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GREENING THE POWER MIX:

Policies for Expanding Solar Photovoltaic Electricity in Viet Nam

March 2016

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Foreword

In late 2015 the Government of Viet Nam issued its Intended Nationally Determined Contribution to the UN Framework Convention on Climate Change, and also its Renewable Energy Development Strategy, which I commend very highly.

These policies set the framework for major reductions in future greenhouse gas emissions in Viet Nam, which helps reducing the threat of dangerous global climate change.

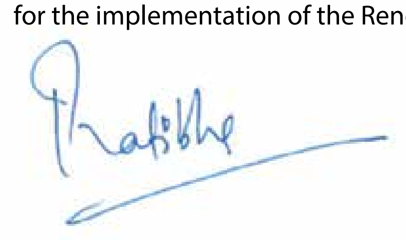
This policy discussion paper addresses how Viet Nam can achieve the targets in these policies by internalising the costs of coal-based power to people, the environment and the economy, and by stimulating the development of solar photovoltaic power generation.

In addition, the world adopted the Sustainable Development Goals, also in 2015. Viet Nam has actively supported the formulation of the Sustainable Development Goals and intends to achieve them at the national level.

This paper shows that renewable energy, and in particular solar photovoltaic power generation can play a key role in achieving Sustainable Development Goal 7, "Ensure access to affordable, reliable, sustainable and modern energy for all", which is important especially for the remotest and poorest Vietnamese communities and households who do not yet benefit from regular access to electricity. Achieving this will help children to study better, productivity to go up, and poverty to be eliminated.

This paper is based on research by many national and international experts, and has benefitted from several dialogues with policy makers, businesses, and development partners.

It is the third in a series on fossil fuel fiscal policy reform, and makes proposals that will have long-term social, economic and environmental benefits. I highly recommend using this paper, especially for the implementation of the Renewable Energy Development Strategy.



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The main author of this policy discussion paper was Koos Neefjes, formerly of UNDP Viet Nam's Policy Advisory Team (PAT). Others at UNDP contributed to the concept, background research and consultation workshops, including Ta Thi Thanh Huong, Michaela Prokop, Pham Thi Lien Phuong, and Vu Thi Thu Hang. They also commented on various drafts, as did Maureen Boyle, Jan Rijpma and Andrew Spezowka of UNDP, which was very helpful.

The paper is heavily based on background reports commissioned by UNDP. Several of those were prepared by the Institute of Energy (IoE) under the Ministry of Industry and Trade (MOIT), whose team was led by Nguyen Duc Cuong and included Ly Ngoc Thang and Vu Binh Duong. GreenID prepared an important report on coal. Their team was led by Nguy Thi Khanh and included Ngo Duc Lam, Nguyen Van Hanh, Nguyen Tien Chinh, To Quoc Tru, Hoang Thanh Binh, and Maarten Jan Akkerman. Other commissioned background reports were prepared by Srinivasan Sunderasan and Vamshi Krishna Kottam, and by Trinh Quang Dung. Several of those authors also commented in-depth on the draft policy discussion paper. Their work is gratefully acknowledged, as well as the contributions from interviewees to some of those studies.

Peer reviews and detailed comments on the draft paper were expertly provided by Nguyen Manh Hai (Central Institute for Economic Management, CIEM), Nguyen Quoc Khanh (independent energy expert), Gavin Smith (Dragon Capital), and Franz Gerner (World Bank).

Core elements of the draft paper were provided as technical inputs into the formulation of the Solar PV Support Policy and the Renewable Energy Development Strategy, by the Renewable Energy Department of MOIT. The director of this department, Pham Trong Thuc, and senior official Pham Huong Giang provided very perceptive feedback on those inputs.

The draft paper was presented to technical workshops organised by the Institute of Energy. Participants from MOIT; the IoE; business organisations such as the Viet Nam Chamber of Commerce and Industry (VCCI) and Eurocham; development partners including the UK-FCO, GIZ, the European Union, AFD, KfW, ADB, JICA, USAID and others; NGOs such as GreenID and WWF; and internationally funded projects provided comments on draft conclusions and made recommendations – all contributions made by participants were very much appreciated.

The research, consultation workshops and writing of this paper were made possible with funding from UNDP and the UK Foreign and Commonwealth Office (UK-FCO), which is also gratefully acknowledged.

GreenID

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List of Acronyms [Glossary]

AC	Alternating Current
ATC	Aggregate Technical and Commercial Losses [*in power transmission and distribution*]
CDM	Clean Development Mechanism [*allows a developed country with emission-reduction commitments under the Kyoto Protocol to implement an emission-reduction project in developing countries; such projects can earn certified emission reduction (CER) credits, each equivalent to one ton of CO_2, which can be counted towards meeting Kyoto Protocol targets of the developed country concerned*]
CPI	Consumer Price Index
CO_2e	Carbon-dioxide equivalent [*Global warming potential of a gas or gases emitted, expressed in terms of the equivalent global warming potential of CO_2*]
DC	Direct Current
ERAV	Electricity Regulatory Authority of Viet Nam
EVN	Viet Nam Electricity Group
FiT	Feed-in-tariff [*a guaranteed, preferential, fixed electricity price for a fixed tenure, after which time, the generators receive the market price for electricity; funded from state budgets or from cross-subsidies*]
FBCC	Fluidized Bed Coal Combustion [*technology used in coal-fired power plants*]
GDP	Gross Domestic Product
GENCOMs	power generation companies
GHG	greenhouse gas
GHI	Global Horizontal Irradiation [*a common indicator of solar PV potential (kWh/m^2 day). GHI is the total amount of shortwave radiation received from above by a surface horizontal to the ground. This value includes both Direct Normal Irradiance (DNI) and Diffuse Horizontal Irradiance (DIF). DNI is solar radiation that comes in a straight line from the direction of the sun at its current position in the sky. DIF is solar radiation that does not arrive on a direct path from the sun, but has been scattered by molecules and particles in the atmosphere and comes equally from all directions*]
GreenID	Green Innovation and Development Centre
GW	Giga Watt [*1000 MW; 1,000,000 kW*]
IEA	International Energy Agency
IoE	Institute of Energy
IPPs	Independent Power Producers
IRR	Internal Rate of Return
kV	kilo Volt [*1000 V*]
kW	kilo Watt [*1000 W*]
kWh	kilo-Watt hour [*one thousand or 10^3 Watt hours*]
kWp	kilo-Watt peak (see Watt peak)
LCoE	Levelised Cost of Energy [*computed by (i) estimating the costs involved in building, operating, maintaining, renewing a solar PV or other power plant over its useful life, (ii) converting the stream of costs into an annuity at the cost of capital, and (iii) dividing the annuity by the projected power output during an average year*.]
LDUs	Local Distribution Utilities
LV	low voltage [*voltage in the range 50–1000 V AC or 120–1500 V DC ; used in the customer distribution system*]
MSW	Municipal solid waste
MV	medium voltage [*Medium voltage distribution systems carry medium voltage power (between 2 kV and 35 kV) to distribution transformers to low voltage systems*]

MW	Mega Watt [*1000 kW; 1,000,000 Watt*]
MWh	Mega Watt – hour
O&M	Operation and Maintenance
PDP VII	Power Development Plan VII: Prime Minister Decision 1208/QD-TTg of 21 July 2011, on approval of "the national Power Development Plan for the 2011 - 2020 period with a vision to 2030"
PDP VII-revised	Power Development Plan VII-revised: Prime Minister Decision 428/QD-TTg of 18 March 2016, on approval of "Adjustments of the national Power Development Plan for the 2011 - 2020 period with a vision to 2030"
PLF	Plant Load Factor [*a measure of efficiency of capacity utilization during production*]
PPA	Power Purchase Agreement [*usually by an independent power producer (IPP) with an electricity utility at pre-determined prices, for a pre-determined tenure*]
PCC	Pulverized Coal Combustion [*technology used in coal-fired power plants*]
RE	Renewable Energy [IEA: "*Energy derived from natural processes (e.g. sunlight and wind) that are replenished at a faster rate than they are consumed*".]
REDS	Renewable Energy Development Strategy
RET	Renewable Energy Technology
SDGs	Sustainable Development Goals
SHP	small hydro power [*with an installed capacity below 30MW*]
SMEs	Small and medium sized enterprises
SOEs	State Owned Enterprises
Solar PV	Solar photovoltaic
T&D	Transmission & Distribution
TW	Tera Watt [*one trillion (10^{12}) watts*]
TWh	Tera Watt hour [*one trillion (10^{12}) Watt hours*]
UNDP	United Nations Development Programme
USD	United States dollars [*1 USD = 100 USD cent*]
VCCI	Viet Nam Chamber of Commerce and Industry
VEPF	Viet Nam Environmental Protection Fund
VGGS	Viet Nam Green Growth Strategy
VINACOMIN	Viet Nam National Coal - Mineral Industries Holding Corporation
VND	Viet Nam Dong [*national currency*]
Wp	Watt peak *[sometimes referred to as "peak Watt": a unit of measurement for the nominal power of a solar photovoltaic module, reflecting the maximum / rated power output from the module at 25°C; it is the amount of power a PV module could supply if it were to receive 1000 Watt of solar irradiance per square meter area*]

Summary

Viet Nam actively engaged in the process of formulation of the global Sustainable Development Goals (SDGs), and it aims to achieve those. Goal 7 of the 17 SDGs is "Ensure access to affordable, reliable, sustainable and modern energy for all", with targets on universal access to energy services, increasing the share of renewable energy, and improvement in energy efficiency. These three targets are already reflected in Vietnamese policy. This policy discussion paper aims to provide recommendations to expand solar PV power generation and consumption, in order to help achieve SDG-7 in Viet Nam.

The future of electricity supply in Viet Nam can be strongly based on renewable energy, especially solar Photovoltaic (PV) power. This would limit Viet Nam's growing dependency on energy imports including coal imports. It would also have economic, environmental, social and health advantages, and would be a major contribution of Viet Nam to the mitigation of global climate change.

Official plans suggest that coal-based power will make up more than half of the power mix by 2030. The main reasons for these plans are that Viet Nam needs a large amount of power to support its economic growth; Viet Nam has substantial coal reserves; and coal is seen as a cheap source of power. In addition, Viet Nam lacks the public financial capital for expansion of its power supply whereas international private financiers and equipment and construction companies remain interested in investing in coal-fired power plants in Viet Nam. But all these reasons can be challenged.

The electricity demand projections have recently been lowered and plans for expansion of renewable energy were increased. "Power Development Plan VII-revised" and the Renewable Energy Development Strategy (REDS) also reduced the projected coal imports for power production in 2030 when compared to the projections in Power Development Plan VII. The achievement of the new targets would be a major step towards achieving the greenhouse gas emissions mitigation component in Viet Nam's Intended Nationally Determined Contribution (INDC) that it submitted to the UN Framework Convention on Climate Change (UNFCCC) in 2015.

However, coal-based power will remain dominant and there will still be a large amount of coal import with associated long-term dependency on international markets. Some analysts believe that developing the infrastructure for large scale imports and distribution of coal has not been fully included in plans and cost estimates, and requires very considerable investments.

Coal mining and transport cause environmental destruction and pollution, and coal-fired power plants cause air pollution and produce vast amounts of fly ash that must be transported, landfilled and/or used. Furthermore, Viet Nam's environmental standards in this context are (much) more permissive than in other countries. This causes health problems and premature deaths and it affects agriculture and other livelihoods, and the overall economy. These are real costs but they are largely "external" to the calculations of the cost of coal-based power. Importantly, building the planned coal-fired power plants threatens to lock-in long-term greenhouse gas emissions, and will contribute to making Viet Nam a large emitter of greenhouse gasses per capita in 2030.

In addition, much of the generated power is currently sold at prices below the cost of delivering it to customers, even without internalising the above external costs of coal-based power. Coal-based power production in Viet Nam is still indirectly subsidised, by cheap hydropower and various other mechanisms. Assuming a modest carbon price of 5 or 10 USD/tonne CO_2, to illustrate what phase out of fossil fuel subsidies and internalising of the costs of using coal means for the cost price of coal-based power, suggest that this would make various forms of renewable energy competitive

and would help to attract domestic and international private investment into solar PV power production.

The REDS sets renewable energy targets, including solar PV targets. The advantages of solar PV are obvious from an environmental, health and also livelihood perspective, as domestic industry could develop (construction, maintenance and possibly also equipment assembly and manufacturing), and jobs will be created. The REDS proposes an environmental fee on the use of fossil fuel, with revenue for a Sustainable Energy Promotion Fund that will aim to support renewable energy development. Other measures for achieving this strategy's targets such as tax exemptions are also included, and Viet Nam already has some support policies in place for developing wind and biomass-based power production, whilst a similar policy for solar PV electricity is available in draft.

Solar irradiation in Viet Nam is good, and the potential for solar PV is particularly high in the centre and south of the country. In some countries solar PV can now be installed to produce power at a "levelised cost" per kWh electricity below that of coal and most other forms of power generation. However, the perceived high financial risks in Viet Nam and therefore the cost of capital, as well as a lack of capacities mean that the first solar PV investments in Viet Nam are likely to be more expensive than the costs of coal-based power, unless a carbon price (tax, fee or otherwise) would be imposed.

Based on model calculations a "Feed-in-Tariff" (FiT) of 15 USD cents/kWh for mainland solar PV power plants is proposed, and for power plants on islands a FiT of 19 USD cents/kWh, over a lifetime period of 20 years. The island-FiT is cheap compared with diesel generated power which is common on islands and so solar PV should be a preferred option for any future investment. However, the mainland FiT is higher than the draft solar PV policy of the Government of 11.2 USD cents/kWh, and both are higher than the 2015 average retail tariff of 7.6 USD cents/kWh.

It is recommended that these should be regulated as *maximum FiTs*. The Government and EVN could then negotiate investments below that maximum, or "reverse auctions" might be held to ensure that investors will go as far below this price as possible. A lower and fixed FiT may initially not attract any investor and therefore the solar PV power market would not be able to develop. Auctioning eliminates the information asymmetry between investors and regulators, whilst it keeps the costs within predictable boundaries. Successive auctions can be held based on lessons learned and as solar PV investment costs are reducing internationally, so certain to-be-installed power production projects are expected to push the tariff progressively lower. It is recommended that the agreed price (to be paid to the investor) would be guaranteed for the lifetime of the project (typically 20 years), and that the (maximum) FiT will be adjusted at certain intervals. In this way financiers, equipment manufacturers and suppliers and construction companies will gain experience, the market can develop and further cost reductions will be achievable.

Advantages also include that solar PV can be "distributed" i.e. power can be produced near consumers, at different scales. This can take the form of grid-connected "rooftop" installations; as off-grid individual or collective systems that include battery banks; or solar PV can be employed as part of hybrid mini-grid systems. All of those applications could improve access to power by remote communities and islands, reaching the few percent of Viet Nam's population that is not yet grid connected, and households or businesses that currently experience erratic power supply.

It is recommended that a "net-metering" policy will be issued for small scale grid connected solar PV systems (including "rooftop") that are primarily meant for on-site consumption. These systems feed small amounts of excess power into the grid that is off-set against what they buy (they draw electricity from the grid when their production is insufficient). The owners would "sell" and "buy" against the prevailing retail tariff, essentially by using two-way electricity meters. This could enable development of distributed solar PV in at least three typical situations:

Firstly, according to the current electricity regulations, the present retail tariffs for certain businesses during “normal” and “peak” hours of consumption, when solar irradiation is high, are considerably higher than the average tariff. This makes it likely that with a net-metering policy and the present or slightly increased national retail tariffs it is financially attractive for businesses to invest in rooftop solar PV systems. Model calculations suggest that there is no need for a premium FiT to stimulate this. And as retail tariffs will go up further over the coming years and costs will reduce, rooftop solar will become attractive for a growing number of businesses.

Secondly, rooftop solar PV will also be financially attractive for households who pay for part of their consumption according to the highest tier in the block tariff scheme for residential electricity consumers. This group of potential investors particularly requires simplified administrative requirements for installing rooftop solar PV and connecting it to the grid, as per international experience. As retail tariffs will edge up over the coming years and solar PV technology costs will come down, more and more households are expected to become interested in investing.

Thirdly, solar PV can play a central role in improving access to electricity in remote areas and islands, especially the villages and households not yet connected to the grid. Solar PV power is much cheaper than power produced with diesel generators (currently operating in particular on islands), and if battery banks are included or solar PV is a part of hybrid mini-grids it can compete well with the alternative of grid extension for low numbers of households and high costs of transmission and distribution. Local off-grid systems can be connected to the national grid at a later date, meaning that poor and remote households can benefit from electricity in the short term and do not need to wait for full national grid coverage, even if that will prove to have advantages.

Further recommendations for stimulating solar power plant investments as well as on-grid and off-grid “rooftop” and community solar PV systems are primarily geared towards lowering the initial capital investment and reducing investor risks: favourable tax policies; loan guarantees or a Government stimulus package through banks; ODA grants or soft loans to prepare the first “reverse auctions” of solar PV power plants; subsidies for solar PV systems in remote areas and islands (Government, provinces, EVN and/or ODA); and accessing special (domestic) funds to support domestic manufacturers and suppliers or operators of solar PV equipment.

It is proposed that Viet Nam’s indirect subsidies on fossil fuels in the power sector are fully removed and that Viet Nam starts internalising the external costs of fossil fuel use, as is also included in the Renewable Energy Development Strategy (REDS) through an environmental fee on fossil fuel use. The low the retail price of electricity is the primary barrier to development of solar PV and indirect subsidy phase out and a carbon price or environmental fee would mean that the average electricity retail price must go up gradually, for example by 5-10% per year over three years. This would be combined with phasing out of all forms of support to coal-based power.

Regulations to stimulate renewable energy could also include the option of imposing “portfolio standards”, i.e. regulating that a specific share of electricity produced by power generation companies must be generated from renewable energy; and the option of Performance Based Standards, i.e. specifying allowable levels of GHG emissions per unit of output of power generation companies.

Encouraging investments in solar PV power plants, “rooftop” and community systems also requires urgent issuing of technical and environmental standards; administrative procedures (e.g. net-metering); and guidelines for land use planning, environmental impact assessment, and consultation with local stakeholders. Furthermore, development of the solar PV sector requires increased capacities of many stakeholders, which could be partly supported by ODA.

