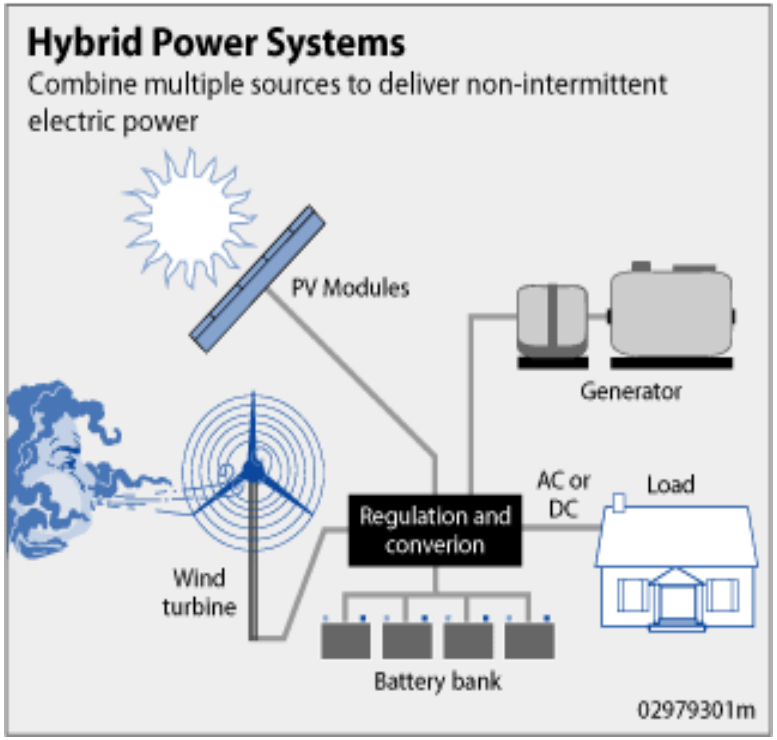
Hybrid Grid Solar PV Power Projects

Alternative Energy Development Board

February 2019

Introduction

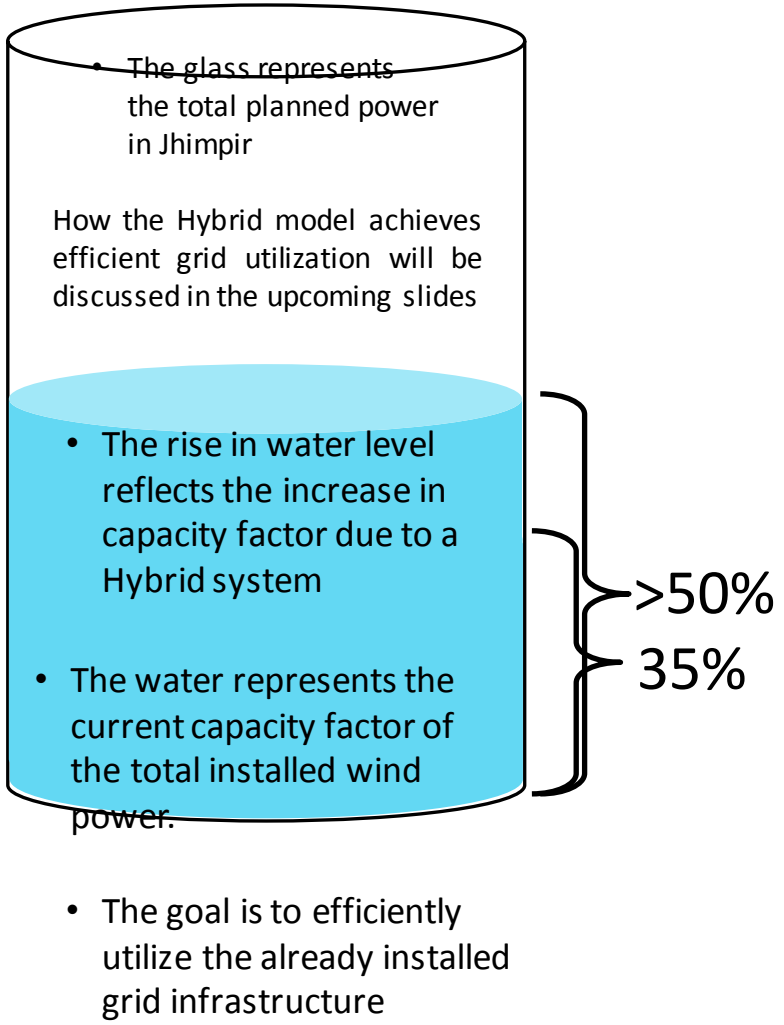
- A Hybrid system can be achieved by harnessing energy through two or more different resources
- There are many examples of hybrid energy systems such as wind/solar, wind/diesel, solar/diesel, wind/solar/diesel and other configurations



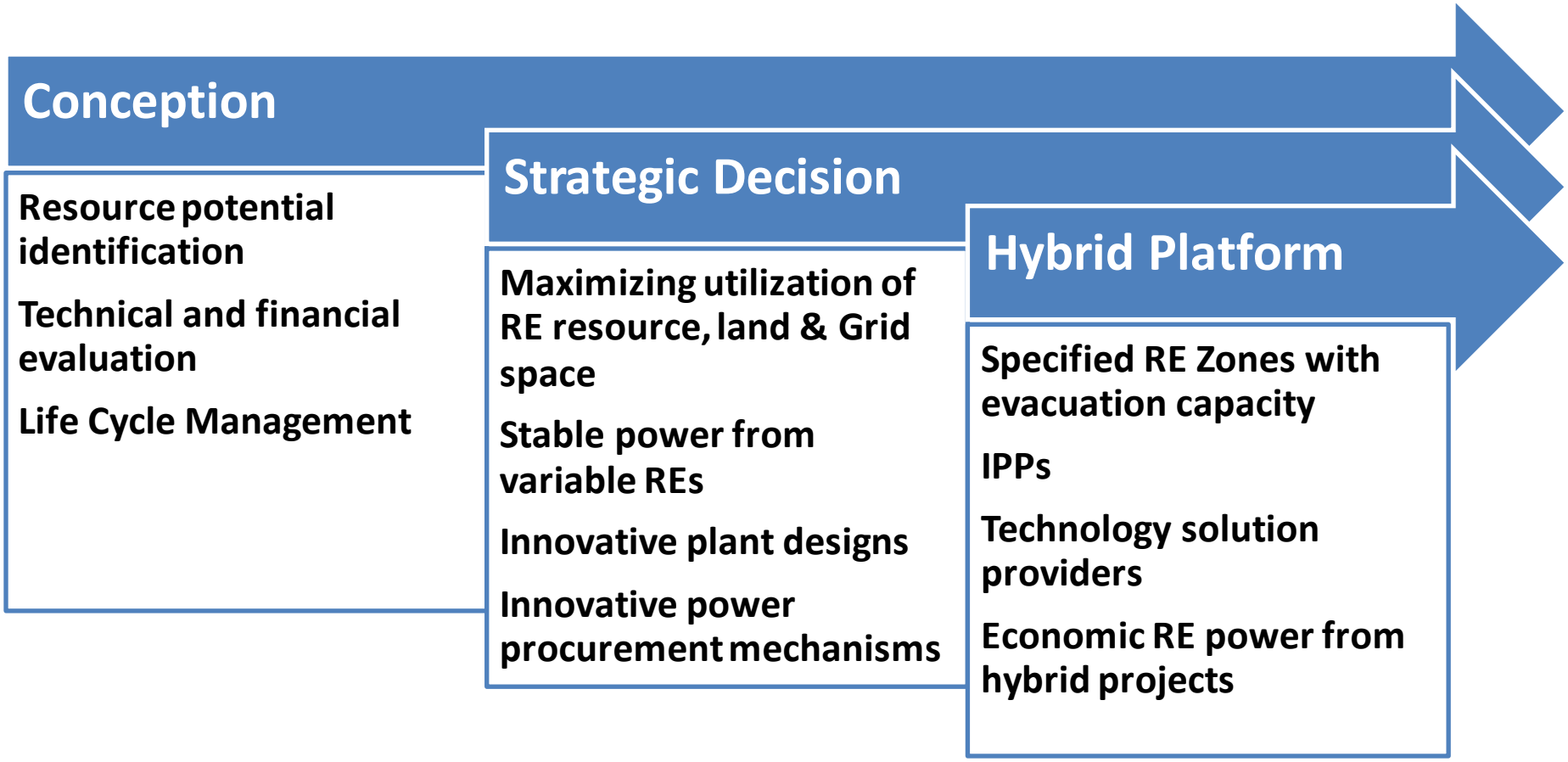
Why Hybrid?

- Higher capacity factor simultaneously also yields a higher efficiency in terms of 'Grid Utilization' and thus lower LCOE.
- Efficient utilization of national assets = higher savings for the economy
- *Capacity factors of existing wind farms ranges between 31% - 35%.*
- *By switching to a Wind-Solar Hybrid system the capacity factor can increase to 45% - 50%.*

