencies and reduce emissions in several industrial sectors (e.g. Chu Duc Khai et al., 2015; Tang Thi Hong Loan et al., 2015; Pedersen et al., 2016). NAMA proposals sometimes include elements of Public Private Partnerships, with some public financing or ODA for e.g., capacity building and investment in technologies by private businesses.

Table 6 - Technologies to Increase Energy Efficiency, and Reduce Energy Demand and GHG Emissions (in Viet Nam's NDC, 2015)

Negative cost (=financial benefits) per tonne GHG emission mitigation:

- High efficiency residential lighting (E3)
- Cement-making technology improvements (E5)
- Brick-making technology improvements (E6)
- Passenger transport mode shift - private to public (E8)
- Freight transport switch from road (E9)

Very low costs per tonne GHG emission mitigation:

- High efficiency residential air conditioning (E1)
- High efficiency residential refrigerators (E2)
- High efficiency commercial air conditioning (E10)

Based on: MONRE (2015), where the above technology codes are used.

Table 7 - Technology Options to Increase Energy Efficiency and Reduce Demand (JICA & MONRE, 2017)

- High efficiency air conditioning and refrigeration (E1, E2, E10) such as inverter air conditioners and refrigerators already penetrated the market, and with labelling and promotion could see widespread adoption, as is the case for high efficiency residential lighting (E3) because LED are already being produced in Viet Nam and available everywhere;
- Commercially proven and mature technologies are available for cement making (E5), including Waste Heat Recovery (WHR) power systems, and for brick-making (E6) there is Vertical Shaft Brick Kiln technology;
- Passenger transport mode shift - private to public (E8) is happening to some extent, although the first Bus Rapid Transit (BRT) trials are no undivided success and urban railways have been delayed multiple times and become costly;
- Several additional technologies could be financially attractive and reduce emissions. Notably technologies to increase energy efficiency in the pulp and paper, steel, beverage and fertilizer industries. In the transport sector the promotion of bicycle use, biofuels, and electric/hybrid vehicles are deemed opportunities that were not considered in the NDC of 2015.

Based on: JICA & MONRE (2017). Note: technology codes are also used in MONRE (2015).

One set of technologies that was not considered in formulating the NDC, and that could usefully be addressed in the formulation of a revised NDC, is electric transport. Whether that results in considerable reduction of emissions depends on the power mix of a country, and in combination with high penetration of RE, this could strongly reduce national emissions. There is also likely a major impact on urban air quality from the electrification of transport. In particular, if charging takes place during peaks of intermittent solar and wind power supply, a nation's vehicle batteries can jointly become a huge "virtual" energy storage, and thereby address one of the limitations of these sources of power. The role of power storage in vehicles has been estimated to be significant in the case of the EU (Adel et al., 2018). Viet Nam has not addressed this in transport policies or the NDC yet, but international developments such as the uptake of electric cars as well as regulation on phasing out of diesel and petrol cars is gathering pace. Viet Nam must plan to benefit from this over the period to 2030. Its car park and bus fleets are expanding rapidly, which means a lock-in of at least 5-10 years of pollution from vehicles, unless electrified. Electric mopeds are already spreading in Viet Nam. The current plans for production of electric vehicles in Viet Nam may trigger their wider uptake.

An important policy driver for improved energy efficiency has been the Viet Nam Energy Efficiency Programme (VNEEP) (SR Viet Nam, 2006) and activities are continuing to be supported by the MOIT. This has, for example, enabled the setting of energy efficiency standards in many sub-sectors.

5.3 Fiscal Policies for Increasing Energy Efficiency and Energy Saving

Fiscal policies may be the main barrier to increased EE and energy saving. Prices of electricity, and also other energy prices such as petrol and diesel, are low in Viet Nam compared to other countries. This is due to a combination of indirect subsidies, low environmental taxes and fees and an absence of a carbon pricing mechanism (carbon tax, fee, or cap-and-trade system) (UNDP-Viet Nam, 2012, 2014, 2016). Raising energy prices through elimination of energy retail price caps, reduced support to e.g. (fuel) transport infrastructure, and internalisation of external costs will influence consumer behaviour. But how effective this is for increasing EE and reducing energy demand depends on price-demand elasticities, which are internationally relatively low for petrol consumption (i.e. a higher petrol price incentivises only few customers to drive fewer kilometres).

The technological drivers for higher EE can and should be therefore complemented by fiscal drivers. This can happen through phase out of all public support for fossil fuel use, such as fossil fuel transport infrastructure investments, and taxation or carbon fees to internalise the full cost of fossil fuel consumption. This will increase power prices and trigger EE investments. RE will at the same time become more attractive, and because RE is becoming cheaper over time there will be a downward pressure on retail prices as fossil fuels will have a reduced share in the power mix. A carbon tax or fee would also generate additional State revenue for the period of significant fossil fuel consumption. Such revenues could be redistributed to consumers / tax payers (e.g. through a reduction of other taxes) or be reinvested. If reinvested in low carbon, productive activities, GDP growth is expected to increase (see further in section 6.1).

5.4 Financing Energy Efficiency and Energy Saving

According to UNDP-Viet Nam (2018a), estimated private sector investments into energy efficiency accounted for approximately USD 630 million over the period 2011-2015. As mentioned in section 4.7, according to UNDP-Viet Nam (2018b), there is an estimated USD 10 billion of foreign private investor capital (immediately) available for "cleaner energy and energy saving", if (regulatory) barriers are removed. This was a snap-shot analysis of well-established investors and institutions known to have an interest in Viet Nam, the actual investment and the actual capital available could be more.

