MINISTRY OF INDUSTRY AND TRADE
INSTITUTE OF ENERGY

SOLUTIONS TO IMPROVE THE INTEGRALABILITY OF RENEWABLE ENERGY SOURCES INTO VIETNAM'S POWER SYSTEM

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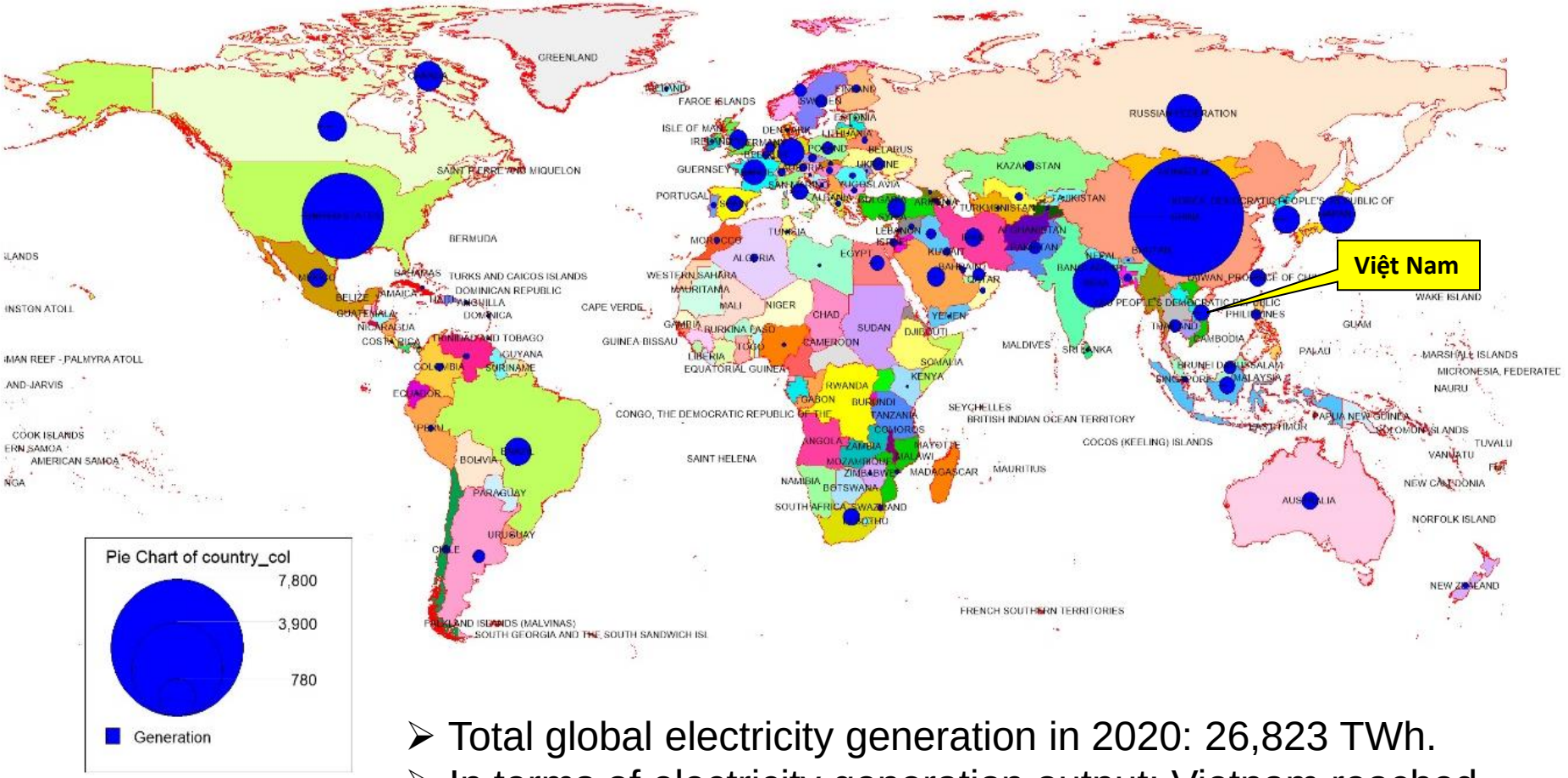
Outline

1. The need to increase the proportion of renewable energy sources in Vietnam's generation mix
2. Solutions to increase renewable energy from planning and implementation of Power Development Plan (PDP)
3. Creating operational flexibility in electrical grid system design
4. Building a smart electrical system
5. Conclusions

No. 1:

The need to increase the proportion of renewable energy sources in Vietnam's generation mix

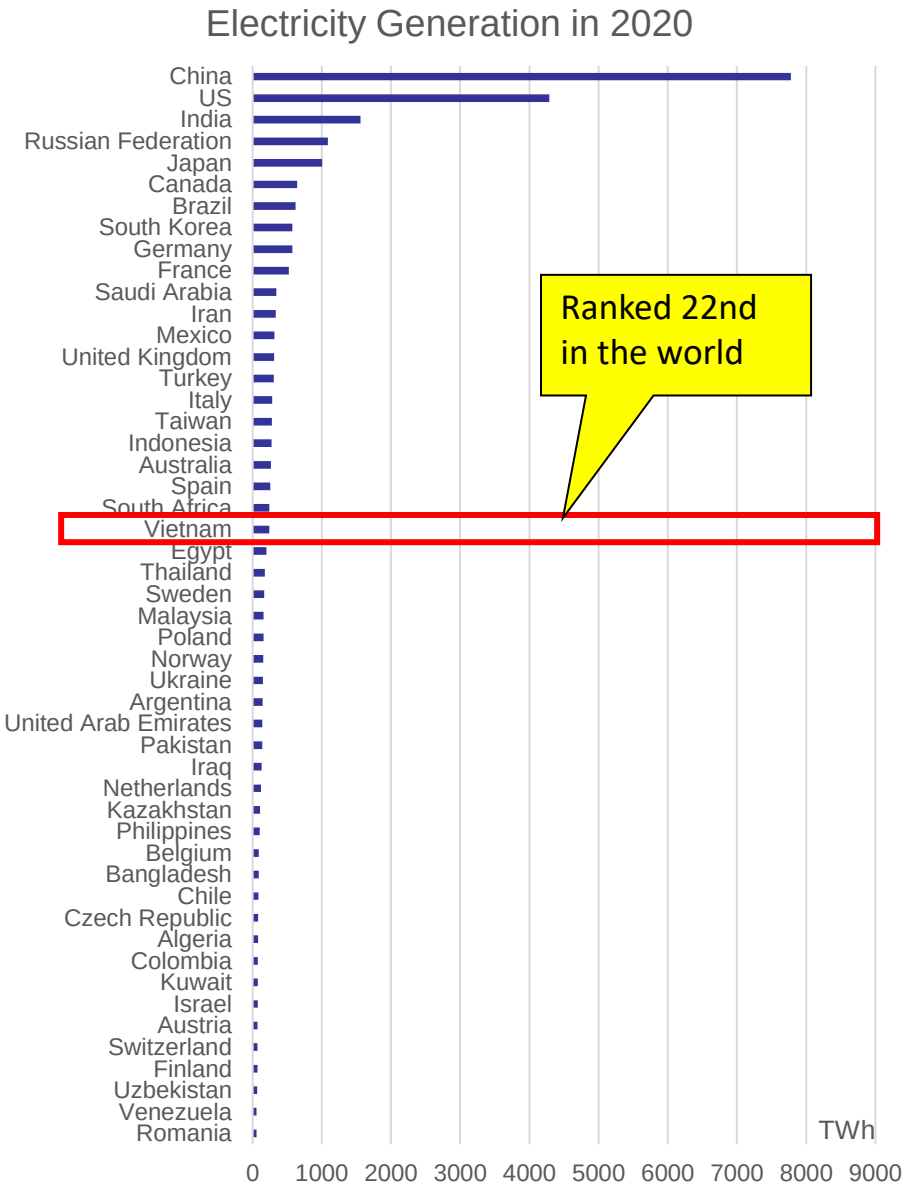
The power system of Vietnam has grown to a large scale in the world



