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The Challenges and Opportunities for the Power Transmission Grid of Vietnam

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ABSTRACT

As a rapidly developing country, Vietnam will witness a substantial growth in electricity demand in the coming decades. The surging demand will exert a huge pressure on the power transmission grid in the country. Therefore, this paper fully examines the challenges and opportunities for the power transmission grid of Vietnam. Firstly, the historical evolution and the prospected changes were reviewed, in terms of the energy demand, the production capacity, and the split in energy sources. Next, the current constraints on the power transmission grid were identified, which are related to the history and geography of Vietnam. On this basis, the authors expected that coal-fired energy production will increase in the short term, due to the rising energy demand and the limited new hydropower resources. Finally, several suggestions were put forward to improve the power transmission grid in Vietnam, namely, developing renewable energy sources, upgrading HVAC to HVDC lines, introducing MVDC links if conditions permit. The research provides a reference for the future development of the energy sector in Vietnam.

1. INTRODUCTION

HVDC technologies will certainly represent a growing part of energy transmission systems owing to the new sources of energy introduced, especially renewable energy, and to the need for strengthening energy networks with the de-carbonation of the energy. To cite an example of such an evolution, in prospects proposed by Cigre working group C1.35 on global energy network, 99% of the lines would be HVDC, either submarine between continents or overhead on the land [1]. China is also developing extra high voltage corridors to transmit energy from the west of the country where most of the hydropower is concentrated to the consumption area of megapoles of the east of the country with some innovative challenges of hybrid LCC and VSC technologies in the same 'branched' network [2].

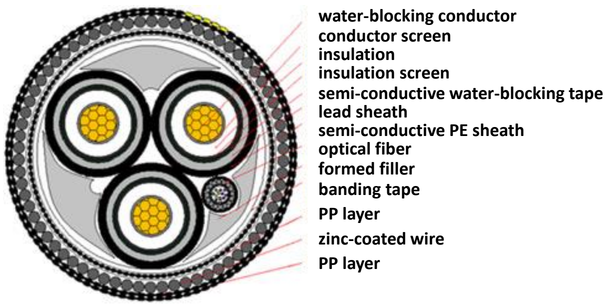
This massive introduction of DC links is a reality today for example in Europe with the France-Spain 320kV line made with extruded insulation cables in operation since 2015 [3], the construction of the Savoy-Piemont 320kV line [4], the building of offshore windfarms connected to the shore with DC links [5, 6], and the decision to build HVDC corridors through Germany fully made with buried cables [7]. All these examples are with HVDC cables. The switch from HVAC to HVDC systems has this great advantage that there is virtually no limit on transmission length, even for cable technology owing to the fact that the compensation of the capacitive current is no longer a necessity. Besides, for off-shore cables, at equivalent capacity, DC cables technology constitutes a great simplification in manufacture, reducing the cable from a 3-core for HVAC to a single core (Figure 1), and also reducing the weight and facilitating transport and laying of the cables [8]. In this example for a 200 MW transmission, the diameter is reduced by 40% and the weight by 60%. Today, it seems that the main limitation to the development of cable links is the cost itself vs. overhead solutions.

So, in developing countries, overhead lines will certainly be preferred for a while but when technologies will be mature no doubt that cable technologies will spread.

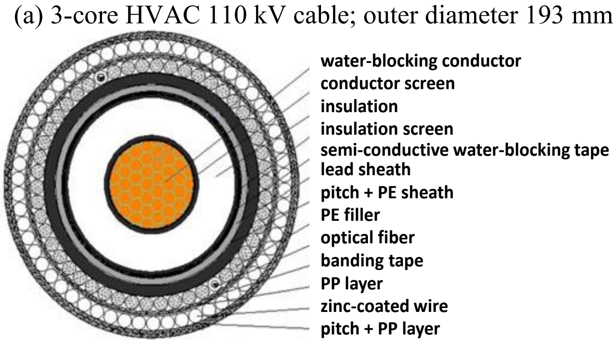
However, still with DC cables, some issues remain. The progressive switch from oil-filled insulation to extruded insulation that has been operated over the last 40 years for HVAC cables is much more recent for HVDC. Insulations involving pressurized oil tend to be avoided for environmental and maintenance reasons. The behavior of extruded cables under DC stress, regarding space charge build-up and field redistribution, particularly at polarity reversal stages as used in converter technologies using IGBT, is not fully under control [9]. For these reasons, materials improvement, characterization and modelling are still intensively researched, both for cables and accessories and in general for the power conversion equipment.

The paper is a summary report of a workshop [10] organized in Hanoi in Sept 2018 on green energy and networks. The objective was to present opportunities and challenges with HVDC cable links and to put it in relation to the current situation of the energy network in Vietnam and to the evolution forecasted for the energy generation and management in the country and at its borders. It was also a milestone of a joint project in which a relevant case study of energy transmission link that could be turned to HVDC. We report herein mainly on the current evolution of the

Vietnamese electricity network and we discuss the way DC energy transmission could be incorporated in such context.