Improving EE is a core recommendation by the Viet Nam Business Forum (VBF) to the Government: "enhancing the role of Government and using Demand Side Management tools to reduce waste and attract private sector investment and innovation in efficiencies" (VBF, 2016). According to UNDP-Viet Nam (2018b), the focus must be on EE investment by energy-intensive industrial sectors, with estimated needs of USD 3.6 billion (cement, steel, pulp and paper, sugar, chemical, textile, food processing, bricks and ceramics). These include sectors where NAMAs have been formulated (see section 5.2). Households and communities must also be encouraged to make EE investments, e.g. in street-lighting and air-conditioning. UNDP-Viet Nam (2018b) notes that domestic banks could provide most of the finance required. But their first recommendation is adjustment of the electricity price to stimulate such investments.

Higher energy prices will be the result of energy transition in the first years of energy transition, especially if a carbon tax or fee would be included. Several surveys show that small energy price increases of 5-10 percent over e.g. 3 years could be absorbed by domestic small and medium enterprises (SMEs). Companies will take energy saving measures, but domestic SMEs will be reluctant to make major investments with such price increases. Most foreign invested companies could sustain annual energy cost increases of 10 percent and seem more open to investments to achieve the required energy efficiency improvements. Support programmes helping businesses to improve energy efficiencies are however not yet very effective (Willenbockel and Hoang, 2011; Nguyen Manh Hai et al., 2015; Dang Thi Thu Hoai and Tran Toan Thang, 2013; UNDP-Viet Nam, 2014; Garg et al., 2015. Discussed further in section 6.3.).

UNDP-Viet Nam (2018b) also recommends that support policies should be enhanced, and especially dedicated funds that co-finance EE investments and guarantees for investments. In fact, the World Bank recently initiated a significant EE support facility of this kind, including finance from the Green Climate Fund. Other recommendations for increasing private investment in EE by UNDP-Viet Nam (2018b) are that the Government should set up a certification or accreditation scheme for Energy Service Companies (ESCOs) and to facilitate their operations; compulsory energy savings targets for major energy users; and raising awareness about EE investment opportunities and EE labels and standards, which would encourage households and SMEs to invest in energy efficiency and energy saving.

6. Macro-economic benefits of increased GHG emission mitigation

Several researchers have looked into the macro economic effects of energy transition in Viet Nam and of the GHG emission targets in the NDC (Willenbockel and Ho Cong Hoa, 2011; UNDP-Viet Nam, 2012, 2014, 2017; IES & MKE, 2016; Audinet et al., 2016; Pham Lan Huong, 2018). Some of these studies reviewed the effects of energy transition, others of greenhouse gas mitigation targets. Several used computational general equilibrium (CGE) models, assessing expected impacts on GDP, investments, consumption, export and import, inflation and employment, as well as income distribution.

6.1 GDP Growth

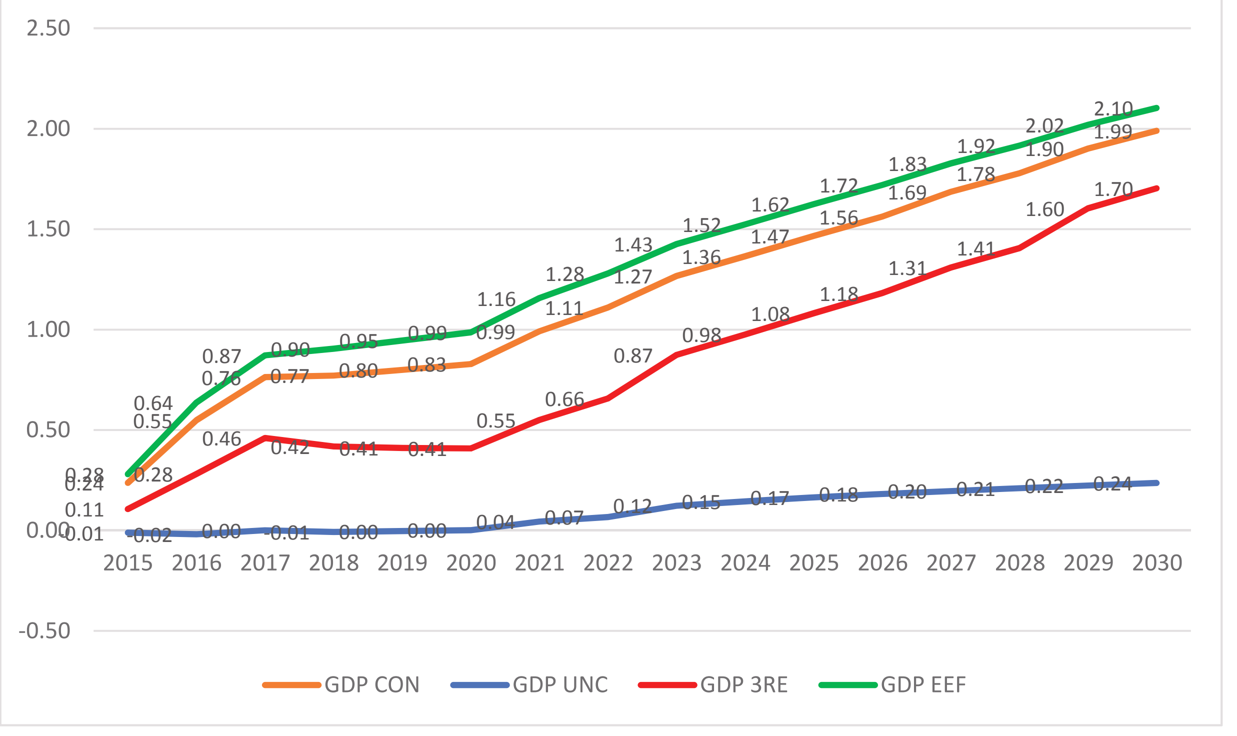
Audinet et al. (2016) found that for a low carbon scenario (with high RE penetration and EE) over the period 2012-2030, GDP growth would in the first few years be somewhat lower than a business as usual (BAU) scenario, but for most of the period it would be higher. This was explained by higher initial (investment) costs, and lower expenditures and higher efficiencies later. The gains and losses estimated with their model were small, which is consistent with modelling at the global level. Willenbockel and Ho Cong Hoa (2011) and UNDP-Viet Nam (2012) found that GDP will moderately increase over the period to 2030 as a result of a somewhat higher energy price, more RE and higher EE. They find that this is particularly the case if funds saved from subsidy removal and a carbon tax are invested in productive, low-carbon activities.

