Beyond IGCEP 2022

Renewable Energy Scenarios for Pakistan

Presented By

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Study on behalf of

Agora Energiewende

Power Planners International

PPI

Grid analysis
what is the impact of additional VRE on the grid?

Power Planners International

Methodology

Grid System data 2028 model provided by NTDC (Latest Available)

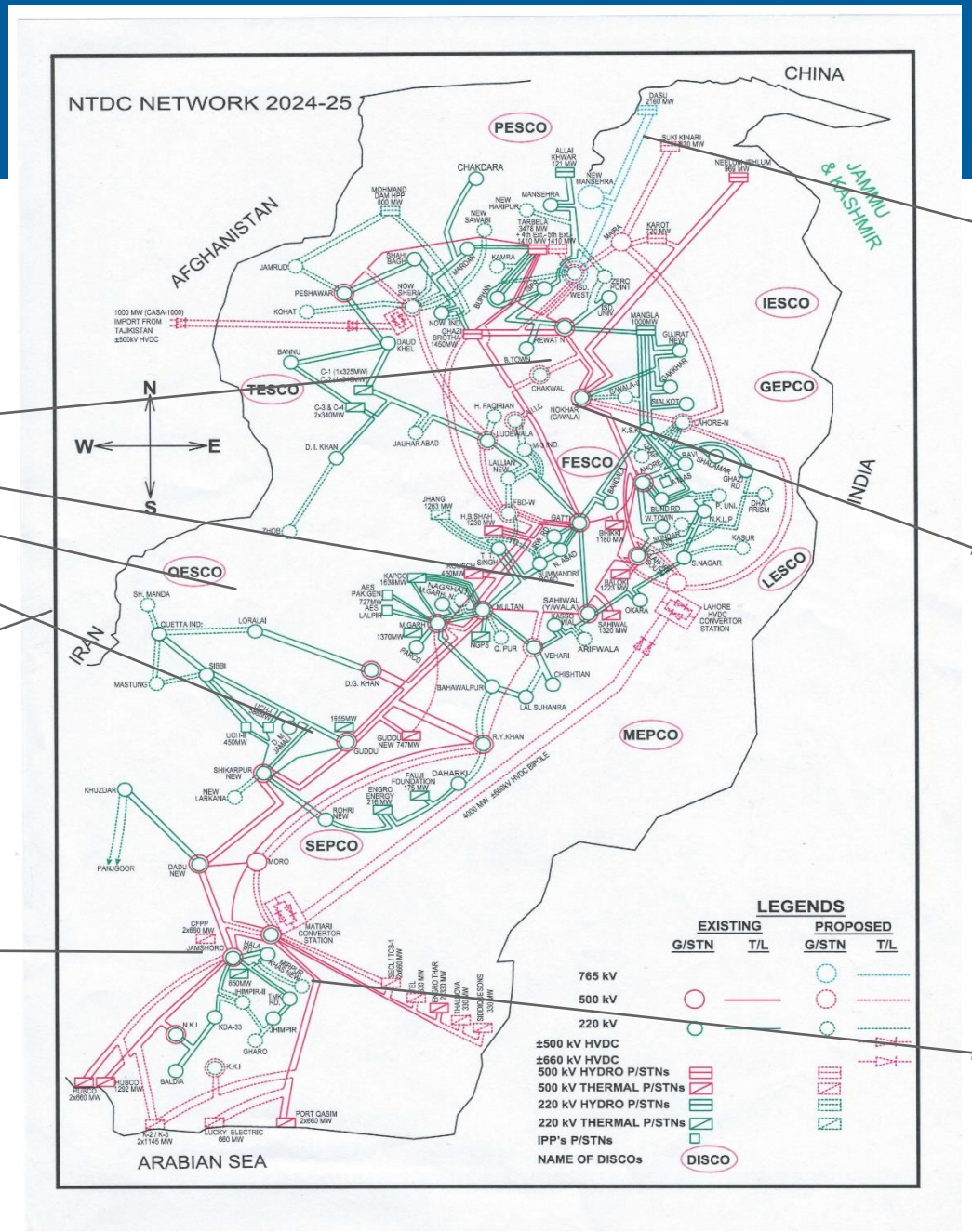
Scenario Studied Summer and Winter Scenarios (Day and Evening)

Peak load scenario studied with max dispatch of RE to see full impact

Power Flow Analysis performed to see the impact of RE plants integration on the system

- System checked under both Normal (N-Conditions) and Contingency (N – 1 Condition)
- Power Flows on the Transmission Lines monitored
- Voltages on the Bus Bars monitored