Under-utilized Grid Infrastructure

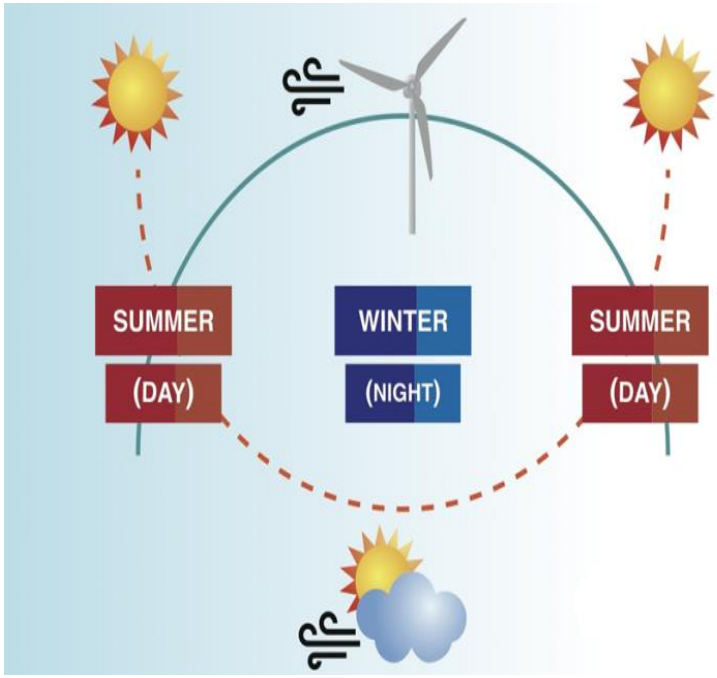


Hybridizing Wind & Solar PV



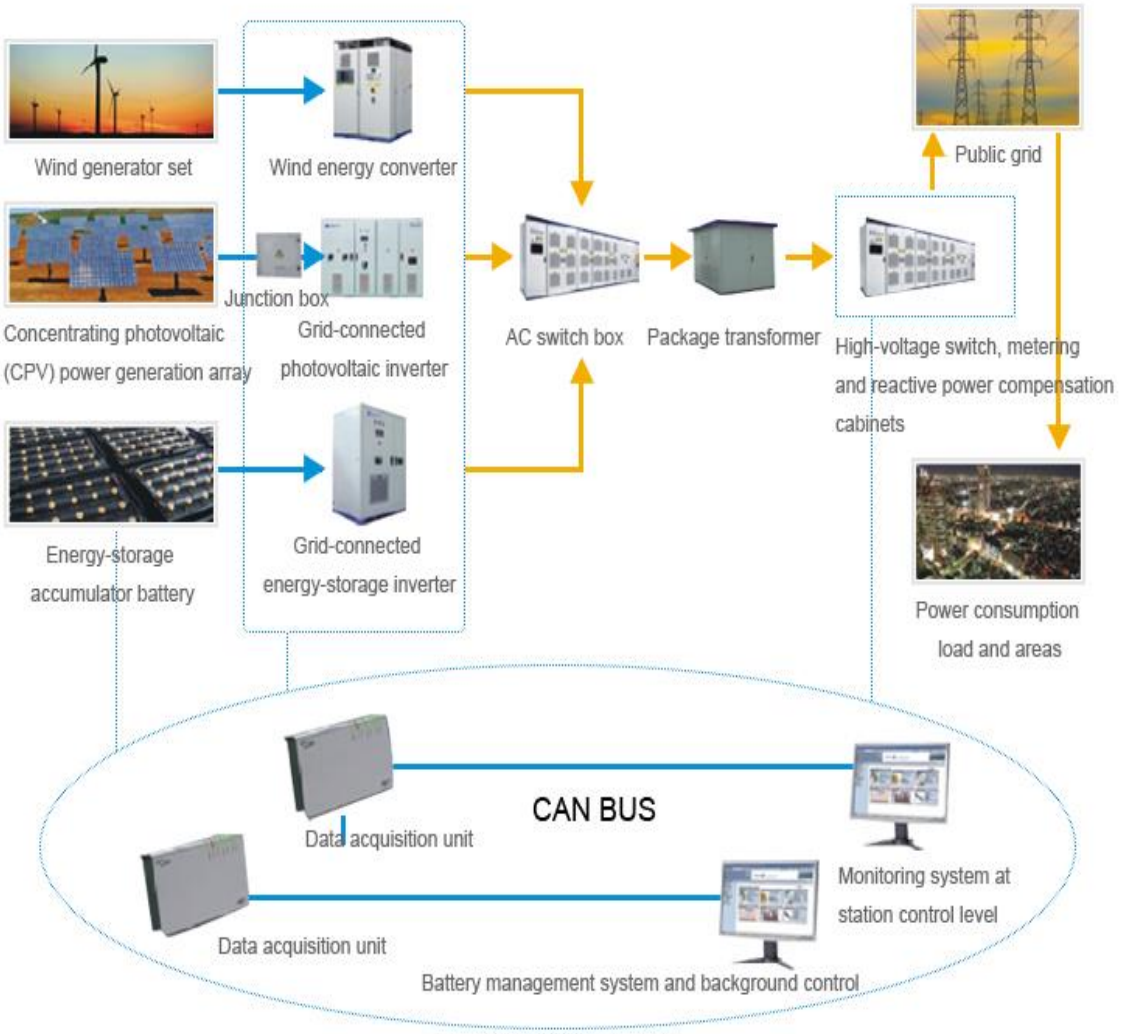
The Wind-Solar Hybrid System

- Based on the significantly large datasets and prudent PV modeling, the Wind – Solar Hybrid potential in Pakistan has been assessed.
- Effects of one technology on the other (e.g. shadow analysis of WTGs on PV), various curtailment scenarios on Solar PV at times of excessive generation etc. have been assessed.
- The studies confirm that low energy output by each Wind Farm during the daylight hours at low winds can be supplemented by the installation of a Solar PV plant.
- The study envisages that the existing Wind Farms in the area will be able to dispatch higher energy in hybrid mode (supplemented by solar) to the national grid.



The Wind-Solar Hybrid System

- The principle implies curtailment during the time when the combined power output of a Wind + Solar Hybrid is more than the allocated capacity to a particular project (i.e. 50 MW in many wind power projects in Pakistan).
- Studies are also being undertaken for each project to determine level of risk for opting curtailment probability, if applicable, to determine the capacity of PV..
- A module of using battery bank for storing the excessive energy during high production period and subsequent dispatch during low production time needs to be studied, however, seems feasible option



CASE STUDY – WIND-SOLAR HYBRID PROJECT IN JHIMPIR

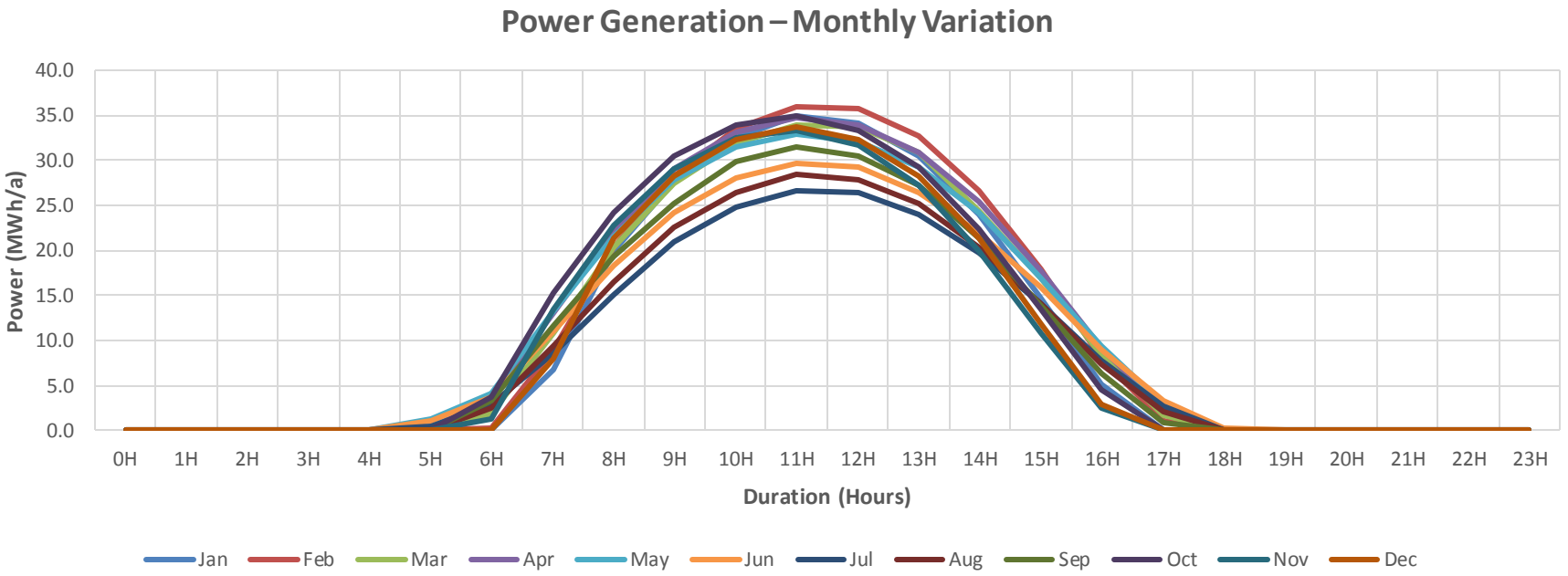
Hybridizing 50 MW Wind Power Project in Jhimpir, Sindh with Solar PV

- Around 1,000 MW wind Power is installed in Jhimpir, Sindh
- NTDCL has confirmed evacuation for around 1750 MW wind power in this area
- NTDCL accounts for 100% capacity while analyzing grid integration studies
- There are relatively few times during the year when plants are at full capacity
- Annual plant capacity factors usually remain between 31-37%, keeping grid capacity un-utilized most of the time (The result is very different if you are at full power 37% of the time versus you are at 37% power all of the time).
- Hybridizing solar during day time will increase the overall plant capacity factor as well as grid-utilization factor

50 MW Solar Power Generation

(Microscopic Analysis – Single SPP)