- Total global electricity generation in 2020: 26,823 TWh.
- In terms of electricity generation output: Vietnam reached 239 TWh, ranking 22nd in the world.

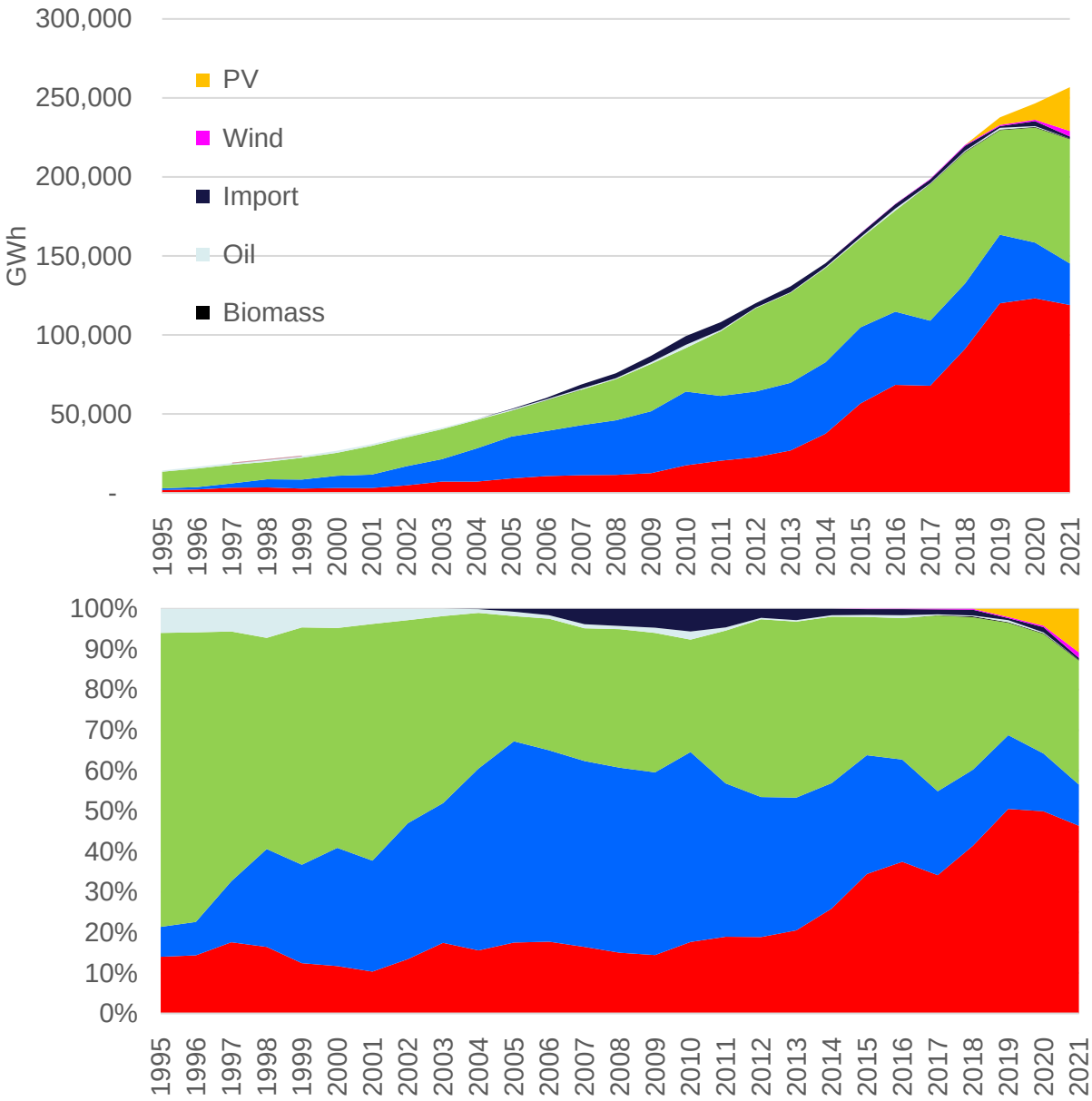
Ranking the scale of electricity generation in 2020

