Beyond IGCEP 2022

An Ambitious Renewable Energy Scenario for Pakistan

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8.2 | The Experts in Renewable Energy

Study on behalf of Agora Energiewende

Content

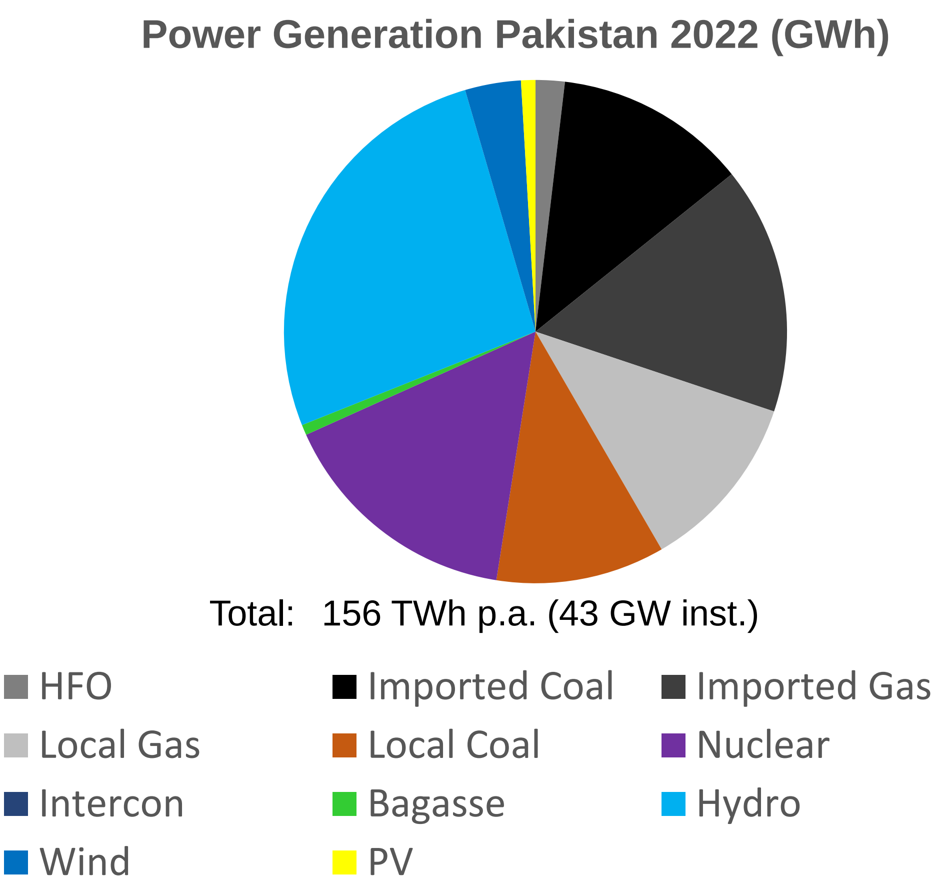
1. Introduction and Background

Background & Objective of the Analysis: More VRE into IGCEP

- NTDC has presented the **IGCEP 2022** in September 2022, which lays out a roadmap for generation capacity planning until 2031.
- This IGCEP is much more progressive in terms of wind (7 GW) and solar (14 GW) power than the last version (2021) but still includes substantial further investment into local coal and other fossil fuel plants.
- This analysis discusses and evaluates **scenarios with more PV and wind** energy than laid out in the IGCEP 2022 as an input for the IGCEP 2023 to validate such scenarios.

Pakistan Energy Mix

- Pakistan historically strongly relies on hydro power.
- To cover demand-supply gap, heavy capacities in thermal plants have been added over the years: coal, heavy fuel oil, gas and nuclear. Apart from some domestic coal and gas, all fuels are imported.
- Solar and wind are yet at their initial stage (1% (1 GW) and 4% (6 GW) of total energy).



2022: A New Situation in the Energy Market

Due to **developments in the global energy market** since March 2022, a completely new situation has evolved also for Pakistan:

Imported coal and gas prices have doubled in 2022
- ➡ major increase for Pakistan‘s electricity cost
- ➡ rising electricity prices and loadshedding
- ➡ severe economic and social problems

In July/August 2022, **Government of Pakistan (GoP) decided to maximise renewable energy, especially solar,** in the Pakistan energy mix on a priority basis.