1. Introduction

Viet Nam did well in terms of achieving the Millennium Development Goals (MDGs), and its achievements on poverty reduction in the period until 2015 stand out. Viet Nam has also actively engaged in the process of formulation of the global Sustainable Development Goals (SDGs)[1], and it aims to achieve those.

Goal 7 of the 17 SDGs is "Ensure access to affordable, reliable, sustainable and modern energy for all", and the related targets are: by 2030, (7.1) ensure universal access to affordable, reliable and modern energy services; (7.2) increase substantially the share of renewable energy in the global energy mix; and (7.3) double the global rate of improvement in energy efficiency.

These three targets are already reflected in Vietnamese policy, and the country is performing quite well, although more needs to happen:

1. By the end of 2013, over 98 percent of Vietnamese households had access to electricity and Viet Nam is aiming for 100 percent by 2020. Households that are not yet grid-connected are mainly in the remote rural areas, including ethnic minority communities.
2. Hydropower provides one quarter of Viet Nam's electricity, but the power mix is becoming more dependent on fossil fuels. Non-hydro renewable energy sources, notably wind, solar and biomass-based power have important potential, and although application is still very limited Viet Nam has adopted targets to scale those up.
3. The energy intensity of Viet Nam's economy is declining slightly but it is still comparatively high. Energy efficiency in some enterprises and economic sectors are improving as a result of for example the National Target Programme on Energy Efficiency and Conservation.

This policy discussion paper aims to provide ***recommendations to expand solar PV power generation and consumption***, especially in order to help ***achieve the first two of the SDG7 targets***.

The paper assesses the potential of solar Photovoltaic (PV) for changing the current trend of strongly expanding coal-based power. It explains how solar PV ***can reduce future dependence on (imported) coal, reduce severe*** economic, environmental, livelihood, social and health ***externalities,*** and ***reduce future greenhouse gas (GHG) emissions***.[2] This should support the achievement of targets in Viet Nam's Renewable Energy Development Strategy, Viet Nam's Intended Nationally Determined Contribution (INDC)[3], and of SDG7, including benefits for remote and relatively poor communities and households.

This paper draws on a wide range of sources, in particular commissioned reports that analyse: national power production and distribution policy; the coal industry and coal fired power production in Viet Nam; international experiences with solar PV promotion; national policies and practices on solar PV; and the nascent national solar PV industry (IoE, 2014a; IoE 2014b; IoE, 2015; Sunderasan, 2014; GreenID, 2015; Trinh Quang Dũng, 2015).

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[1] "Transforming Our World: the 2030 Agenda for Sustainable Development": https://sustainabledevelopment.un.org/

[2] This paper does <u>not</u> address the question of the need for baseload capacity in the power system, which can be provided by coal and not solar PV. This is because even with a much lower coal-based supply Viet Nam can draw baseload from coal, gas and (planned) nuclear power as well as hydro-electricity including pumped storage.

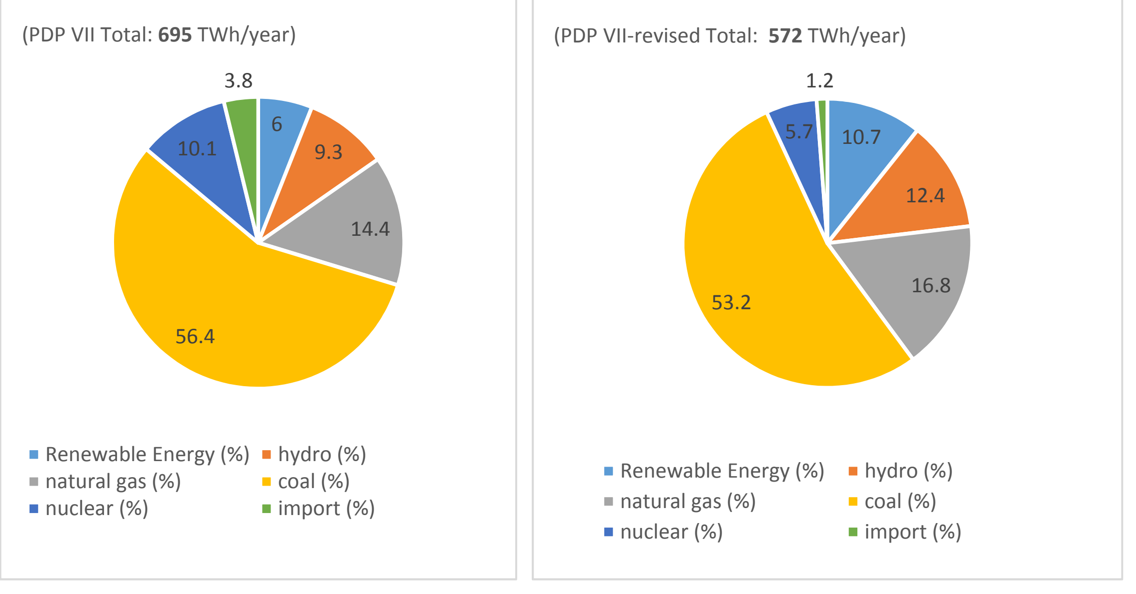
[3] This was submitted by Viet Nam to the UN Framework Convention on Climate Change (UNFCCC) and includes "contributions" to reducing greenhouse gas (GHG) emissions as well as climate change adaptation. INDCs are part of the agreements reached in Paris, 2015. See: http://unfccc.int/focus/indc_portal/items/8766.php

2. The Externalised Costs and Impacts of a Future of Coal-based Electricity

The future of electricity supply in Viet Nam can be strongly based on renewable energy, including solar PV, and not be dominated by extremely polluting coal-based power. Strong expansion of solar PV is possible in Viet Nam and would limit Viet Nam's growing dependency on energy imports. It would also have economic, environmental, social and health advantages and would be a major contribution of Viet Nam to mitigation of global climate change.

Official policy projections in Power Development Plan VII (2011-2020 with vision to 2030) ("PDP VII"[4]) were that renewable energy would make up 6% of total annual electricity production in 2030, including biomass and wind-based power, but coal-based power would be by far the dominant source with 56.4%. The revised plan ("PDP VII-revised"[5]) has reduced the total power demand projections for 2030 from 695 to 572 TWh/year; reduced the planned total coal-based power and the share of coal in the power mix; reduced the total and the share of nuclear-based electricity; and increased the total and share of renewable and of gas-based power (see Figure 1).

Figure 1 - Projected electricity output by 2030 (PDP VII and PDP VII-revised)



PDP VII was part of the "business as usual" (BAU) greenhouse gas (GHG) emissions scenario in Viet Nam's Intended Nationally Determined Contribution (INDC), which it submitted to the UN Framework Convention on Climate Change (UNFCCC) in late 2015. In its INDC, Viet Nam targets an 8% reduction in GHG emissions against BAU with domestic actions, and a 25% reduction with international support. Fossil fuel use in the power sector is a primary contributor to future greenhouse gas emissions. The BAU would lead to Viet Nam emitting 7.4 tonnes "equivalent carbon dioxide" (CO_2e)[6] of GHG emissions per capita in 2030, and the 8% target to nearly 7 tonnes/capita

[4] Decision 1208/QD-TTg of 21 July 2011, on approval of "the national Power Development Plan for the 2011 - 2020 period with a vision to 2030"
[5] Decision 428/QD-TTg of 18 March 2016, on approval of "Adjustments of the national Power Development Plan for the 2011 - 2020 period with a vision to 2030"
[6] CO_2e = concentration of CO_2 that would cause the same level of warming as a certain type of greenhouse gas

respectively (Wörlen and Riesenberg, 2015). This means that Viet Nam would be emitting more GHG per capita than the EU, whose average emissions are projected to be 6 tonnes /capita in 2030, according to its INDC. However, the PDP VII-revised targets would be a major contribution towards Viet Nam's 25% conditional GHG emission reduction target, which would be leading to about 5.3 tonnes/capita CO_2e emissions in 2030[7].

Despite the new targets in PDP VII-revised, coal remains the most important future power source by far and an ambitious programme of coal-based power development remains in place. The adjusted coal targets still require completion of nearly 100 coal-fired power units within several new and existing coal-fired power plants (complexes) between 2016 and 2030[8].

The adjusted future scenario of PDP VII-revised, and possibly more ambition to reduce reliance on coal, can be accomplished if the real cost of coal-fired power is considered, as well as the real benefits of solar PV. Solar PV is one of the renewable energy technologies with most potential in Viet Nam, although it is currently only employed at a very small scale. There are several uncounted but real costs of the planned coal-based power that strongly out-weigh any disadvantages of solar PV.

Figure 2 - Planned domestic production and import of coal for power production

(million tons)	2015	2020	2025	2030
Coal sector development plan to 2020 with outlook to 2030 (60/QD-TTg, 09/01/2012)				
Coal demand total	56.2-60.7	112.4-120.3	145.5-177.5	220.3-270.1
Coal demand for electricity	33.6-38	82.8-90.8	112.7-144.7	181.3-231.1
Mining production total	55-58	60-65	66-70	75
Mining North-East	55-58	59-64	64-68	65
Mining Red River Delta	0	0.5-1	2	10
Domestic coal for electricity [a]	27	30	35	40
PDP 2011-2020 with outlook to 2030 (PDP VII) (1208/QD-TTg, 21/07/2011)				
Coal demand for electricity		67.3		171
Expected import for electricity [b]	6.6-11	37.3	77.7	131
Adjusted PDP 2011-2020 with outlook to 2030 (PDP VII-revised) (428/QD-TTg, 18/03/2016)				
Coal demand for electricity		63	95	129
Expected import for electricity [c]		33	60	89

[a] Source: "Perspective Development of Vietnam Coal Industry", presentation by Le Minh Chuan, CEO of VINACOMIN, at: Clean Coal Day in Japan, 20th Anniversary Tokyo, 6 September 2011.
[b] Based on the data in Prime Minister Decision 1208/QD-TTg and estimated domestic coal for electricity
[c] Based on the data in Prime Minister Decision 428/QD-TTg and estimated domestic coal for electricity

PDP VII required vast amounts of imported coal for electricity production and those figures were also adjusted in PDP VII-revised (Figure 2). But major imports will still be required whereas infrastructure to import and transport coal is underdeveloped and costly, and investment in major infrastructure is not fully incorporated in the projections of costs of coal-based power (GreenID, 2015).

[7] see http://www4.unfccc.int/submissions/INDC/Submission%20Pages/submissions.aspx for the EU and Viet Nam INDC. In the estimates provided here the Vietnamese population in 2030 is assumed to be 110 million.
[8] These nearly 100 units are listed in Decision 428/QD-TTg of 18 March 2016.

The coal mining targets were not fully achieved. For example, actual domestic coal production in 2015 was 37.3 million tonnes instead of 55-58 million tons (see Figure 2). This was partly due to the heavy rains in July/August 2015 that flooded mines and stopped production for some time.

These rains also caused collapse of a badly protected mine-waste facility in Cam Pha, and coal-slurry entered settlements and streams. The rains, floods and slurry lead to the death of several people; destroyed houses, goods and equipment; and caused major environmental pollution of the surroundings, of canals and of Halong Bay (Figure 3).

Figure 3 - Images of the mine-waste disaster in Cam Pha, July/August 2015

Even before this disaster it had become apparent that there are many negative effects of coal mining that are not being prevented. And the costs of prevention measures or the costs of coal mining, coal transport and coal use to the environment, human health and livelihoods are not fully accounted for in the cost price of coal – so coal seems cheaper than it should be.

For example, Loi Dinh Chinh et al. (2007) assessed the environmental impacts of the life cycle of anthracite production in Viet Nam and identified major issues, including (i) dust pollution; (ii) noise pollution; and (iii) acid and turbid mine drainage water. This study also proposed pollution prevention and treatment options.

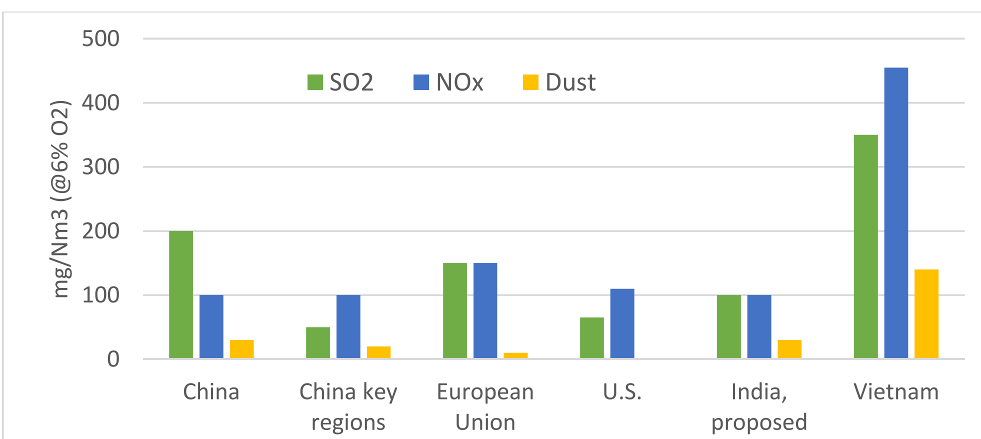
A more recent study of chemical composition of rice-paddy soils in Cam Pha, a major mining area, showed very high concentrations of toxic metals from coal-mining, suggesting that no effective preventive measures have been taken to date. They found associated decrease in rice production even though local paddy varieties appeared to have adapted to the pollution. They also found high levels contamination of rice plants and rice grains, "which may lead to metal accumulation (e.g., Cd) in human organs and in turn to severe disease" (Martinez et al., 2013). Apart from human suffering, diseases cause reduced income and increased expenditure for treatment, which are real costs to families, the State, and the economy.

Nevertheless, investment in new coal-fired power plants, using domestic as well as imported coal and domestic as well as foreign technology and investment capital is continuing, so total power supply is steadily increasing (Figure 4).

Figure 4 - Images of announcements of development of coal-fired power plants

The pollution standards that new coal-fired power plants must adhere to in Viet Nam are considerably more permissive than standards in other countries (Figure 5). Furthermore, companies from countries with strict pollution limits are designing, financing and/or constructing coal-fired power plants in Viet Nam with technological specifications that are not accepted in their home countries.

Figure 5 - Emissions limits for new coal-fired power plants



Source: Myllyvirta, Lauri (2015)

Nevertheless, coal-fired power plants in Viet Nam must be designed and built with measures to limit environmental impacts, as specified in Environmental Impact Assessment (EIA) reports that are mandatory for such investment projects. This normally includes measures to prevent pollution from transport, storage and treatment of waste, notably fly-ash. However, the coal-fired power plants do not always adhere to these commitments or are slow to implement them, and the proposed

measures may not fully deal with the risk of pollution as a result of coal transport, power production, and transport and treatment of waste from coal-fired power plants.
This is also the case with the latest large scale investments, such as the Vinh Tan power complex, including Vinh Tan 1,2,3,4,4(extended), with a total installed capacity of 6,404 MW. The Vinh Tan 2 units are operating (with a total installed capacity of 1200 MW) and the others are under planning or construction (DOST Binh Thuan, 2016). Once completed the Vinh Tan power complex is expected to produce 3.8 million tonnes of fly ash per year, for which the only measure taken so far is landfilling nearby the complex (see Figure 6).

Figure 6 – Images of local environmental impacts of the Vinh Tan 2 power plant

Vinh Tan 2 is currently producing 4,400 tonnes of waste per day and numerous trucks crossing Highway 1 are taking this to the landfill. Initial measures such as covering trucks, watering roads and landfill, compacting and covering landfill were inadequate, causing widespread dust pollution of fields, settlements and homes since the first of two units of Vinh Tan 2 was switched on in January 2014. In addition, the smoke stacks also produce dust that is precipitating on local residents (Figure 6). This led to local protests in early 2015 and the central Government had to intervene to make sure that the operator complied with standards for transport and landfilling of fly ash. However, the measures taken were by February 2016 still not adequate, according to a report by provincial authorities[9].

In addition, the size of the planned landfill near the Vinh Tan power plant complex is inadequate in the medium to long term. Plans for relocation of some local residents and for using fly ash in for example brick making (so that less landfilling of fly ash would be needed) are being made by the local authorities but this will require major investments including construction of brick making factories.

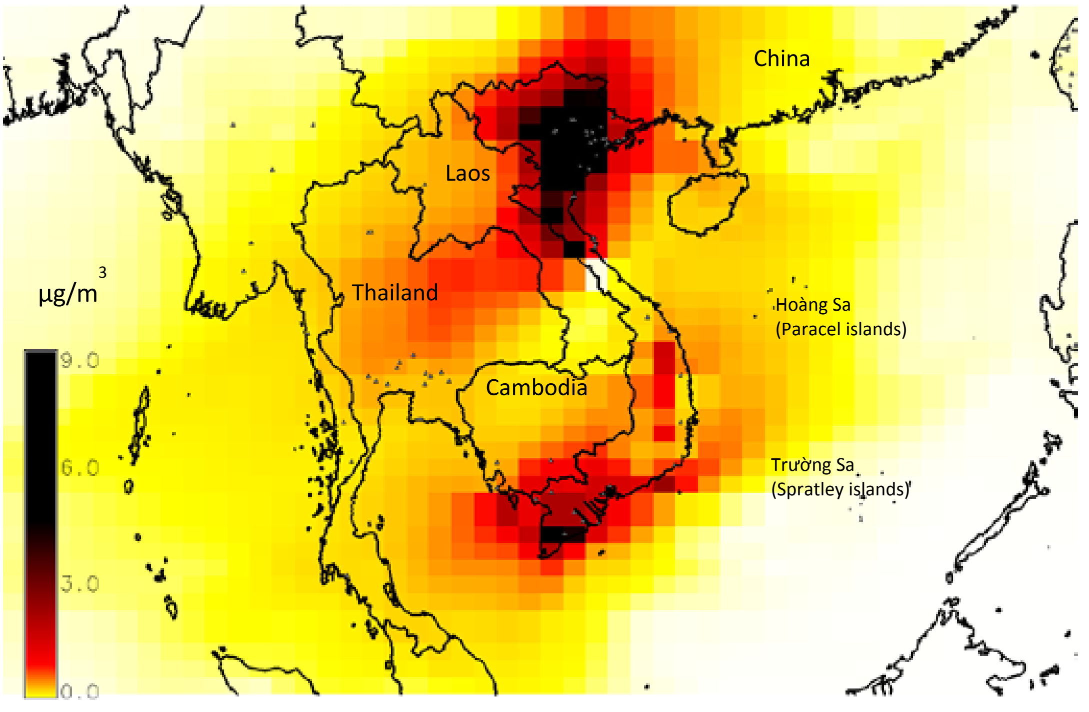
The authorities are seeking finance for some of this, but according to the "polluter pays" principle, that is also applied in the Vietnamese Law on Environmental Protection, this would have to be the duty of the owners of power plants. It should have been part of the original plans and/or a condition

[9] http://vietnamnews.vn/environment/281921/vinh-tan-power-plant-still-polluting-residential-areas.html and http://www.thanhniennews.com/society/pollution-at-vietnam-power-plant-persists-despite-public-outcry-58658.html

for investment approval, and therefore such costs should be included in the cost price of coal-fired power from the Vinh Tan complex (and all other coal-fired power plants).