STT	Tên nước	2015	2016	2017	2018	2020
1	China	5815	6133	6604	7166	7779
2	US	4349	4348	4303	4462	4287
3	India	1317	1402	1471	1579	1561
4	Russian Federation	1068	1091	1091	1109	1085
5	Japan	1030	1035	1042	1053	1005
6	Canada	659	664	660	656	644
7	Brazil	581	579	589	601	620
8	South Korea	548	561	576	593	574
9	Germany	648	650	653	643	572
10	France	572	556	554	574	525
11	Saudi Arabia	339	345	349	344	341
12	Iran	279	286	305	314	332
13	Mexico	310	319	325	335	313
14	United Kingdom	339	339	338	333	313
15	Turkey	262	274	297	305	305
16	Italy	283	290	296	290	283
17	Taiwan	258	264	270	276	280
18	Indonesia	234	248	255	267	275
19	Australia	254	258	259	263	265
20	Spain	281	275	276	274	256
21	South Africa	250	253	255	256	239
22	Vietnam	164	183	198	220	239
23	Egypt	182	188	193	199	199
24	Thailand	178	180	177	178	176
25	Sweden	162	156	164	163	169
26	Malaysia	150	157	161	171	160
27	Poland	165	167	170	170	158
28	Norway	145	149	149	147	154
29	Ukraine	164	165	156	160	149
30	Argentina	145	147	146	147	143
31	United Arab Emirates	127	130	135	136	138
32	Pakistan	111	116	128	138	138
33	Iraq	75	86	94	100	131
34	Netherlands	110	115	117	114	122
35	Kazakhstan	92	95	103	107	109
36	Philippines	82	91	94	100	102



Structure of electricity production in recent years

- Power production growth in the period 2000-2021 will reach 11.4%/year
- Electricity generation in 2021 will reach 256 billion kWh.
- The main types of electricity produced in 2021: 46% coal-fired power; hydroelectricity 31%; gas thermal power 10%.
- The proportion of electricity produced by renewable energy sources (wind power, solar power) has increased from 0% in 2018 to 12.1% in 2021.
- CO2 emission in electricity generation 2021: 117 M.t.



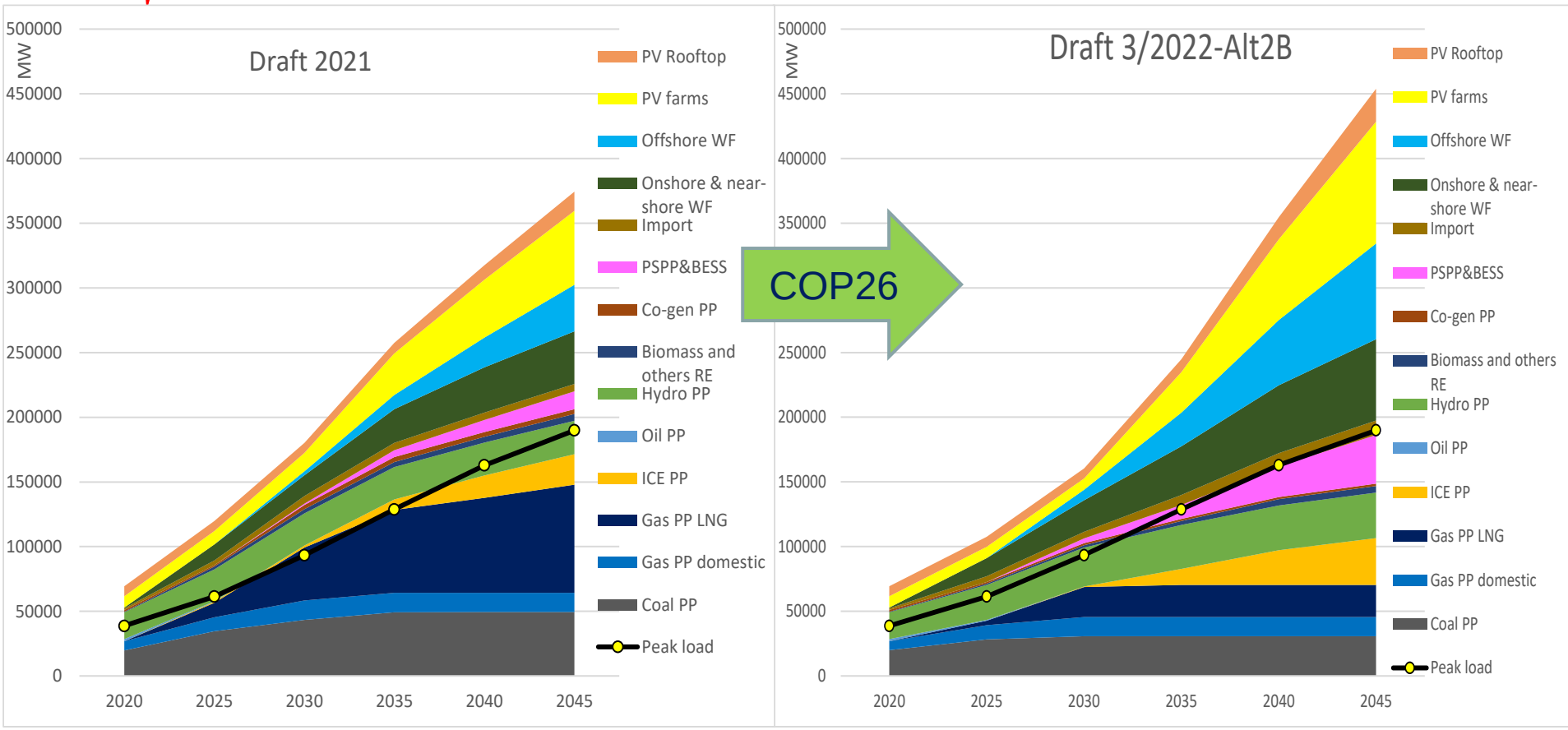
The need to increase the share of renewable energy

1. Law on Environmental Protection No. 72/2020/QH14 passed by the National Assembly on November 17th , 2020, effective from January 1st , 2022: Clause 5, State policy on environmental protection: 3… “develop clean energy and renewable energy; development of technical infrastructure for environmental protection.”
2. Decree No. 06/2022/ND-CP dated January 7th , 2022 Regulations on mitigation of greenhouse gas emissions and protection of the ozone layer: Article 12, the Ministry of Natural Resources and Environment to submit to the Prime Minister for promulgation the total quota greenhouse gas emissions, reserve quota rates and auctions for the period 2026 - 2030 and annually; allocating greenhouse gas emission quotas to facilities.
3. Resolution No. 55-NQ/TW dated February 11th, 2020 of the Politburo on orientations of Vietnam's national energy development strategy to 2030, with a vision to 2045: “To develop synchronously, rationally and diversify forms of energy; prioritizing the exploitation, exhaustive and efficient use of renewable energy, new energy, and clean energy.”
4. Vietnam's commitment at the 26th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP26) in November 2021 towards net zero emissions in Vietnam by 2050.
5. Decision No. 888/QD-TTg dated July 25th , 2022 of the Prime Minister approving the Scheme on tasks and solutions to implement the results of the COP26: Focus on developing new renewable, zero-emission energy sources, energy storage technologies and carbon capture, storage and use technologies.
6. Decision No. 1658/QD-TTg dated October 1st , 2021 of the Prime Minister approving the National Strategy on Green Growth for the 2021-2030 period, with a vision to 2050: towards a green economy, neutralizing - carbon and contribute to the goal of limiting global temperature rise.