(a) 3-core HVAC 110 kV cable; outer diameter 193 mm



(b) +/- 160 kV HVDC cable; outer diameter 111 mm

Figure 1. Examples of structures of HV submarine cables rated for 200 MW. Weight reduced by over 60% [8]

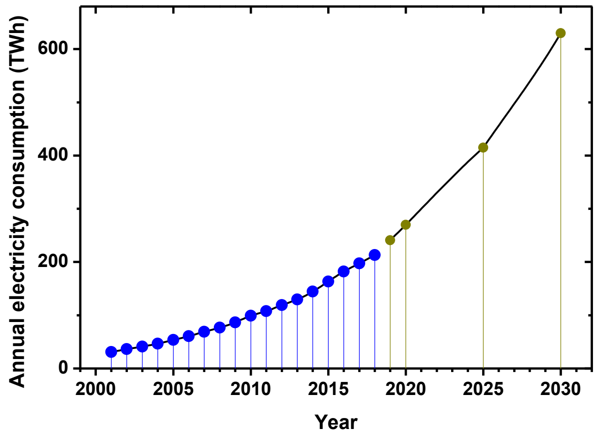
2. FACTS AND FIGURES FOR THE ENERGY SOURCES AND DEMAND IN VIETNAM

Vietnam has a relatively late development of electricity system compared to other countries in the world due to the historical impact of the wars. The power system only really developed when the 500 kV lines are put into use, along with the strong opening of the economy. This late development is illustrated in Figure 2 that represents the evolution in terms of power consumption and in peak power over the last 17 years [11, 12]. The peak power is a particularly critical quantity for sizing the electrical network planning and investment [13, 14]. The growth rate is of the order 10-15%/year over the last 15 years.

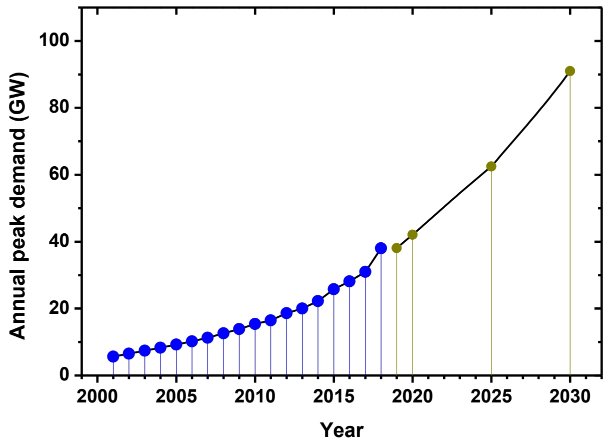
2.1 Fast growing demand

According to the last figures available, for 2018, the total electricity production and importation of Vietnam was 212.9 TWh, increasing by 10% compared to 2017 [12], making Vietnam ranked at 2nd among ASEAN countries and 23rd in the world. The peak demand of the system shares the same growing rate, being of 35 GW in 2018 and increasing by 14% compared to 2017 (Figure 2b). According to the forecast (Figure 2a), the growth rate should remain at ~ 11% per year up to 2020, decreasing to 8.5 ~ 9% per year for the period of 2021 – 2030. The peak demand would be nearly 100 GW in 2030, meaning that the system will require over 3 GW/year of new generators to satisfy the demand.

The fast increase in demand is due to the current trend of using a wide range of technological equipment, especially electrical appliances and devices such as air conditioners in all households. In addition, there is a strong increase of industry investment and a gradual shift from heat engine vehicles to electrical ones. Therefore, the peak load growth rate may continue to stay high, even increase in the future. The fast increase in the demand poses challenges for adapting the electrical network and a lot of difficulties to secure the supply, especially with the reduction of domestic fuel sources supply like coal and natural gas.



(a) Annual electricity consumption



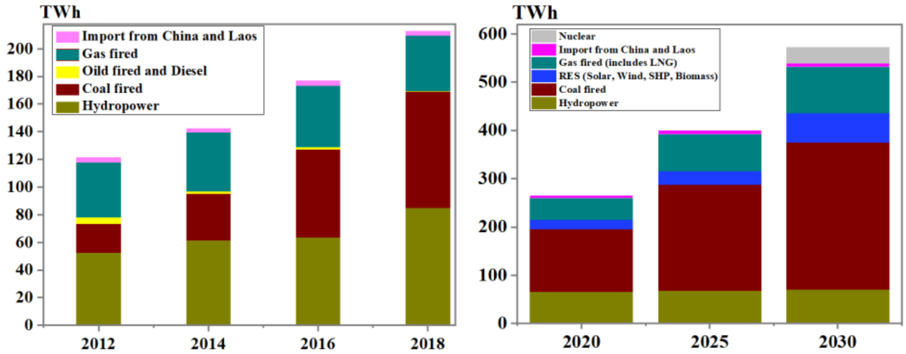
(b) Annual peak demand

Figure 2. Evolution of the annual electricity needs over the period 2001-2018 (in blue) and forecasted figures (in green) according to PDP7