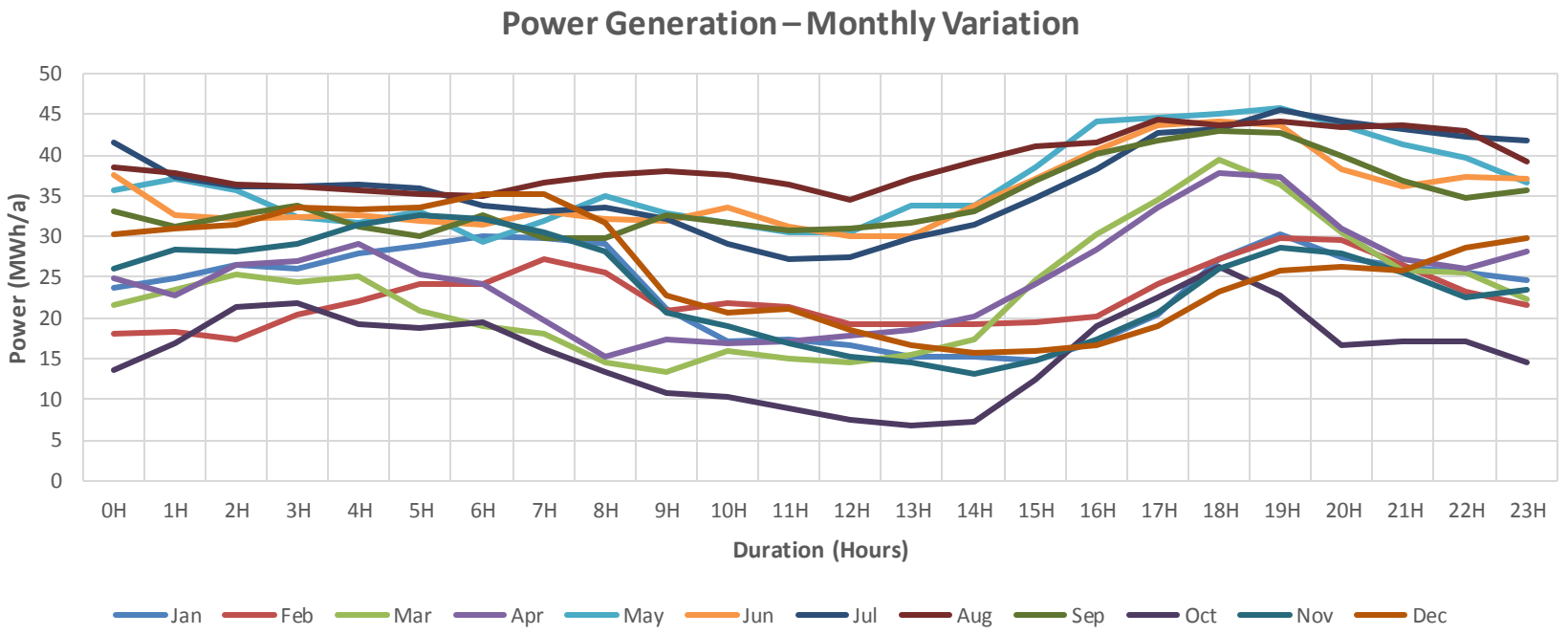
- In addition to the fact that Solar and Wind are complementary during the 24 hours in a day – solar irradiance peaks during the daylight hours.



50 MW Wind Power Generation

(Microscopic Analysis – Single WPP)

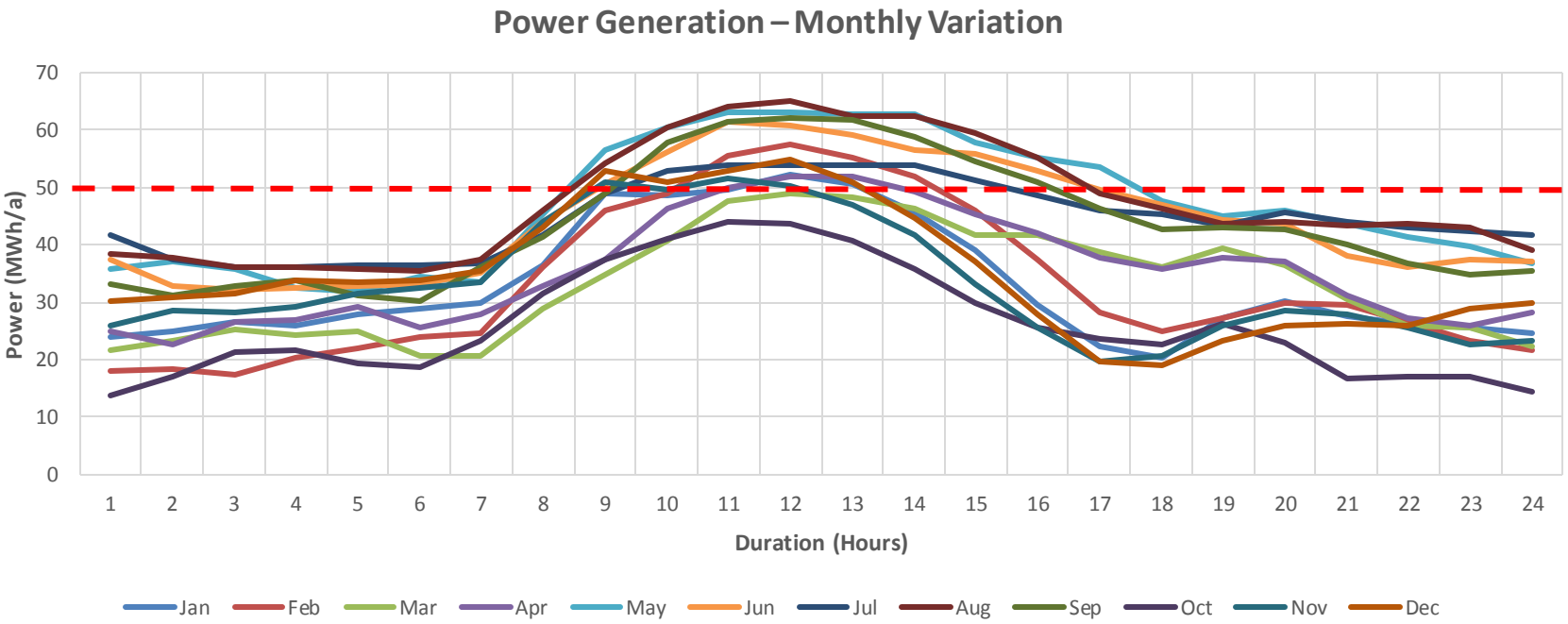
- In addition to the fact that Solar and Wind are complementary during the 24 hours in a day – wind peaks during the night hours



50 + 50 MW Hybrid Generation

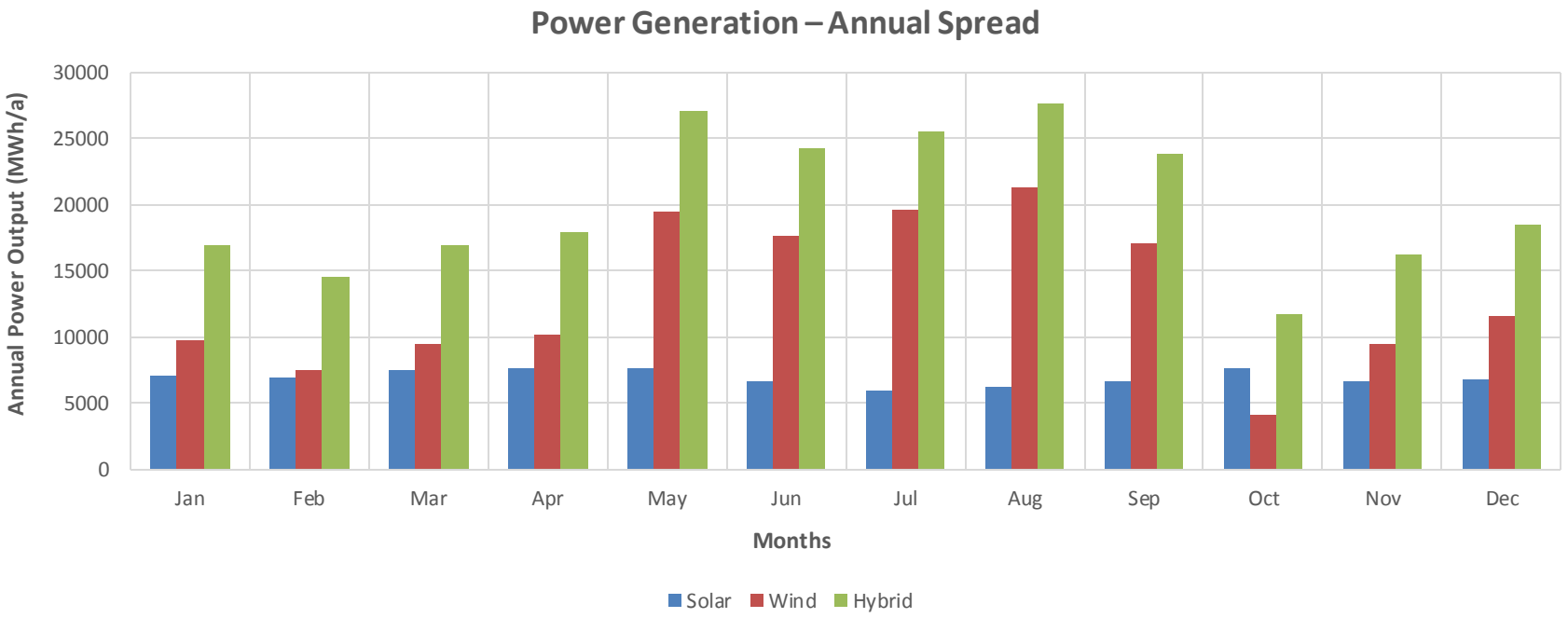
(Microscopic Analysis – Single HPP)

- In the Hybrid Power Plant case, both resources are superimposed to yield an immensely improved result, a trend can also be seen during the year where solar irradiance can complement the low wind season.