Finally, air pollution from coal-fired power plants at a national scale is also increasing dramatically. If all plants that were planned according to PDP VII would be built by 2030, then premature deaths as a result of emissions from coal-fired power plants in Viet Nam would increase from an estimated 4,263 in 2011 to 25,402 per year in 2030 (Koplitz et al., 2015)[10]. These figures are based on the use of a simulation model that also produced Figure 7, which shows that the pollution caused by the power plants would not be limited to the territory of Viet Nam[11].

Figure 7 – PM2.5 level attributed to planned Vietnamese coal-fired plants in 2030 according to PDP VII



Source: Myllyvirta, Lauri (2015)

[10] Fine particulate matter (PM2.5) increases the risk of developing respiratory and cardiovascular diseases.
[11] The figures would be lower had this simulation used the PDP VII-revised coal-fired power plant targets, but the order of magnitude of the risk would be similar.

3. The Costs of Coal-based Electricity and Retail Tariffs in Viet Nam

Expert analysis of the "levelized cost" of coal-fired power from some of the facilities currently operating and under construction in Viet Nam is given in Figure 8. The levelized cost of energy or electricity (LcoE) is a common measure to compare different technology options. In this context it estimates the average costs per kWh production over the lifetime of a power plant, considering all investment, operation and maintenance costs. The LcoE in the case of coal-fired power is strongly dependent on the choice of technology and the cost of capital for the initial investment, as well as the price of coal over the lifetime of the power plant. The LcoEs are expressed in the present value of the first year of operation.

Figure 8 – LcoE of some coal-fired power plants in Viet Nam according to different coal price scenarios (excl. T&D)

Coal-power price *(USD cent/kWh)* / Power plant	Constant coal price, as in 2014	Coal price increase by 1.5% per year	Coal price increase by 2% per year	Coal price increase by 3% per year	Coal price increase by 5% per year	Coal price increase by 7% per year	Coal price increase by 10 % per year
In operation							
Mạo Khê	5.51	5.94	6.1	6.46	7.35	8.57	11.32
Cẩm Phả	6	6.55	6.75	7.22	8.374	9.95	13.52
Quảng Ninh 1	6.58	7.18	7.41	7.92	9.2	10.94	14.85
Quảng Ninh 2	5.58	6.21	6.46	7.02	8.46	10.48	15.26
Under construction							
Na Dương 2	6.08	6.62	6.83	7.31	8.54	10.28	14.4
Long Phú 1 (import coal)	8.38	8.98	9.21	9.73	11.02	12.78	16.78
Sông Hậu 1 (import coal)	7.92	8.56	8.8	9.35	10.74	12.65	17.02

Source: GreenID (2015)

The 2014 fuel price was used as base price for the calculations in Figure 8. This was assumed to remain unchanged throughout the lifetime of the investment projects (which was 30 years in this assessment), or increase on average by 1.5%; 2%; 3%; 5%; 7% or 10% per year. Two of the plants under construction will depend on imported coal which is more expensive than domestic coal (Song Hau 1 and Long Phu 1); all the other plants use domestic coal. Obviously, a higher price of coal leads to an increase in the variable costs and therefore the LCoE (GreenID, 2015).

The range of LCoEs in the base case is 5.51-8.38 USD cent/kWh. Based on international literature a 2% average increase of the coal price over 30 years is seen as the most realistic assumption (GreenID, 2015), which leads to LCoEs of 6.1-9.21 USD cent/kWh[12]. This is the cost of electricity production at the power plant, meaning there are additional costs for transmission and distribution (T&D) of power.

[12] Global coal prices reduced significantly in 2015 and started a slow recovery in early 2016 (see e.g. http://knoema.com/xfakeuc/coal-prices-long-term-forecast-to-2020-data-and-charts). In the period to 2020 several agencies predict a continued recovery (http://knoema.com/xfakeuc/coal-prices-long-term-forecast-to-2020-data-and-charts). Importantly, coal-fired power plants often agree long-term purchase contracts for certain prices in order to guarantee supply and avoid price fluctuations.

Most of the externalities discussed above, of costs to the environment, health, livelihoods, and global climate change are not or not fully included in the cost of coal-based power, even though they are real costs to people, communities, the State and the economy. Internalising these costs can be done by forcing power plants, coal mines, and waste transporters and processors to take all necessary and possible mitigation measures and cover all costs, including relocation of people, prevention of pollution, payment of hospital costs etc.

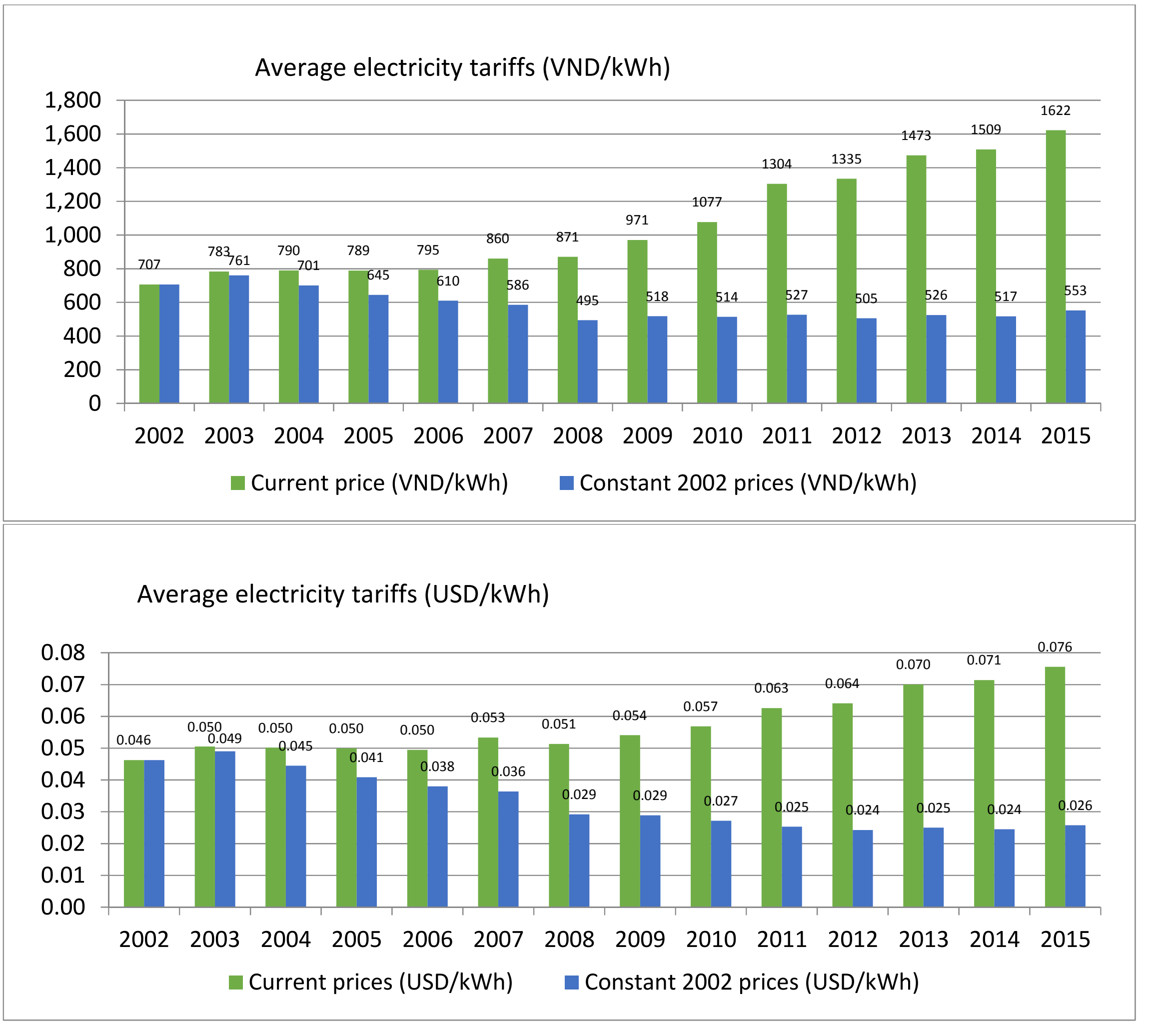
This can be partly stimulated through environmental (carbon) taxes and fees, or through cap-and-trade of carbon emissions, because these measures create incentives to limit pollution. However, the collected revenue does not necessarily compensate local people for health problems or income losses, or for the consequences of global climate change. Nevertheless, the externalised costs can be expressed in financial terms, for example by making reasonable assumptions regarding a carbon price based on international experience, upon which a comparison with LCoEs of other forms of power production that have fewer externalities becomes more fair and reasonable.

Figure 9 - LCoE of coal-fired power plants including a carbon price (A. constant 2014 coal price; B. annual 2% increase in coal price) (excl. T&D)

Source: GreenID (2015)

Figure 9 gives estimated LCoEs of the same power plants as in Figure 8, but imposes a carbon price of 5 USD/tonne CO_2 or 10 USD/ tonne of CO_2, for the base case and for an average coal price increase of 2% per year. With a carbon price of 5 USD/ ton, this means that the LCoE range for a 2% average increase of the coal price over 30 years becomes 6.67-9.79 USD cent/kWh; and with a carbon price of 10 USD/tonne CO_2 the LCoE range becomes 7.24-10.40 USD cent/kWh.

Figure 10 - Average electricity retail tariffs in Viet Nam



Source: UNDP Viet Nam (2014), updated with official average retail rates for 2014 and 2015 and annual inflation and exchange rates as issued by the State Bank of Viet Nam and GSO.

The above LCoEs of coal-fired power apply to the electricity cost at the power plants. The additional costs for transmission and distribution (T&D) depend on the quality of infrastructure and distances between power plants and consumers. These are estimated in Viet Nam at about 9.5-10% on average (Audinet et al., 2014)[13], making the actual costs of delivery of electricity to consumer premises in Figure 9 higher by about 10%. This means for the studied power plants that the costs of delivery to the consumer range from (5.51+10%=) **6.06** USD cents/kWh (Mao Khe power plant; coal staying at

[13] See also: http://knoema.com/WBSE4ALL2015/sustainable-energy-for-all?tsId=1100420

2014 prices; no carbon price), to (10.40+10%=) **11.44** USD cents/kWh (Long Phu 1 power plant; imported coal that is increasing in price by 2% per year; and a USD10/tonne CO_2 carbon price).

Average electricity retail prices are shown in Figure 10. The LCoE of coal-based power from the Mao Khe power plant at 6.06 USD cents/kWh in the basic scenario (assuming no coal price rises and no carbon price; but including T&D costs) is below the average retail price of 7.6 USD cents/ kWh in 2015 (=VND 1,622). However, the cost of power from Long Phu 1 and Song Hau 1 (both running on imported coal) is higher than the retail price even in this basic scenario (see Figure 8), meaning that EVN (as the single buyer of power in Viet Nam) will be making losses on those power plants unless the retail price of electricity goes up.

Assuming a modest degree of internalisation of real costs to the environment, health and livelihoods of coal-fired power with a carbon price of just 5 USD/ tonne of CO_2 plus a gradually increasing price of coal and incorporating the T&D costs, would mean that all of the studied coal-fired power plants except Mao Khe would be loss making. With a carbon price of 10 USD/ tonne of CO_2 this obviously becomes more pronounced.

The two carbon prices used in these calculations, of 5 and 10 USD/tonne CO2 make the LCoEs higher by roughly 10% and 20% respectively, which is a low estimate of the full costs of externalities. A model study in 2008 estimated that the alternative of renewable energy and other low emitting technologies could avoid external costs of the then planned fossil fuel-based expansion of power production "equivalent to 4.4 US cent/kWh", which is about 40-60% of the calculated LCoEs. The additional electricity production cost was estimated to increase by 2.6 US cent/kWh so that a net benefit of internalizing the externalities was estimated at 1.8 US cent/kWh (Khanh Q. Nguyen, 2008).

The retail price of power in Viet Nam remains artificially low by international comparison (Figure 14 and Figure 15). This is thanks to pricing policies that lead to indirect subsidies to the power sector, according to international definitions of subsidy. Initial steps to eliminate the indirect subsidies have been made, notably by raising domestic coal prices. Subsidies on fossil fuels have decreased over the past years but are still significant (see Figure 11).

Figure 11 - Consumption subsidies for fossil fuels in Viet Nam

Energy Source	2007	2008	2009	2010	2011	2012	2013	2014
Oil	0.32	1.09	0	1.09	1.6	0.5	0.0	0.0
Gas	0.09	0.21	0.13	0.19	0.3	0. 3	0.2	0.3
Coal	0.01	0.01	0.01	0.02	0.0	0	0.0	0.0
Electricity	1.68	2.25	1.06	3.19	4.1	4.5	1.0	0.7
Total (billion USD)	2.1	3.56	1.2	4.49	6.0	5.3	1.2	1.0

Source: UNDP Viet Nam, 2014; International Energy Agency, 2016 http://www.worldenergyoutlook.org/resources/energysubsidies/fossilfuelsubsidydatabase/ (Last accessed on 22 January 2016; data for 2011, 2012 and 2013 were retrieved earlier from http://www.iea.org/subsidy/index.html). The IEA estimates change periodically to reflect better estimates and new data.). See also IEA (2015a).

These subsidies are calculated by making comparisons with international prices of electricity. They are a cost to Vietnamese taxpayers because low electricity prices are made possible by forgoing profits and revenue from state-owned enterprises to the State (e.g.: coal is sold domestically for a price below the international market price, meaning that VINACOMIN cannot contribute much to the State's revenue); investment guarantees and cheap loans to EVN and other operators in the power sector (e.g. State investment and ODA to power transmission lines); and environmental and social externalities (UNDP, 2014). EVN (as the single buyer of power) also has access to a large amount of very cheap hydropower, which is enabling it to make up for the losses from producing power with fossil fuels (or buying that), but this also means that little or no revenue is paid to the State as owner of EVN and power generation companies – and so the State must raise revenue from (other) sources (such as VAT, corporation tax, income tax, import / export tax, environmental fees, etc.).

The average retail price of electricity in Viet Nam was 7.6 USD cents/kWh in 2015. The block tariff scheme for households is shown in Figure 12, with high-consuming households paying a higher price for more units of power consumed per month. In Figure 13 some specific retail tariffs are given for manufacturing and commercial enterprises and for hospitals and schools. Both households and industry pay less on average than in other countries, where tariffs are generally higher or much higher compared to Viet Nam (see Figure 14 and Figure 15).

Figure 12 – The Incremental Block Tariff scheme: electricity prices for households

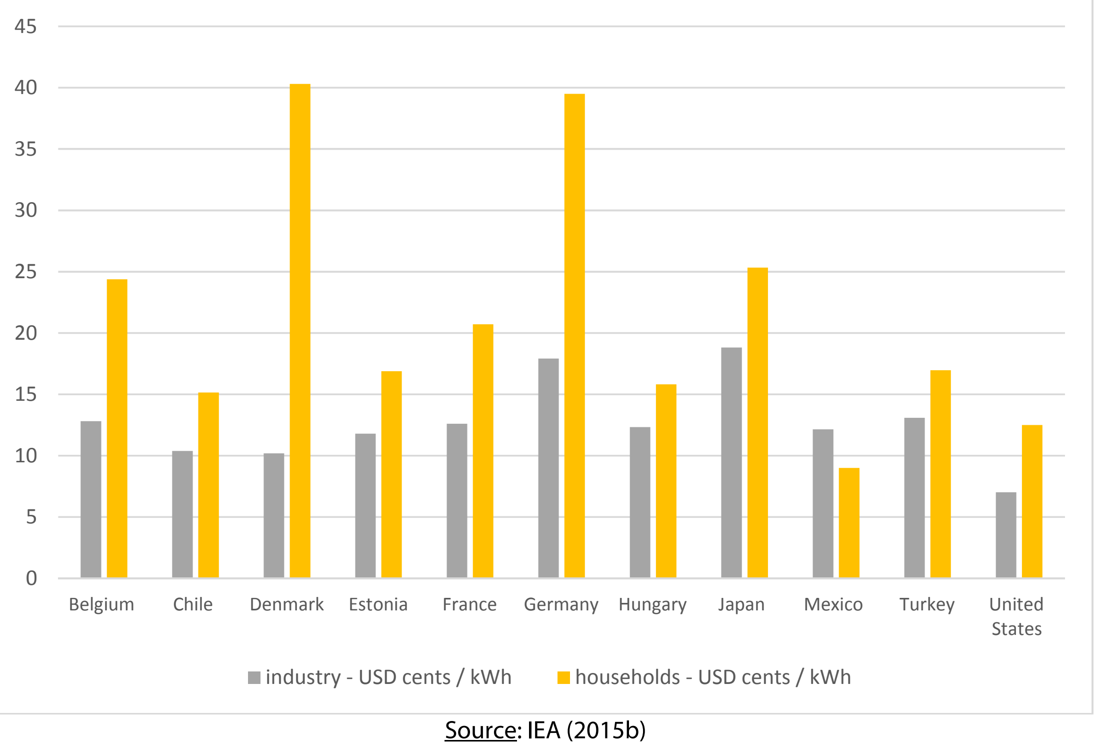
From Decision 28/2014/QĐ-TTg		2256/QĐ-BCT (12/03/15)	1USD=VND21,458 (2015)	1USD=VND22,300 (early 2016)
average retail price:	**(% of)**	**VND 1,622**	**USD 0.076**	**USD 0.073**
0-50 kWh/month	92%	VND 1,492	USD 0.070	USD 0.067
51-100	95%	VND 1,541	USD 0.072	USD 0.069
101-200	110%	VND 1,784	USD 0.083	USD 0.080
201-300	138%	VND 2,238	USD 0.104	USD 0.100
301-400	154%	VND 2,498	USD 0.116	USD 0.112
>400 kWh/month	159%	VND 2,579	USD 0.120	USD 0.116
Prepaid card	132%	VND 2,141	USD 0.100	USD 0.096