2.2 The split in energy sources

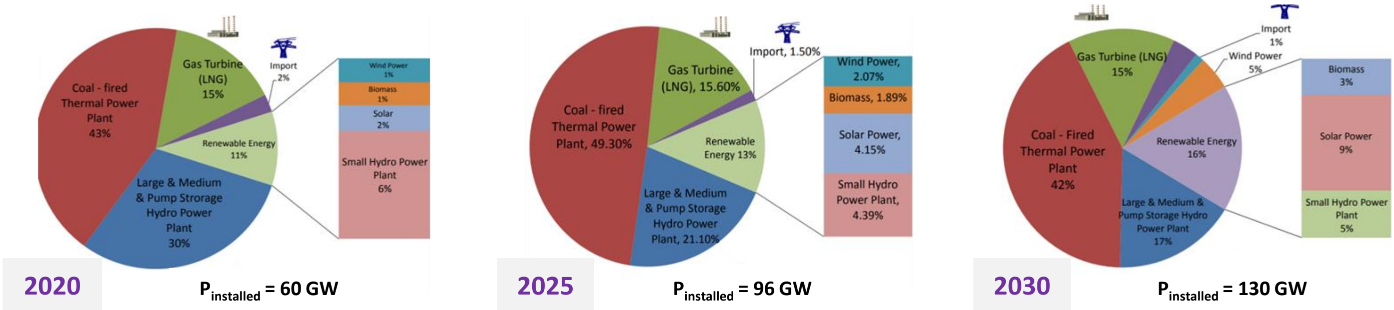
According to the recent EVN annual report [12], EVN – state owner corporation, contributed by the end of 2018 up to 58% of the national power generation system, including large-scale hydropower, coal-fired, gas-fired power plants with a total installed capacity of 28.2 GW out of a total of 48.6 GW for the country. The largest capacity was from hydropower (40%) before coal-fired thermal power (38%) in 2018. In recent years there has been significant development in coal fired power plants (from about 23% in 2013 to 38% now of total installed capacity, mostly located in the North and central regions of Vietnam) as well as gas-fired plants in the South (which account for approximately 18% of total installed capacity).

Hydropower and coal-fired thermal power had equivalent contributions at 40% in 2018 (Figure 3). The production of electricity has increased by 75% between 2012 and 2018 (Figure 3a). In recent years, the increase in production was covered principally by the increase in capacity of coal fired power plants.

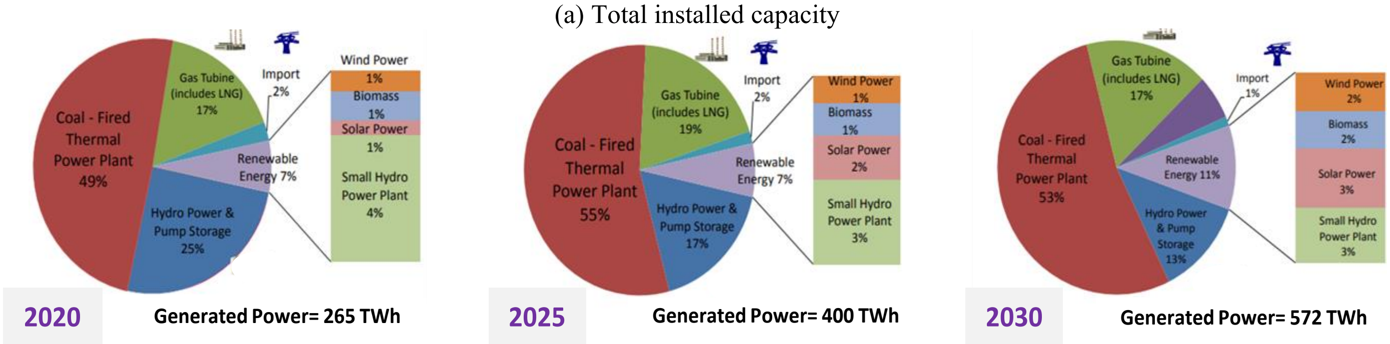


(a) during the period 2012-2018 (b) planed production according to PDP7

Figure 3. Power generation output portfolio



(a) Total installed capacity



(b) Total energy production

Figure 4. The forecasted structure of targeted power sources for 2020-2030 [10, 15]

Figure 4 compares the forecasted distribution of power sources according to the revised Power Development Master Plan VII (PDP7) for the period 2020 to 2030 [15]. For an understanding of the roles played by the different stakeholders in the definition of the plan, please consider a recent paper addressing current institutional framework and energy market structure of the country [16]. From 2020 to 2030, the total installed capacity for Vietnam would be increased from 60 GW up to 129.5 GW and the production from 265 TWh up to 572 TWh. Coal-fired thermal power is projected to be the main source by far for electricity production. The capacity of hydropower does not evolve substantially during the period. Other renewable energies are showing an upward trend. The specificities for these 3 different energy sources are detailed below.