IES & MKE (2016) uses a similar BAU to Audinet et al. (2016) and Willenbockel and Ho Cong Hoa (2011). All BAUs were based on (then) existing energy policies, including the projections in Power Development Plan 7 (PDP7: SR Viet Nam, 2011a). IES & MKE (2016) present two low carbon scenarios to 2050, including one where Viet Nam would become independent of fossil fuels for power production by 2050. Both low carbon scenarios require major improvements in EE, but nevertheless, total power (energy) consumption will rise with more deployment of RE. This study shows that capital and operating costs in the BAU and the low carbon scenarios are initially very similar, but after some years they are a considerably larger fraction of GDP in the BAU compared to the low carbon scenarios, because of energy efficiency improvements in the low carbon scenarios and because of high costs of fossil fuel use in the BAU.

Pham Lan Huong (2018) reviewed the macro-economic effects of the NDC targets and related technology applications (see sections 2-5). She reviewed the effects on GDP growth of the 8 and 25 percent (unconditional and conditional) GHG emission reduction targets against BAU, including the different shares of the Agriculture, LULUCF, Waste and Energy sectors (see also Figure 1). She fed the NDC projections for different technologies into a CGE model, including increased investment in some sectors, or reduced consumption (for example of certain fuels). She modelled the period 2015-2030, with a 2014 baseline. The study shows that in the period 2015-2019, GDP growth compared to the BAU is reducing marginally for the unconditional 8 percent GHG emission reduction target (-0.003% to -0.011%). The explanation is that higher investment takes place for achieving reduced GHG emissions, but with the same level of economic outputs (i.e. slightly lower investment efficiency). But GDP is higher than the BAU over the period 2020-2030, i.e. the economic impacts the investments needed to reach the 8 percent target are positive, though by only 0.24% in 2030 (see Figure 5). Thesmall initial contraction and increased GDP growth afterwards is consistent with results found by Willenbockel and Ho Cong Hoa (2011), Audinet et al. (2016) and IES & MKE (2016).

The impact of conditional NDC target of 25 percent emissions reduction against BAU is much stronger. GDP in this conditional "CON" scenario (see Figure 5) is always higher than in the BAU, reaching nearly 2% increase compared with the BAU in 2030. This suggests that a significantly higher investment flow would cushion the economy during the adjustment period. For example, investments in energy efficiency measures in key sectors (e.g. cement; brick production) seem to offset higher energy consumption. Households make upfront investments in technology that are offset by lower energy consumption.

Figure 5 – GDP growth under the unconditional (UNC) emissions reduction NDC scenario (8 percent reduction compared with BAU) and the conditional (CON) 25 percent scenario, as well as theoretical scenarios of high RE and EE



Source: Pham Lan Huong (2018).

Notes:

- Y-axis gives percentage change compared to BAU.
- UNC is the unconditional 8 percent emissions reduction NDC target, compared with BAU.
- CON is the conditional 25 percent target in the NDC.
- 3RE is a scenario with renewable energy investment is tripled compared to CON
- EEF is a scenario twice the energy efficiency investment compared to CON

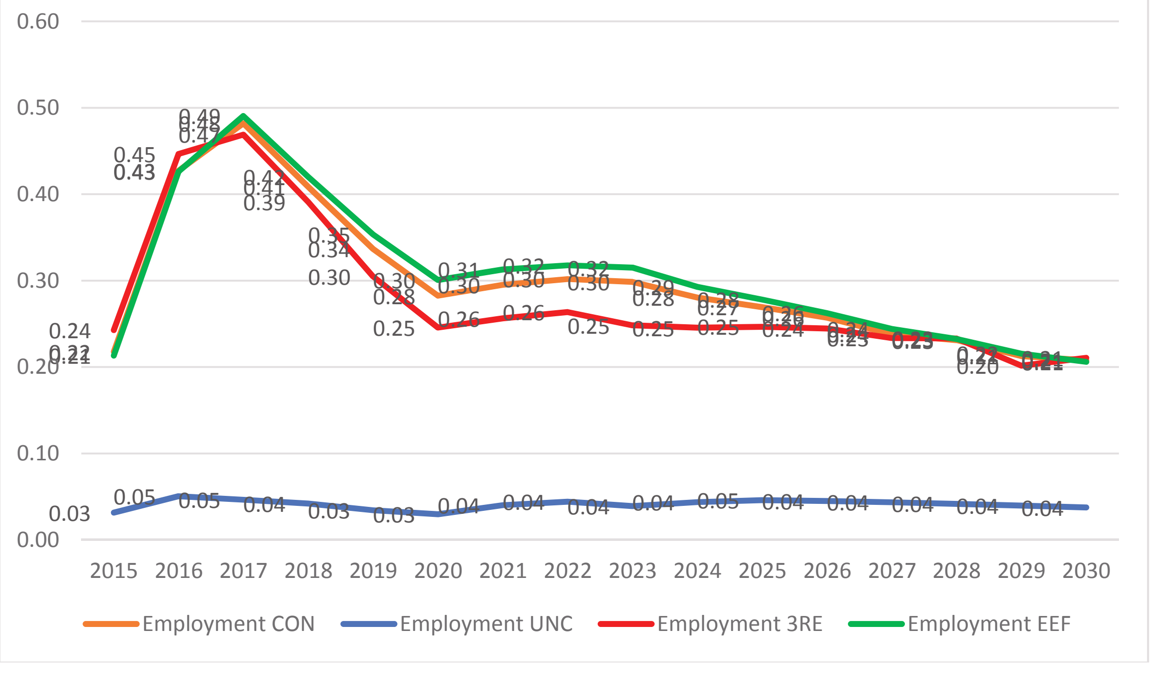
These projections of additional GDP growth, lower emissions, and a lower share of GDP needed for electricity as a result of energy transition are small. In reality, the differences may be larger because of the use of disruptive technology. Notably solar PV cost projections have proven to be outdated several times in the past years, with costs of technology decreasing more rapidly than expected (IEA, 2016; RLS, 2016). There is also significant energy efficiency potential with "best available technologies" (BAT) with potentially strong impacts on energy demand (JICA-MONRE, 2017). Also, the environmental costs and externalities of fossil fuel use have not been sufficiently accounted, but internalising those costs and reducing the effects will likely increase economic activity.

