Evolving Architecture of the 21st Century Grid with Two Way Power Flows

An Integrated Approach on Transmission Planning Studies for Bulk RE Evacuation in Indian context

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Introduction

- India has also set an ambitious target for renewable energy capacity addition of 175 GW by 2022 and 450 GW (recently increased to 500 GW) by 2030.
- Resource rich locations for Solar and Wind energy are concentrated in a few pockets around the country.
- Transmission network planning studies play an important role in designing the network which is optimal both technically and economically.
- This paper discusses strategy for development of network models for transmission planning of large RE farms including aspects such as planning horizon and extent to which network is to be modelled.
- A comparative analysis between HVAC and Hybrid (HVAC + HVDC) transmission schemes has also been illustrated

Data Requirement

Existing Power System Network

- Existing network data is required
- Modelled up to 220 kV (up to 132 kV for exceptional cases).

Load Forecasting

- EPS report published by CEA covers year-wise electricity demand projection of all India

Generation Expansion

- NEP Volume I (Generation) is considered for generation expansion details.
- MNRE and SECI publishes details about upcoming Renewable energy schemes.

Substation Planning

- New Substation/ extension of existing s/s is generally planned for pooling of RE.
- NEP Volume II (Transmission) suggests about the substation requirement.

Transmission Expansion

- Transmission planning for RE power plant would entail identification of transmission technology based on distance from load centers
- NEP Volume II (Transmission) also gives information regarding new transmission lines planned for other plants

System Assumptions

Basic Assumptions

- Existing network database to be considered for development of model
- Upcoming 765kV, 400kV and 220kV transmission lines to be modelled as per the data available
- Wherever information unavailable, generation injection is assumed to be injected at 400/765kV level

Generations: Thermal Power Plants

- Thermal generating units to be decommissioned as per NEP data.
- Thermal generating units to be shut down/backed down to their minimum technical limits i.e., 55% for maximum RE scenario.

Generations: RE Power Plant

- RE generators to be modelled in lumps (MW/GW range) and injected at pooling point.
- For peak case Shunt reactors to be disconnected and shunt capacitor to be put into service wherever required.
- Rooftop PV generation quantum to be considered and adjusted in load and generation values.

Transmission Lines

- Transmission line and transformer parameters are considered as per existing rating or CEA Transmission line planning manual

Load

- The load to be scaled up proportionately as per the existing load with projection from 19th EPS report [9] of CEA.
- A power factor of 0.95 to be considered for loads.

System Description

The study was carried out with PSS/E software version 35.0.

The analysis has been carried out as per the CEA transmission planning criteria guidelines

- Network Database
- 20 GW injection in Area 1
- Load increment as per EPS'19
- Study assumptions as per slide 4
- Scenarios considered:
  Peak: Solar Maximised
  Off Peak: Solar min and Solar max
- Power flow analysis
- Short Circuit and Reactive power analysis
- N-1 Contingency study for proposed lines
- **Transmission scheme proposal along with required reactive power compensation**

For reactive power compensation study for different scenarios requirement of shunt capacitors, shunt reactors (bus reactors), static VAR compensators or other FACTS devices are also performed.

Case Study

- A case study has been used to showcase the transmission planning philosophy and some practical experiences
- Zone 1 is considered as a **resource-rich state** where upcoming RE generation are planned and all the surplus RE power is exported to zones 2, 3 and 4
- Upcoming RE generation is planned to evacuate through 400/765 kV voltage levels.
- Two scenarios, HVAC and Hybrid (HVAC + HVDC) transmission schemes have been explored to evacuate power from zone 1 to other zones

Table shows upcoming generation injection quantity and bus number in zone 1

Zone	Bus number	Generation Injection (MW)
Zone 1	Bus 1402	6000
	Bus 1404	6000
	Bus 1405	8000
Total		20000

Table shows power export from zone 1 to other zones*

From	To	Case I -HVAC	Case II -Hybrid (HVAC + HVDC)
Zone 1	Zone 2	9751	10392
	Zone 3	12404	12550
	Zone 4	3363	4523
Total		25518	27465