2.3 Contribution from hydroelectricity

With sloping areas of relief and many rivers, a tropical climate with high annual rainfall, a long-lasting rainy season (from June to December), Vietnam has a huge hydropower potential. With a total current capacity of 19.7 GW, hydro power accounts nearly for a half (42%) of the total installed capacity of the country. Hydro-power plants represent a major and indispensable part of the system. They are spread throughout the country, but are still concentrated in the Northern and the Central Highlands. Some big hydro-power plants like Son La (2400 MW), Hoa Binh (1920 MW), Lai Chau (1200 MW), Ialy (720 MW) play as strategic and multi-purpose hydro power plants: They act at supplying the water and reducing floods, as river transportation means, and for the power grid ensure frequency regulation and voltage stabilization of the entire system and contribute to a large amount of electricity production.

Hydropower plants have a great advantage in operation compared to other generation technologies, such as low operating costs, simple operation with low probability of failure, the ability to increase or decrease capacity in a short time, the ability to produce or receive reactive power. Hydroelectricity is thus utilized in the system for frequency control, provision for spinning and fast start reserve, hence for grid voltage regulation.

However, its operation depends a lot on natural conditions, especially on hydrological conditions and is always a very complex task. Optimizing the operation of the reservoirs to avoid spilling in flood season and depletion of water, ensuring capacity in dry season is always a problem for system operator as well as power plants. Moreover, as the characteristics of agriculture rely heavily on irrigation which is supplied from rivers, hydropower plants in Vietnam, in addition to electricity generation, also take a responsibility for providing water for agriculture. For this purpose, Vietnam government has issued many regulations to tightly monitor the operation of hydropower plants, stipulating the water level of the reservoir from time to time during the year, leading to more complicated and more constrained operation.

By encouraging the involvement of private investors in the electricity sector, reducing the pressure on state investment and leveraging on energy from the rivers, the government has adopted "an avoidable cost" policy. Many small hydropower plants (with power under 30 MW) have been built and operated, with a total capacity of around 4 GW. In the past few years, with concerns about the effects of hydropower on the environment as well as the dependence of the electricity sector on natural conditions, the planning and construction of new hydropower plants has been undertaken by the government, tightening the construction standards, introducing strictly operating regulations. Thus, from nearly 50% of the capacity of the system in 2012, hydropower now is only about 40%.

2.4 Dependence on coal

With the recent controlling and tightening hydropower development policies, hydropower development will not be as high as it is now. In addition, with the decline in supply of natural gas as well as delayed in the construction of gas turbine power plants, the power supply of the system will mainly rely on coal alone. This is all the more the case as the demand growth rate stays high and other energy sources are limited: the potential for hydropower has been fully exploited, the availability of natural gas supply declines, nuclear power projects have been abandoned and renewable energy demands high initial investment and offer low stability.

Currently, coal-fired power plants constitute the main development strategy with lower investment cost and shorter construction time compared to the same capacity for hydro-power. From 15% of the system in 2010, there are now 18.5 GW of installed capacity, accounting for nearly 40% of the total capacity of the whole system, using 36 Mtons of coal per year. According to PDP7, Vietnam will have 26 GW of coal-fired power in 2020 and 48 GW in 2025.

Years ago, because of the proximity of coal mines, coal-fired power plants were only located in the North-East and their capacity was still small (50 – 100 MW/unit). Nowadays, most of new constructed coal-fired power plants are located in Southern area, where the demand in electricity is high. They have larger unit capacity (~ 600 MW/unit), like in the thermal power complexes of Vinh Tan or Duyen Hai. Unlike old coal-fired power plants which use domestic coal in the north, existing and future plants in Southern Vietnam will use imported coal, often from Australia or Indonesia. By 2030, Vietnam will need to import about 85 Mtons of coal a year to supply for thermal power plants.

The environmental impact is also a major problem: many power plants have been built since the 1980s, using old technology, releasing large quantities of COx and NOx. Within PDP7, the government has clarified measures to minimize the impact of environmental pollution, which requires the use of ash wastes for the production of building materials and other industries to reduce the area of waste disposal sites, ensuring compliance with regulations. At the same time, to encourage the use of modern technological lines to reduce environmental pollution, care has to be taken to fully carry out the work of monitoring, measurement and management of environmental impact.