To assess the effects of a considerably higher ambition, Figure 5 also shows GDP growth under theoretical scenarios of high RE and EE. In the "3RE" scenario renewable energy investment is tripled compared to CON and in "EEF" the energy efficiency investment is doubled, compared to CON. By comparison, GDP growth turns out lower in the 3RE scenario than that in CON because of the low efficiency of the additional RE investment. It is, however, still considerably higher than in the UNC, suggesting that instead of the perceived costs to the economy of high ambition, it still delivers considerable positive growth benefits, whereas tripling RE investment would evidently have many environmental and social co-benefits and reduce dependency on fuel imports. This might be different if the costs of investments of RE would turn out to be lower than costs that were assumed for NDC (investment efficiency would be higher), but that was not modelled.

GDP growth is the highest in the EEF scenario, meaning that considerable additional investment in EE would be economically effective. This is challenging the perception that more ambition would lead to costs to the country's economy; instead it delivers benefit. However, for the most ambitious scenarios (CON, 3RE, EEF), the question arises from where the investments required would come. Sections 4.7 and 5.4 discussed availability of private sector investment capital, including foreign investment and domestic private capital. One broad conclusion from those sections, as well as the CGE modelling reported by Pham Lan Huong (2018), is that enabling policies and regulation is needed for mobilizing private sector investments, including farmers, households, SMEs, as well as larger domestic and foreign companies. Fiscal policies (tax and subsidy reforms) would also change investment behaviour, as has been argued in UNDP-Viet Nam (2012, 2014, 2016, 2017).

6.2 Employment

Figure 6 – Employment growth in the unconditional (UNC) emissions reduction NDC target (8 percent reduction compared with BAU) and the conditional (CON) 25 percent target, as well as theoretical scenarios of high RE and EE



Source: Pham Lan Huong (2018).

Notes:

- Y-axis gives percentage change compared to BAU.
- UNC is the unconditional 8 percent emissions reduction NDC target, compared with BAU.
- CON is the conditional 25 percent target in the NDC.
- 3RE is a scenario with renewable energy investment is tripled compared to CON
- EEF is a scenario twice the energy efficiency investment compared to CON

Pham Lan Huong (2018) also modelled the employment effects of the NDC targets compared to BAU. The NDC makes a positive impact on employment, considering all sectors and the activities proposed for the NDC in 2015. The analysis shows that employment effects are minor, but positive as per the conditional emissions reduction target, and quite significant if Viet Nam would achieve the conditional target. She concludes that most job creation comes during the first three years in forestry because of larger investment into this sector during these years.

In both targets, the relative contribution from the energy sector is minor, but nevertheless, employment is also created. The difference for total employment generation of tripling RE investment (scenario 3RE) and doubling EE investment (scenario EEF) were also modelled. Figure 6 shows the in the EEF scenario, employment increases further, though by a very small margin compared to the CON scenario. In the 3RE scenario, the employment effects are slightly lower than the CON scenario, but still considerably higher than the UNC scenario. This means that employment generation also remains very positive, even if Viet Nam would aim much higher than in the CON scenario with considerable emissions reductions from the energy sector. Therefore, apart from GDP growth (instead of contraction), high ambitions would have positive effects on employment and provide environmental and social co-benefits and reduce dependency on fuel imports.

International experience also shows an increase in net employment from expansion of renewable energy, compared to the BAU of fossil fuel use. Women are a minority of workers but their share in jobs is higher in renewable energy compared to the fossil fuel industry of coal mining, petroleum and gas exploration, fuel transport and distribution, and e.g. construction and operation of thermal power plants. Jobs in RE and EE are comparatively "green and clean" and many jobs require a fairly high skill level (RLS, 2016; Neefjes and Dang Thi Thu Hoai, 2017).