Figure 13 - Electricity retail tariffs in Viet Nam per selected user category

From Decision 28/2014/QĐ-TTg		2256/QĐ-BCT (12/03/15)	1USD=VND21,458 (2015)	1USD=VND22,300 (early 2016)
average retail price:	**(% of)**	**VND 1,622**	**USD 0.076**	**USD 0.073**
1. Manufacturing units				
1.1 Voltage > 110 kV				
a) normal hours	84%	1,388	0.065	0.062
b) low hours	52%	869	0.040	0.039
c) peak hours	150%	2,459	0.115	0.110
1.2 Voltage 22 kV -110 kV				
a) normal hours	85%	1,405	0.065	0.063
b) low hours	54%	902	0.042	0.040
c) peak hours	156%	2,556	0.119	0.115
1.3 Voltage 6 kV - 22 kV				
a) normal hours	88%	1,453	0.068	0.065
b) low hours	56%	934	0.044	0.042
c) peak hours	161%	2,637	0.123	0.118
1.4 Voltage < 6 kV				
a) normal hours	92%	1,518	0.071	0.068
b) low hours	59%	983	0.046	0.044
c) peak hours	167%	2,735	0.127	0.123
2. Administrative units				
2.1 Hospitals, kindergartens, schools				
2.1.1 Voltage > 6 kV	90%	1,460	0.068	0.065
2.1.2 Voltage < 6 kV	96%	1,557	0.073	0.070
3. Commercial business				
3.1 Voltage > 22 kV				
a) normal hours	133%	2,125	0.099	0.095
b) low hours	75%	1,185	0.055	0.053
c) peak hours	230%	3,699	0.172	0.166
3.2 Voltage 6 kV - 22 kV				
a) normal hours	143%	2,287	0.107	0.103
b) low hours	85%	1,347	0.063	0.060
c) peak hours	238%	3,829	0.178	0.172
3.3 Voltage below 6 kV				
a) normal hours	145%	2,320	0.108	0.104
b) low hours	89%	1,412	0.066	0.063
c) peak hours	248%	3,991	0.186	0.179

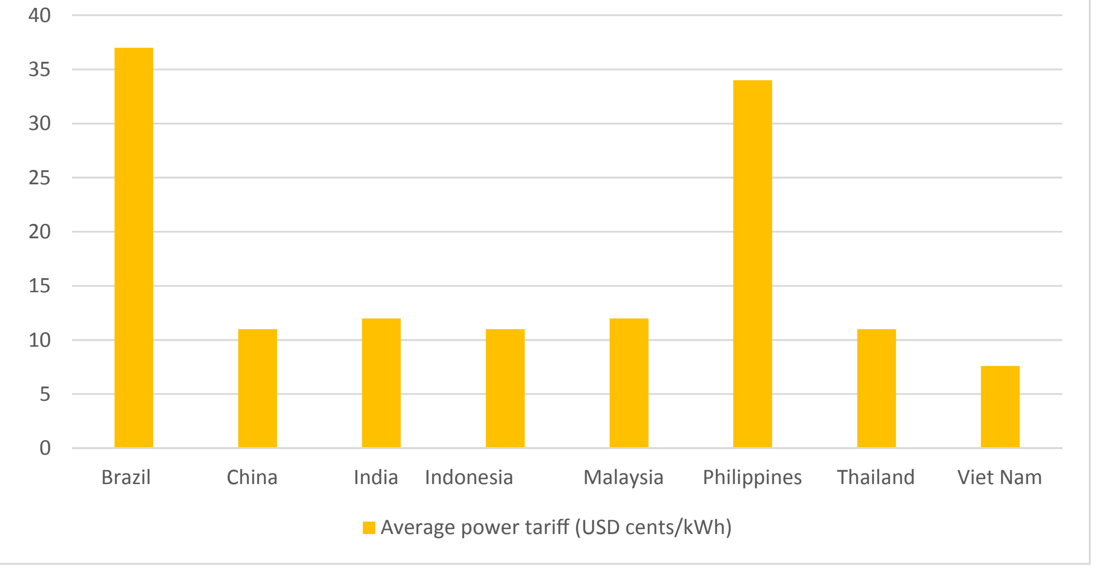
Note: a) Normal hours: Mon-Sat 04h00 - 09h30; 11h30 - 17h00; 20h00 - 22h00. Sun 04h00 - 22h00
b) low hours: Mon-Sun 22h00 - 04h00
c) Peak hours: Mon-Sat 09h30 - 11h30; 17h00 - 20h00

Figure 14 - Electricity retail tariffs in some OECD countries (Q1 2015)



Source: IEA (2015b)

Figure 15 – Average electricity retail prices in some developing countries (2015)



Sources: http://www.statista.com/statistics/477995/global-prices-of-electricity-by-select-country/; and IEA (2015a)

4. Policies to Develop Solar PV

The Government has started to show how the future can become more sustainable, green and clean. For example, the Viet Nam Green Growth Strategy (VGGS) was adopted in 2012 and proposes to phase-out fossil fuel subsidies and reinforce renewable energy development[14]. The macro-economic and the environmental case for this subsidy phase-out and introduction of a carbon price was made (UNDP Viet Nam, 2012), and a roadmap for fossil fuel fiscal reform was proposed in support of the implementation of the VGGS and various energy-sector policies (UNDP Viet Nam, 2014).

Viet Nam has recently adopted the Renewable Energy Development Strategy (REDS)[15] and the revised Power Development Plan VII (PDP VII-revised). These policies reduce the projected coal imports for power production in 2030, when compared to the projections in PDP VII (Figure 1 and Figure 16). The REDS sets hydro-electricity and renewable energy targets, including biomass, wind and solar PV electricity production targets for 2020, 2030 and (tentatively) 2050. The targets on hydro-electricity and biomass were increased when compared to PDP VII, and solar PV targets were added (Figure 18).

Figure 16 - Some differences between PDP VII and the REDS

	2020 PDP VII	2020 RED Strtgy	2030 PDP VII	2030 RED Strtgy	2050 RED Strtgy
GHG emission reduction vs BAU (% of total emissions from energy activities, including power sector)		-5%		-25%	-45%
Coal use for power (coal import redctn vs BAU) (million tonne)	67.3		171	(-40)	(-150)
Renewable & Hydro-electricity production (TWh/ year)	79.6	101.0	106.3	186	452
Total electricity from biomass (TWh/yr)	2.0	7.8	7.6	37	85
Total electricity from wind (TWh/yr)	2.3	2.5	16.7	16	53
Total electricity from solar (TWh/yr)	0.0	1.4	0.0	35	210
Total hydropower production (TWh/yr)	64.7	90	64.6	96	104
Total power production (TWh/yr)	**330**	**265**	**695**	**590**	**1,050**

Source: PDP VII and REDS (Decisions 1208/QD-TTg and 2068/QĐ-TTg).
Note: Some data are given in those policy documents, others were derived from them, which explains minor inconsistencies in the table and with data from PDP VII-revised that is discussed in section 2.

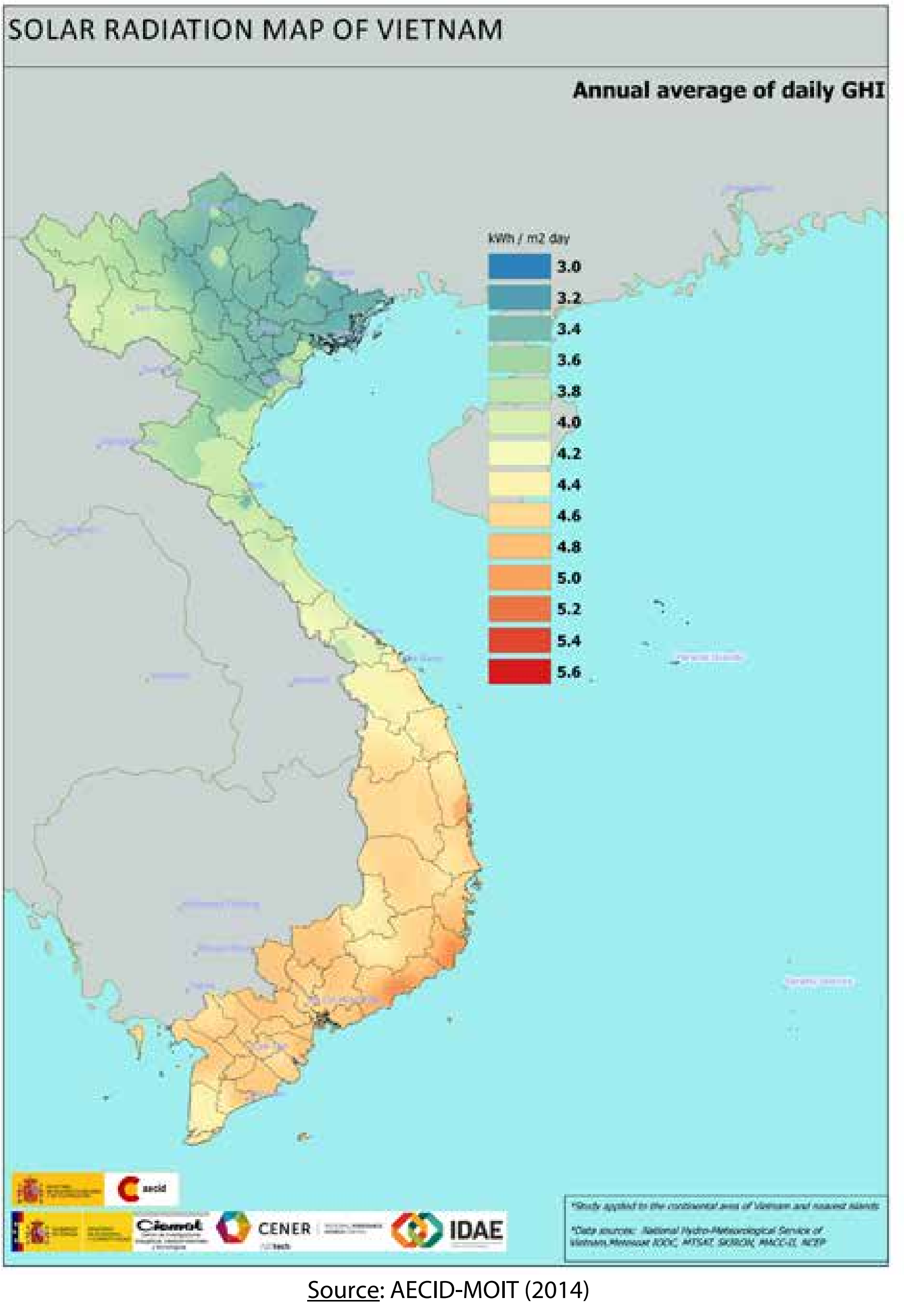
The advantages of solar PV are obvious from an environmental, health and also livelihood perspective. Domestic industry could develop, in construction, maintenance and possibly also

[14] Decision 1393/QĐ-TTg, 25 September2012, on the Approval of the National Green Growth Strategy
[15] Decision 2068/QĐ-TTg, 25 November 2015, on the Approval of the Viet Nam Renewable Energy Development Strategy up to 2030 with an outlook to 2050

equipment assembly and manufacturing, and jobs will be created. It reduces dependency on imports, as is the case with coal. In addition, solar PV power plant construction can be much faster than coal or other power plants, so it is also useful for responding to steadily increasing demand in Viet Nam.

According to the REDS, the solar PV power production in 2050 will be 20% of the total power produced in Viet Nam (1,050 TWh/year) (see Figure 16 and Figure 18), and by that time it will be the most important source of renewable energy. Indeed, solar irradiation in Viet Nam is good, and the potential for solar PV is particularly high in the centre and south of the country (Figure 17).

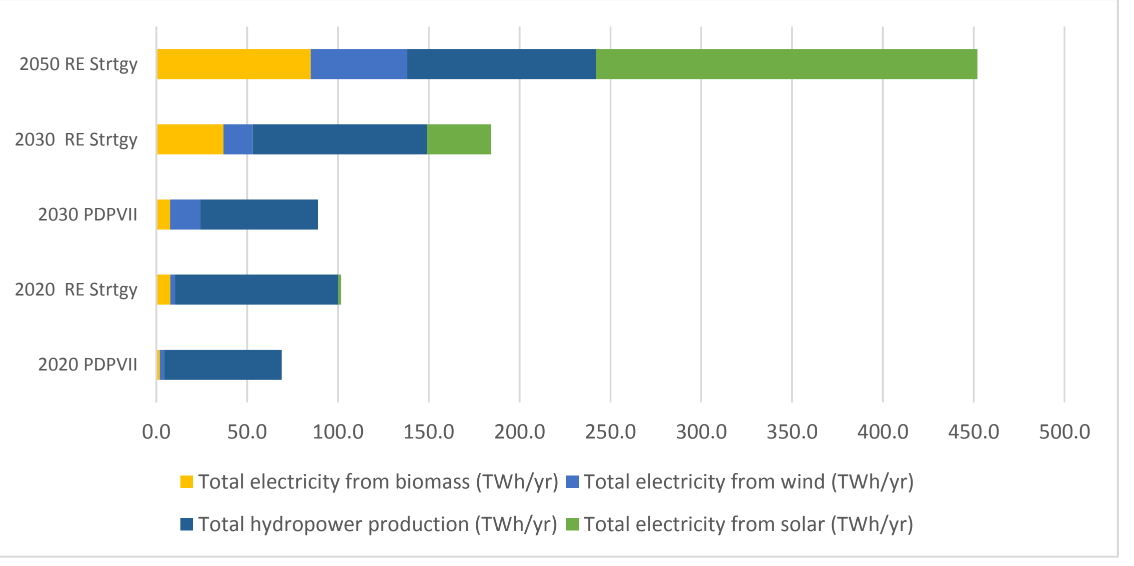
Figure 17 – Map of Global Horizontal Irradiation (GHI)



Source: AECID-MOIT (2014)

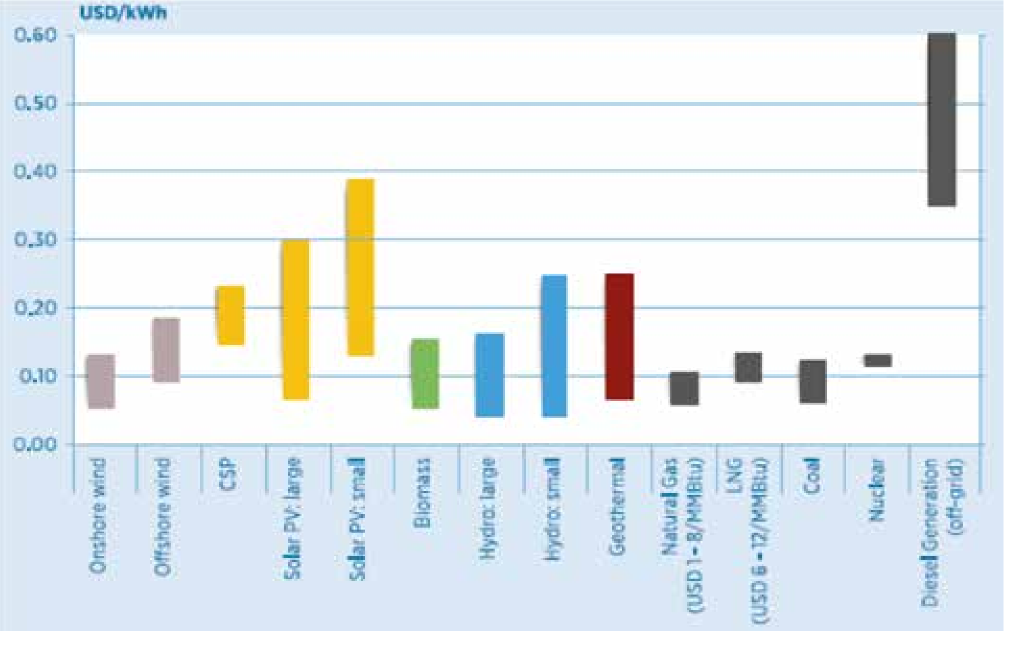
Note: GHI (kWh/m^2 day) is a common indicator of solar PV potential (see also glossary).

Figure 18 – Targets on Hydro and Renewable Electricity Production in PDP VII and the Renewable Energy Development Strategy



Source: PDP VII and REDS (Decisions 1208/QD-TTg and 2068/QĐ-TTg). The targets in PDP VII-revised (Decision 428/QD-TTg) are similar to those of the REDS but do not cover 2050.
Note: Some data are given in those policies, and others were derived from them.

Figure 19 - International ranges of LCoEs of different forms of power production

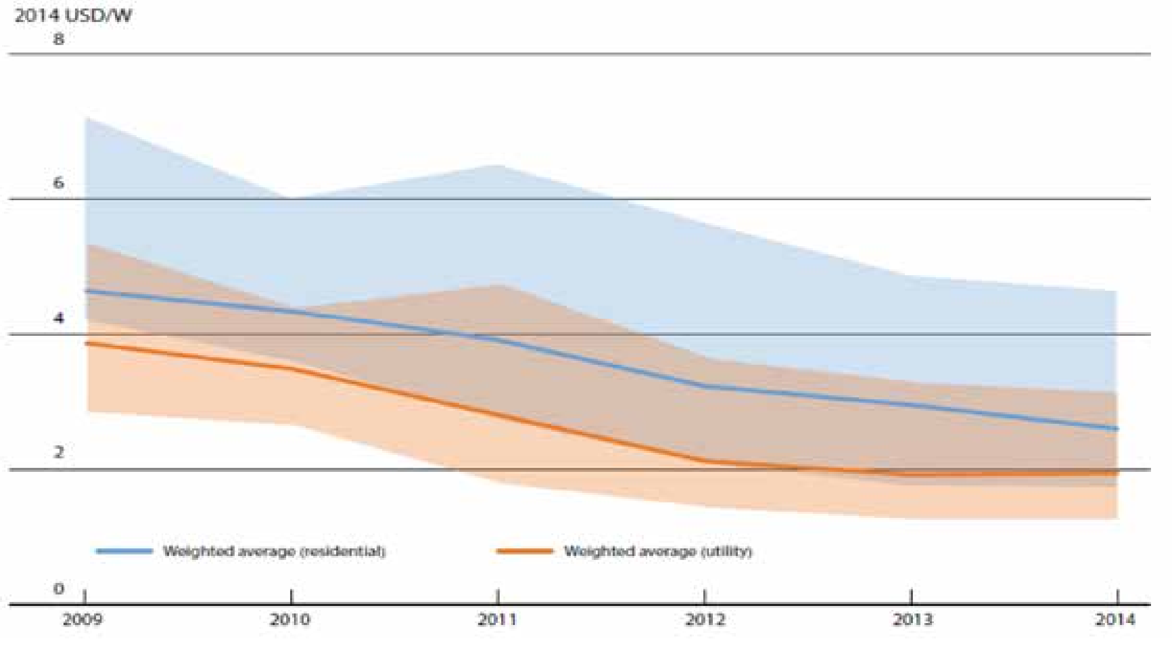


Source: IRENA (2015b). Note: Cost levels are for 2014.