2.5 Renewable other than hydropower

Compared with other countries, renewable energy in Vietnam is developing relatively late. European countries have begun to shift from fossil fuels to renewable energy in the early years of the 21st century, with as target to reach 20% in gross final consumption of energy from renewable sources by 2020 and at least 27% by 2030. In Europe wind production became the first renewable source in 2017 [17], before hydropower, and far ahead solar. For 2018, 14% of the energy was produced by wind [18], and nearly 50% of new capacity installed was for wind, with a growing part from offshore production. In Asia, China is a very successful country in the development of renewable energy. With the advantage of low production cost for solar panels, large area of land, renewable energy now accounts for a quarter of the total annual electricity production.

Located in the tropical area, close to the equator with hot climate and long sunshine duration (~3000 h/year), a 3400 km long coastal line with an average wind speed of 6 m/s, Vietnam has enormous potential for renewable energy, especially with solar and wind. But for now, solar power and wind power are still relatively modest in Vietnam: with only about 300 MW of wind and 150MW of solar, it accounts for less than 1% of the all electrical power production. To promote the development of renewable energy while declining traditional energy sources, the government decided a new policy in September 2018 with guaranteed purchase prices to attract investors. The goal is that by 2020, renewable energy will account for 10% of the total electricity production, 16 TWh of wind and 36 TWh of solar energy in 2030.

Vietnam's Wind energy potential is considerably high in comparison to Thailand, Laos or Cambodia [19]. According to a report by the GIZ Vietnam [20], the potential of wind power is about 27 GW. Presently, the capacity in operation is about 300 MW of wind power plants [21]. According to PDP7, the total capacity of installed wind power is expected to reach 800 MW in 2020, 2 GW in 2025 and 6 GW in 2030, which account for 0.8% of the share of produced electricity in 2020, 1% in 2025 and 2.1% in 2030.

Vietnam has also a high potential in solar energy, particularly in its central and southern regions [22]. The solar energy density is lower in the North due to the annual winter-spring cloudy and drizzle sky. A theoretical potential was estimated to about 2 – 5 GW for residential and commercial rooftops, and 20 GW for solar photovoltaic (PV) plants. However, the deployment of solar power is still modest, as well as studies related to grid-connected PV systems are still limited to the demonstration phases. An ambitious development of solar is proposed in PDP 7: the capacity of solar Photovoltaic shall increase from around 84 MW at end 2018 [21] to 850 MW by 2020 and to 12 GW by 2030.

With the support policies, the number of renewable energy projects has increased sharply in the past two years. At present, 110 renewable energy projects with as total capacity 7.5 GW of solar and 2 GW of wind power were approved. However, besides many advantages that are zero operating costs, low emissions and support from the government, renewable energy also has many disadvantages. As wind and solar energy production are indeterminate and difficult to predict, the system needs to have a corresponding power supply in case of renewable energy production affected by the weather. In addition, the increase of renewable energy in the system will have impacts on grid operational characteristics such as grid congestion, power quality, redundancy, system stability and system reliability. Already, some researches also address the impact of transmitted energy fluctuation due to introduction of renewable energy on the lifetime of insulated systems [23]. Therefore, to manage the increase in global energy demand and exploit safely renewable sources, the electrical network has to evolve. We present below the current network structure and the needs for strengthening it.

3. CURRENT ENERGY GRID AND EVOLUTIONS

3.1 The structure of the network

Vietnam electricity grid system, affected by history and natural topography, is divided into separate regions: North, Central and South, which had initially their own standards and technologies. Over time, with the unification of the country and the economic development, especially in the Southern region, it was necessary to unify the entire grid into a unified standard, to connect separate regional electrical systems, so as to transmit a large amount of capacity from the North to the South. The first 500 kV line with 1500 km was put into operation in 1994 after more than 2 years of construction. It integrates the 3 regional systems (previously operated independently), thereby enhancing the coordination, increasing the stability and the general reliability of the whole system. Since then, after 25 years of operation and expansion, the system has over 7500 km of 500 kV and nearly 40.000 km of 110 and 220 kV lines (Figure 5). It actually contributes for an essential part in the economic development of Vietnam.

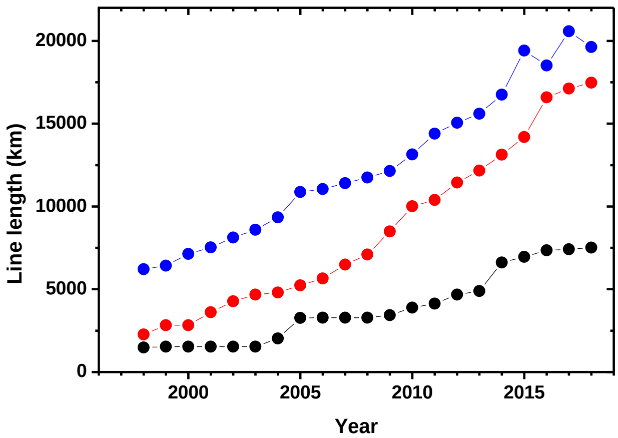


Figure 5. Evolution of grid transmission line length from 1998 to 2018

Being not only an internal grid, the system also connects with neighboring networks to import and export electricity, see Figure 6 [24] and Table 1. Since 2005, to minimize the risk of power shortage in peak periods (usually in the dry season), Vietnam has begun to connect and import electricity from China Southern Grid. The annual purchase volume is about 1.5 TWh through two 220 kV lines with 800 MW peak. The connection to Laos is to take advantage of abundant hydropower resources. In the Southern Vietnam, a 220 kV transmission line with 200 MW peak connects to Cambodia's grid since 2000, for exporting about 1 TWh/year to Cambodia.