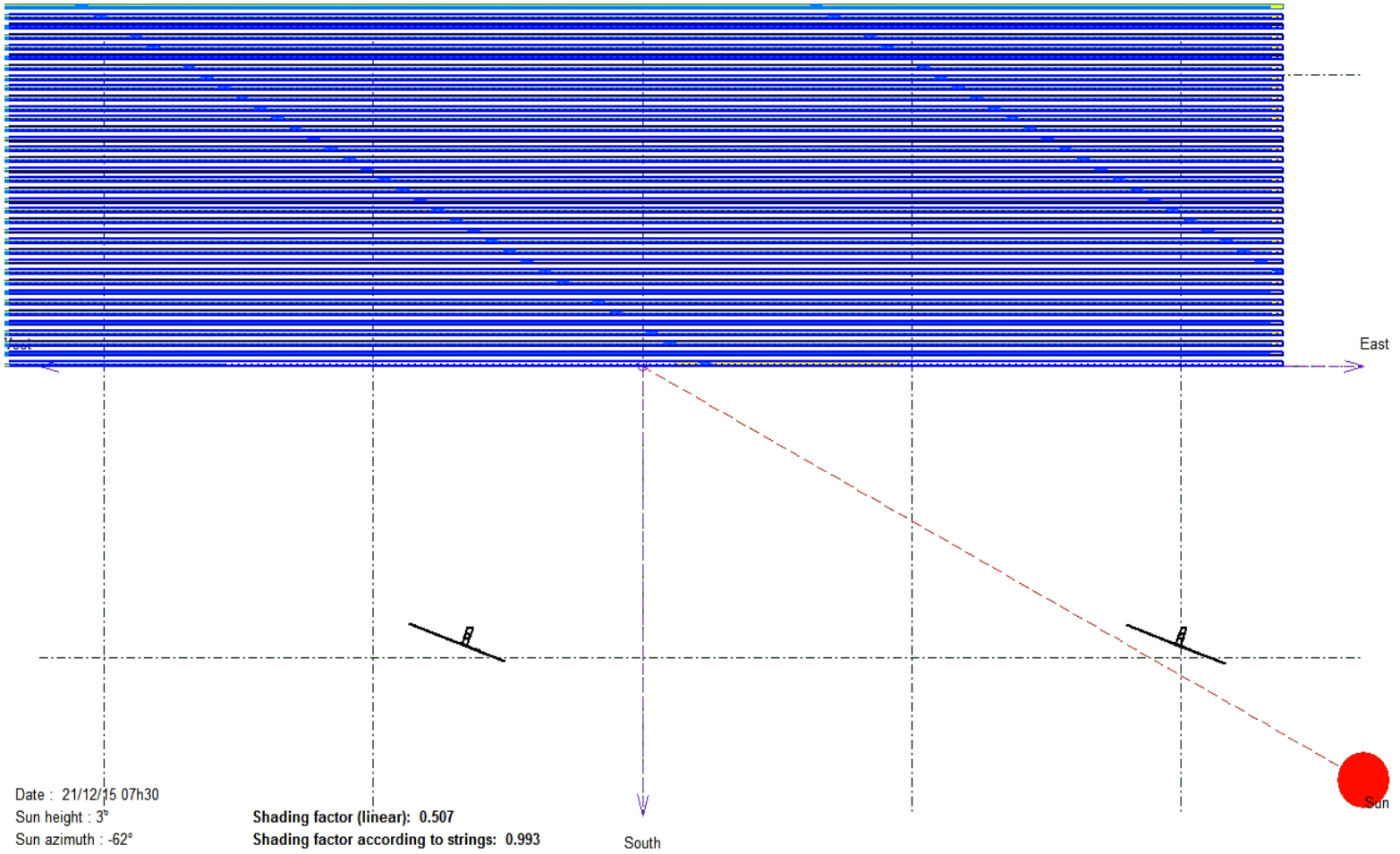
Hybrid Generation (Microscopic Analysis – Single HPP)

Which resource does what and by how much?



50 MW Wind+ 50 MW Solar PV

Shadow Analysis of WTG Towers on Solar Panels

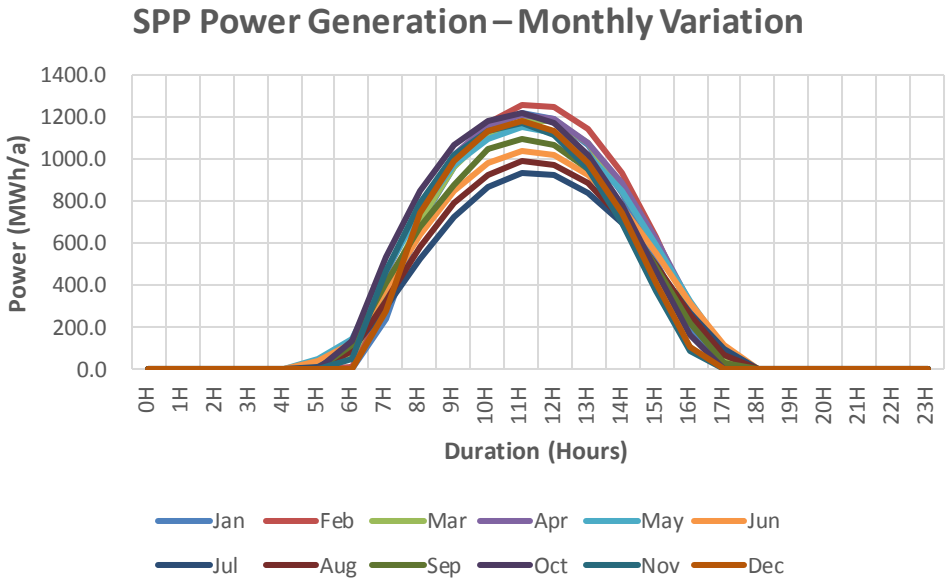


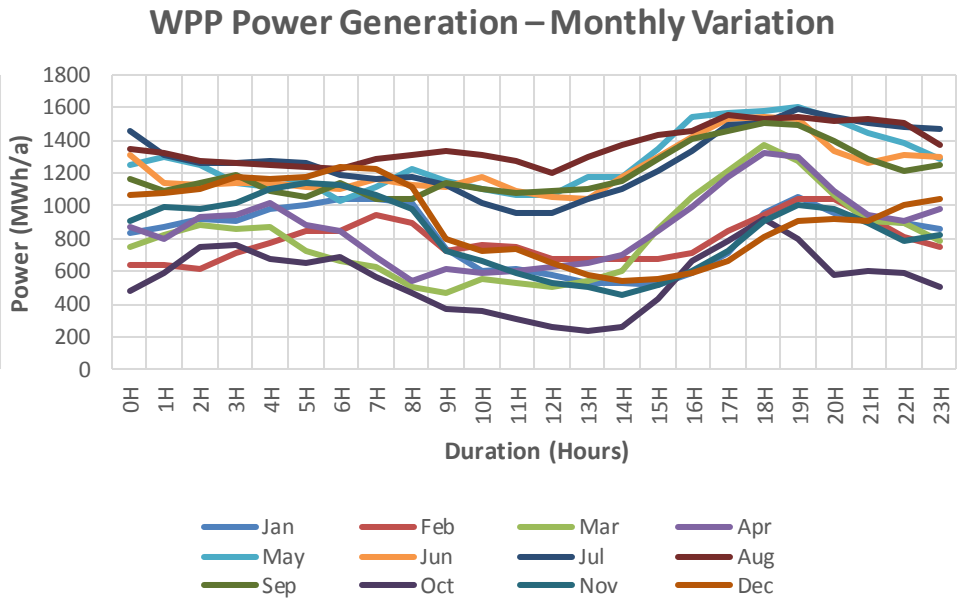
Think Bigger

Since, 1750 MW wind is going to install in one, location, this can be taken as one big wind farm and can be studied for hybridizing solar

Jhimpir HPP Model (Macroscopic Analysis - Regional)

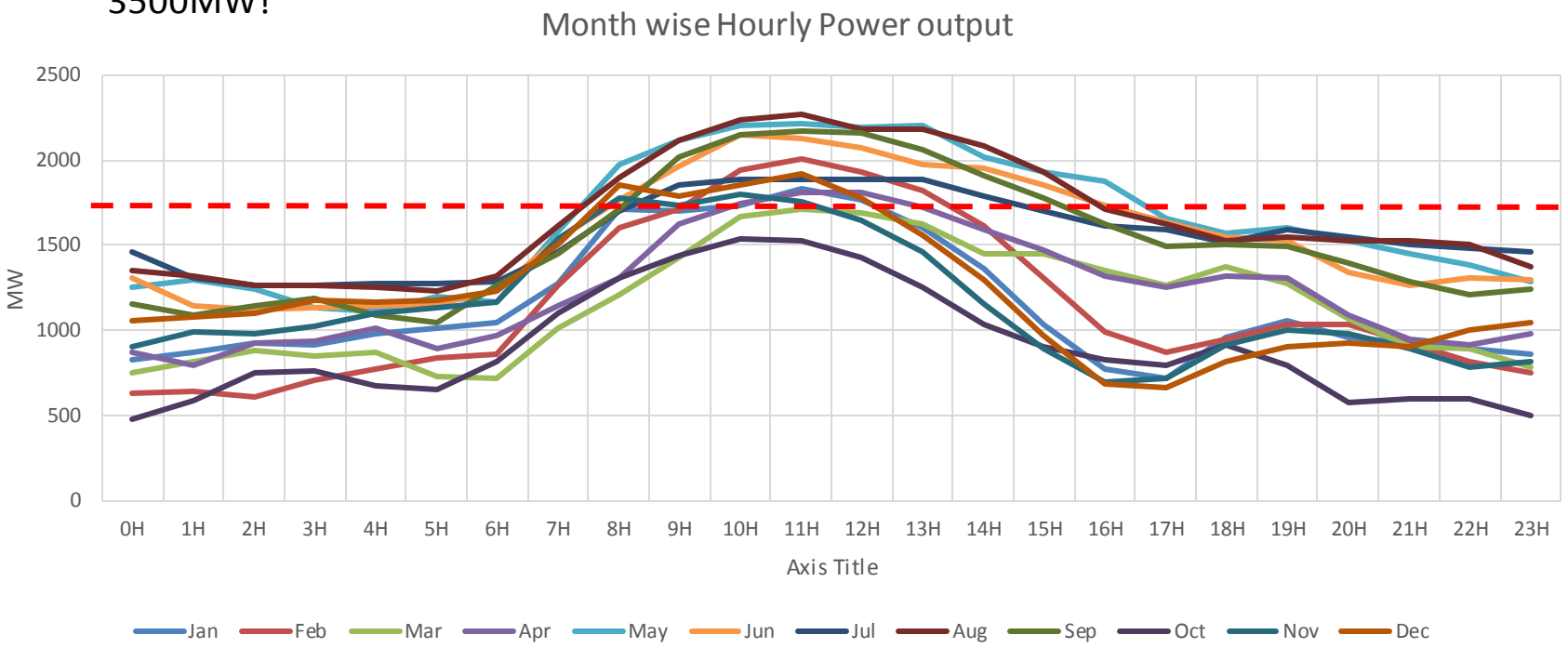
- In addition to the fact that Solar and Wind are complementary during the 24 hours in a day – wind peaks during the night hours, a trend can also be seen during the year where solar irradiance can complement the low wind season.