Some other data are available on the prospects for employment from an energy transition in Viet Nam (and research is ongoing). According to Audinet et al. (2016), there will be limited impact of low carbon economic scenarios on employment. Employment gains in low-carbon sectors of the economy are expected to even out the job losses in carbon-intensive sectors, such as coal mining. Estimates of current employment are about 140,000 coal mining jobs and about 120,000 power sector employees (Neefjes and Dang Thi Thu Hoai, 2017). A transition to a low carbon economy in Viet Nam would initially not lead to the closing of thermal power or other existing power plants. It would mean not building planned coal power plants that would be using imported coal. Substituting these plants with RE power plants will not cost mining jobs in Viet Nam or jobs in thermal power plants, but will generate new, additional jobs.

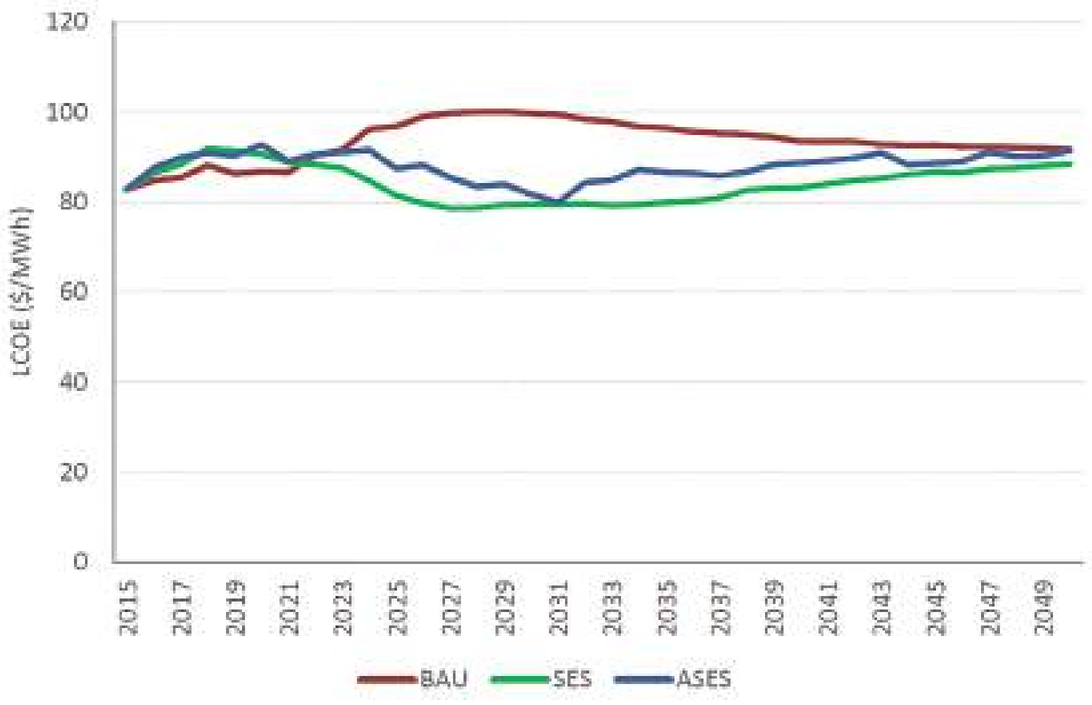
But in the longer term, existing thermal power plants and domestic coal mining would be phased out, e.g. according to low carbon scenarios to 2050 that were developed and analysed by IES & MKE (2016). Their "Sustainable Energy Sector" (SES) and "Advanced Sustainable Energy Sector" (ASES) scenario both show an increase in EE and in RE penetration. The most ambitious is the ASES scenario, with a 100 percent renewable power sector by 2050. The SES scenario would almost double job-years over the period 2015-2050 compared to BAU, and the ASES would almost triple it, driven especially by renewable energy deployment and strong energy efficiency measures.

New jobs in the energy sector would come from manufacture of energy efficiency technology and installation, retrofitting of equipment and buildings, as well as energy auditors and other advisory functions. The manufacture and assembly of solar PV and wind power equipment is already happening in Viet Nam for export and would grow as a result of a substantial domestic market. CGE modelling of the Vietnamese economy can however not ascertain with high confidence whether RE equipment manufacturing jobs are created only within Viet Nam or whether a share is foreign jobs, because it depends on competition in international markets. Jobs would be in the construction of RE plants and smaller numbers in maintenance and operation of RE plants. Phase out of fossil fuel supply pipelines will not only reduce the number of jobs of e.g. drivers, but also indirectly affect other jobs in the transport sector (e.g. boat and truck manufacture, harbour construction and maintenance) and it is unclear whether such indirect effects were included in the modelling or not.

6.3 Effects of Electricity Tariffsof Energy Transition on Businesses

According to Audinet et al. (2016), the costs of electricity will be slightly higher in their low carbon scenarios compared to the BAU scenario. Modelling by IES & MKE (2016) concluded that both their low carbon scenarios (SES and ASES, as discussed in section 6.2) will result in a lower electricity price for nearly all of the period until 2050, but that initially the price would be higher than the BAU. The most ambitious scenario ASES aims for 100 percent renewable power sector by 2050 and would deliver slightly higher costs than the SES scenario (see Figure 7). The average electricity retail tariff in Viet Nam has remained constantly low for a significant period of time, as shown in Figure 8.