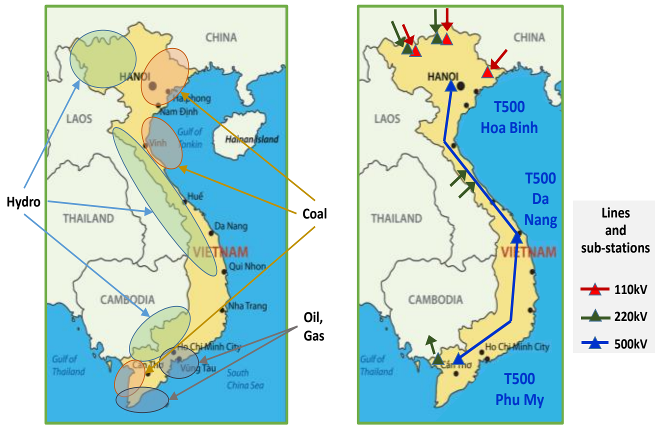


Figure 6. The broad distribution of energy sources (left) and network structure (right) [24]

Table 1. Capability and annual volume of import and export transmission lines

Nation	Line	Capacity (MW)	Annual volume (MWh)
China	Malutang – Ha Giang Xinqiao – Lao Cai	450 350	750 ~ 800 700 ~ 750
Laos	Xekaman 1 – Thanh My Xekaman 3 – Thanh My	290 250	900 ~ 1100 900 ~ 1200
Cambodia	Takeo – Chau Doc	200	700 ~ 800

With the rapid development of the demand, the transmission system is heavily solicited for balancing the capacity of the system. The demand is not homogeneously distributed over the country. The North (with region of Hanoi) and the South (with Ho Chi Minh City) absorb about 45% of the power each while the Central part acts mainly as a transmission corridor and production site. The total transmitted energy between regions in 2017 is 33 TWh. In particular, transmission lines between North and Central part of Vietnam are always in high load status, especially in flood season. In the near future, with the slowly construction progress of new power plants in the South and limitations of primary energy sources, the shortage of power supply in the Southern region will continue and transmission system will still assume a large capacity transmission from the North and Central to the South. So, the transmission congestion will still be a problem to be solved for Vietnam's system in the near future. The reinforcement of the 220 kV/500 kV AC grid is very significant with 25 projects of sub-stations extension and lines build-up by 2025. This includes notably the third 500 kV line which is under construction.

The congestion is also seen on the regional grid due to a large concentration of residents in cities. The local transmission network connecting from the substations, to the power plants and to the cities is often heavily loaded, especially in the two biggest cities that are Hanoi and Ho Chi Minh City. In addition, the natural topography divides the Northern region in two areas: east side where most of the largest hydropower plants are located, and west where a number of coal-fired thermal power plants are installed. With that configuration, the transmission lines linking these two areas often carry high loads.

3.2 The impact of renewable energy

Along with above issues, the strong increase of renewable energy in the system has also brought many challenges. Technically, wind or large solar power plants are often installed in areas far away from the load so the transmission line is heavy and expensive. This power source is unstable and fluctuates in very large capacity in the short term and needs backup resources such as hydropower or electrical storage devices. Besides, Vietnam has little operational experience integrating the wind and solar power. For renewable energy integration, Vietnam should address important issues that are network infrastructure development, incorporation of energy storage systems and precise and agile management of the system through grid automation.

The grid system, that presently receives 300 MW from solar power plants, could face an increase of the installed capacity to over 4 GW in 2019 from plants concentrated mainly in the Southern and Central regions, where the transmission grid system (110 and 220 kV) has not been developed to meet such a large capacity. According to EVN report [11], the current grid can only absorb for 2 GW of renewable energy. Therefore a large part of the capacity would be curtailed and the situation could be worse in the coming years.

In addition to investing in the upgrade and building of new transmission lines to release all the power from renewable power plants which licensed for construction, EVN expects to build and put into operation new energy storage systems, apply a smart grid to control and optimize the system.

The massive incorporation of renewable energy has to go with a strong transmission and distribution grid with strong interconnections to neighboring power markets. Denmark for example has the majority of its power from wind, but this goes with interconnectors to Norway and Sweden making it possible to balance wind power and hydro power [25]. To the North of Vietnam, the energy exchange with China could be strengthened by building a 500 kV line (Honghe – Soc Son project with 400 km transmission line) [26].