Grid Map
showing energy sources and load centres



Solar Spread out in Punjab, Sindh and Balochistan

Chaghi Cluster

Wind Corridor

Hydro

Load Centers

Coal & Nuclear

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RE Potential

- All the existing RE plants (as of 2022) considered
- All the Committed RE (having Generation License) plants
- Planned Power Plants as per IGCEP (modelled in NTDC data)
- Additional **3.5 GW RE plants** compared to already planned till 2028 have been considered

Category	Solar (GW)	Wind (GW)
Existing	0.62	1.24
Committed	0.29	1.25
Planned	5.65	3.55
Additional	2.95	0.50
Total	**9.51**	**6.54**
Grand Total		**16.0 GW**

Operational constraints taken into account for system dispatch

Approach used for dispatching various power plants with the increasing amount of RE

Day Time, taken at full AC capacity	Evening Time, Solar Power reduced to zero
▪ Gas Turbines switched Off during day time ▪ For Combined Cycle power plants, operation at minimum dispatch with ST on-bar and GT reduced (Minimum GT on-bar) as per requirement ▪ Coal fired Power Plants, Turbines kept on-bar with output reduced to 50% ▪ Remaining dispatch adjusted with Hydro power dispatch reduction during day time ➢ Storage Dam reduction by 40 % ➢ Run of river reduction by 25 %	▪ Hydro dispatched increased to maximum to meet the demand ▪ Coal Plants power increased ▪ Gas turbines switched on as per the requirement

Few additional interconnections to connect additional large VRE parks

Location	Size (MW)	Proposed Interconnection
CHISTIAN SOLAR PARK	300	• Interconnection with 220/132 kV Chishtian Grid Station • 45 km long 132 kV Transmission Line
QA SOLAR PARK	200	• Interconnection with 220/132 kV Lal Suhanra Grid Station
DERA ISMAIL KHAN	400	• 220 kV Transmission Line from Solar Park to DI Khan 220 kV (15-20 km)
JAUHARABAD	500	• 220 kV Transmission Line from Solar Park to JAUHARABAD 220 kV (25-30 km)
RAHIM YAR KHAN	400	• 220 kV Transmission Line from Solar Park to RAHIM YAR KHAN (40-45 km)
DADU	400	• 220 kV Transmission Line from Solar Park to DADU 220 kV (40-45 km)
DERA GHAZI KHAN	500	• 220 kV Transmission Line from Solar Park to DG Khan 220 kV (15-20 km)
CHAGHI	500+250	• 220 kV line from Chaghi to Mastung with a mid-way switching station would be required. Line length would 450-500 km

Load Flow Analysis:
Only few grid reinforcements required for integrating additional VRE

- Transmission System Expansion Plan (TSEP) prepared by NTDC and DISCOs accommodated most of the RE generation
- No issues observed under N conditions
- A few reinforcements will be required for integrating the additional RE in the system to meet N-1 criteria

Proposed reinforcements to strengthen the grid system beyond the off-take point

- Reinforcement at Jhimpir Corridor is required even without additional proposed RE Plants
- Remaining reinforcement are required for additional proposed RE Plants
- Reinforcement needs are low because of the use of re-dispatching measures

Location	Size (MW)	Proposed Interconnection
CHISTIAN SOLAR PARK	300	• Hasilpur – Chistian 132 kV line opening
QA SOLAR PARK	200	• Lal Suhanra – Karorpakka double circuit (25 km) re-conductor • Bypass Lal Suhanra at Crest Energy – Bahwalpur cantt line
Jhimpir Wind Corridor	2900	• Proposed 500 kV Jhimpir Grid Station should be Looped In/Out at the 500 kV Double Circuit rather than one. • Dispatch should be managed via operational measure for coal and wind, curtailment of wind can be considered in this regard.
DERA ISMAIL KHAN	400	• DI Khan – DI Khan – II 132 kV line re-conductor (8 km)

With more VRE, direction of power flow is significantly high from south to middle of the country (load centre)

- With increased wind power interconnection in the South power flow from South to mid country becomes more critical
- Combined power from Coal Plants, Nuclear Plants and Wind Power may cause congestion on the 500 kV lines
- Dispatch becomes more critical and during high wind scenario either coal plants power should be reduced or curtailment of wind power would be required.