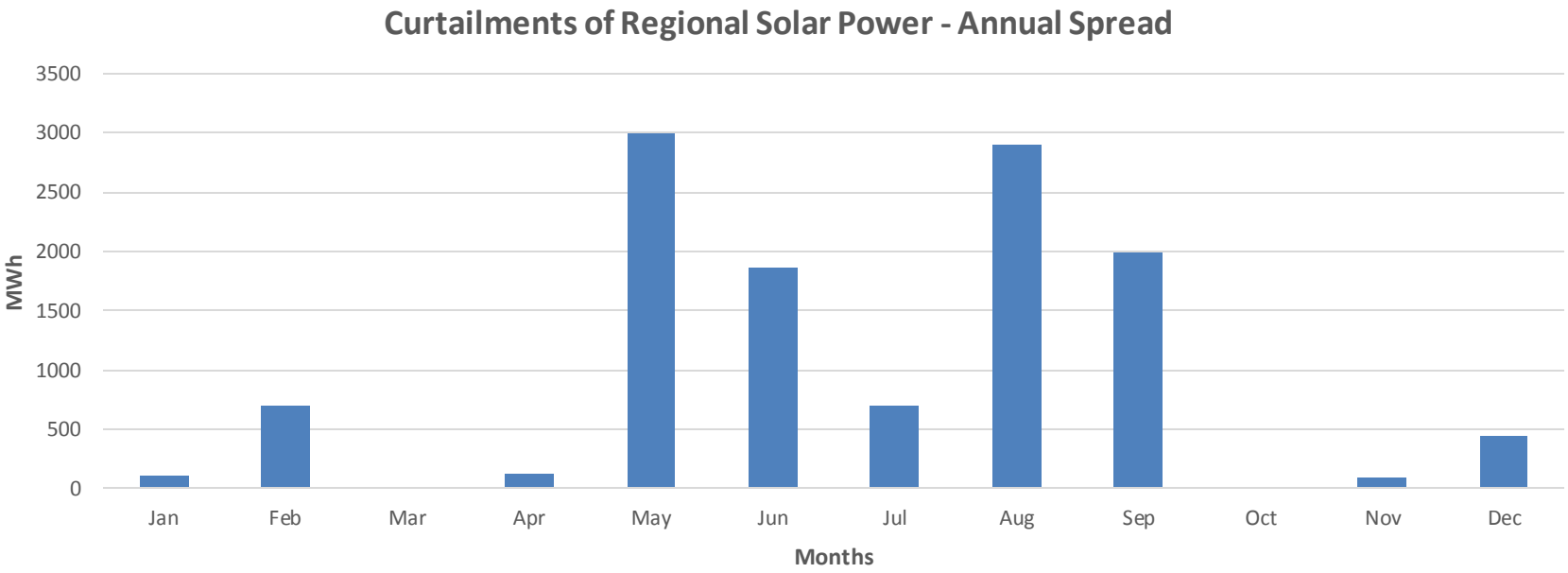
Jhimpir HPP Model (Macroscopic Analysis - Regional)

- The end result holds great significance;
  - The entire region is being considered as an HPP model
  - Curtailments would have to be regional
  - The Wind-Solar Hybrid composition is 50 – 50 MW; total installed capacity would be 2 x 1750 = 3500MW!



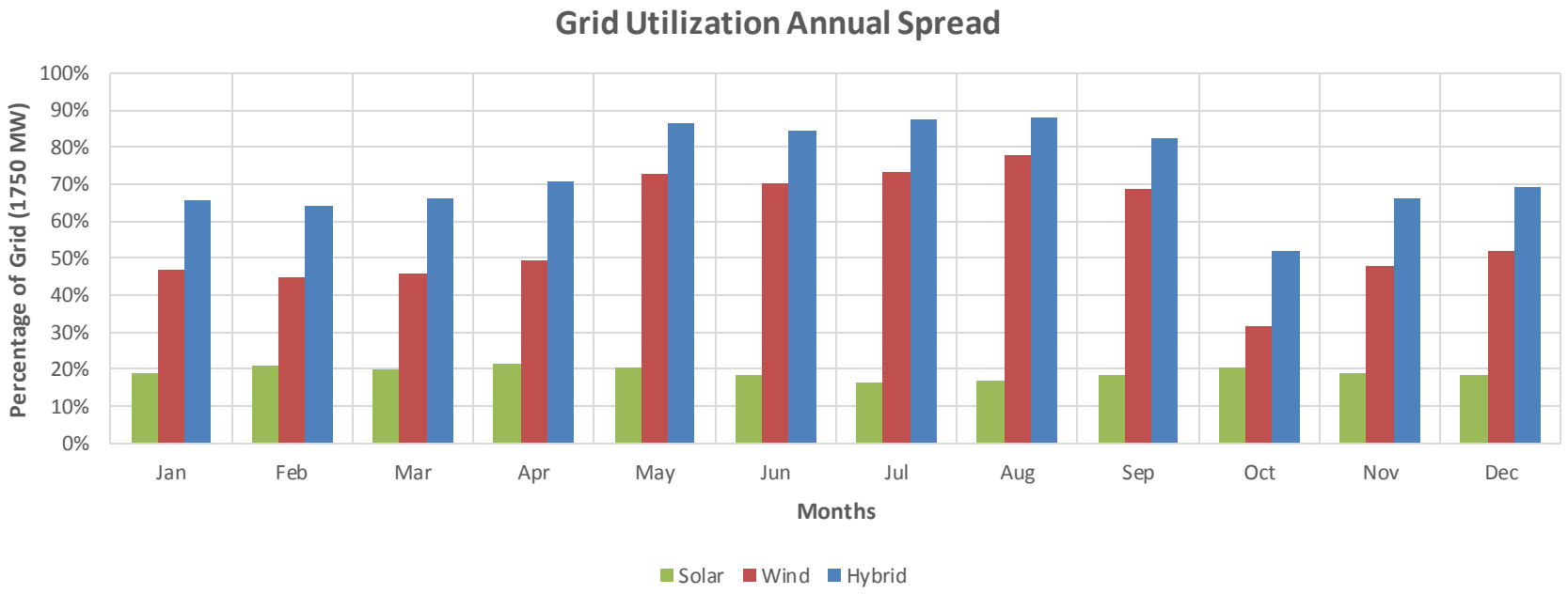
Regional Hybrid Generation (Breaching Threshold = Curtailments of Solar PV)

- As seen previously, the 1750MW barrier is crossed by the region HPP annually… Curtailment!



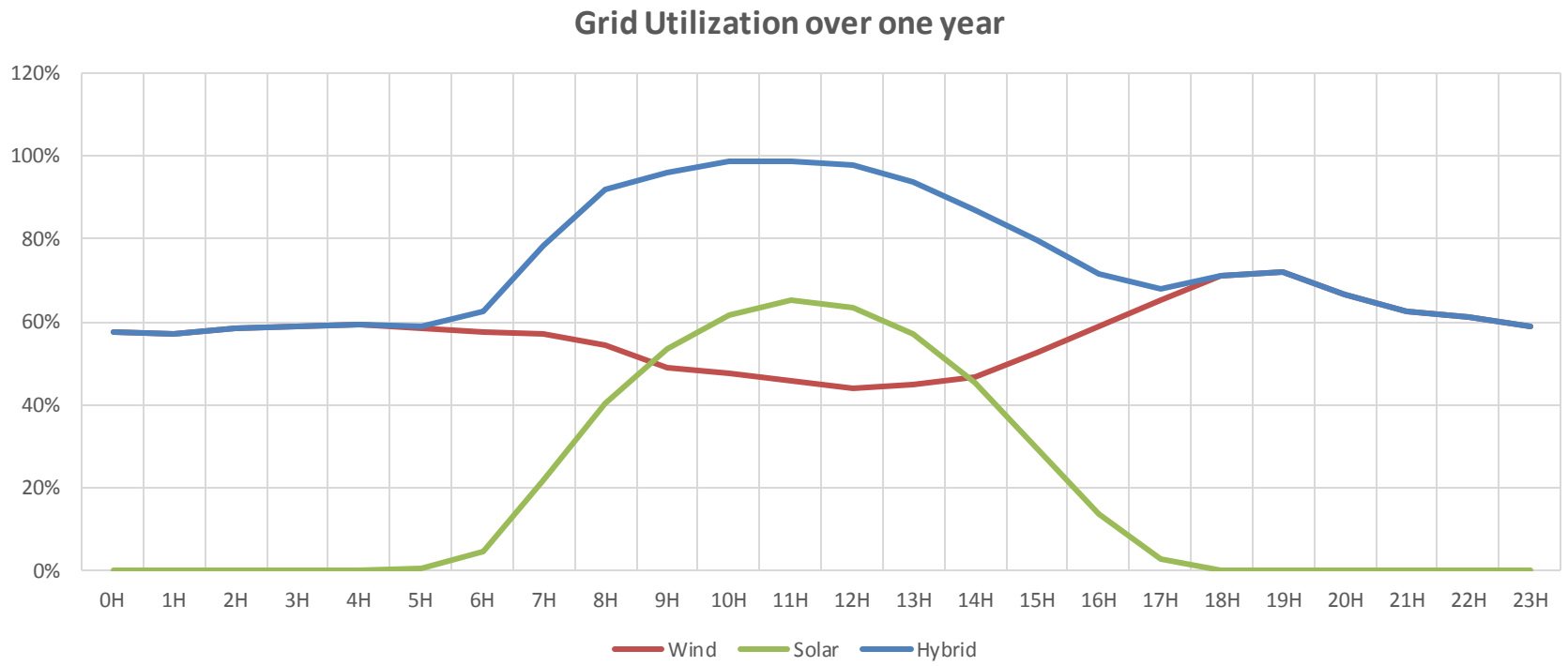
Grid Utilization (Regional)

- Based on how much power is produced from each component after considering their respective capacity factors, the Grid Utilization of the Hybrid System for the region can be visualized as below.