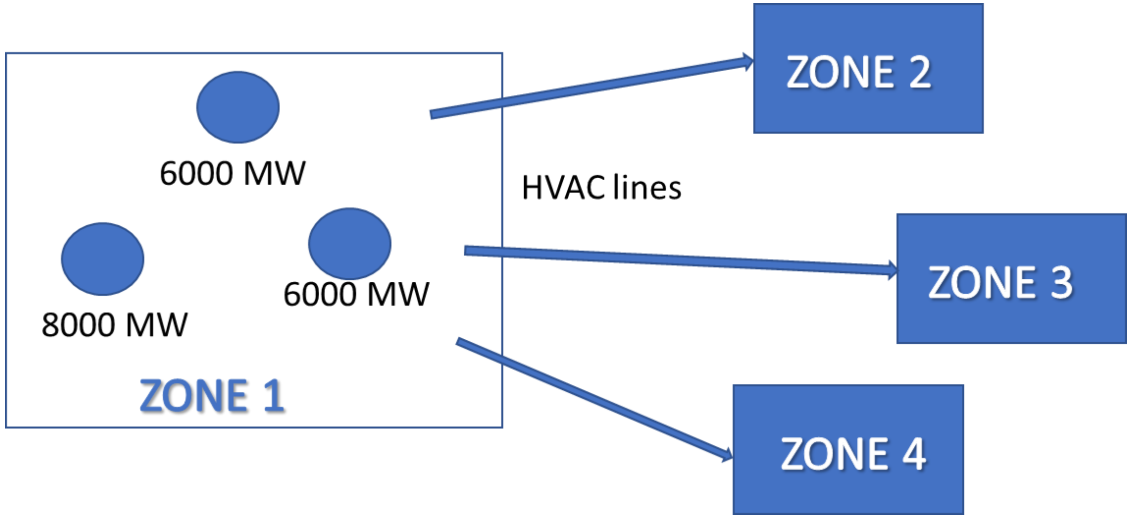
*Irrespective of upcoming generation injection in zone 1

Case Study

Case 1: HVAC Transmission Scheme

- Power evacuation of 20 GW from Zone 1 using high capacity EHV 765 kV AC lines with a SIL of ~2100 MW

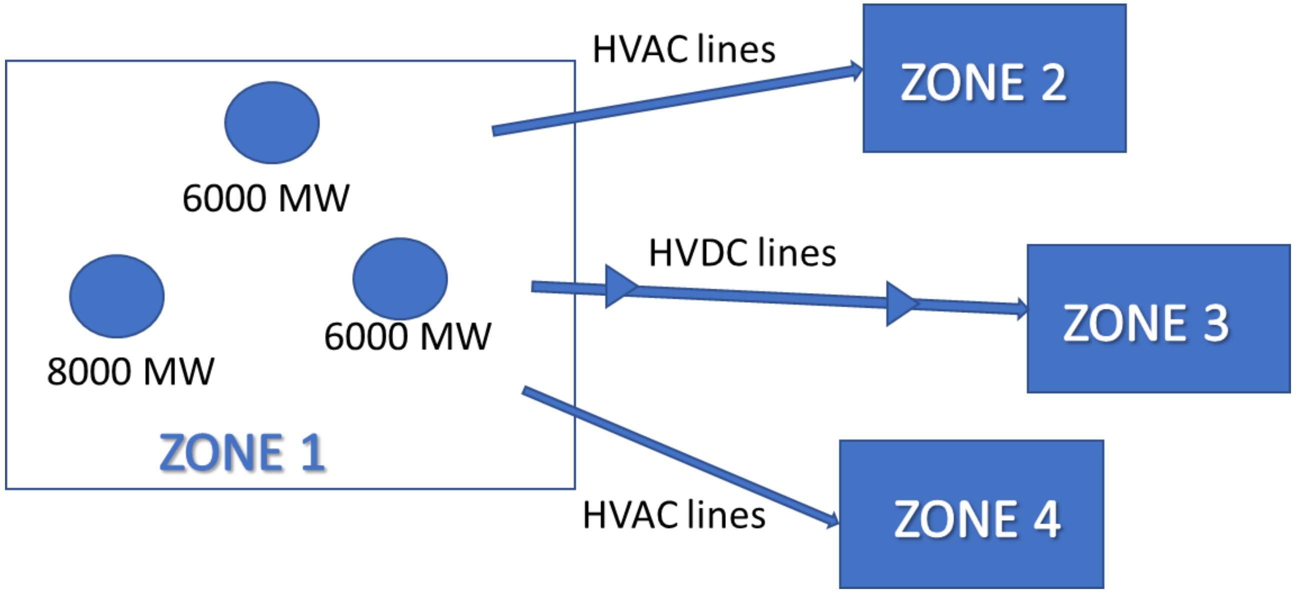
- Power evacuation is planned from three power pooling substations via two intermediate switching stations. These switching stations have been used to feed power either directly to load centers or to transfer power through existing underutilized infrastructure through Loop In Loop Out (LILO) arrangements.