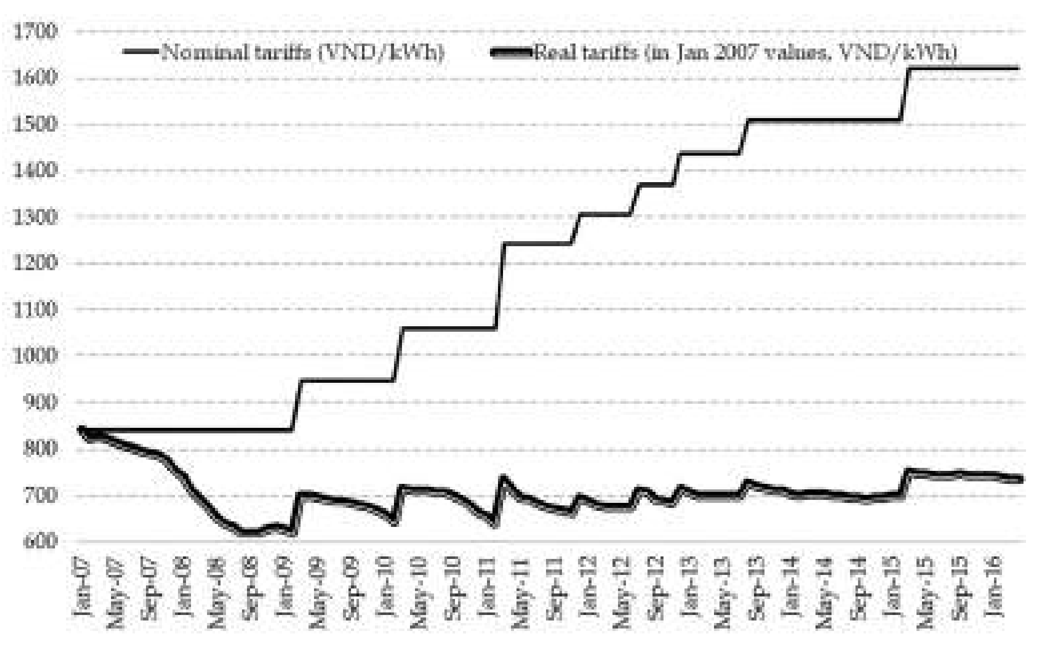
Figure 7 - Modelled Levelized Costs of Electricity (LCOE) of the Power Mix to 2050



Source: IES & MKE (2016)

World Bank (2016) suggest that the price of electricity should go up by perhaps 15 percent in real terms, in order to make EVN group financially viable. UNDP-Viet Nam (2012) estimated that up to 3 annual 5-10 percent increases in real terms would be the result of phase out of indirect subsidies and imposition of a carbon tax or fee, i.e. about 20 percent in total. This price increase could be the main driver for increasing RE deployment and increasing EE if it would be imposed on fossil fuels, as the various modelled low carbon scenarios would require. This focus would increase prices somewhat and decrease prices later because the cost of RE keeps decreasing, as modelling by Audinet et al. (2016) and IES & MKE (2016) suggests (see Figure 7).

Figure 8 - Average Electricity Retail Prices (Nominal and Real)



Source: La et al. (2017)

But the short-term energy price increase in most energy transition scenarios could affect certain businesses. Several surveys suggest that domestic SMEs with high levels of energy consumption are vulnerable, and a small proportion of foreign invested businesses are high energy consumers too. Nguyen Manh Hai et al. (2015) reviewed support programmes that are assisting businesses to increase energy efficiency: "energy efficiency programmes and policies for the business sector in general and for SMEs in particular have shown many positive effects that may help businesses cope with short and medium term price effects of ongoing fossil fuel fiscal policy reform, [but] many aspects of these programs and policies need to be improved".

According to Willenbockel and Hoang (2011), most Vietnamese firms could cope with gradual increases in energy costs of 5-10 percent per year over three years and off-set those through energy saving. A survey of Vietnamese firms by Dang Thi Thu Hoai and Tran Toan Thang (2013) concluded that with such energy price rises, firms are likely to take energy saving measures. Higher price increases could lead them to raise output prices, but businesses are reluctant to invest in costly energy saving technology. According to Garg et al. (2015), Viet Nam's low energy prices are not a key determinant for the large majority of foreign investors to come to Viet Nam. They could and would absorb sustained price rises of more than 10 per cent per year over several years. Both domestic and foreign invested businesses are more concerned with power supply stability than unit costs of energy (see also UNDP-Viet Nam, 2014).

6.4 Effects of Higher Energy Costs on Low Income Households

In particular, low income households will be affected by the potential increase in the price of energy, specifically electricity. Several analyses of their challenges also propose mitigation measures for the period that price increases are likely (and probably necessary) to achieve energy transition.

Analysis in 2013 suggested that the direct effects on low income households of energy price increases could be noticeable, and also that indirect effects on prices of other goods and services can be substantial. Furthermore, an increase of 20 percent increase in electricity and petroleum prices could cause 4 percent inflation (CAF-VASS, 2013; UNDP-Viet Nam, 2014). However, the inflationary pressures have reduced since then and impacts on low income households can be mitigated through comparatively simple changes in the pricing system of electricity.

In 2014, the "lifeline tariff" to ensure electricity supply to the poor was eliminated while the (electricity) cash transfer scheme to poor and "social policy households" was expanded with payments equivalent to the electricity cost of 30 kWh/month. Changes were also made to the "Incremental Block Tariff" scheme, making it considerably less progressive. However, a survey showed that the cash transfers are administratively inefficient. If maintained, they should be coordinated with the wider social assistance programmes of the Government (La et al., 2017; UNDP-Viet Nam, 2017).

To effectively and efficiently protect low income groups from higher energy (electricity) prices in the transition towards a competitive retail power market and low carbon economy, it was recommended to: (a) drop the complex eligibility criteria for support; (b) to introduce a more progressive tariff structure including a zero or nominal tariff for the first 30kWh for all electricity users; and (c) to eliminate the cash transfer scheme or integrate it into other social assistance programmes for those households not yet connected to the national power grid. This would mean that the cost of providing electricity to all, including low income households that consume little electricity, is covered through higher charges imposed on other blocks, i.e. the better off households consuming more.