In countries with the most favourable conditions, large-scale solar PV can now be installed to produce power at a "levelized cost of electricity" (LCoE) of 6-7 USD cents/ kWh, which makes it competitive with coal and most other forms of power generation. However, the range of reported production costs is very wide (Figure 19).

The LCoEs in Figure 19 need to be compared with the LCoEs for Vietnamese coal-based power production as given in Figure 8 and Figure 9, i.e. without the Transmission and Distribution (T&D) costs. The LCoEs for coal-based power in Viet Nam in those figures fall within the international range given for coal-based power in Figure 19. Figure 20 shows that solar PV costs are declining rapidly.

Figure 20 - Estimated Global Average Installed Costs for Utility-Scale and Residential Solar PV Systems and the Range



Source: IRENA (2015a)

However, the perceived high financial risks of investment in power generation in Viet Nam and therefore costs of capital, and the lack of capacities for manufacture, installation and operation of solar PV in Viet Nam mean that the first solar PV investments in Viet Nam are likely to be more expensive than the LCoE of coal-based power.

This means that Viet Nam must subsidize solar PV in the first years, as it is doing in the case of some fossil fuel based power even without considering externalities. Alternatively, it can increase electricity retail tariffs, phase out fossil fuel subsidies, and internalize the economic, environmental, livelihood, social and health cost of coal-based power. The latter can be done imposing a price for carbon and other pollution, for example through a fee, a (carbon) tax, or through cap-and-trade of GHG emissions from the use of fossil fuel. This would make Vietnamese policy vis-à-vis coal consistent with trends in countries such as China and India – as demonstrated in Box 1.

Whichever way of internalising the externalities is chosen, it will make electricity more expensive, at least temporarily. This can be made feasible by strengthening existing support measures for low-income households and certain businesses, who will experience disadvantages from power tariff increases (UNDP-Viet Nam, 2012, 2014).

In fact, the REDS proposes that users of fossil fuels must pay environmental fees and that a portion of these fees will be put in a Sustainable Energy Promotion Fund, which will support the development of renewable energy. Whether this will be effective in attracting investors in solar PV will depend on the use of this Fund, on the height of the environmental fee, and on the consequences of this policy change for the costs price of coal-based power as well as the retail tariffs of power in Viet Nam, assuming that EVN as single buyer will not be able to absorb (more) losses on its operations.

Box 1 - Plans to limit coal-dependency in major developing countries in 2015

China to reduce coal consumption for better air
China will slash coal consumption by 160 million tons over the next five years to reduce air pollution, according to an action plan jointly released by the Ministry of Industry and Information Technology (MIIT) and the Ministry of Finance on March 6 [2015]. Currently, China's coal consumption accounts for about 66 percent of primary energy use, 35 percentage points higher than the world average. The highlight of the action plan is using fiscal and financial policies to support coal consumption cuts by 'pumping more funds and financing to battle pollution,' said Gao Yunhu, a senior official of MIIT. According to the annual government work report delivered by Premier Li Keqiang, the Chinese government plans to reduce energy intensity (units of energy per unit of GDP) by 3.1 percent in 2015.

Source: http://en.ccchina.gov.cn/Detail.aspx?newsId=51313&TId=96

India doubles coal tax to promote renewables
India is set to double tax on coal production and use the revenues to promote clean energy and electric vehicles. Finance Minister Arun Jaitley made the announcement in his budget speech, indicating India's growing commitment to tackling climate change. Prime Minister Narendra Modi's government has set ambitious targets for clean energy since it swept to power in May and has raised taxes on coal, petrol and diesel. The administration has embarked on a high-profile "solar mission" to deliver up to 100GW of solar power by 2019, as part of 175GW of clean energy it aims to install by 2022.

Source: http://en.ccchina.gov.cn/Detail.aspx?newsId=51233&TId=97
Accessed on 21 March 2015

Other measures that are proposed by the REDS for achieving its targets include: investment credit for renewable energy; exemptions from import duties for certain equipment, inputs and semi-finished products that are not domestically produced; exemption and reduction of corporate income tax (if considered investment priorities as per law on taxes); and exemption or reduction of land use costs. All those measures mean that somehow the Government foregoes revenue (from taxation, and from revenue should investments be made by State-owned Enterprises).

The REDS does not give detailed regulation for implementation, which is yet to be issued. However, Viet Nam already has (more detailed) support policies for developing wind and biomass-based power production, and a similar policy for solar Photovoltaic (PV) electricity is available in draft. The existing policies provide a range of concrete measures, including Feed-in-Tariffs (the price for which EVN buys power from producers) for wind power production (7.8 USD cents/kWh)[16]; power from biomass (cogeneration of heat & electricity: 5.8 USD cent/kWh)[17]; municipal solid waste based power (landfill methane capture and use: 7.28 USD cent/kWh; and direct incineration: 10.05 USD cents/kWh)[18].

The draft decision on support to solar PV distinguishes power plants (a FiT of 11.2 USD cents/kWh) and "rooftop" power production (14 USD cents/kWh). This is discussed further in the next sections.

[16] Decision 37/2011/QD-TTg on the mechanism supporting the development of wind power projects in Viet Nam
[17] Decision 24/2014/QD-TTg of 24 March 2014 on the biomass power price support mechanism
[18] Decision 31/2014/QD-TTg on the mechanism supporting the development of power projects using solid waste

5. Feed-in-Tariffs for solar PV power plants

A very common way to stimulate investment in renewable energy is to pay a premium tariff for the period in which a specific technology is not yet fully competitive with fossil fuel-based power production. This is usually known as a Feed-in-Tariff (FiT). There is a very wide variety of FiTs and related policies for solar PV systems being applied in other countries, because actual cost structures depend on many factors (Sunderasan, 2014; IoE, 2015; Trinh Quang Dung, 2015).

Solar PV installations have surged *only* in countries offering a generous FiT. But some of the schemes have offered unrealistically high rates, resulting in faster than anticipated build-up of large plants, stretching government budgets, which is one of the problems that Viet Nam must avoid (see Box 2).

Box 2 – Examples of solar PV FiTs and related policies in different countries

- **Germany** is a global leader in solar PV. It has managed to sustain investor enthusiasm by revising incentives in keeping with falling hardware costs, while maintaining steady internal rates of return for solar PV investors. It uses a formula-based mechanism for decline in the FiT rates to contain subsidy allocations without frequent policy revision. Nevertheless, the cost of the FiT was underestimated and in April 2014 it placed a ceiling of 2.5GW of new solar installations per year to slow the pace of power bill increases.
- **China** is the country with its installed solar PV capacity expanding faster than any. It has provided soft loans to Chinese equipment manufacturers, which has fuelled the rapid scaling up of the solar PV sector in the country as well as exports of equipment.
- **Italy**'s target for 2020 was 8000 MW solar PV, but the country was "at risk" of achieving the target almost ten years earlier with a system of FiTs for solar PV systems by homeowners and small businesses, as tariffs stayed high even when technology prices fell. By mid-2011 the FiTs were scaled down more frequently and system sizes were capped, but the systems are still expanding.
- **The Czech Republic**'s goal of 1.63 GW solar PV capacity installed by 2020 was achieved almost ten years ahead of schedule on the back of very attractive tariffs, causing a rise in electricity rates and leading to grid instability. The Czech Republic cross-subsidized with surcharges levied on consumers. The FiTs for all renewable energy technologies ended and a tax was introduced in 2014, partly retroactively, causing international investors to take legal steps. The installed solar PV capacity is about a quarter of the peak summer demand of about 8-9 GW, contributing to "peak demand parity", which is a measure of saturation.
- **Spain** had an "open-budget" scheme to support the growth of the solar PV through fiscal interventions. It offered above-market solar PV FiTs in 2007, causing great interest. But the subsidies rose fast and the FiT was dramatically reduced in 2009 and 2010, and dismantled in 2012. Companies filed suits because policy changes were "retroactive, discriminatory and very damaging" to investor interests, and they impacted on 115,000 jobs.
- To install 2000 MW of solar PV by the end of 2014, **Indonesia** offered a FiT of USD 0.25 per kWh but only few bids were received, possibly owing to time constraints in bid preparation and submission as well as stringent and unclear regulations set for the bidding and selection process, and possibly the narrow margins also discouraged investors. Considering the geographical spread of the islands and the difficulties involved in connecting them to a common grid, it also launched the "100 island with 100% solar power" programme.

Source: Sunderasan, 2014.

Power generators depend on adequate financial returns on their investments. They need predictable and assured revenue, which means that perceived risks for getting a good return on their capital investment must be low. The LCoE of producing solar PV power is strongly dependent on the height of upfront investments, whereas there is no cost to inputs and comparatively low operation and maintenance cost over the life of a project (typically 20-25 years) – this is a very different "picture" when compared to coal-fired power plants. Therefore, investors seek stable policy environments with credible commitments to sell the power generated over the life of a solar PV project.

Based on the model calculations of the LCoE of solar PV in Viet Nam (see Annex I), a Feed-in-Tariff of 15 USD cents/kWh is proposed for mainland power plants, which should be paid over the lifetime of the investment project, i.e. 20 years. This LCoE (FiT) estimate falls at the lower end of the range of international LCoEs in Figure 19 and FiTs paid in other countries (Box 2). An even lower initial FiT may not attract any investor and therefore the solar PV power market would not be able to develop.

The assessment was done for power plants on the mainland and on islands, for different equity return scenarios, as well as two levels of system investment costs. The most important input parameters and assumptions in the model calculations are given in Box 3; the detailed assessment is given in Annex I.

Box 3 - Assumptions and input parameters for assessment of the solar PV FiT in Viet Nam, for power plants on the mainland and islands

- The system cost is USD 1,766 per installed kWp. This is based on a quote from a Vietnamese project developer and includes system design, supply and installation of project equipment (solar modules, installation hardware, lightning protection, earthing, cabling etc.), transportation, erection, testing & commissioning and project management costs (Trinh Quang Dũng, 2015). It does not include costs of a battery bank. Interest on project debt is assumed to be fixed at 7% per annum on the outstanding loan amount. Project debt is repaid over a ten-year period starting immediately upon plant commissioning. Other estimates of total system costs for Viet Nam are higher, e.g. USD 2,000 / kWp (IoE, 2015).
- The total system costs are assumed for small power plants (1 MW), and rise in direct proportion to the size of the plant. In reality the average costs per installed kWp decline marginally with rising project sizes.
- Power plants installed on islands are assumed to cost 25% more because of transportation and handling.
- The useful life of the solar PV plant is assumed to be 20 years. In investment projects a lifetime of 25 years may also be used. Actual power production may however extend beyond this lifetime of 20 or 25 years.
- Assumed equity return is 10% or 15%, which depends on the risk assessment of the investors.
- The computed FiTs (i.e. premium tariffs) apply for the first ten years of plant operations. Design tariffs are lowered by 50% for years 11 through 20. Constant tariffs over a 20-year period are also calculated.
- The corporate income tax is modelled at a constant 25% over the 20-year life. Tax incentives were not considered but could reduce investment costs and improve the conditions for repayment of loans.
- The cost of land for power plants and the value from alternative use of land were not considered.
- Operating expenses including plant maintenance are estimated at 5% of revenues / year.
- Based on solar resource data, the power generation during the average day is computed at 4.50 kWh / installed kWp (AECID, 2014; see also Figure 17). Of this, DC-AC conversion, battery charge-discharge, and other losses are estimated at 0.50 kWh / installed kWp, so a net amount of 4.00 kWh/kWp is exported to the utility grid each day, or 1,460 kWh/kWp per year. However, average power fed into the grid over the lifetime of a project may be higher or lower, depending especially on irradiation in the given location.
- Performance degradation over the life of the plant or because of temperature is ignored. In practice power output may decline by 1% each year, and output suffers when ambient temperatures rise above 25°C.
- Some scenarios are with limited battery back-up for use at the power plant, for local distribution, and/or for emergencies. Batteries are assumed to be of medium quality and replaced once every 4 years.

Power plants on islands, with 25% more investment cost per kWp installed capacity, would require a FiT of 19 USD cents/kWh for a 20-year period (see also Annex I). The influence of a modest land price or that of a small battery bank for local use on the recommended FiT for solar PV on the mainland or islands is very limited.

The mainland and island FiTs for solar PV are both comparatively low by international comparison (Figure 19), because they are based on optimistic assumptions such as a comparatively low equity return rate of 10% and irradiation levels in the most favourable parts of the country. These FiTs are therefore at the "edge" of being able to attract sufficient interest of (private) investors. Nevertheless, they are also higher than the LCoE of coal-fired power plants (Figure 8 and Figure 9), and higher than FiTs already regulated for other forms of renewable energy in Viet Nam (see section 4). The proposed

FiTs are high compared with the average retail tariff in Viet Nam, and in addition they are high when compared to the FiT of 11.2 USD cents/kWh proposed in the draft solar PV support policy. The "single buyer" EVN would make a larger loss than the loss that it is making on some other power sources.

However, the proposed island-FiT is attractive when compared with the costs of diesel generated power, which costs typically above 40 USD cents/kWh and is common on islands: solar PV systems, possibly including small battery banks should thus be a preferred option for power generation on islands from now on.

Furthermore, if the external costs of coal would be internalised (see section 2) the comparison with coal-based power would look very differently – and those are costs now born by ordinary people, the State and the economy. If the average power retail tariff would go up as a result of phase out of indirect subsidies and an environmental fee and/or carbon price on fossil fuel based power, the comparison will also look very differently – and it has been demonstrated that such price increases are likely to increase GDP growth rather than decrease growth (UNDP-Viet Nam, 2012). It would enable EVN (as single buyer) to make a profit on solar PV and contribute to State revenue.

Even without a sustained effort at such energy sector reform, power retail tariffs are very likely to go up gradually over the coming years. Reasons include the debt and losses or minimal profits of EVN and other State Owned Enterprises in the energy sector which are unsustainable and will not generate sufficient capital for investment in power generation and distribution. PDP VII targets an electricity price "in 2020 equivalent to 8-9 USD Cents" in nominal terms (i.e. not considering inflation), which implies that tariffs will remain subsidised and well below international prices until 2020 (see also Figure 10). The PDP VII-revised does not repeat this but raises several points on the electricity price, including "*the selling price of electricity must stimulate the development of electricity, creating an environment for investment attraction and competition encouragement in production, transmission, distribution and use of electricity*"; "*Electricity prices are adjusted gradually to achieve long-term marginal cost of electricity system, to ensure that the electricity industry is capable of sustainable development, meeting the demand for power system development*"; and "*The pricing of electricity must aim to conserve energy, avoid waste in non-renewable energy sources, and encourage the rational use of energy sources and use of domestic energy, reducing reliance on imported energy*."

But to develop solar PV in Viet Nam there is a need for subsidy, at least in the near future. It is proposed that this will be given by regulating that EVN will buy solar PV from approved plants against a premium tariff and cross-subsidise that from other power sources, notably hydro-electricity, pending retail tariff and other energy sector reforms.

With such a mechanism for subsidising solar PV power plants the proposed FiTs for solar PV power plants for the mainland and islands can effectively incentivise investments. It is however also proposed that these FiTs for power plants of 15 USD cents/kWh on the mainland and 19 USD cents/kWh on islands should be regulated as ***maximum FiTs.***

It is also suggested that "reverse auctions" would be held to select solar PV schemes, especially to agree the first major solar PV power plant investments. This has several advantages and implications:

- Auctioning (below these maximum FiTs) eliminates the information asymmetry between investors and regulators, whilst it keeps the costs within predictable boundaries.
- Schemes that would be auctioned would have a capacity ceiling or target and e.g. a predetermined location, and bids will be invited to get to the lowest possible FiT.
- Successive auctions can be based on lessons learned, and as solar PV investment costs are reducing internationally, further to-be-installed power production projects are expected to push the tariff progressively lower.
- The authorities and bidders could be supported by ODA in management of the auctioning process and technical preparations – this would reduce the costs and "keep the playing field

level". Such support might also be drawn from the Sustainable Energy Promotion Fund which is proposed in the REDS, when that is up and running.

There are also other ways for the Government and / or EVN as single buyer to negotiate prices below the maximum FiTs, with domestic and / or foreign investors, equipment suppliers / manufacturers and / or construction companies.

In order to guide the process, whichever way of selecting investors is applied, the authorities should provide clear indications on expected project locations and sizes of installed capacity. PDP VII-revised gives some prospective renewable energy schemes over the period to 2030, but this may be modified and elaborated.

Prospective domestic and/or foreign investors may be seeking some form of loan guarantee for their equity in solar PV plants, which will bring down perceived investor risks related to no or late payment by the utility (the "single buyer").

The (maximum) FiT should be adjusted at certain intervals, as technology develops, solar PV technology efficiency improves and equipment cost prices come down. In this way the market can develop, i.e. financiers, equipment suppliers and construction companies will gain experience, and further cost reductions will be achievable.

Additional measures to develop solar PV in Viet Nam are discussed in section 7.

6. Distributed solar PV power generation and consumption

Solar PV can be produced near consumers, and comparatively small scale, i.e. be a "distributed" source of power. A smaller scale tends to mean that the unit cost of the investment is higher, but transmission and distribution costs are limited. This can take the form of grid-connected "rooftop" systems (for households, businesses)[19]; off-grid individual or collective systems that include battery banks; or solar PV can be employed as community systems or as part of hybrid mini-grids.

In many cases investors (households, groups of households and businesses) will be driven by a long term reduction in electricity bills. And many applications could improve access to power by remote communities and islands, reaching the few percent of Viet Nam's population that is not yet grid connected, as well as households or businesses that currently experience erratic power supply.