No. 2:

Solutions to increase renewable energy from planning and implementation of Power Development Plan

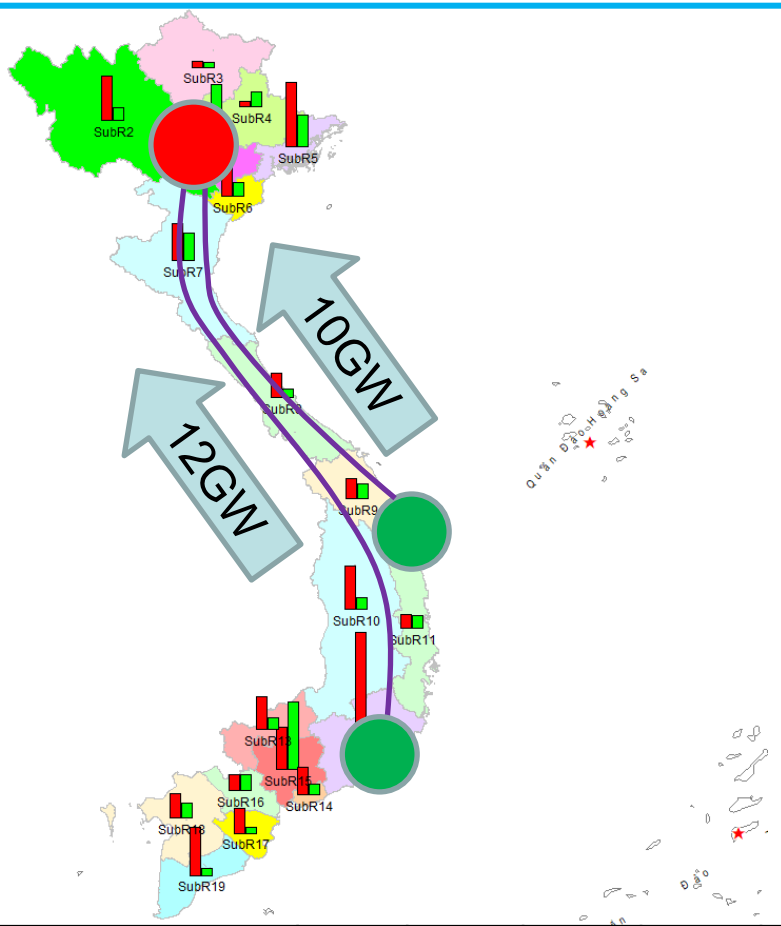
Development orientation in power source structure



- Towards the goal of NET ZERO 2050, the proportion of RE capacity will gradually increase: in 2020 it will reach 25%, reaching ~32% in 2030, reaching ~58% in 2045.
- Increase the proportion of highly flexible power sources
- Build new power sources with the capability of storing energy.
- Convert coal and gas thermal power plants to use more environmentally friendly fuels (Green NH3, Green H2, Biomass).

Demand for inter-regional transmission

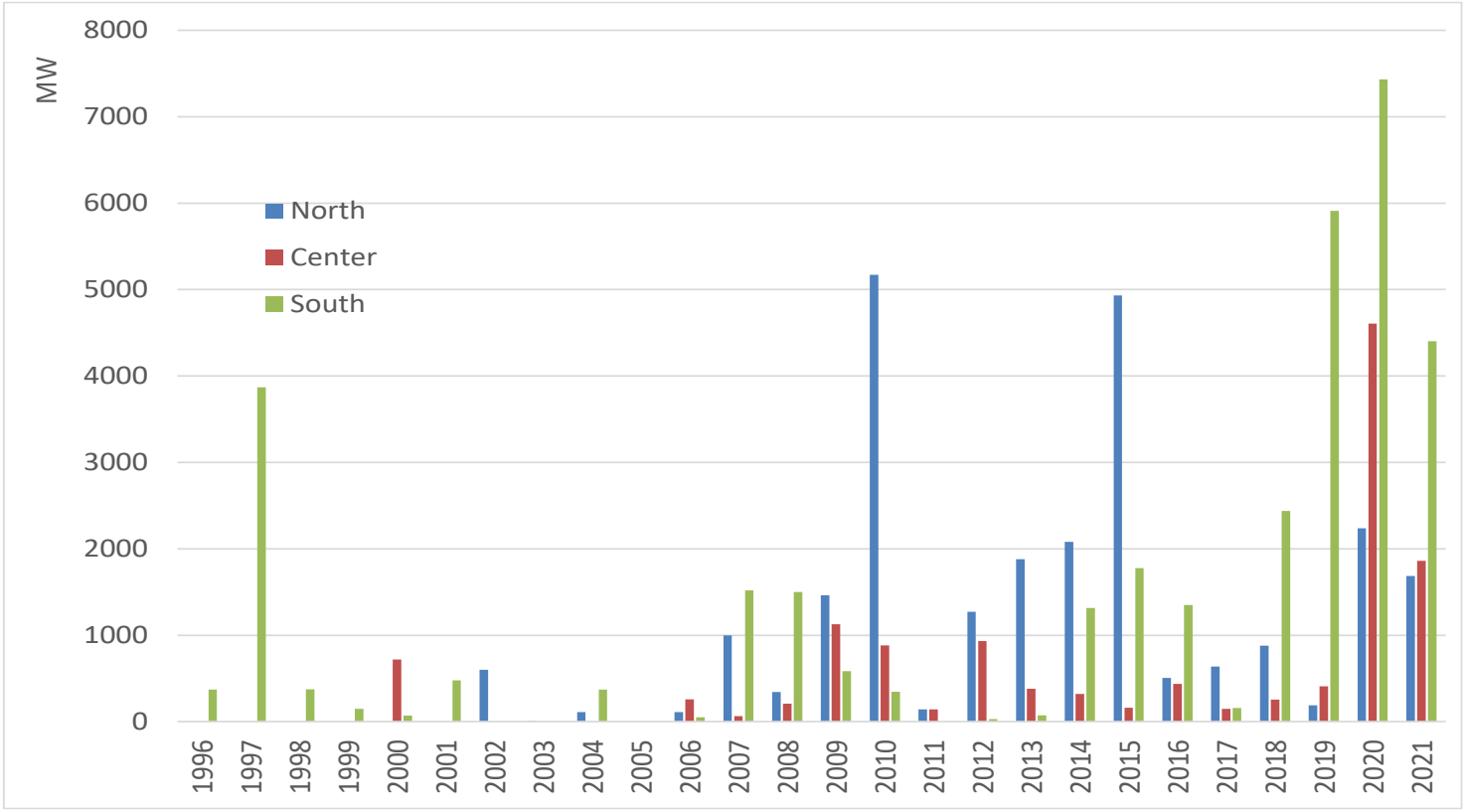
- Additional transmission capacity from Central to North is 5 GW in 2035, 10 GW in 2040; energy transmission is 47-65 billion kWh/year.
- In order to take advantage of the best offshore wind potential in the country, the demand for electricity transmission from Ninh Thuan and Binh Thuan to the North is up to 27 billion kWh in 2040 and 63 billion kWh in 2045.
- At the transmission distance of 1000 - 1500 km, HVDC +/-500 kV, +/-800 kV or UHVAC 800 - 1000 kV technology should be considered and studied.