6.5 Exports of Renewable Energy Equipment

Audinet et al. (2016) found that under the low carbon development scenario, exports would be 8 percent higher by 2030 than under the BAU scenario. This is partly explained by growth potential in low-carbon and renewable energy technologies for export to other countries as well as for use in Viet Nam.

The Renewable Energy Development Strategy and the support policies for wind and solar PV all include measures to encourage development of local manufacturing industry for RE equipment while also enabling import of certain equipment through reduced import duties (SR Viet Nam, 2011b, 2015b, 2017).

Despite a tiny domestic market for solar PV and wind power equipment, Viet Nam is already exporting wind towers and manufactured and assembled solar PV equipment. Examples of this are provided in Neefjes and Dang Thi Thu Hoai (2017), including Solar BK, a wholly Vietnamese company based in Ho Chi Minh City (HCMC) that is manufacturing solar PV cells and panels as well as solar water heaters; they are the largest supplier of solar PV systems to the Vietnamese market and are exporting equipment. CS Wind Viet Nam in Ba Ria-Vung Tau is part of a South Korean group exporting hundreds of wind towers per year. Foreign invested companies assembling solar panels for export include Canadian Solar in Hai Phong, Boviet Solar Technology Co. and JA Solar in Bac Giang province, and First Solar in HCMC. There are also large international companies represented in Viet Nam that deliver parts of systems to the Vietnamese market, including small parts such as inverters (e.g. ABB) and large parts such as wind turbines (e.g. GE and Siemens-Gamesa).

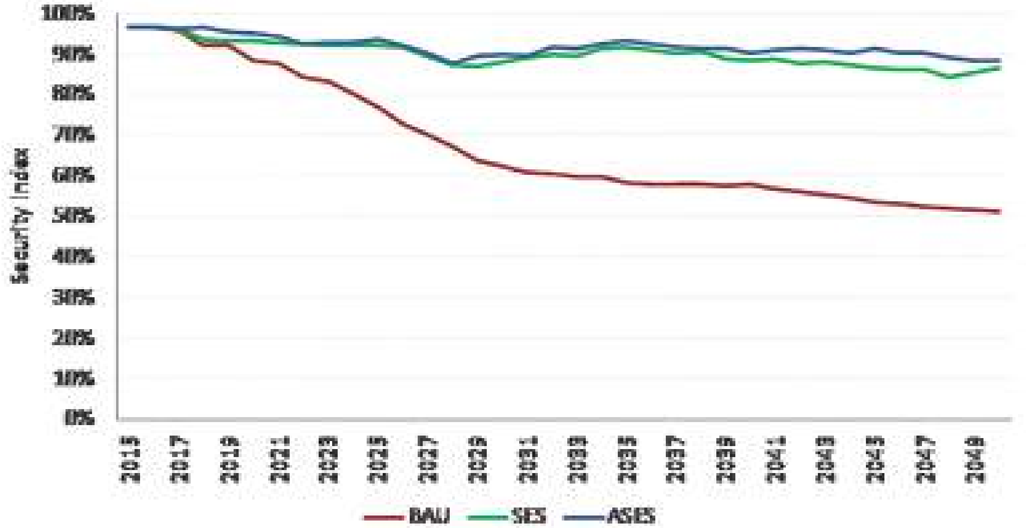
In conclusion, low carbon policies appear to cause technological modernisation and efficiencies and stimulate Viet Nam's exports. There is also a strong basis for further development of the manufacture and export of solar PV and wind power parts. There is a basis for growth of this manufacturing industry if the deployment of solar PV and wind power increases in Viet Nam.

6.6 Energy Security

Viet Nam is already a net energy importer, despite exploitation of domestic coal and petroleum as well as gas fields (the latter are not yet fully developed). The revised Power Development Plan ("PDP7-revised"; SR Viet Nam, 2016) projects growth in the deployments of coal and gas-based thermal power plants that mostly rely on imported fuels. Reliance on imported fuels signifies price risks over very long periods of time (the lifecycle of coal power plants could be as long as 40-60 years even if designed for 25-35 years), and it affects the national trade and foreign currency balances. Security questions can be raised at times of major typhoons, and political tensions could conceivably disrupt coal and liquid natural gas (LNG) supply chains.

Improved EE (i.e. reduced energy demand) and larger scale RE deployment as modelled by IES & MKE (2016) mean a strongly reduced dependency on international fossil fuel markets compared to the BAU, as demonstrated by a fuel security index in Figure 9.

Figure 9 - Security Index: percentage of electricity produced with sources within Viet Nam



Source: IES & MKE (2016)

More RE would likely mean a more decentralised power supply system, with distributed power generation on rooftops and comparatively small power plants in different places. [10] This can increase local energy security because failure of a single (small) production unit can easily be compensated in an interconnected grid. Solar PV rooftop systems can also be complemented with some storage capacity, e.g. as alternative to back-up diesel generators for hotels, offices and factories. Power supply interruption can be costly to businesses and back-up diesel generators are expensive, polluting and noisy. Businesses feel that stable and guaranteed power supply is important (see also section 6.3), which could thus be aided by integration of solar PV and some storage capacity.

Interruption of power supply can also be harmful to farmers requiring irrigation of fields and oxygenation of aquaculture ponds. Irrigation pumps and aquaculture farms are often at the extreme ends of electricity distribution systems, and vulnerable to breakdown. Thus, power use in remote areas, where often diesel engines are used because of security of supply to irrigate agriculture and aquaculture, can also benefit from solar PV. These may be used during sunny hours, and possibly include limited-scale power storage if additional functionality is required.