The LCoE (and potential FiT) for these systems was also assessed (see Annex I). Specific assumptions and inputs for these systems are given in Box 4, which are in addition to those listed in Box 3. The basic system costs of 1,766 USD/kWp (see Box 3) was determined for a small power plant of 1 MW and is assumed to also apply to household, business and community "rooftop" systems (typically between 1-100 kWp). This is a low estimate of system cost (see also Figure 20). However, although at a small scale some components will be more expensive, land price does not apply and operation and maintenance costs may be lower and tax-exemption and certain subsidies may apply (see also section 7). With the same low equity return rate of 10% and favourable irradiation levels as were used in section 5, the LCoE is also estimated at 15 USD cents/kWh for a 20-year lifetime (details in Annex I).

Box 4 - Additional assumptions for assessment of the LCoE/ FiT for "rooftop", off-grid and mini-grid solar PV systems

- Most "rooftop" systems are assumed to be grid connected, and operators are assumed to be net-consumers of power from the grid. Power produced in excess of on-site consumption will be fed into the grid, and power is taken off the grid when production is insufficient. This means that battery banks are only needed if risks of black outs are high and back-up generation capacity is needed.
- Off-grid rooftop and mini-grid systems are assumed to be designed with adequate battery back-up to enable energy time shifting: for the power generated during the day to be consumed during the evening and night.
- Technical feasibility of "rooftop" systems, including structural strength, availability of shadow-free-spaces, and floor space for battery banks was not assessed.

6.1 Grid-connected "rooftop" solar PV systems

It is ***not*** recommended to translate this LCoE into a FiT for grid-connected "rooftop" systems. Instead it is suggested that a "***net-metering***" policy will be issued for systems that are primarily meant for on-site consumption. They feed small amounts of excess production into the grid that is off-set against what they buy (drawing electricity from the grid when their production is insufficient); and they are assumed to be net-consumers of grid-power. It is proposed that the owners would "sell"

[19] Businesses and households could also choose to erect such systems in e.g. gardens, above parking spaces, floating in ponds; and some solar PV technologies generate power from building facades and windows.

against the prevailing retail tariff but as net-consumers just experience a reduced monthly bill. This can be accomplished by using two-way electricity meters or smart meters[20].

Grid-connected rooftop systems must face low administrative barriers. For example, the owners of these systems should ensure that the inter-connection is made according to appropriate technical standards and that approved meters are installed, but there should be no requirement such as registration as a power producing company and agreement of a PPA, which should only be applied to power plants that have the sole purpose of selling power – this is illustrated in Box 5.

Box 5 - A solar PV system on the roof of the Green One UN House in Hanoi

The UN in Viet Nam in cooperation with the Government and supported by international donors has constructed a new office in Hanoi, the "Green One UN House", which has several environmentally friendly features including a 110 kWp solar PV system on its roof. In the absence of regulations for connecting solar PV to the national grid, the UN entered into negotiations with EVN (Viet Nam Electricity Group). The aim was to feed excess power into the grid (produced e.g. during the weekend) and procure electricity when demand exceeds supply. The solar PV system is expected to generate 10 percent of annual total electricity demand of the Green One UN House.

It took over one year in order to agree a contract from the date that the UN received EVN approval for the inter-connection, several meetings with EVN and MOIT, and intense communication. It was agreed that any excess electricity that is produced by the UN (for example when the building is unoccupied in the weekend) will be fed into the EVN grid *for free*, and it will not be subtracted from the power EVN supplies to the UN. The reasons for this are as follows:

- Viet Nam does not yet have "net-metering" regulations or grid connection codes for solar PV that are common in many countries in the case of rooftop solar PV.
- The regulations for power plants with the sole purpose of selling power had to be applied to the UN, because there was no regulation yet for cases where selling power to the grid is a minor aim and most power that is produced is off-set against what a (net-)consumer buys. Circular 25/2013/TT-BCT on licensing of power producers prescribes that if the installed capacity of a power plant is < 50 kWp the seller is exempted from various regulations, however the UN system is larger and needs to get MOIT approval. The UN was treated as a power producing company that needs to be registered and granted a business license for selling power (the UN cannot do that) and it would need to pay VAT on its earnings from selling power (the UN cannot produce VAT invoices).
- If the UN would have been able to register as a power producing and selling company and would be able to issue VAT invoices, it would have to enter into a Power Purchasing Agreement (PPA) with EVN (the single buyer), just like any power producer in Viet Nam. The relevant price of power is regulated by Decision 18/2008/QD-BCT on "*Avoided cost tariff and standardized power purchase agreement for small renewable energy power plants*". The actual price paid by EVN is calculated annually based on "*the most expensive power generating unit in the national power grid, which would be avoided*", which is low by international comparison. This regulation was designed for small-scale hydropower production, which is one of the cheapest forms of power production and not for rooftop solar PV. The "avoided costs" thus regulated annually are below the cost price of solar PV power production, and unattractive for investors in solar PV.

The UN expects that as a national solar PV support policy is developed there will be a new agreement with EVN that should be more favourable to the UN, and similarly any other customer of EVN who wants to install a rooftop solar PV system to reduce its electricity bill.

[20] Net-metering means that power companies accept all excess power produced by households or business and off-set that against the bills, for a price identical to or just below the prevailing retail tariffs. A somewhat lower "buying tariff" would mean that EVN is compensated for their distribution costs and power losses, but these are small and overall tariffs are low, so this is not recommended here.

The draft solar PV support policy suggests a FiT of 14 USD cents/kWh, but it is here suggested *not* to provide a premium tariff FiT. The first reason is that net-metering against the prevailing retail tariff is administratively the simplest possible option. Secondly, a premium tariff might incentivise local producers to sell all power produced to EVN and not to consume any on-site produced power. The third justification for recommending a net-metering policy without premium FiT, despite a comparatively low prevailing retail tariff, is that there are various ways to keep the upfront investment cost low and possibly lower that the assumed LCoE of 15 USD cents/kWh, including tax incentives that are discussed in section 7.

Fourthly, the current retail tariffs are already such that solar PV "rooftop" is attractive for some customers, and as retail tariffs will go up further over the coming years and costs will reduce (Figure 20), rooftop solar will become attractive to many.

Figure 12 shows that high-consuming households with solar PV rooftop systems would produce power to reduce the total they pay in the highest tier of retail prices, which was 12 USD cents/kWh in 2015. This makes it likely that with a "net-metering" policy and support measures as discussed in section 7, it is financially attractive for some households to invest in rooftop solar PV systems. And as retail tariffs will increase over the coming years and solar PV system costs will reduce, rooftop solar will become attractive for a growing number of households.

According to the current electricity regulations, retail tariffs for manufacturing and commercial businesses during "normal" and "peak" hours of consumption, when solar irradiation is high, are higher than the average tariff.
These subsidies are calculated by making comparisons with international prices of electricity. They are a cost to Vietnamese taxpayers because low electricity prices are made possible by forgoing profits and revenue from state-owned enterprises to the State (e.g.: coal is sold domestically for a price below the international market price, meaning that VINACOMIN cannot contribute much to the State's revenue); investment guarantees and cheap loans to EVN and other operators in the power sector (e.g. State investment and ODA to power transmission lines); and environmental and social externalities (UNDP, 2014). EVN (as the single buyer of power) also has access to a large amount of very cheap hydropower, which is enabling it to make up for the losses from producing power with fossil fuels (or buying that), but this also means that little or no revenue is paid to the State as owner of EVN and power generation companies – and so the State must raise revenue from (other) sources (such as VAT, corporation tax, income tax, import / export tax, environmental fees, etc.).

The average retail price of electricity in Viet Nam was 7.6 USD cents/kWh in 2015. The block tariff scheme for households is shown in Figure 12, with high-consuming households paying a higher price for more units of power consumed per month. In Figure 13 some specific retail tariffs are given for manufacturing and commercial enterprises and for hospitals and schools. Both households and industry pay less on average than in other countries, where tariffs are generally higher or much higher compared to Viet Nam (see Figure 14 and Figure 15).

Figure 12 – The Incremental Block Tariff scheme: electricity prices for households

From Decision 28/2014/QĐ-TTg		2256/QĐ-BCT (12/03/15)	1USD=VND21,458 (2015)	1USD=VND22,300 (early 2016)
average retail price:	**(% of)**	VND 1,622	USD 0.076	USD 0.073
0-50 kWh/month	92%	VND 1,492	USD 0.070	USD 0.067
51-100	95%	VND 1,541	USD 0.072	USD 0.069
101-200	110%	VND 1,784	USD 0.083	USD 0.080
201-300	138%	VND 2,238	USD 0.104	USD 0.100
301-400	154%	VND 2,498	USD 0.116	USD 0.112
>400 kWh/month	159%	VND 2,579	USD 0.120	USD 0.116
Prepaid card	132%	VND 2,141	USD 0.100	USD 0.096

Figure 13Figure 13 shows that commercial enterprises pay rates between 17-19 USD cents/kWh during “peak hours”, some of which fall during day time, and 10-11 USD cents/kWh during “normal hours” (including afternoons). Depending on their consumption, this already off-sets some solar power against the highest retail tariff and daily off-set can average-out to a level close to the LCoE here presented. In other words, rooftop solar is already financially interesting for some (commercial) businesses, especially if support measures as discussed in section 7 apply, and as retail tariffs increase also for other businesses.

In areas regularly facing blackouts of the public grid-supply, grid-connected “rooftop” systems might include battery banks so that they avoid the need for backup generators. The LCoE of 15 USD cents/kWh for a 20-year lifetime of systems of 100 kWp or larger is not very sensitive to the cost of modest battery banks, and investors would avoid the cost of diesel or petrol back-up generators (see also Annex I)

Net-metering is regulated in other countries with different upper size limits, with in some countries a big upper size limit or no limit. The size limit should not matter much if the producer is a net-consumer and feed-in to the grid remains limited even at peak production. Typical installed capacity for households may be 1-5 kWp, small remote communities and island systems 20-200 kWp (e.g. a pilot system on Con Dao island is 36 kWp) and offices and businesses “rooftop systems” 50-500 kWp (e.g. the Green One UN House is 110 kWp; see Box 5). However, some businesses are expected to be interested in larger systems as they have roof and parking space sometimes over 10,000 m2, whereas for example airport facilities might also consider as much as 2 MW. It is recommended to regulate a maximum limit that would accommodate such large-scale businesses.

6.2 Off-grid solar PV systems

The "rooftop" solar PV systems discussed in section 6.1 may alternatively be off-grid because the grid-connection costs money and some investors may expect to consume all on-site power production, making the interconnection un-necessary. This would also avoid any administrative procedure and the inter-connection cost. These owners would off-set their production against the prevailing power tariff (which they would pay in the alternative situation) and they do not need the grid as a virtual storage. This arrangement will also become particularly attractive as retail tariffs will go up further over the coming years and solar PV system costs will reduce.

If these systems are at a long distance from the public grid they would also include battery banks for 24 hour/day supply, which is likely to be cheaper than the alternative of diesel or petrol generators.

Other businesses or households would still draw power from the public grid, even though they never feed excess production into it. In situations where blackouts are common these solar PV systems may also include battery banks, so that there is no need for backup diesel or petrol generators.

With off-grid systems and the possibility of combining off-grid with consumption from the grid (but keeping the systems separate), choices must be made regarding the use of Direct Current (DC) or Alternating Current (AC) because this affects the type of equipment that can be used (DC-AC conversion requires an inverter, and causes some energy loss).

6.3 Community solar PV systems and hybrid mini-grids

According to PDP VII Viet Nam aims for nearly 100% electricity coverage of rural households by 2020, primarily through grid-extension[21]. Viet Nam targets an additional 377,000 households with electricity in mountainous and island areas between 2011 and 2015, and a further 231,000 households by 2020, especially from local renewable sources. PDP VII proposes to achieve this by developing "favourable mechanisms for management and investment to maintain and develop power sources in the regions".

Since the early 1990s, local authorities or groups of households built low voltage (LV)[22] and also medium voltage (MV)[23] electricity distribution systems, purchased power at a subsidised price and sold it to users. These systems responded to local demand and were managed in diverse ways. Whilst the central Government is the primary source of funding for local authorities, households were the main source of financing rural electrification between 1990 and 2012. Households paid part of the LV and MV systems, the connection to their house, and the meter, but their share of total expenditure declined in recent years. Consumer prices were very high in the early years and the high costs in the 1990s excluded some of the poorest households and villages. From the late 1990s EVN is in charge of all MV distribution, and licensed Local Distribution Utilities (LDUs) were introduced to manage LV systems. Currently LDUs across the country purchase power from EVN at a wholesale tariff and charge consumers the regulated consumer tariff. The harmonisation of consumer tariffs across the country amounts to cross-subsidisation of rural electricity consumers by urban consumers (Scott and Greenhill, 2014; World Bank, 2011).

Viet Nam has a cash transfer scheme to low-income electricity users which was reformed and transferred from EVN to the Ministry of Labour and Social Affairs (MOLISA) and local authorities,

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[21] PDP VII-revised reaffirmed the aim: "meet the target of 2020, namely, by 2020, most of the rural households can get access to electricity".
[22] The International Electro-technical Commission (IEC) defines "supply system low voltage" as voltage in the range 50–1000 V AC or 120–1500 V DC.
[23] Primary distribution lines carry medium voltage (MV) power (ranging between 2 kV and 35 kV) to distribution transformers to low voltage (LV) lines.

according to Decision 28/2014/QĐ-TTg. The cash transfer is equivalent to 30 kWh consumption per month at the price of the first block in the Incremental Block Tariff (IBT) scheme (i.e. the regulated consumer tariff; see Figure 12) for households that are classified as the poor and some other low income households. It is financed by the central and local authorities and has been estimated to cost around US$48m per year if fully implemented (UNDP Viet Nam, 2014). Furthermore, rural grid expansion is ongoing according to Decision 2081/QD-TTg of 8 November 2013, "*program on electricity supply to rural, mountainous and island area 2013-2020*", and on 28 May 2014 MOIT issued Circular 8373/BCT-TCNL with guidance on the "*formulation, evaluation and approval of projects and implementation of investment projects in off-grid rural electricity supply from renewable power sources*". This also demonstrates the willingness and capacity of Viet Nam to invest in remote and low income households to access electricity, grid-connected and off-grid.

This policy context and the history of local management and cross subsidisation is important for developing and managing power systems in the remotest areas where communities and households are not yet connected to the national grid. Reaching the remotest people with national grid-extension is comparatively costly whereas they tend to be amongst the poorest of Viet Nam and have very limited ability to contribute themselves.

Solar PV community systems may be grid-connected, in urban areas (high rise apartment buildings) and in rural areas where investment in grid-connection is comparatively low. In these situations, net-metering gives benefit at times of excess on-site power production whereas there would be limited need for battery storage of power if this is in areas with few blackouts.

Off-grid solar PV can also play an important role in achieving the 100% coverage target. It could reduce the financial burden for improving access to electricity in remote areas, because the cost per household and local contribution may be lower when compared with grid extension for low numbers of households. Off-grid solar PV systems in remote communities would include battery banks.

Solar PV could also be a part of hybrid mini-grids[24], many of which also include battery banks for continuous supply. Collective solar PV systems would save on some equipment cost (notably inverters, which are a costly component of solar PV systems), when compared with large numbers of very small stand-alone solar PV systems per homestead, unless households are scattered and distances from the community generator / solar PV system would be substantial.

If off-grid is preferred for the period that grid extension does not yet reach the community concerned systems could choose Direct Current (DC) circuits to minimize loss of power from conversion to Alternating Current (AC) through inverters. Local off-grid systems can be connected to the grid at a later date, but then DC-AC conversion is needed. The use of DC or AC should be considered at planning stage because it affects the type of equipment that can be used.

Further recommendations for stimulating on-grid and off-grid community solar PV systems are made in section 7.

[24] Hybrid mini-grids typically draw power from different sources such as diesel, hydro and solar power, for supply to (groups of) small communities. See e.g. Roland and Glania (2011).

7. Recommendations to stimulate solar PV and achieve SDG 7 in Viet Nam

7.1 Gradually raising the electricity retail price

Solar PV power generation and consumption in Viet Nam can be initiated within the current fiscal framework, as is demonstrated in sections 5 and 6, where a premium FiT for solar PV power plants, net-metering for "rooftop" solar PV and community systems are proposed. This would make a major contribution towards achieving Sustainable Development Goal 7 in Viet Nam (see section 1). However, the primary barrier to development of solar PV at different scales is the low retail tariff, which makes renewable energy including solar PV seem expensive.

The low retail tariff is caused by price regulation that leads to indirect subsidisation (see Figure 10 and Figure 11). The low tariff forces losses in the electricity sector; cross subsidization (e.g. hydropower to coal-based power); forgone State revenue (State-owned enterprises that make losses or very little profit do not pay much revenue to the State, so the State must raise other revenue); various State support to electricity generation, transmission and distribution; and a failure to internalise social and environmental costs (especially from coal mining, transport and use).

All of those are however costs to taxpayers. There is therefore a strong case for the phase-out of indirect fossil fuel subsidies and introduction of a carbon price, in order to start internalising the external costs of fossil fuel use, as has been proposed in the Renewable Energy Development Strategy (REDS) through an environmental fee on fossil fuel use.

What this could mean for the average retail tariffs, and what kind of actions are needed to mitigate negative effects of retail price increases on low-income households and certain businesses has been addressed by various analysts (see: UNDP Viet Nam, 2014). The conclusion is that a gradual increase of electricity prices by 5-10% per year in real terms over a period of e.g. three years would be feasible for most. Negative effects on low-income households and certain businesses can be mitigated within the existing policy framework with some additions and modifications[25].

Such price increases would mean that electricity in Viet Nam would remain cheap compared with other countries (see Figure 14 and Figure 15) and yet it would make solar PV and other renewable energy a financially attractive alternative source of power, both at the scale of power plants and as a form of distributed power generation under a net-metering regime.

A roadmap of power retail price increases should also be issued, so that both EVN as single buyer and investors in power plants and "rooftop" systems have adequate information to calculate their LCoEs, and potential profits and losses over the lifetime of a solar PV project.

7.2 Phasing out all support to coal-based power

Coal-fired power plant construction has peaked in most countries, and international development agencies have scaled down financing of coal-based power. The above mentioned environmental fee in the REDS and a price on carbon would make coal-based power a less attractive option in Viet Nam too, and indirectly incentivise renewable energy investment.