Transfer direction/year	2025	2030	2035	2040	2045
Alt 2B (COP26)					
Center => North	4,5	19,4	47,3	56,3	65,4
North => Center	2,3	0,0	0,0	0,0	0,0
Center => South	15,2	21,5	6,1	5,8	4,3
South => Center	1,8	6,4	13,1	5,2	2,8
South => North	0,0	0,0	0,0	26,9	62,6

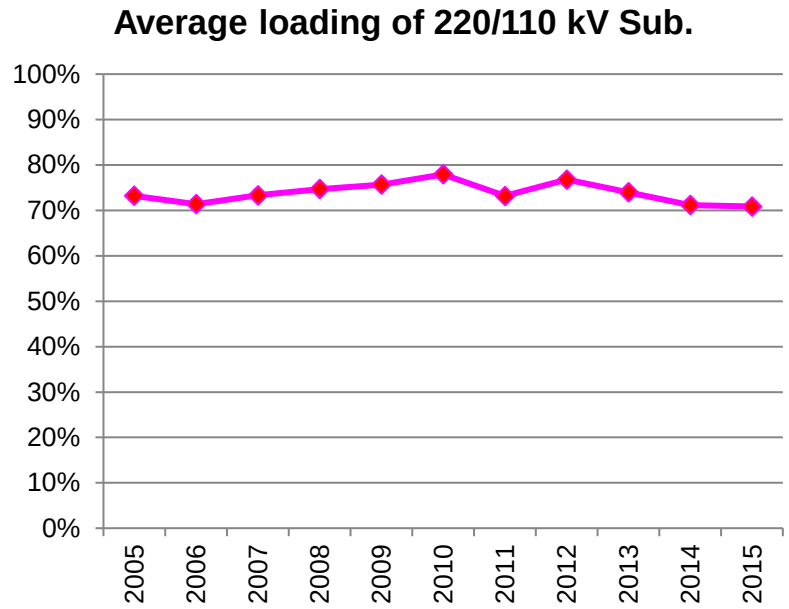
Đơn vị/Unit: TWh

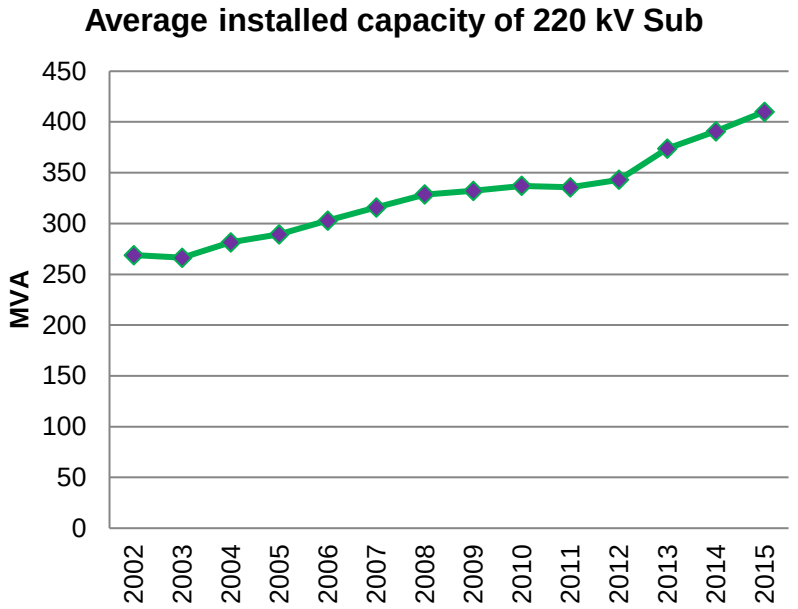
It is necessary to have strict management of PDP to avoid imbalance in electricity between regions



- In the period 2010-2021, the installed capacity of the whole system increases by 51 GW, with uneven distribution among areas.
- Consequences: the heavy operation of the 500 kV north-south interconnected grid, posing a high level of risk to power supply security.