Additional investigations will be required to look at voltage control and system stability

- With Renewable Generation replacing the conventional generation
  - Voltage Control and reactive power capability may become an issue and additional may be required
  - Grid Stability may also be affected as the system inertia level decreases along with the voltage control
  - Extensive System Stability Studies would be required to test system performance under different events of disturbances

Integrating further VRE to reach 33 GW by 2031 will require a new HVDC line and the reinforcement of existing corridors

- A big chunk of hybrid RE at Chaghi wind corridor of nearly 6 GW
- ± 800 kV HVDC Bipole from Chaghi to Mid-Country (near Muzaffargarh or Multan)
- Reinforcement of 500 kV and 220 kV network in the Mid-Country for onward transmission of power received from Chaghi
- Dispatch of conventional generation to be readjusted to accommodate additional RES to be integrated by 2031

Recommendations

Grid Recommendations I

- All the Stakeholders need to work out a **policy for the integration of large amount of RE** in the system
- System operator need to have **more local / regional control centres** and have accurate **forecasting** for inter-day and intra-day RE outputs
- **NTDC** needs to prepare a proper set of guidelines for all the developers regarding all the **necessary studies** and proper data regarding their detailed designs
- **SVCs or preferably STATCOM** should be recommended to be installed along with RE plants which should provide the reactive power support irrespective of the active power of RE plants

Grid Recommendations II

- Reactive compensation should also contain proper **filter devices** to contain the harmonic contents
- **Operating Reserve** to be evaluated statistically and validated through dynamic simulations
- **Operational Studies** would required to be carried out more often to see the transfer and flow of power with the changing output of RE
- **Transfer limits between different areas** needs to be worked out **prior to every season** and NPCC to ensure the power transfer be in limits to have more reliable system operation

Conclusions

Grid Studies Conclusions

- With the implementation of TSEP, **most of the RE plants can be integrated** with only a few reinforcements in the system
- **Balanced dispatch policy considering ramp up/down capability of conventional plants** would be required to manage the dispatch within day and evening time
- **Reduced dispatch of On-Bar Conventional Plants** would also provide enough reserve margin for catering the variability of RE plants
- **With the re-dispatching of plants** and keeping the generation on-bar, system inertia helps keeping the RoCoF within limits

Thank You for Your Attention

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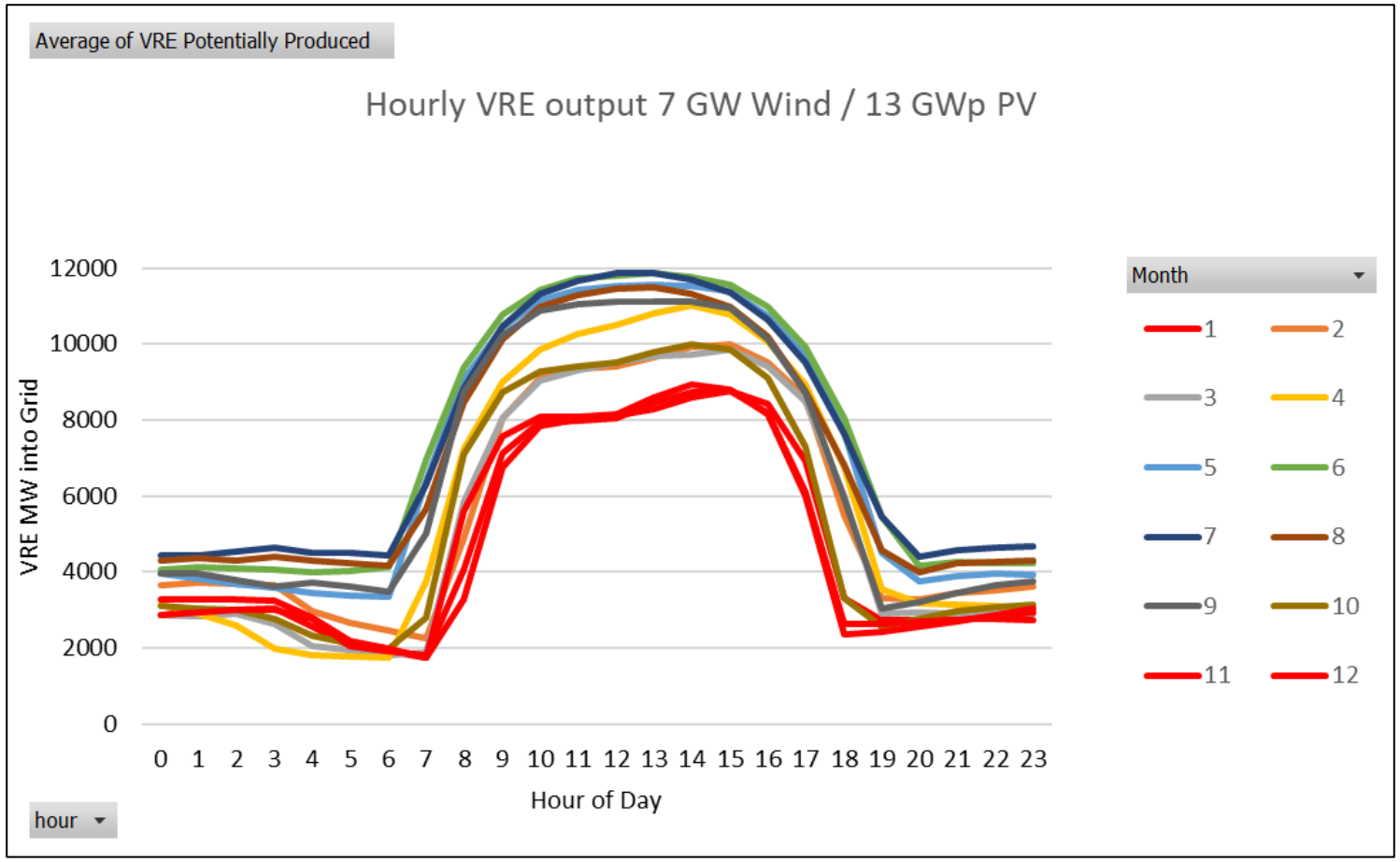
Sizing 2031 IGCEP analysis down to 2028 grid model