The Government of Viet Nam could also do the following:

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[25] This was explained in UNDP-Viet Nam (2014). Further work on assessing potential impacts on households and businesses of price increases is ongoing in a cooperative effort by UNDP and national research organisations, which will be concluded in 2016.

- Cease all direct and indirect financial support to coal mining, coal-fired power plant construction, construction of related transport infrastructure, and storage and processing of waste, and ensure that all costs are carried by owners / investors in mines and coal-fired power plants. (Current support measures include for example grants, loans or loan guarantees for investment in infrastructure, and access to cheap land for construction of facilities.)
- Regulate stricter environmental standards for coal mining, coal transport and coal-fired power plants, that are in-line with those in other countries (see Figure 5).
- Ensure that all environmental standards and mitigation measures agreed in Environmental Impact Assessments of mines, coal transport, and coal-fired power plants are strictly followed.

7.3 Measures to limit investment costs of solar PV

Many solar PV support measures in addition to those in sections 5 and 6 are focused on reducing the initial capital investment and reducing investor risks (and hence the level of interest on loans):

- Tax policy can help attract investors and support solar PV investments in several ways, most of which are mentioned in the REDS and the draft solar PV support policy, such as exemption from import tax on solar PV system-parts and key inputs; exemption from corporate income tax for solar PV power plants and businesses producing or assembling solar PV equipment in Viet Nam; exemption from Value Added Tax (VAT) on solar PV produced power.
- Commercial bank lending rates in VND fluctuate roughly between 7%-10%, although the tenure of loans varies. To maintain or reduce this over a long period of time, the Government could provide loan guarantees or a stimulus package through banks for "loans for solar PV". This could target domestic industry (and thus help to develop that), and be applied to a limited total installed capacity, for example 500 MW to 1,000 MW installed capacity nationally.
- The main ODA lenders to Viet Nam's energy sector may provide loans or capital towards loan guarantee arrangements to reduce capital expenditure. ODA grants or soft loans could also help prepare the first "reverse auctions" of solar PV power plants as discussed in section 5.
- The Government, provinces, and/or EVN could mobilize domestic funds and (non-refundable) ODA to subsidize solar PV systems in remote areas and islands (see also section 6). This would target communities and households that are not yet grid-connected, where interconnection is expensive because of for example remoteness, or where connections are frequently interrupted and of low quality. These funds would focus on reducing the initial capital investment of (notably) community systems with battery storage or community solar PV systems that are grid connected, and on building capacities in the solar PV supply chain including (local) companies and LDUs involved in installation, operation and maintenance.
- With subsidies, tax exemptions as well as capacity building, solar PV businesses, banks and other investors could also be drawn into Public Private Partnerships (PPPs). PPPs could target remote communities, potentially leading to large scale use of solar PV in reaching the last few percent of Vietnamese households that do not have access to power yet. This requires awareness raising and capacity building of equipment manufacturers and suppliers as well as lenders and LDUs. Bank risks in lending for community or rooftop systems for businesses may be reduced through loan guarantee funds for which there are precedents in Viet Nam.
- In addition to the Sustainable Energy Promotion Fund announced in the REDS, there are other national funding windows that can be used to support domestic manufacturers and suppliers or operators of solar PV equipment. This includes the Development Fund for Science and Technology and the Viet Nam Environmental Protection Fund (VEPF) which could grant or lend money, or provide loan guarantees for loans from commercial banks and thus reduce interest charged on loans for investment in solar PV systems, especially those in the range of 10-50 kWp installed capacity (Trinh Quang Dung, 2015).

7.4 Regulations to stimulate renewable energy

FiTs (as discussed in section 5 and 6) are often preferred over imposing "portfolio standards", i.e. regulating that a specific share of electricity produced by power generation companies (GENCOMs) must be generated from renewable energy. The Government could consider this in addition to FiTs for reaching the targets set in the REDS. Portfolio standards would encourage GENCOMs to seek investment capital and enter into agreements with equipment manufacturers and suppliers, instead of relying mainly on new investors and operators (IPPs, Independent Power Producers) for development of solar PV power plants.

Performance Based Standards could also be set, e.g. specifying allowable levels of GHG emissions per unit of output (MWh of electricity generated), averaged across technology options applied by GENCOMs. These standards could progressively be made more stringent. Investors would then choose among alternatives of renewable and low emissions technologies to generate the desired output at the allowable emission levels, with the lowest overall costs.

Operationalising investments in solar PV power plants requires a number of regulations, as follows:

- Power Purchase Agreements PPA must be issued, applying to the lifetime of a solar PV project, e.g. 20 years, in which EVN (the "single buyer") accepts all power produced and power prices are agreed for the full period. This price (in USD) could be higher in the first years and lower in the last years, or remain constant (see also Annex I).
- In order to support development of the domestic industry (e.g. equipment manufacturers) the Government could specify a limited set of solar PV technologies to which domestic companies already have access. Alternatively, the Government could decide to aim for the lowest price, which may encourage more foreign investors and suppliers. In the latter case the Government could demand that foreign investors should partner with domestic companies, which is justified by the financial support measures that it provides.
- Technical and environmental standards are needed that apply to importation, manufacture, installation and operation of solar PV systems, including the disposal of end-of-life equipment. Construction regulations need to consider extreme weather risks (e.g. typhoons).
- During the planning phase of solar PV power plants, competition with alternative land uses must be considered. Tensions may be alleviated by adequate planning procedures at the national and local level, well-designed environmental impact assessment guidelines, consultations with local stakeholders in the planning process, and communication strategies concerning critical issues. Alternatives should also be considered, such as solar power plants floating on hydro-electric lakes (which already have power transmission infrastructure).

Depending on choices with regards to a premium FiT or net-metering with "rooftop" solar PV there is a need for specific regulations (see also section 6). This would include:

- Regulations for EVN to accept net-metering, and excess power produced.
- An administrative system such as a "one-stop-shop" in provinces to enable solar PV "rooftop" producers to register, install and connect their solar PV systems
- Technical standards and procedures for grid connection of rooftop solar PV systems.
- Support with financing of systems (in case net-metering is chosen over a premium FiT)
- Clarity on environmental standards and regulations that apply to this situation.

There is also a need for specific regulations regarding investment and net-metering of grid connected community systems, and support to off-grid community systems and hybrid mini-grids in remote communities and islands. Subsidies on the capital costs of systems will be key for the success and should be seen as alternative to grid-expansion expenditure, which may be from the central Government or provinces, EVN and/or ODA sources, in addition to e.g. tax exemptions for equipment (see also section 7.2).

7.5 Capacity building to stimulate solar PV

Solar PV investments will start in Viet Nam from a very small industrial and knowledge base. Much is yet to be agreed and regulated, and tried out. In order to make best use of the existing knowledge and capacities and to optimize the potential for PPPs and both private and public investments in solar PV power plants, business rooftop solar PV as well as community systems it is recommended to create a multi-stakeholder national body, following experiences in other countries. This would aim to exchange lessons and advise the Government on the best ways forward in developing the solar PV sector. Membership should include representatives from central and local authorities, EVN, ERAV (the Electricity Regulatory Authority of Viet Nam), VCCI, private enterprises in the solar PV industry, financiers, and researchers.

Development of the solar PV sector in Viet Nam requires increased capacities of many stakeholders. This may be supported by the Government and ODA-funded projects. There is a need for ....

- Awareness raising and capacity building on solar PV policies and regulations and the available technical and financial solar PV system options, of MOIT and EVN staff as well as local authorities and local personnel of power distribution companies (EVN and LDUs).
- Capacity building of ERAV, MOIT and local authorities re enabling policies such as access to land (solar PV power plants), and for monitoring and enforcement of solar PV regulations.
- Training of central and local Government personnel of MOIT, DOIT, MOST and DOST, as well as personnel of EVN on technology and business development related to different solar PV systems / market segments.
- Training of central and provincial personnel of banks, on investment risks and potential financial returns of different configurations of solar PV systems, and formulation and assessment of solar PV investment plans (solar PV power plants, "rooftop" as well as community systems).
- Training of personnel of vocational training centres, who will train (male and female) technicians of solar PV assembly or manufacturing plants and local workshops, on the components of solar PV systems, installation, and Operation & Maintenance (O&M).
- Awareness raising and capacity building of a range of stakeholders, including representatives of DOIT local EVN and LDUs on mechanisms to consult with local communities in the context of development of community solar PV systems and hybrid mini-grids in remote areas.
- Raising awareness and building capacity of community representatives and targeted households of social, environmental and economic benefits and costs of solar PV, who are expected to participate in making key decisions on priorities and modalities.

Finally, as more and more investments in solar PV and other renewable power sources are made and power plants will come on-line there will be a need for refinement in grid management because some forms of renewable energy produce intermittent power. If net-metering is applied at a large scale, large numbers of distributed generation units could lead to grid-stability (as power is produced during sunny hours when there is also high demand), or grid-instability, which must be assessed and dealing with this may require infrastructure upgrades. Grid-instability risks can partly be addressed through centralised national grid management and wind and solar energy forecasting. Countries that are advanced with solar PV and other renewables will be able to offer Viet Nam useful lessons in addressing this.

References

AECID-MOIT (2014). *Maps of solar resource and potential in Viet Nam*. Produced by a Spanish consortium of CIEMAT, CENER and IDEA.

Audinet, Pierre, Bipul Singh, Duane T. Kexel, Suphachol Suphachalasai, Pedzi Makumbe and Kristy Mayer (2014). *Exploring a Low-Carbon Development Path for Vietnam*. World Bank

DOST Binh Thuan (2016). *Coal Ash from Coal-Fired Power Plants in Vietnam: Opportunities and Challenges - the Case Study of Vinh Tan Power Complex*, Presentation by Binh Thuan Department of Science and Technology to the workshop on "Coal ash from coal-fired power plants in Vietnam: Opportunities and Challenges" by GreenID / Sustainable Energy Alliance / WWF, Hanoi, 12 January 2016

Eurocham (2010). *Energy Position Paper*, European Chamber of Commerce in Viet Nam.

Gabbard, Alex (1993). "Coal Combustion: Nuclear Resource or Danger", *Oak Ridge National Laboratory Review*, Vol26 nr.3, nr.4, 1993

GIZ (2014). *Technical assistance to the Ministry of Industry and Trade on a proposal of an appropriate support mechanism for wind power in Viet Nam*.

GreenID (2013). *Analysis of Environmental and Social Costs and Risks of Hydropower Dams, with a Case Study of Song Tranh 2 Hydropower Plant*. Hanoi: Green Innovation and Development Centre (GreenID)

GreenID (2015), *Fiscal Policies on Fossil Fuel: Coal and Coal Fired Power Plants in Viet Nam*. Report by Green Innovation and Development Centre for UNDP-Viet Nam. Ha Noi, July 6th 2015.

IEA (2015a), *Southeast Energy Asia Energy Outlook 2015 - World Energy Outlook Special Report*. International Energy Agency

IEA (2015b), *Key World Energy Statistics 2015*

IoE (2014a). *Survey and document expert views on barriers to expansion of solar power generation and consumption in Viet Nam*. Draft. Report under UNDP project "Fossil Fuel Fiscal Policy research & dialogue Phase III: Fiscal policy reform and other incentives to limit growth in coal fired power and support non-hydro renewable energy development". Hanoi: Institute of Energy.

IoE (2014b). *Output 2.2: Analyze and document fiscal, financial, technical, regulatory and other barriers to expansion of non-hydro renewable power generation and consumption in Viet Nam, especially solar power*. Draft. Report under UNDP project "Fossil Fuel Fiscal Policy research & dialogue Phase III: Fiscal policy reform and other incentives to limit growth in coal fired power and support non-hydro renewable energy development". Hanoi: Institute of Energy.

IoE (2015). *Activity 4.1: Analyze costs of non-hydro renewable power, especially solar power generation.* Draft. Report under UNDP project "Fossil Fuel Fiscal Policy research & dialogue Phase III: Fiscal policy reform and other incentives to limit growth in coal fired power and support non-hydro renewable energy development". Hanoi: Institute of Energy.

IRENA (2015a). *Renewable power generation costs in 2014*. International Renewable Energy Agency. www.irena.org/publications

IRENA (2015b). *Rethinking Energy: Renewable Energy and Climate Change*. http://www.irena.org/

Khanh Q. Nguyen (2008). "Internalizing Externalities Into Capacity Expansion Planning: The Case of Electricity in Vietnam", *Energy*, Vol. 33, 2008, p. 740 – 746.

Koplitz, Shannon N., Daniel J. Jacob, Lauri Myllyvirta, Melissa P. Sulprizio, and Colleen Reid (2015). *Burden of disease from rising coal emissions in Southeast Asia: Preliminary Findings*, Harvard University and Greenpeace International.

Loi Dinh Chinh, Shabbir H. Gheewala and Sébastien Bonnet (2007). "Integrated Environmental Assessment and Pollution Prevention in Vietnam: The Case of Anthracite Production", *Journal of Cleaner Production*, Vol. 15, 2007, p. 1768 – 1777.

Martinez, Raul E., J. Eduardo Marquez, Hoàng Thị Bích Hòa, Reto Gieré (2013). 'Open-pit coal-mining effects on rice paddy soil composition and metal bioavailability to *Oryza sativa* L. plants in Cam Pha, northeastern Vietnam', in: *Environmental Science and Pollution Research*, November 2013, Volume 20, Issue 11, pp 7686-7698. Springer.

MOIT (2014). *Report on 15 years of Viet Nam's rural electrification and orientation, assignments, solutions for implementation of rural electrification in the period 2014-2015*. Hanoi: Ministry of Industry and Trade.

MONRE (2014). *The Initial Biennial Updated Report of Viet Nam to the United Nations Framework Convention on Climate Change*. Hanoi: Ministry of Natural Resources and Environment (MONRE) and Viet Nam Publishing House of Natural Resources, Environment and Cartography (NARENCA)

Myllyvirta, Lauri (2015). "Impacts of planned coal-fired power plant expansion on air quality and health in Vietnam", presentation on 29 September 2015 at Conference "Coal & Coal-fired power plants: What have not been known?", Sustainable Energy Alliance, GreenID, Hanoi.

Nguyen Thai Hoa, Kei Gomi and Yuzuru Matsuoka (2014). "Low Carbon Energy Scenario Development in Vietnam", *International Conference on Future Environment and Energy*, IPCBEE Vol.61, 2014, http://www.ipcbee.com/vol61/001-ICFEE2014-S003.pdf, last accessed 10 May 2014.

Polo, J., M.Gastón, J.M.Vindel, I.Pagola (2015). "Spatial variability and clustering of global solar irradiation in Vietnam from sunshine duration measurements", in: *Renewable and Sustainable Energy Reviews* 42 (2015) 1326–1334. Elsevier

Rolland, Simon, Guido Glania (2011). *Hybrid mini-grids for rural electrification: lessons learned*. Brussels: Alliance for Rural Electrification (ARE), for the United States Agency for International Development (USAID)

Scott, Andrew, and Romilly Greenhill (2014). *Turning the lights on Sustainable energy and development in Viet Nam*. Country case study report. London: Overseas Development Institute (ODI)

Sunderasan, Srinivasan (2014). *Best Practices in Fiscal Policy to Stimulate Solar PV in Vietnam - International Experiences*. Report for UNDP Viet Nam by Verdurous Solutions

The Economist (2014a). "Coal: The Fuel of the Future, Unfortunately", *The Economist* print edition, 19 April 2014, http://www.economist.com/news/business/21600987-cheap-ubiquitous-and-flexible-fuel-just-one-problem-fuel-future, last accessed 4 June 2015.

The Economist (2014b). "Electricity in Vietnam: A Heavy Load", *The Economist* print edition, 31 August 2013, http://www.economist.com/news/asia/21584374-vietnams-power-grid-under-strain-all-kinds-fuses-may-blow-heavy-load, last accessed 10 May 2014

Trinh Quang Dũng (2015). *Chính sách giá năng lượng mặt trời ("Feed-in-Tariff", FiT) ở Việt Nam – Các thông tin cơ sở.* Draft of 19/03/2015. [Basic information on Feed-in-Tariff (FiT) policy in Viet Nam]

UNDP Viet Nam (2012). *Fossil Fuel Fiscal Policies and Greenhouse Gas Emissions in Viet Nam*. Ha Noi, Viet Nam

UNDP Viet Nam (2014). *Green Growth and Fossil Fuel Fiscal Policies in Viet Nam - Recommendations on a Roadmap for Policy Reform*. Ha Noi, Viet Nam

Vu Trong Khanh (2013). "Vietnam Clamping Down on Coal Exports as Domestic Energy Needs Rise", *The Wall Street Journal – Asia*, 10 July 2013, http://online.wsj.com/news/articles/SB10001424127887324879504578596901530238408, last accessed 10 May 2014.

World Bank (2011). *State and People, Central and Local, Working Together: The Vietnam Rural Electrification Experience*. Asia Sustainable and Alternative Energy Program. Washington D.C.: International Bank for Reconstruction and Development / The World Bank.

Wörlen, Christine, and Sarah Riesenberg (2015). *Situation analysis of the Vietnamese electricity sector*, Berlin: Arepo Consult, for Rosa Luxemburg Stiftung.

Annex I Possible solar PV Feed-in-tariffs for Viet Nam

AI.A Assumptions

An estimate of solar PV investment costs for the Vietnamese condition is **USD 1,766** per installed kWp, for systems up to 1 MW (which is a small ground mounted solar PV power plant – a size of roughly 1 ha - and could also apply to commercial rooftop solar PV systems as some factories have more than 10,000 m2 roof space). This falls at the low end of the range of international costs, and total installed capital costs for the Vietnamese situation tend to be higher, e.g. USD 2,000 / kWp (IoE, 2015). The USD 1,766 estimate includes system design, supply and installation of project equipment (solar modules, installation hardware, lightning protection, earthing, cabling etc.), transportation, erection, testing & commissioning and project management costs (Trinh Quang Dũng, 2015). Interest on project debt is assumed to be fixed at 7% per annum on the outstanding loan amount. Project debt is repaid over a ten-year period starting immediately upon plant commissioning.