Local coal
- \+ low-cost
- − high CO_2 emissions
- − long lead time

Solar PV & wind
- \+ nearly as low in cost
- \+ no CO_2 emissions
- \+ very short lead time (solar)

Study framework and scope of the analysis

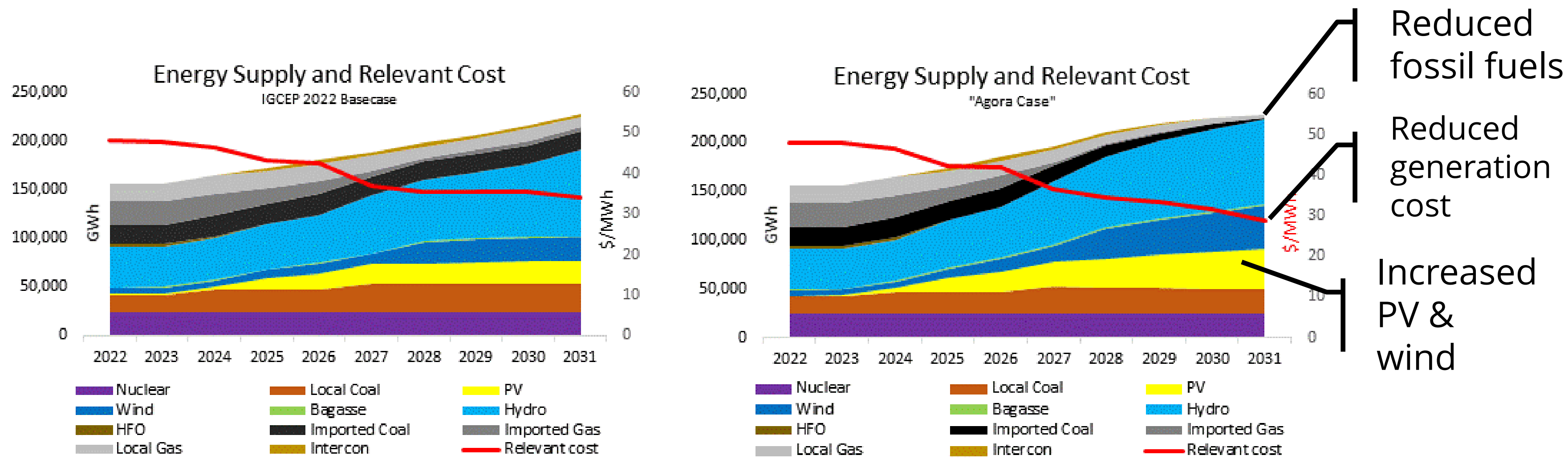
- Objective of the analysis: “**Would further wind and solar plants (beyond IGCEP 2022) be financially beneficial** (by replacing fossil energy)?”
- Method:
  - 1/ **Capacity expansion** focuses on the 2030/2031 of the IGCEP by NTDC (hourly resolution)
  - 2/ **Grid analysis** focuses on 2028 of the TSEP by NTDC (no grid planning data available beyond that)
- The following options are evaluated:
  - **VRE as per IGCEP 2022** (base case)
  - **Optimized VRE proposal**: Increased VRE capacities (incl. curtailment), 5 GW solar+wind plant at Chaghi (Balochistan), load shift from night to day through time-of-use tariffs, flexible coal and hydro power dispatch
  - **„Hydro storage“**: Same as (2) plus using additional pump storage capacity for new HPP plants

2. IGCEP 2022 and Optimized Option

VRE Generation can increase further to 33 GW: Analysis

→RE share for 2030 can go up **from 35% to 60%** with decreasing cost**.**

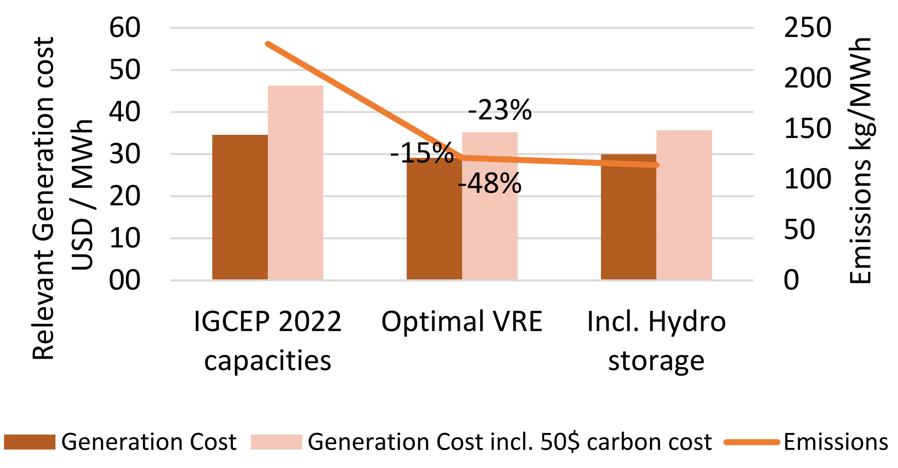
→2030 spot year: Peak demand 45 GW (29 GW in 2022), VRE 33 GW (3 GW), thermal + hydro 49 GW (40 GW).