	PV GWp	Wind GW
Conclusion of 2031 IGCEP analysis	**24**	**12**
Balochistan GW Park, commissioning 2028 – 2031	-4	-5
Other utility scale developments in 2029-2031	-3	
Distributed PV and NM 2023-2031	-4	
Total utility scale capacity for grid integration 2028 model	**13**	**7**

Simulation of power into grid considering spread locations



Source: Data from VRE locational analysis, 2020

Existing RE Plants

SOLAR PLANTS	
PLANT	**Size (MW)**
QAD-SOL-I	100
APPOLO-SOLAR	100
BEST-GREEN	100
CREST-ENERGY	100
ZENFA	100
HARAPA SOLAR	15
OURSUN (KE)	50
GHARO SOLAR (KE)	50
Total	**615 (MW)**

WIND PLANTS	
PLANT	**Size (MW)**
TGF	50
SACHAL	50
UEPL	99
TAPAL	30
FFC	50
ZORLUE	56
SAPPHIRE	50
METRO	50
GA-1	50
YUNUS	50
TGF-2	50
TGF-3	50
JHMPR WP	50
HAWA	50
TRICON-A	50
TRICON-B	50
TRICON-C	50
MASTER	50
HARTFORD	50
FWELL-1	50
FWELL-2	50
DAWOOD	50
TENAGA	50
ZEPHYR	50
Total	**1235 (MW)**

Category-III (Committed) RE Plants

SOLAR PLANTS	
PLANT	**Size (MW)**
ZORLU	100
Helios	50
Meridian	50
HNDS	50
ACCESS-SOLAR	10
ELEC. ACCESS	10
BUKSH ENERGY	10.5
SAFE SOLARPP	10.5
Total	**291 (MW)**

WIND PLANTS	
PLANT	**Size (MW)**
TRICOM	50
Gul Ahmed	50
Artistic	50
ACT-2	50
Transatlantic	50
DIN	50
Zulekha	50
Western	50
Shaheen	50
Indus	50
Noor	50
Nasda	50
Lake side	50
Metro-2	60
Master Green	50
Category-III Others	489
Total	**1235 (MW)**

Planned RE Plants (IGCEP)

SOLAR PLANTS	
Location	**Size (MW)**
HAVELI BAHADUR SHAH	1200
JHANG	600
MUZAFFAR GARH	600
ROJHAN	100
TAUNSA	50
SIACHEN	100
PEZU	100
KULACHI	100
DINA	100
AHMADAL	50
FATEH JANG	100
KHARIAN	50
DINGA	30
HABIBABAD	30
CHUNIAN	30
NOORSAR	30
DARYAKHAN	100
MANJHAND	50
MEHRABPUR	100
JACOBABAD	100
SUKKUR	100
SANGHAR	100
MACH	30
MUSLIM BAGH	50
DARZANDA	50
KHUZDAR	100
QA SOLAR PARK	300
PANJGUR	50
NARA	50
QUETTA	50
BOSTAN	50
KUCHLAK	200
SOLAR (KE)	900
Total	**5650 (MW)**

WIND PLANTS	
Location	**Size (MW)**
MACH	50
MUSLIM BAGH	100
DARZANDA	100
KHUZDAR	200
JHIMPIR	2903
WIND (KE)	200
Total	**3553 (MW)**

Additional RE Plants

SOLAR PLANTS	
Location	**Size (MW)**
CHISTIAN SOLAR PARK	300
QA SOLAR PARK	200
DERA ISMAIL KHAN	400
JAUHARABAD	500
RAHIM YAR KHAN	400
DADU	400
DERA GHAZI KHAN	500
CHAGHI	250
Total	**2950 (MW)**

WIND PLANTS	
Location	**Size (MW)**
CHAGHI	500
Total	**500 (MW)**