Besides the development of production and transmission infrastructures, energy storage constitutes one strategy for smoothing the needs in maximum power, optimizing the inputs from renewable and smoothing the transmission congestion, as depicted in Figure 7 [27]. Because of its strong infrastructure in hydropower, hydraulic energy storage could be a solution for Vietnam. The other solution to storage could be with using batteries: from the fleet of electrical vehicles on the one hand, and with dedicated ESS – Electrical storage systems. Although there is a huge potential for development and the market seems to be booming, yet ESS are still in its early stages, so the investment to own and operate the system is still relatively high. This will require improvements in performances as well as a reduction in initial investment costs so that ESS can be easily accessible to the majority of users. Besides, up to now the presence of a large and easily regulated source through hydropower and the possibility of developing it from Laos did not justify the investment in hydroelectric storage infrastructures [28].

Finally, to meet challenges in strengthening the national transmission network, the disruptions of wind and solar energy can be addressed by upgrading the power transmission system with integrated power technology and by modern digital technology.

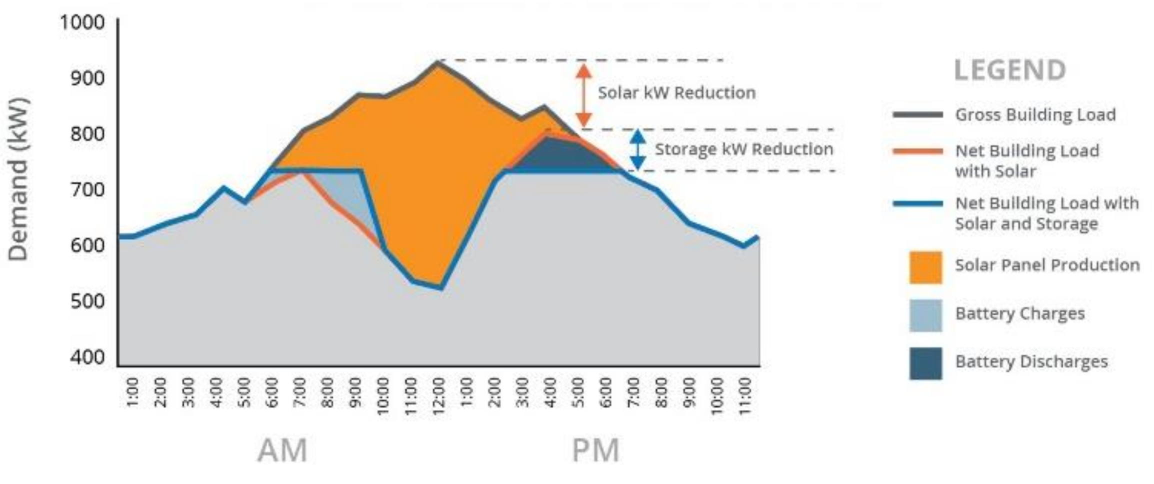


Figure 7. Daily peak-smoothing in power by associating renewable energy and storage [27]

3.3 Master plan and uncertainties

As for many other countries, with today's rapid evolution in this field, the future of electricity network will substantially depend on evolutions in the demand, on the national and internal policies and on the technical and economical progresses in power engineering.

The incorporation of electrical vehicles will have a strong impact on the network but the speed of market penetration is difficult to anticipate. The impact is not only on the consumed power; it can also contribute to the general equilibrium of the network with providing a storage capacity. More generally the energy used in transport is complex in Vietnam [25] even though there is objectively more penetration of electrical propulsion to come. Besides cars, the marked of motorbikes (representing presently one of the main transport means in Vietnam) is developing fast [29]. High speed train projects have been postponed several times. Despite competition from budget airlines and the unpopularity of rail travel, developing a modern high speed railway system between Hanoi and Ho Chi Minh City may just be more a matter of pride for Vietnam.

The choice of compensating the demand by massive incorporation of coal exposes to two uncertainties of international nature. First, although more efficient technologies are coming, it is not in favor of the compliance to the national committed target at COP21 about CO_2 emission reduction and it can be affected by carbon tax policies. Second, it brings some dependence to other countries for primary energy as the coal will be imported e.g. from Australia or Indonesia. By 2030 and beyond, with the increase of price of fossil energy and progress for cheaper renewable, it can be anticipated that new orientation in favor of renewable energies will emerge.

3.4 Potentialities for HVDC and cable energy transmission

As stated previously, the massive introduction of renewable energy requires strong inter-regional cooperation. In this perspective, power lines at the boarder should be viewed no more as a one-way transmission of energy from source to charge but as an exchange with energy flux that can be reversed on a daily basis.