Effective Grid Utilization

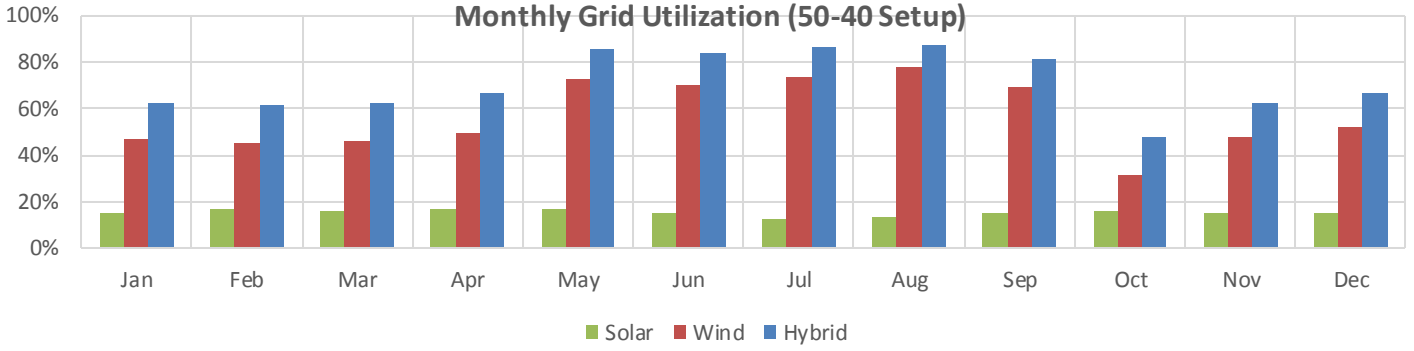
Daily Spread

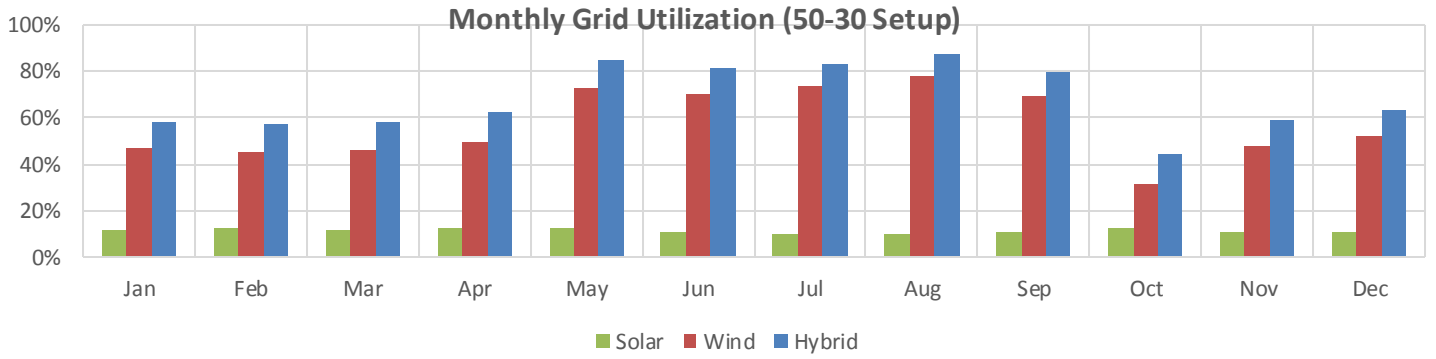


Grid Utilization & Combating Curtailments

- The HPP component shares can be tweaked after considering opportunity costs… Less Solar Power Installation for achieving Lower Curtailments.
- For this purpose 2 variations are being considered
  - **50** MW Wind – **40** MW Solar & **50** MW Wind – **30** MW Solar

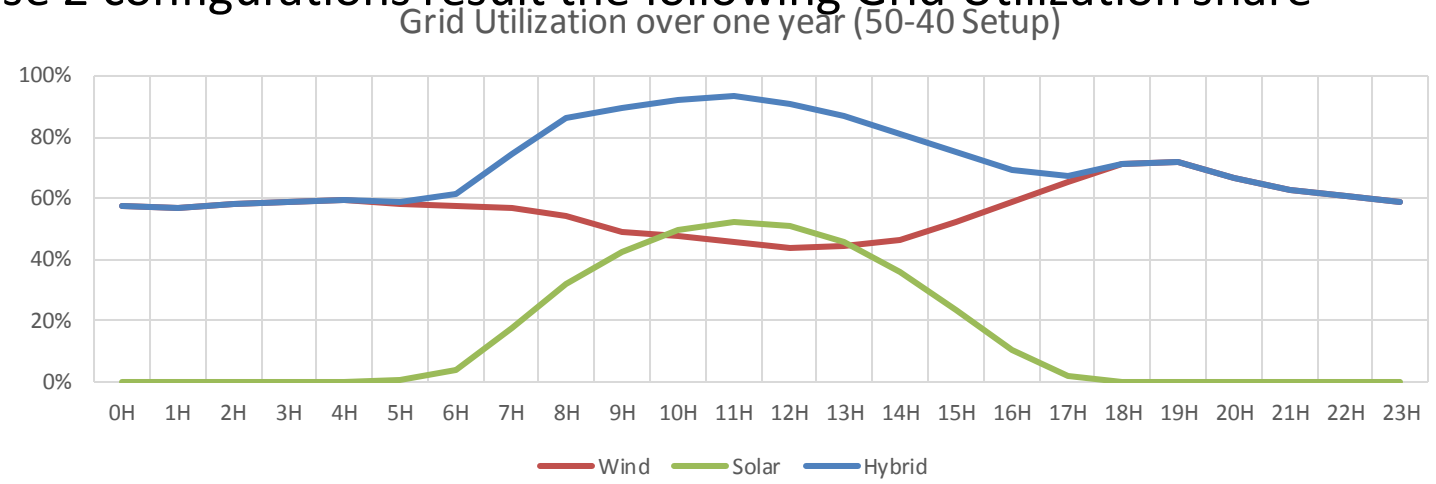
Below is the Grid Utilization share for these configurations at regional level

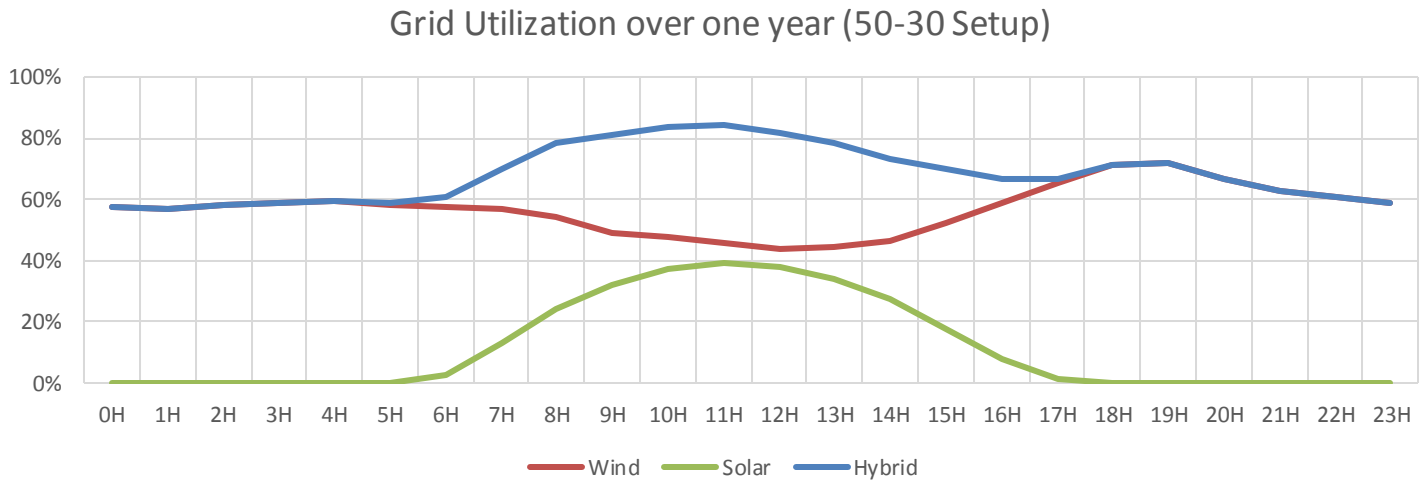




Effective Grid Utilization

- These 2 configurations result the following Grid Utilization share

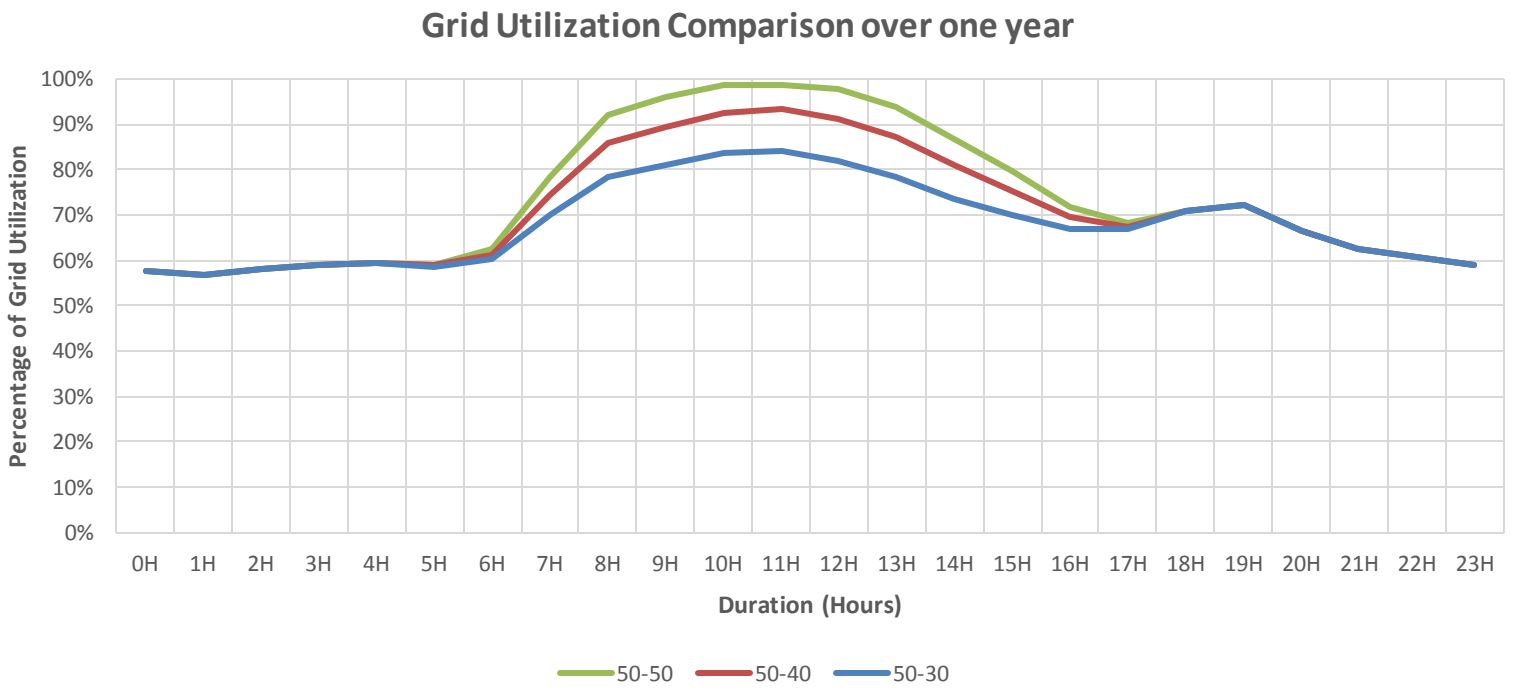




Effective Grid Utilization

Comparison of Grid Utilization under these 3 configurations:

1. 50 MW Wind – 50 MW Solar
2. 50 MW Wind – 40 MW Solar
3. 50 MW Wind – 30 MW Solar

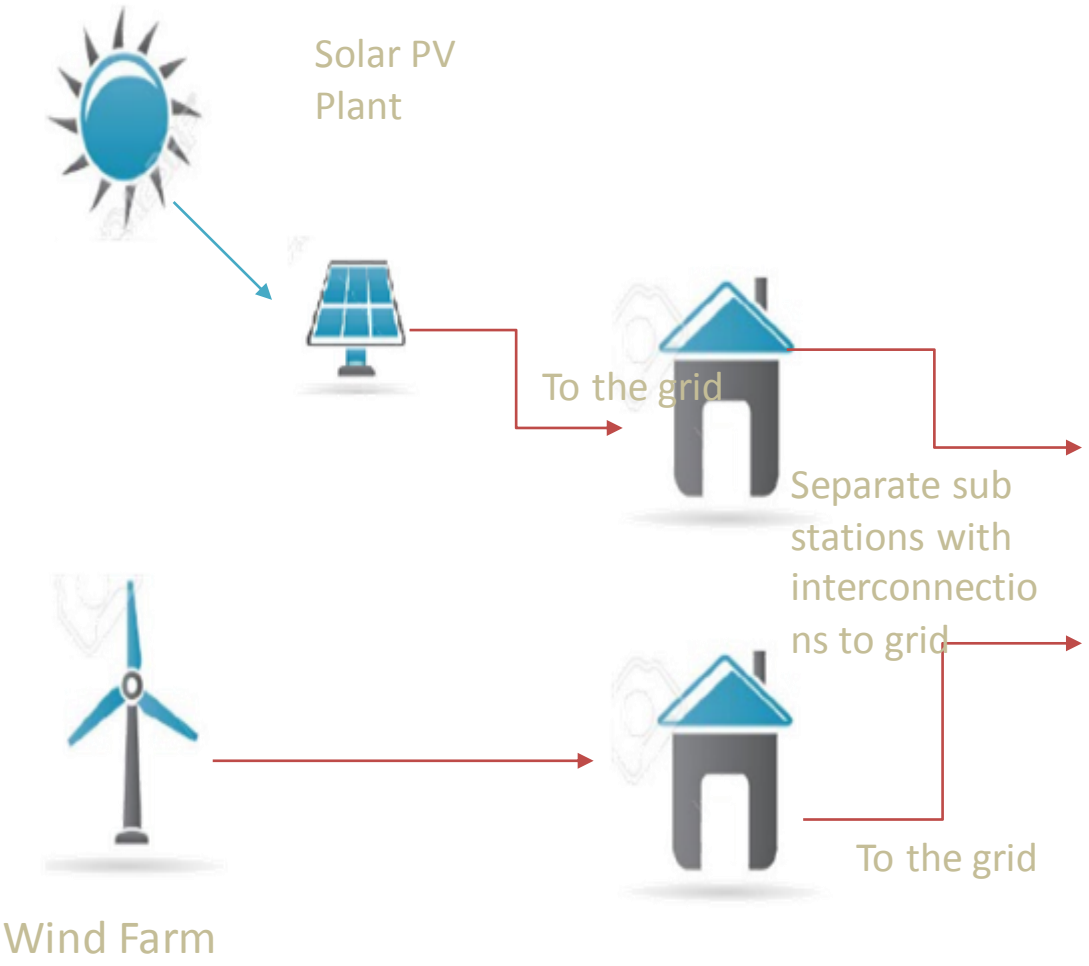


Grid Utilization in numbers

- As opposed to green field power plants, installation of a new grid is not required
- Additional power generation capacity increases the utilization rate of the already installed grid connection assets
- Smaller Solar Power Plant resulted in lesser curtailment as seen in previous graph, the same is tabulated below
- An optimization could be done to look at the perfect combination - which would likely be between these values

Configuration	Tech	Installed Capacity [MW]	Capacity Factor [%]	% Avg. Grid Utilization per annum	Annual Production [GWh/a]	% Annual Curtailments	Solar Curtailments [GWh/a]
50-50	Wind	1750	35.0%	57%	5366	3% - 5 %	459 - 756
	Hybrid	3500	52.7%	74%	8085		
Configuration	Tech	Installed Capacity [MW]	Capacity Factor [%]	% Avg. Grid Utilization per annum	Annual Production [GWh/a]	% Annual Curtailments	Solar Curtailments [GWh/a]
50-40	Wind	1750	35.0%	57%	5366	1% - 3%	122 - 367
	Hybrid	3150	50.4%	71%	7724.528		
Configuration	Tech	Installed Capacity [MW]	Capacity Factor [%]	% Avg. Grid Utilization per annum	Annual Production [GWh/a]	% Annual Curtailments	Solar Curtailments [GWh/a]
50-30	Wind	1750	35.0%	57%	5366	< 1%	< 91
	Hybrid	2800	47.4%	68%	7259		

Alternate Model - Separate sub station configuration



- Solar PV on the buffer land between WTGs installations
- Addition of a new substation for solar power
- Use of existing Grid Interconnection Facility
- Additional assets incorporated under a separate SPV

Hybrid Grid Solar PV Power Projects in Pakistan

- The Power Division, Ministry of Energy approved developing and executing ***solar PV power projects*** within the premises of existing wind power projects under ***grid hybrid mechanism***.
- AEDB has, So far, issued ***Fifteen (15) Letters of Intent (LOIs)*** for such projects and ***six (06)*** more applications are received
- The sponsors inquiring about ***tariff mechanism*** for these projects.
- As per previous RE Policy 2006, there were three options for determining tariff for these projects i.e. **(i)** ***cost plus***, **(ii)** ***upfront***, and **(iii)** ***competitive bidding with/without benchmark tariff.***
- The RE Policy 2006 has expired; the govt needs to specify power procurement mechanism from existing grid hybrid wind-solar PV projects

Hybrid Grid Solar PV Power Projects with Existing Wind Projects in Pakistan

Benefits for Purchaser/Operator regarding Hybrid Grid Projects

- Better utilization of the existing transmission system and
- Better performance without investing any additional money
- Expectedly cheaper electricity from solar PV

Limitation of land and grid

- Only those companies are eligible that have installed or are installing wind power plants.
- Land and grid slot is specific for the existing wind power projects.

Energy Curtailment Risk

- Risk of power curtailment to avoid crossing allowable capacity is with Sponsors

Hybrid Grid Solar PV Power Projects with Existing Wind Projects in Pakistan

Security Documents, Enterprise Structure, Financing and Interconnection

- The Sponsors will:
  - establish separate special purpose company to undertake the project;
  - sign separate project documents with the power purchaser and AEDB;
- Lenders Limitations; land being mortgaged for wind power projects.
- Separate metering for the solar PV power plants
- The solar PV project complex might include whole infrastructure including separate sub-station with allied infrastructure and Interconnection arrangements

Operating Requirements

- Operating requirements for solar PV plant are different and unique, would require separate O&M arrangements

Hybrid Grid Solar PV Power Projects with Existing Wind Projects in Pakistan

Limitation for Competition

- Open competition is not possible since land, interconnection and grid slots are specific for existing wind projects
- Cost escalations and monopolization among sponsors are associated risks

Limitation for Cost Plus Tariff

- Unattractive in several ways such as:
  - –Projects are likely to quote escalated costs
  - –Projects will try to shift risk or seek higher tariffs to absorb curtailment
  - –Cause increase in project development period
  - –Put projects in a circular situation between tariff, costs and financing numbers approved by NEPRA and contracted with contractors & lenders
  - –Delays in projects becoming operational

- **A one-time Upfront Tariff seems appropriate Choice for these hybrid projects**
  - –Investors' risk - upfront tariff assumes government knows amount of curtailment (or losses that the project is likely to have), which might not be the case