Criteria for substation loads in PDP



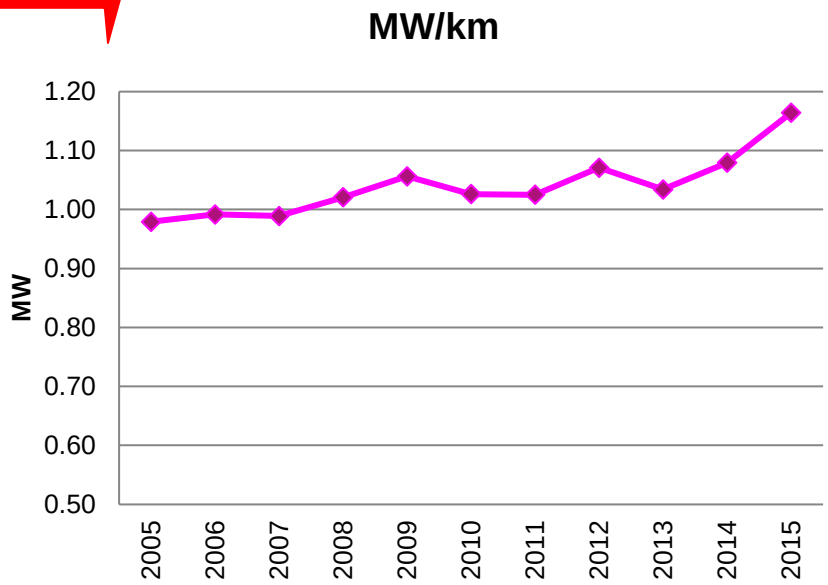


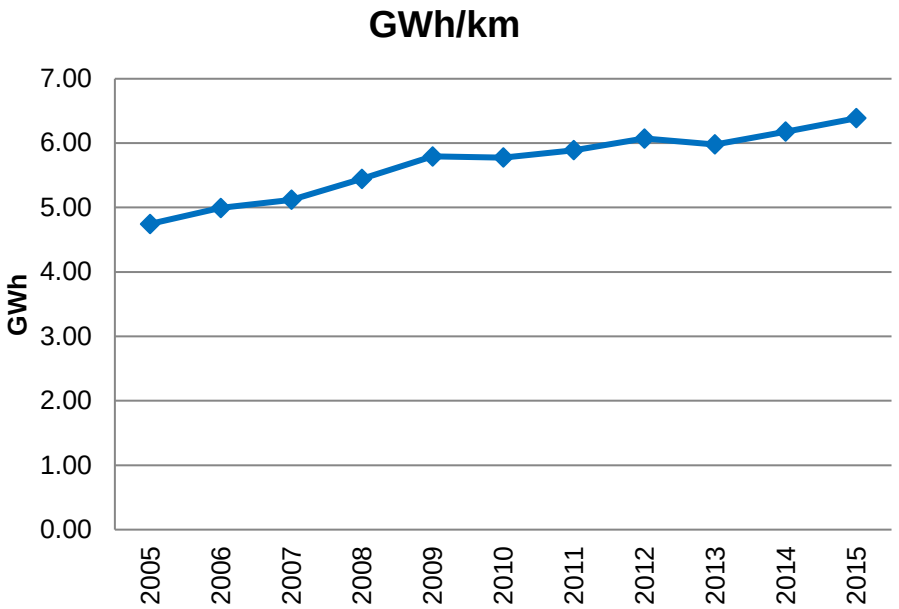
- The PDP usually sets the loading criterion of the Substations around 75%. In fact, the average load factor of 220/110 kV substations is in the range of 70-80%. However, many Substations do not meet the N-1 criteria.

❑ Propose solutions:

- It is necessary to consider the loading criterion of the substation should only be at 50% of the rated capacity.
- Standard 4 transformer (MBA) substation design, with large capacity ranges (375 MVA, 450 MVA for 220 kV transformer, and up to 1500 MVA for 500 kV transformer).

Criteria for selection of conductor size





➢Currently, the conductor size of the transmission line (DZ) is selected according to the economic current density method Jkt. Reality has proven that 220kV power transmission lines after 10 years of operation are mostly full and overloaded.

➢ Inadequacies in calculation time frame: 10 years; while the life span of the lines are 40 years.

➢The explosion of renewable energy (renewable energy) such as wind power and solar power can change the method of selecting the conductor size and the method of calculating the economic indicators of the transmission line projects.

❑ Proposal: It is necessary to change the philosophy of selecting transmission lines, adding more development coefficients of the load in the longer period (30-40 years instead of 10 years).

Properly understanding the N-1 criterion will improve the flexibility of the power grid from the PDP design

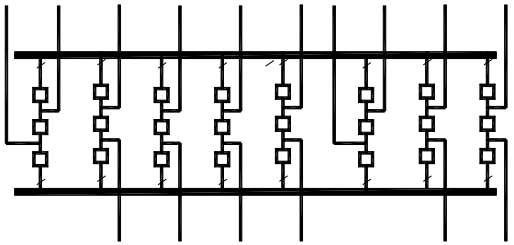
- On the transmission system, there are always some elements that are being repaired or maintained. The N-1 criterion that needs to be considered this case is called the N-M-1 (or N-1-1) criterion.
- Criterion N-1 could be consided the failure of 1 busbar segment of the transmission TBA.
- If the transmission network is planned and designed according to N-M-1 criteria, taking into account the failure of 1 busbar segment, the flexibility of the network will certainly be improved significantly.

No. 3:

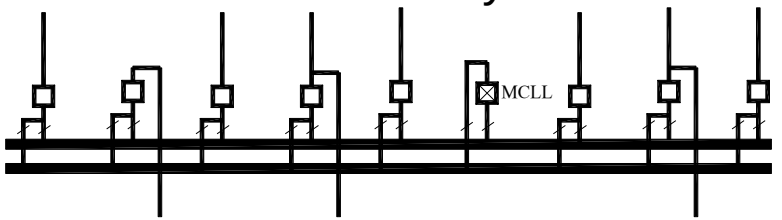
Creating operational flexibility in electrical grid system design

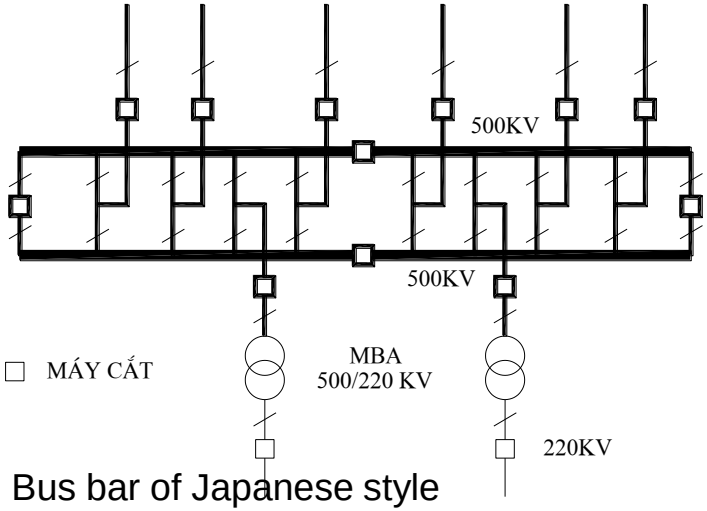
Busbar flexibility is key to Grid Resilience