The fast increase in demand of electrical energy poses a challenge to the supply capacity. Interconnection links with foreign countries to import energy are considered as a solution. The 220 kV HVAC Malutang (China) – Ha Giang – Thai Nguyen transmission line was thus built and put into operation in 2007. The capacity of this line could be increased in the future with either switching to DC or realizing higher voltage line. However, for the massive exchange in electricity in the future, HVDC links tend to be preferred. Examples of increase in the power flow of existing overhead 380 kV AC lines are available notably in Germany [30]. In a previous study in 2011, Nguyen-Mau et al. [26] analyzed some of the weaknesses of the power grid such as the interconnection with Chinese and Laos power systems, the power swing protection (especially at Hatinh – Danang 500 kV transmission line in the central part of Vietnam), or over-voltages occurring when tripping heavily loaded lines. HVDC technologies could be a solution to those features. It was shown by simulation that, due to the capability of fast and independent active and reactive power control, VSC HVDC can greatly improve the stability of a power network. According to Lerch et al [31], strengthening the power transmission system by a separate 500 kV transmission system or HVDC connection between North and South can avoid the system separation at single faults. An alternative is to distribute more power generation across the country. In a report from World Bank technically realized by CESI it was considered that developing a long 500 kV HVDC line (700-800 km) would constitute a viable solution and a pillar for the Smart Grid initiative in the power network of Vietnam [32].

DC energy transmission has application also in the Medium Voltage domain (MVDC). Beyond renewable energy transmission, several applications are targeted ranging as DC microgrids, electric ships, data centers powering, etc. [33]. The expansion of wind power and solar energy systems has huge consequences for the transmission and distribution of electricity making it more complicated and decentralized, with risks for power quality and grid stability. Solutions are provided in the 30-150 kV range [34, 35] that are suited for instance, to connect wind turbines installed on offshore islands or medium-sized solar plants to the AC grid and sensitive, weak distribution networks can be stabilized. Offshore windfarms are an obvious case where cable connections are necessary and it is considered that DC solutions may become competitive beyond 80 km of transmission from the farm to the shore. The world's first HVDC link to connect an offshore wind farm with an AC grid is the BorWin1 project that connects the Bard Offshore 1 wind farm in the North Sea to Germany's mainland AC grid. The 80 wind turbines feed their power into a 36 kV AC cable system. This voltage is transformed to 155 kV AC and then converted into ±150 kV DC to feed two 125 km sea cables, which continue into two 75 km land cables, transmitting 400 MW power to the land. However, the trade-off between HVAC and HVDC solutions is still complex to determine, as besides losses, questions of reliability and architecture of the offshore grid come into the balance [36, 37]. While there is a project for backing HVDC for the Norfolk Vanguard windfarm (UK, 1.8 GW), the longest cable connection in the world for an offshore windfarm has just been installed: the 200 km-long cable is powered under 220 kV HVAC [38].

Back to the case of Vietnam, building offshore windfarms seems out of scope at the moment. There are however several PV plants projects of medium size capacity, such as Hong Phong 1A-B at Binh Thuan (250 MWp), BIM 2 at Ninh Thuan (250 MW) provinces, etc. that are planned to be built connected to the 110 kV transmission lines.

The above analysis shows that DC energy transmission is a possibility for improving the quality of the grid in Vietnam, especially at a time where a strong strengthening and stabilization of the network is necessary. As to HVDC cables the investment it represents is certainly still an issue for today. The first step will be to integrate more power electronics and upgrading existing overhead HVAC lines for HVDC. The MVDC links are still in the infancy, and have not yet really penetrated the market. Perhaps in the far future, offshore windfarms with effective resources of the country along the very long coast could benefit from these technologies.

4. CONCLUSION

As a rapidly developing country and with the changes in the primary source of energy, the electrical grid of Vietnam will necessarily evolve and strengthen in the next decades with a demand in energy estimated to twice as today in a twelve-year time.

The short term energy provision is thought with development of fired coal-based electricity with advantages of agility, localization of the production on demand and low investment cost. In parallel, an ambitious development of renewable energy is planned, and it can be forecasted an amplification effect once technology are well implanted, provided the grid can be conveniently managed. HVDC energy links will certainly be integrated on a middle term basis, as a way to stabilize the network. The last pillar of the grid will be the implantation of ESS, in which hydraulic or battery solutions will probably contribute. Though identification of best suited application of HVDC cable links is probably a bit early, a case as the 220 kV HVAC Malutang (China) – Ha Giang – Thai Nguyen transmission line will be considered as case study for equipment modeling.

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NOMENCLATURE

ESS	Electrical Storage System
HVAC	High Voltage Alternative Current
HVDC	High Voltage Direct Current
LCC	Line-Commutated Converter
VSC	Voltage-Source Converter
ASEAN	Association of Southeast Asian Nations with 10 members of states
CESI	Centro Elettrotecnico Sperimentale Italiano: company of energy sector
COP21	Paris summit on climate (2015) leading to agreement on greenhouse-gas-emissions mitigation
EVN	Electricity of Viet Nam: national electricity company
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH: development agency
PDP7	Power Development Plan from the Vietnamese government