The main assumptions and input parameters in the assessment of costs of solar PV power generation in the Vietnamese situation are as follows:

- System cost of USD 1,766 per installed kWp, which excludes a battery bank. Total supply, installation and commissioning costs are assumed to rise in direct proportion to the size of the plant (linearly). In reality the average costs per installed kWp might decline marginally with rising project sizes, so the actual price for small rooftop systems will be somewhat higher.
- Power plants installed on islands are assumed to cost 25% more than mainland plants because of higher transportation and handling costs.
- The useful life of the solar PV plant is assumed to be 20 years (for depreciation). In investment projects a lifetime of 25 years may also be used. Actual power production may off course extend beyond this lifetime of 20 or 25 years.
- Equity return is 10% or 15%, which depends on the risk assessment of the investors.
- The computed FiTs (i.e. premium tariffs) apply for the first ten years of plant operations. Design tariffs are lowered by 50% for years 11 through 20.
- The corporate income tax is modelled at a constant 25% over the 20-year life. Tax incentives were not considered but could reduce system investment costs and improve the conditions for repayment of loans over the lifetime of the project.
- The cost of land for power plants and the value from alternative land use were not considered.
- Operating expenses including plant maintenance are estimated at 5% of revenues / year.
- During the average day GHI is 4.50 kWh per installed kWp per day[26]. DC–AC conversion, battery charge-discharge, and other losses are estimated at 0.50 kWh / installed kWp and a net amount of 4.00 kWh is exported to the utility grid each day, or 1,460 kWh/kWp per year. However, average power fed into the grid over the lifetime of a project may be higher or lower, depending especially on irradiation in the given location. It will higher in much of the Central Highlands and the South, especially in Ninh Thuan and Binh Thuan provinces, and lower in most of the North Central and northern regions.
- Performance degradation over the life of the plant or with higher ambient temperatures is ignored. In practice power output may decline by 1% each year, and power output suffers when ambient temperatures rise above 25°C.

[26] kWp = kilo Watt-peak; the amount of power a PV module could supply if it were to receive 1,000 Watt of solar irradiance per square meter area. Depending on the technology used a system's size of a solar panel array could be 6-8 m2 per kWp, with the efficiency and therefore size depending on the technology used.

- Some scenarios are with limited battery back-up for use at the power plant, for local distribution, and/or for emergencies. Batteries are assumed to be replaced once every 4 years. Batteries with a longer life are available but are more expensive. Scenarios for rooftop and mini-grid systems are assumed to be designed with adequate battery back-up to enable energy time shifting (power generated during the day is consumed at night).
- Rooftop systems are grid connected.
- Technical feasibility of rooftop systems, including structural strength, availability of shadow-free-spaces, and floor space for battery banks was not assessed.

AI.B Grid-connected Power Plants on Mainland

The following data tables result from model runs as illustrated in Annex II. They show costs of solar PV systems for different capital cost assumptions (equity rates of return), including the cases with and without batteries for different system sizes:

System costs per kW = USD 1,766

Power Plant size (kW)	Capital Cost of plant (USD)	Battery Bank Provided (USD)	TARIFF in USD/kWh (for equity rates of return)	
			10%	15%
100	176,600	25,000	0.2474	0.2851
500	882,859	50,000	0.2047	0.2388
1,000	1,766,000	50,000	0.1907	0.2234
5,000	8,830,000	50,000	**0.1793**	**0.2111**

System costs per kW = USD 1,766 (no battery bank)

Power Plant size (kW)	Capital Cost of plant (USD)	TARIFF in USD/kWh (for equity rates of return)	
		10%	15%
100	176,600	0.1764	0.2080
500	882,859	0.1764	0.2080
1,000	1,766,000	0.1764	0.2080
5,000	8,830,000	**0.1764**	**0.2080**

Ground mounted power plants of 1MW capacity and larger would thus be attractive to investors under optimistic assumptions such as access equity at 10%, with a **FiT of USD 0.18 /kWh for the first ten years and USD 0.09 /kWh for the second decade**, which would need to be agreed in a Power Purchase Agreement with the owner/ investor. This differentiated tariff is suggested because it will reduce the risks perceived by investors, but it is similar to a **FiT of USD 0.15 /kWh for a 20-year period** (Annex II).

All those options are low by international comparison and at risk of not attracting sufficient interest of investors, but high when compared with the highest prevailing retail tariffs in Viet Nam: the buyer EVN would make a loss in the first years or even decade, until retail tariffs go up and/or as the lower rate kicks in. This is also high when compared to the proposed USD 0.112 /kWh FiT for solar PV power plants in Viet Nam. This rate as well as the above calculated rates all mean that EVN would make a loss. However, as power retail tariffs go up over the coming 20 years and the FiT for 20 years agreed in a contract might be lower during the last 10 years, there will also be a moment where EVN will make a profit on the rates agreed in a PPA (Power Purchase Agreement) for the 20-year period. In particular, if a power price roadmap over the coming years would indicate when retail tariffs will go up and by how much, then both EVN and investors have adequate information to calculate their potential profits and losses.

The capital investment cost of USD 1,766 /kWp was estimated for systems up to 1 MW and installation and commissioning costs will likely reduce with the size of the plant, so a somewhat lower FiT could attract investors in larger plants. However, the scenario is optimistic especially in terms of perceived risks and expected return on equity, as demonstrated in the tables. In addition, the above FiTs are unlikely to attract investors in solar PV in the northern regions of Viet Nam where irradiation (GHI) is significantly lower when compared to the south central and southern regions (see Figure 17).

If there are no batteries included in the systems instead of a limited battery backup capacity, the modelled FiTs for the smaller systems become lower, but there is hardly any difference for the larger systems. The same applies to an estimated price of (agricultural) land in Ninh Thuan and Binh Thuan, which could be as low as USD 10,000 / ha or roughly USD 50,000 for a solar power plant with installed capacity of 5,000 kW (=5 MW). This additional cost of land is the same as the estimated costs of a battery bank in the above tables and leads to the same conclusion regarding the FiT.

AI.C Grid-connected Power Plants on Islands

The following tables give potential FiTs for solar PV power plants on islands.

System costs per kW = USD 2,207 (= USD 1,766 + 25%)

Power Plant size (kW)	Capital Cost of plant (USD)	Battery Bank Provided (USD)	TARIFF in USD/kWh (for equity rates of return)	
			10%	15%
100	220,750	25,000	0.2915	0.3370
500	1,103,574	50,000	0.2487	0.2907
1,000	2,207,500	50,000	0.2346	0.2753
5,000	11,035,740	50,000	**0.2232**	**0.2630**

System costs per kW = USD 2,207 (= USD 1,766 + 25%) (no battery bank)

Power Plant size (kW)	Capital Cost of plant (USD)	TARIFF in USD/kWh (for equity rates of return)	
		10%	15%
100	220,750	0.2202	0.2599
500	1,103,574	0.2202	0.2599
1,000	2,207,500	0.2202	0.2599
5,000	11,035,740	**0.2202**	**0.2599**

Ground mounted power plants on islands will unlikely be larger than the 5MW modelled, and potential FiTs are given in the above tables. A system of 5 MW installed capacity would thus be attractive to investors under optimistic assumptions such as equity return rate of 10%, with a **FiT of USD 0.22 for the first 10 years and USD 0.11 for the second decade**, even if a small battery bank for local use would be included. This is low by international comparison, and it is attractive when compared with the costs of diesel generated power, which is common on islands: this FiT is attractive to the buyer EVN, especially when general retail tariffs go up, and as the lower rate that EVN would pay the investor kicks in. The differentiated tariff is suggested because it will significantly reduce the risks perceived by investors, but it is similar to a **FiT of USD 0.19 /kWh for the full 20-year period**.

The influence of a modest land price is similar to that of a small battery bank for local use, i.e. this has very limited impact on the recommended FiT for solar PV on islands.

AI.D Grid-connected Commercial Rooftop Systems

It is demonstrated in Figure 20 that total system costs for (larger scale) solar power plants is lower per kWp installed when compared to the average range of costs for rooftop solar PV. The basic estimate for capital costs used in sections AI.B and AI.C is however for a relatively small power plant of 1 MW, which could be a relative large commercial rooftop system – 1 MW requires roughly 10,000 m2 roof space (available in medium to large industrial / commercial enterprises, schools and hospitals, airport buildings, etc.). Internationally, the accepted maximum installed capacity of (commercial) rooftop solar PV systems varies widely, from a small 100 kWp to limitless (unregulated). There are some enterprises/ investors in Viet Nam considering systems that might be larger than 2 MW.

Internationally, most solar PV policies encourage rooftop PV with net-metering, which is sometimes combined with a FiT for the excess power that is exported to the grid. The aim is that most power that is produced on-site is also consumed on-site and net export over a billing period is rare (a zero rate for net export over a billing period has been applied in several cases). The policies generally expect companies (and households – see section AI.E) to remain net consumers of power from the grid.

The range of potential FiTs calculated in section AI.B and AI.C shows that with favourable access to capital (10% on equity), an investment in a 100 kWp system on the mainland with limited battery bank costs USD 0.25 / kWh and a system without battery bank USD 0.18 / kWh; a system of 1 MW with battery bank USD 0.19 / kWh and without battery bank USD 0.18 / kWh. For the purposes of FiT assessment the **USD 0.18 / kWh** without battery banks should be used (though batteries may be attractive for rooftop investors in addition to FiT). This tariff applies to the first ten-year period of an assumed solar farm and in the second decade the tariff would be half (USD 0.09 / kWh), which compares to an average tariff **of USD 0.15 for the 20-year investment lifetime** (see Annex II).

However, if a premium FiT (draft Solar PV Support Policy proposal is USD 0.14 / kWh) is accepted then there are incentives to export all power to the grid and consume none on-site, which would defeat part of the purpose of decentralised generation, put demands on the grid (T&D) and increase losses for EVN. If this would be regulated, a solar PV rooftop system might be treated as power plant with related regulations and the FiT for that purpose should be applied (proposal is USD 0.112 / kWh).

For assessing the feasibility of net-metering for enterprises in Viet Nam, the prevailing tariffs in Viet Nam for manufacturing industry and commercial users must be considered. The prevailing rates demonstrate that (private) investment in solar PV rooftop and net-metering would not be interesting to most enterprises because buying from the grid is cheaper. However, the current tariffs for commercial enterprises are already close to this point, and with modest increase of the average retail tariffs rooftop solar PV will become an interesting business proposition for them.

To stimulate rooftop solar PV in Viet Nam the following options might be considered:

- Combine net-metering with a FiT (of e.g. USD 0.15 kWh). This would require an upper size limit. To limit the liabilities for EVN, choose from:
    - Paying a FiT for <u>net export</u> of electricity (if that happens at all at the end of a billing period) (use bi-directional meters); or

    - Paying a FiT for the gross export of electricity (on-site generation is consumed; export when production is above consumption) (use dual meters, one for import and one for export, for each rate / Time of Day)
- Regulate net-metering without a premium FiT.
    - Regulate a roadmap for real electricity tariff increases over the coming few years
    - Raise awareness that retail tariffs in Viet Nam are unsustainably low and they will very likely go up over the next years – and then a solar PV system will pay itself.
    - Raise awareness of the high likelihood that solar PV systems produce after 20 years.
    - Raise awareness that rooftop systems could include (limited) battery storage capacities for limited additional costs, which can eliminate the need for (diesel, petrol) back-up generation capacity in areas at risk of blackouts which are costly for businesses.
- Subsidise the capital expenditure for solar PV systems of enterprises, for example panels and inverters; and consider tax measures to reduce capital investment costs (import tax). This makes net-metering attractive even in the case of a low retail tariff. Such subsidies could apply to several categories of businesses, especially "category 2" (hospitals and schools), which pay tariffs similar to the average retail tariff and manufacturing businesses (category 1 in Decision 2256/QĐ-BCT). They could also benefit from subsidies on battery banks.

AI.E Household Rooftop and Community Systems

Costs of household-size rooftop are given below, including battery banks, which are useful for grid-connected households that frequently suffer blackouts and require back-up generators, or households that are not grid connected. The systems of 10 kW and up could also apply to community systems in remote areas (grid connected or not), as could systems of 100 kWp (see sections AI.B and AI.C).

System costs per kW = USD 1,766

Power Plant size (kW)	Capital Cost of plant (USD)	Battery Bank Provided (USD)	TARIFF in USD/kWh (for equity rates of return)	
			10%	15%
1	1,766	500	0.319	**0.362**
2	3,532	1,000	0.319	0.362
5	8,830	2,000	0.290	0.331
10	17,660	4,000	0.290	0.331
20	35,320	6,000	**0.262**	0.300

With favourable access to capital (10% return on equity), and investment in a 1-20 kWp system on the mainland with limited battery bank would costs USD 0.32 to USD 0.26 / kWh. Without a battery bank the costs of systems of all sizes are estimated to cost **USD 0.18 / kWh**, which should also here be used for the purposes of FiT assessment in the case of grid connected systems (although batteries may also be attractive at residential and community scale for rooftop investors in grid connected systems). This FiT is assumed to apply to the first ten-year period of a solar PV system as in earlier cases and in the second decade the tariff would be half (USD 0.09 / kWh), which compares to an average tariff **of USD 0.15 / kWh for the 20-year investment lifetime** (see Annex III). As in the case of solar power plants and commercial rooftop systems, the assumptions include a favourable cost of capital (10%).

Further discussion on the usefulness and feasibility of net-metering and the wisdom of a FiT of USD 0.15 / kWh is also parallel to the discussions on commercial rooftop solar PV systems in section AI.D.

However, an important difference is that some household solar PV systems and especially remote area community systems may be at least initially off-grid and perhaps will be connected later as the grid penetrates to the last communities in remote areas; and where such communities have already been connected the supply is often erratic and partial. The investment would then need to be compared with conventional grid expansion and upgrading, which is expensive per community and household in remote and thinly populated areas. This then justify subsidies on small scale solar PV systems for households (up to 3 kW in Andhra Pradesh – see **Error! Reference source not found.**) and communities. Subsidies could include part of the cost of panels, or of inverters, which is a major part of the systems (see Annex I).

ANNEX II Example outputs of LCoE/FiT model Calculation

This Annex gives an example of spreadsheet-model calculations of LCoEs / FiTs for solar PV.

The following calculations demonstrate that a FiT of USD 0.15 / kWh is possible under a number of optimistic assumptions, including capital investment costs of USD 1,766 per installed kWp, equity rate of return of 10%, and no cost of land. The calculated tariff of USD 0.15 / kWh is assumed constant over the 20-year lifetime of the investment.

PARAMETER	UNIT	QUANTITY	REMARKS
Power generated	kWh / day / kW	4.5	Each day for 365 days over 20 years
Storage - discharge and network losses	kWh / day / kW	0.5	Each day for 365 days over 20 years
Net Power sold to utility	kWh / day / kW	4.0	Metered at plant
PPA Tariff applicable for 10 years	%	100%	
PPA Tariff applicable for years 10 to 20	%	100%	In proportion to tariffs for years 1 - 10; enter 100% to compute constant tariff for 20 years
Operating expenses (assumed)	% of revenues	5%	Each year
Corporate Income Tax rate	%	25%	Of Pre-tax profits
Life of plant	year	20.0	for depreciation and return computation
Battery cost / installed kW	USD	0	First lot funded by equity / Replaced once each 4-year period from project cash flows
Average Cost per kWp	USD	1766	
Sponsor Equity	USD 529.80	30%	
Project Debt	USD 1,236.20	70%	
Total Finance	USD 1,766.00	100%	
Principal repayment	year	10	Equated annual instalments
Interest on ($) debt (annual)	% per annum	7%	
Equity IRR		**9.95%**	Use Data/What-If Analysis/Goal Seek to set IRR to 10%, 12% etc. by changing value of PPA tariff in cell E24 below
PPA Tariff	$ / kWh	**0.15000**	Change this to see different IRRs at different tariffs

Debt amortization schedule

(All amounts in USD)

	1	2	3	4	5	6	7	8	9	10
Principal o/s at beginning of year	1236.20	1112.58	988.96	865.34	741.72	618.10	494.48	370.86	247.24	123.62
Principal repaid during year	123.62	123.62	123.62	123.62	123.62	123.62	123.62	123.62	123.62	123.62
Principal o/s at end of year	1112.58	988.96	865.34	741.72	618.10	494.48	370.86	247.24	123.62	0.00
Average principal o/s during year	1174.39	1050.77	927.15	803.53	679.91	556.29	432.67	309.05	185.43	61.81
Interest charge	82.21	73.55	64.90	56.25	47.59	38.94	30.29	21.63	12.98	4.33

Profit & Loss Account

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Annual power generation	kWh	1642.50	1642.50	1642.50	1642.50	1642.50	1642.50	1642.50	1642.50	1642.50	1642.50	821.25	821.25	821.25	821.25	821.25	821.25	821.25	821.25	821.25	821.25
Annual power sales (grid-connected)	kWh	1460.00	1460.00	1460.00	1460.00	1460.00	1460.00	1460.00	1460.00	1460.00	1460.00	730.00	730.00	730.00	730.00	730.00	730.00	730.00	730.00	730.00	730.00
Revenue from sale of power	USD																				
Operating Expenses	5%																				
Interest Expense		219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00	219.00
Depreciation (Battery)		10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95	10.95
Depreciation		82.21	73.55	64.90	56.25	47.59	38.94	30.29	21.63	12.98	4.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Earnings Before Tax		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Tax	25%	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30
Earnings After Tax		37.54	46.20	54.85	63.50	72.16	80.81	89.46	98.12	106.77	115.42	119.75	119.75	119.75	119.75	119.75	119.75	119.75	119.75	119.75	119.75

Cash flow Statement

	Year	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Add back depreciation		88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30	88.30
Add back depreciation (Battery)		0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Deduct principal repayment		-123.62	-123.62	-123.62	-123.62	-123.62	-123.62	-123.62	-123.62	-123.62	-123.62	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Battery Replacement / Other renewal	0	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Equity Outflow	-529.8	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Net Cash flow at year-end	-529.8	-7.16	-0.67	5.82	12.31	18.80	25.29	31.78	38.27	44.76	51.25	178.11	178.11	178.11	178.11	178.11	178.11	178.11	178.11	178.11	178.11
Cumulative cash flows		-7.16	-7.84	-2.02	10.29	29.09	54.37	86.15	124.42	169.18	220.42	398.54	576.65	754.76	932.87	1110.99	1289.10	1467.21	1645.32	1823.44	2001.55
Payback	-529.8	-536.96	-537.64	-531.82	-519.51	-500.71	-475.43	-443.65	-405.38	-360.62	-309.38										

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