New Wind-Solar Hybrid Projects in Pakistan

Quetta Corridor

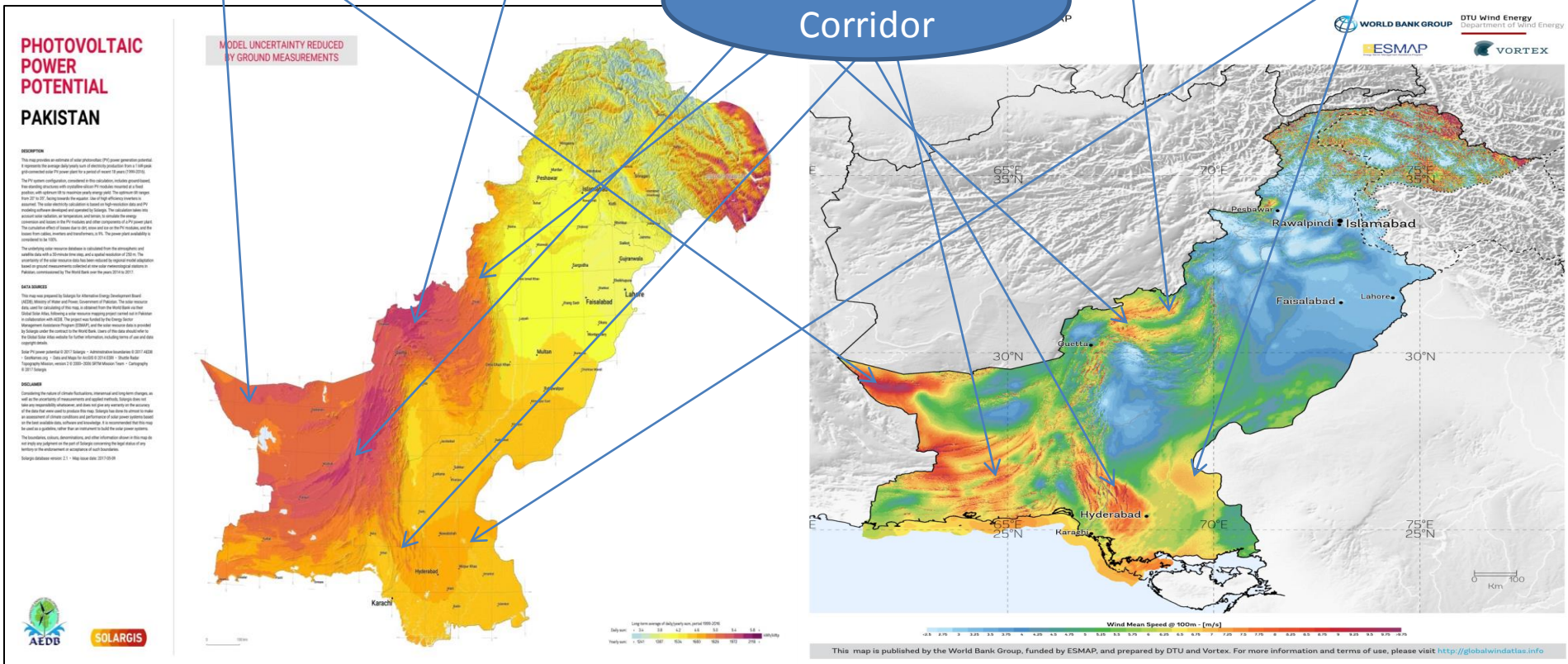
DG Khan Corridor

Chaghi – Taftan Corridor

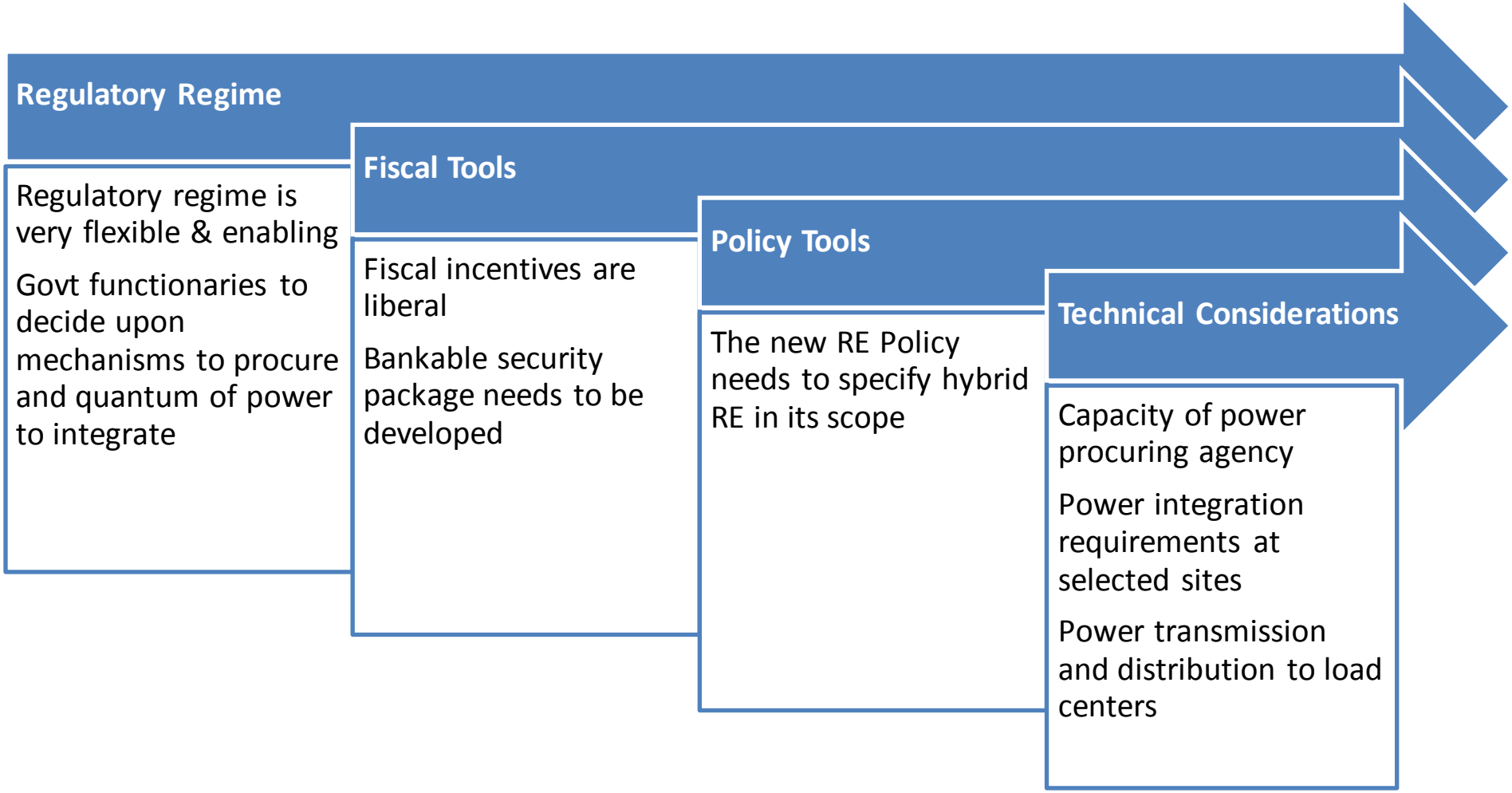
Turbat-Gwadar Corridor

Nagarparkar-Islamkot Corridor

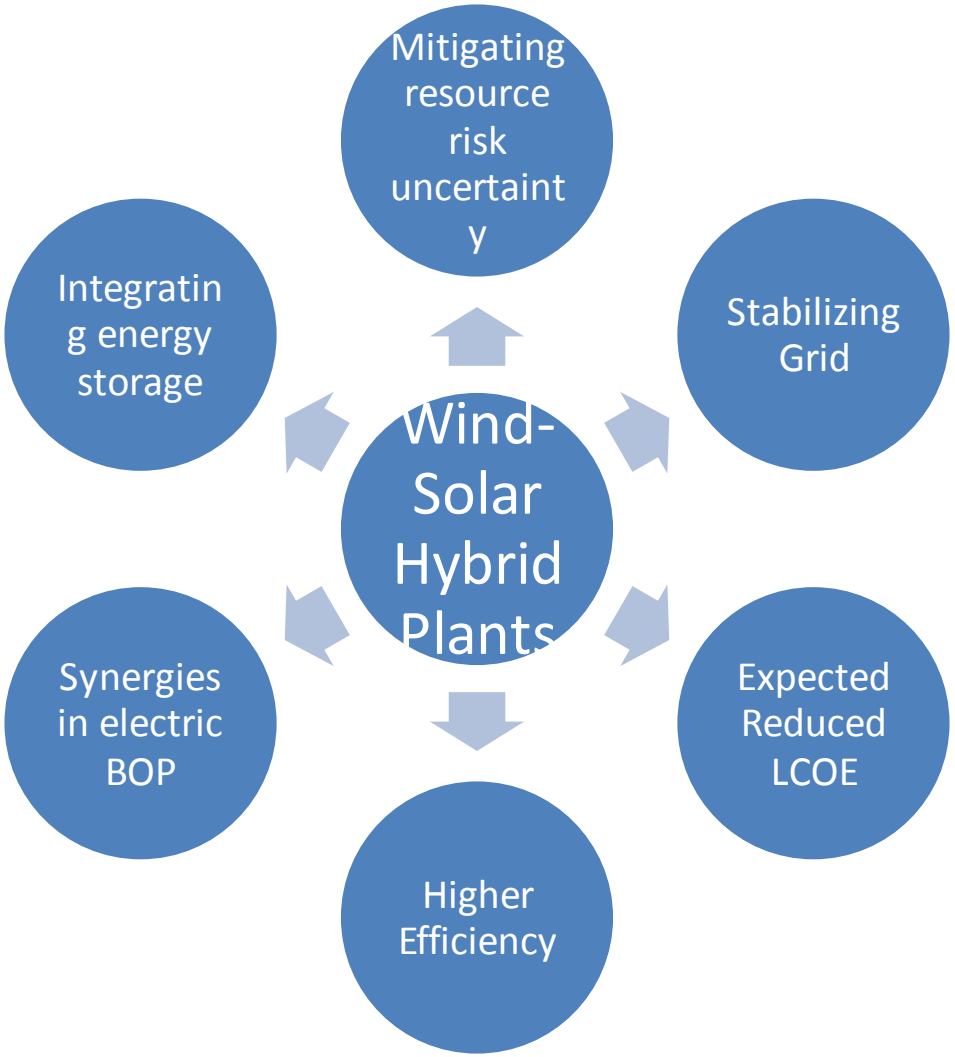
Jhampir-Gharo Corridor



Regulatory, fiscal and policy tools for promotion of hybrid RE concept



New Wind-Solar Hybrid Projects in Pakistan



New Wind-Solar Hybrid Projects in Pakistan

Steps Needed to Develop Wind-Solar Hybrid Projects				
Clear RE Policy be announced supported by bankable security documents	Zones / corridors be identified / developed to attract investment	Power evacuation infrastructure be developed at selected sites	Power Procurement Capacity be designated for each year	Transparent Competitive Bidding be carried

Way Forward

- Existing projects be procured on upfront tariff basis
- Bankable Security Package be developed managing technical and financial issues
- First choice for new power procurement at parks should be RE-Hybridized
- Energy Storage should also be considered for stable power supply - a ramp rate for power can be specified for companies to look at storage as a way to smooth out plant power outputs

Thank you.