7. Accelerating Progress towards the SDGs

Increasing greenhouse gas emissions reduction in Viet Nam offers several co-benefits and can make important contributions towards achieving several of the SDGs (UN, 2015). Some are highlighted here, though not in numerical order:

The analysis of greenhouse emissions reduction potential and suggestions for additional action are evidently consistent with the targets of SDG 13 on urgent action to combat climate change, as it primarily addresses the causes of climate change.

SDG 7 focuses on "Ensuring the world's poor have access to affordable, reliable and modern energy services" and energy is the focus of this paper because of Viet Nam very high projected energy emissions. Viet Nam is doing comparatively well on energy access, with more than 98 percent of all households connected to the grid (EVN, 2017; see also World Bank, 2011), although power supply may be interrupted at times. Increasing the ambition of Viet Nam's NDC would increase energy access (as supply improves, also in remote areas), renewable energy can be deployed at both large and small scale (e.g. rooftop solar PV; community systems; or mini-grids), and energy efficiency are pursued.

SDG 1 on poverty eradication is supported by energy access as well as GHG emissions mitigation in LULUCF, agriculture and waste. For example, mangrove forests reduce exposure of people, communities and livelihood assets from extreme storm surges at the coast. Several agricultural techniques that reduce emissions also reduce the need for some agriculture inputs, reduce costs and increase productivity. Waste management, including recycling, can improve local incomes, health and environmental quality. Stable electricity supply and a low cost "first block" of electricity in a progressive tariff system, as well as access to affordable cooking fuel such as biogas can make a very significant difference for the poorest, whose energy expenditure is often a high share of their income.

The cost of land can be high and inhibit development of e.g. solar PV power plants. However, combined land use is possible, depending on the location, such as combination of both solar PV, wind and/or hydropower, harbours and highways (wind), agriculture, aquaculture and livestock keeping. The latter means that renewable electricity generation by farmers, community groups and cooperatives is possible, as is happening in other countries. In combining solar or wind power generation with local production

10 A thermal coal power plant could include 3-4 units with a capacity each of 600 MW in one locality, benefiting from concentrated transport facilities. Wind and solar power plants may be built with capacities of 30-300 MW, perhaps more, but unlikely to the same size as thermal coal plants in one location.

systems (solar PV on rooftops, above fields combined with shade tolerant crops, walkways and fish ponds; wind turbines along paths and dykes) could provide additional income to rural areas, where relatively large numbers of poor people reside.

SDG 2 on food security is aided by agricultural techniques that reduce emissions and at the same time increase crop resilience and productivity, as well as e.g. higher quality forests. These will also positively affect the achievement of SDG 12 "Ensure sustainable consumption and production patterns." Several agriculture and forestry techniques are already included in the analysis underlying the NDC targets (MONRE, 2015). Additional techniques are being promoted in Viet Nam as "climate smart agriculture", for which there is potential (CIAT and World Bank, 2017; see also section 3). It should also be noted that some forms of biomass-energy may compete for land for food crops, which must be avoided. But the use of residues from processing, farming and e.g. biogas from animal waste tend to support food production and help improve local nutritional values.

Household biogas production and use as alternative to fuelwood or coal improves indoor air quality and especially the health of women and children. It is thus an example of a GHG emissions mitigation activity that contributes to SDG 3 on healthy lives and well-being. People living in the dense urban centres would start to benefit from cleaner air because pollution from power production, industry and transport would be reducing with increased RE and EE. If all planned coal power plants would be built in Viet Nam, air pollution could result in thousands of additional premature deaths per year by 2030 (Koplitz et al., 2015), which could be avoided by more ambitious mitigation in the energy sector.

SDG 4 on education is obviously aided by the energy targets, resulting in stable electricity supply to schools and to enable homework at night.

SDG 5 on gender equality and empowerment of women and girls can be aided by several low carbon techniques and approaches. For example, household level biogas can improve the (indoor, outdoor) environment of women and children, and save time or reduce the workload of women because of reduced dependency on fuelwood. Several agricultural techniques must be focused particularly on women farmers, assist in generating more income, and assist food security. Some of the RE techniques can generate comparatively more employment for women in green and clean jobs, compared to the fossil fuel industry.

SDG 6 "Ensure availability and sustainable management of water and sanitation for all" is supported by transitioning from thermal power to RE, e.g. because large amounts of water are used for cooling of coal-power plants, and wastewater causes pollution unless treated fully. Boosting EE in different industries is usually associated with reduced water pollution and enabling or protecting access to clean water. Water extraction, transport and treatment systems require a large amount of energy, and at least some of this demand could be made cheaper and more reliable with on-site solar PV generation. But water for hydro-power and water demand for household use or agriculture can also compete and contradict, and different interests must be reconciled.

SDG 8 on sustained and inclusive economic growth and employment for all, is likely to be stimulated by enhanced greenhouse gas emission action in different sectors as new technologies are developed and adopted (see section 6). Deploying renewable and energy efficient technologies can spur innovation and reinforce manufacturing and construction employment. Operation and maintenance of RE power facilities may require less, rather than more employment compared to transport of fuel and operation of coal power plants. However, for the foreseeable future, Viet Nam will not be closing existing power generation facilities. Should that start to happen, measures such as re-training must be taken to minimise the negative impacts of transition to RE, and some workforce migration may also be needed. To support clean energy efforts, strengthened financial institutions are necessary for providing capital, credit and insurance to local entrepreneurs.

Several of the positive effects on employment are at the same time a contribution to SDG 9 "Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation".

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