Case Study

Case 2: Hybrid (HVAC+HVDC) Transmission Scheme

- A hybrid (HVAC + HVDC) scheme was also studied to directly feed bulk power to a major load center
- An HVDC link of 5000 MW, 2000 ckms between zone 1 and zone 3 eliminates the requirement of two switching station as well as a 765 kV corridor of line length ~2800 ckms.
- Another important advantage in HVDC lines is the low RoW requirement in comparison to HVAC lines.



Results and Discussion

From the analysis carried out for normal and contingencies operating condition, it is noted that the planned and existing transmission network on 765kV and 400kV is adequate to meet the demand for future growth.

Capex estimates favor HVAC scheme over Hybrid transmission scheme. However, **Hybrid transmission scheme is far more advantageous:**

HVAC Transmission	Hybrid (HVAC + HVDC) Transmission
Multiple tapping/ switching station is required between injection point and load center for long distance evacuation requirement	Bulk power is injected into single nodes and the same is required to be evacuated to distant load centers through dedicated long distance HVDC link
Broader ROW requirement which has time and cost impact on project	Narrower ROW requirement
HVAC does not offer **such capability**	Reverse power flow capability of HVDC can be used to serve power requirement of zone 1 during unavailability of Solar generation
HVAC lines are bound to be underutilized during night hours, requiring reactive elements to be included additionally	This issue would not be there with HVDC links.

Hence, the above advantage of hybrid scheme need to be considered while selecting transmission technology for evacuation of bulk integration of renewable energy along with increase in capex.

Thank You

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Annexure

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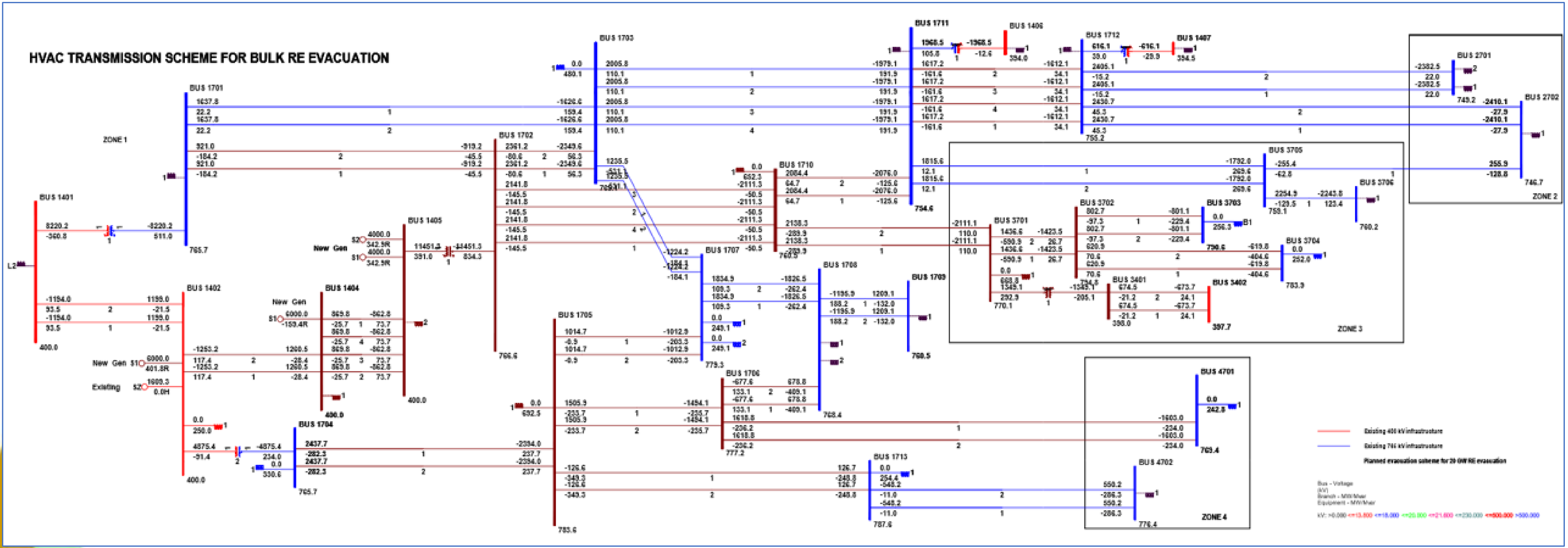
Case Study

Case 1: HVAC transmission scheme for bulk RE evacuation



Case Study

Case 2: Hybrid (HVAC+HVDC) transmission scheme for bulk RE evacuation