Vietnam style

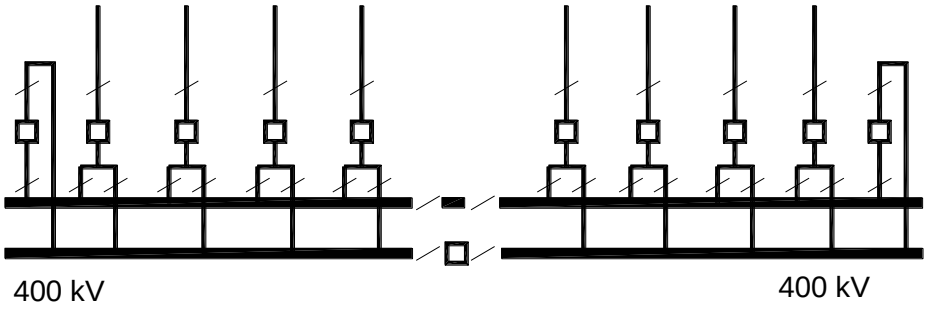


Vietnam style





Bus bar of Japanese style

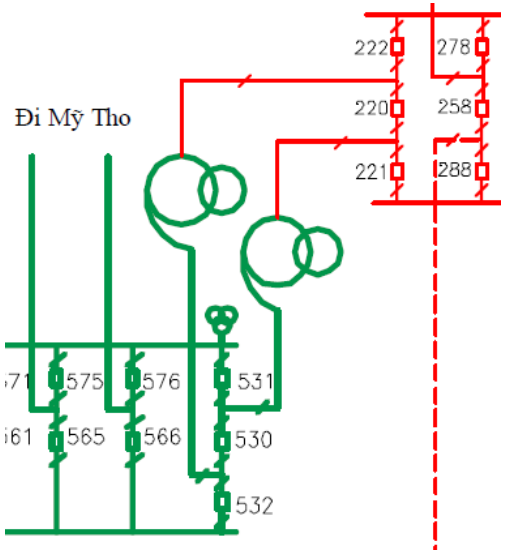


Bus bar of English style

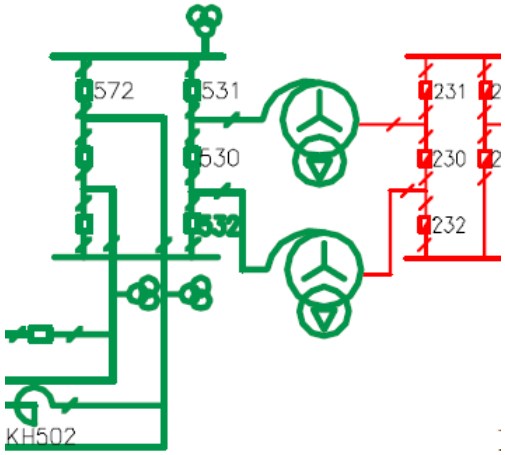
- The diagram with double busbars, or the 3/2, 4/3 diagram of Vietnam, it will be difficult to ensure the N-1 criterion if there is a failure of 1 busbar. In addition, it is difficult to separate the grid to reduce short-circuit currents or to develop different operating modes.

- Proposal: it is necessary to improve the busbar diagrams of the Transmission Substations to creating more flexibility in operation.

Improper arrangement of substation equipment will affect the flexibility of the power grid



500 kV Ô Môn substation diagram



500 kV Vinh Tan substation diagram

- If the relay reports a breakdown of circuit breakers 530, 220, and 230: all 500 kV transformers of the substation will be separated from operation, potentially causing widespread power failure.
- Proposal: The connection principles of lines and transformer feeders in the substation should be clearly specified, and may even become design standards.

Standardization of transmission line design and selection of large conductor size

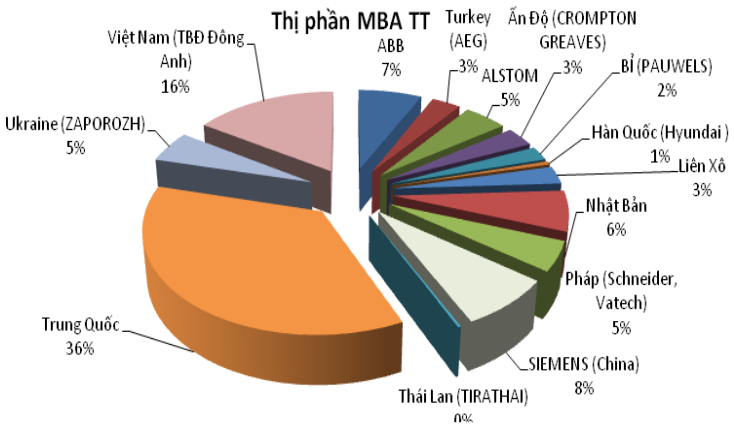
Voltage (kV)	Japan (ACSR or TACSR)	Việt Nam (ACSR)
500	4x410, 6x410, 4x610, 6x610, 4x810, 6x810, 4x1520	4x330, 4x400
275; 220	2x410, 4x410, 2x610, 4x610, 2x810, 4x810, 2x1520, 4x1520	1x300, 1x400, 1x500, 2x330, 2x400, 3x400
154; 110	1x610, 2x610, 1x810, 2x810, 1x240, 1x410, 1x1520	1x185, 1x240, 1x300, 2x185

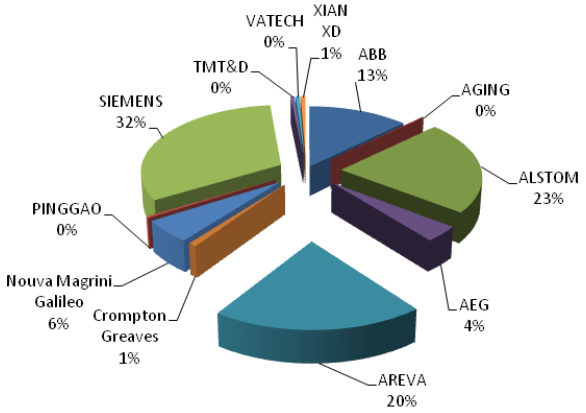
- The current conductor size of transmission lines is quite small, which is the main cause of the inflexibility of the transmission network, in the context of Vietnam's high load growth rate.
- Proposal: consider the solution of building standardized towers, capable of hanging wire with large conductor size, although at the time of initial operation, it is only necessary to hang conductor with smaller size.

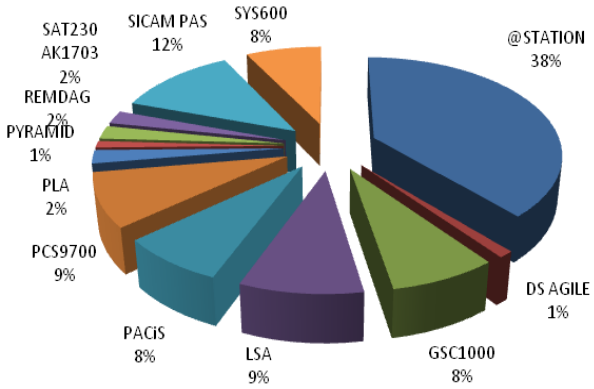
No. 4:

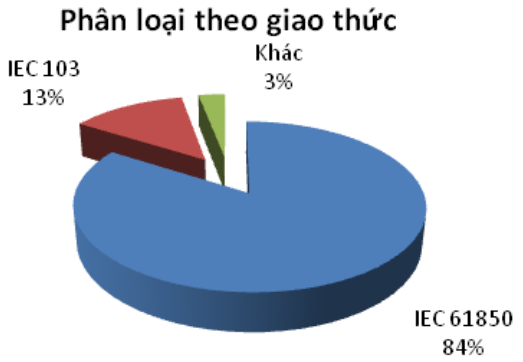
Building a smart electrical system

The variety of devices affects the "smartness" of the transmission grid









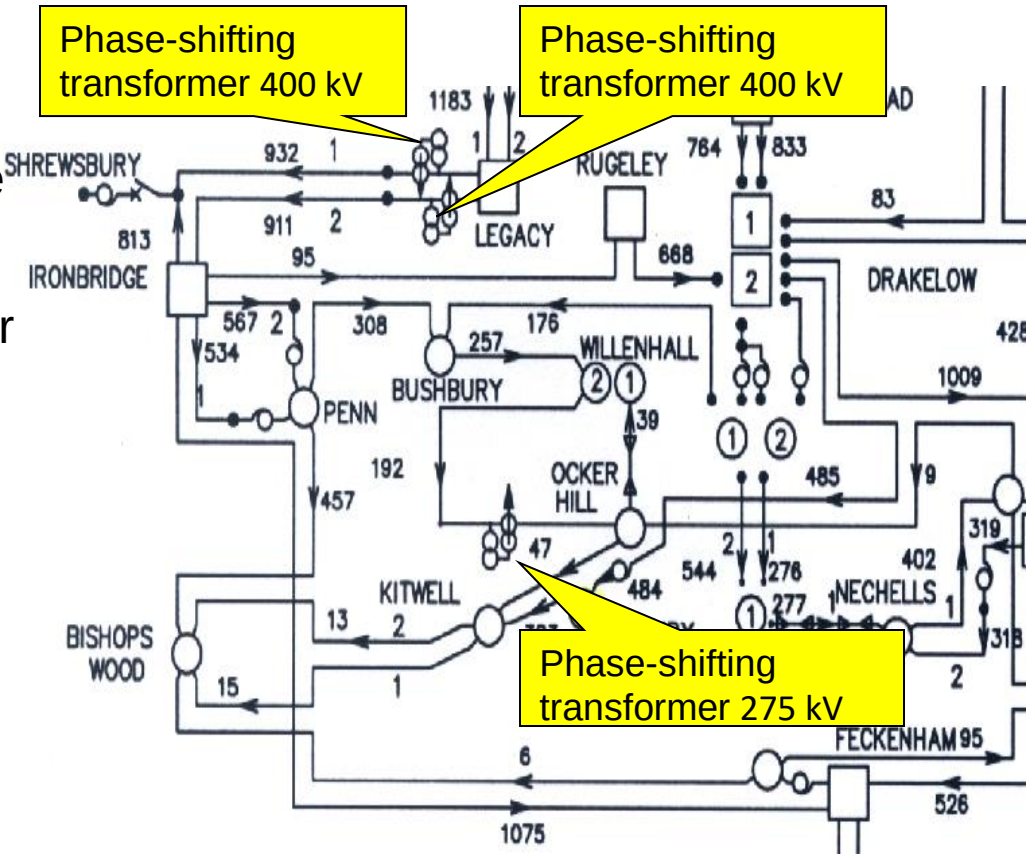
- Improve the quality of equipment, especially transformers;
- Standardizing the automation control system will help speed up the construction of unmanned transmission substations and improve power supply reliability.
- Research on the quality of current equipment on the grid, filtering out poor quality equipment.

Application of FACTS equipment in the transmission grid

- The effect of FACTS devices is to help improve the voltage and frequency of the power system, increase the safety and reliability of power supply, and control the active power flow on the system.

- Some potential FACTS devices for Vietnam Grid are:

  - Static Var Compensator (SVC);
  - Thyristor Controlled Series Capacitor (TCSC) compensator;
  - Phase-shifting transformer (phase-shifting transformer as it is called in the US, Europe or quadrature booster as it is called in the UK)



Applicability of Virtual Power Plant

- **VPP in monitoring and controlling RE sources, distributed sources**

1. Distributed RE (DRE) source control functions
2. Real-time operation tracking
3. Real-time grid status monitoring
4. Plan and current status of maintenance and operation of project equipment and related grid
5. Real-time optimal allocation of mobilization and power curtailment
6. Calculation to keep voltage, control the flow of power, avoid overloading the grid
7. Perform remote device switching
8. Management of equipment and assets of the investor
9. Electricity Production cost Forecast

- **Rooftop solar projects with a very large installed capacity (9.7 GWp) have not met the requirements of monitoring and control => Creating a dangerous gap in the dispatching and operation of the power system. VPP will be a good solution to this problem.**

No. 5:

Conclusions

Conclusion on the proposal of solutions to build a power system with high rated of renewable energy

1. In PDP, when integrating high rate of renewable energy, it is necessary to take into account storage devices and power sources with high flexibility in operation; study and upgrade the transmission capacity of regional interconnection grid systems.
2. The ability of Demand response should also be considered an important source to ensure the safe operation of the system when the proportion of RE is high.
3. It is necessary to consider the criterion of loading of 50% of the rated capacity of the transformer; the use of substations with the size of 4 transformers and the flexible busbar diagram with many sections.
4. For power transmission lines, standardized large conductors should be used, taking into account the load development factor for the next 30-40 years (instead of 10 years) and the possibility of renewable energy development.
5. Design Criterion N-1 needs to be more fully understood and can be replaced by Criterion N-1-1.
6. There needs solutions to filter out poor quality equipment.
7. It is possible to consider using some FACTS devices on the 500-220 kV transmission grid to improve power quality such as using SVC, TCSC and phase shift transformers.
8. Application of VPP in monitoring and controlling RE sources, distributed sources

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Thank you!

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