Increasing VRE by +60% brings Cost and Emission Benefits

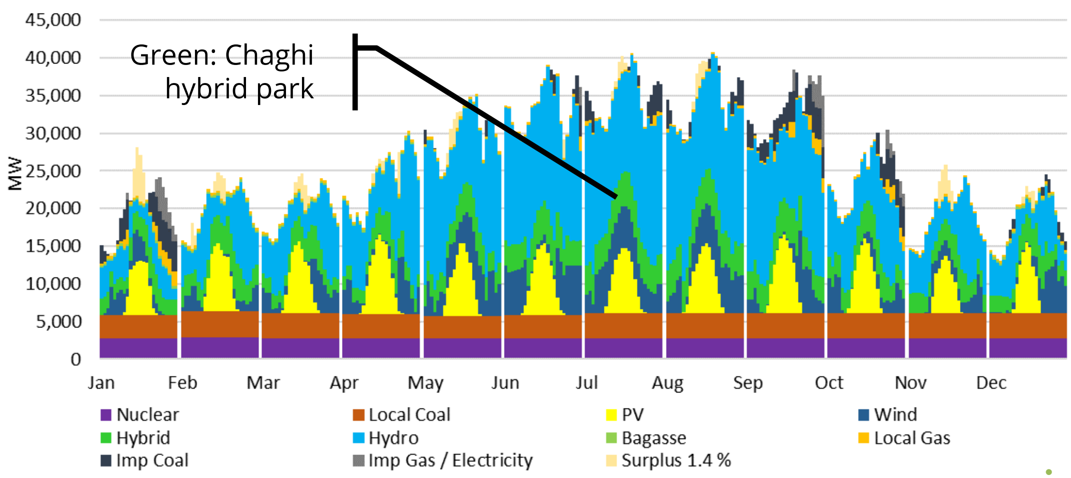
- Generation **costs** in 2030 can **reduce by further 15%, emissions by 48%**
- For this, PV and wind capacities in 2030 have to be increase increased by **+60% (33 GW instead of 21 GW).**
- This includes all costs of VRE (CAPEX and OPEX) while for thermal plants, conservatively, no savings in CAPEX have been assumed here and only fuel savings are considered.

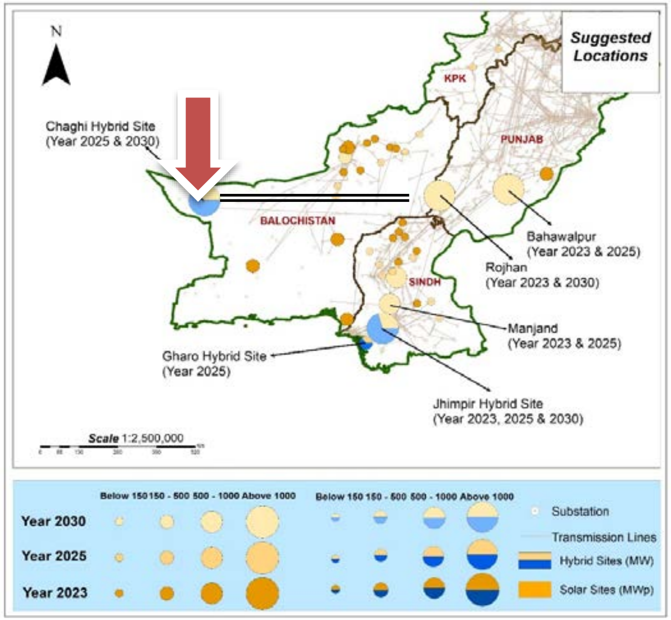
PV GW	**13.7**	**21.4**	**22.2**
Wind GW	**7.0**	**12.0**	**12.0**
VRE Total GW	**21**	**33**	**34**
Hydro GW	**23**	**23**	**23**
Thermal GW	**26**	**26**	**26**
Peak Demand (	**45**	**45**	**45**



5 GW Chaghi PV-Wind Park: Excellent Correlation with Demand

- Park Chaghi: 5 GW wind, 3.75 GWp PV, 5 GW HVDC line
- **65%** utilisation of dedicated HVDC line estimated (load factor)
- Plus excellent correlation with demand and low cost:

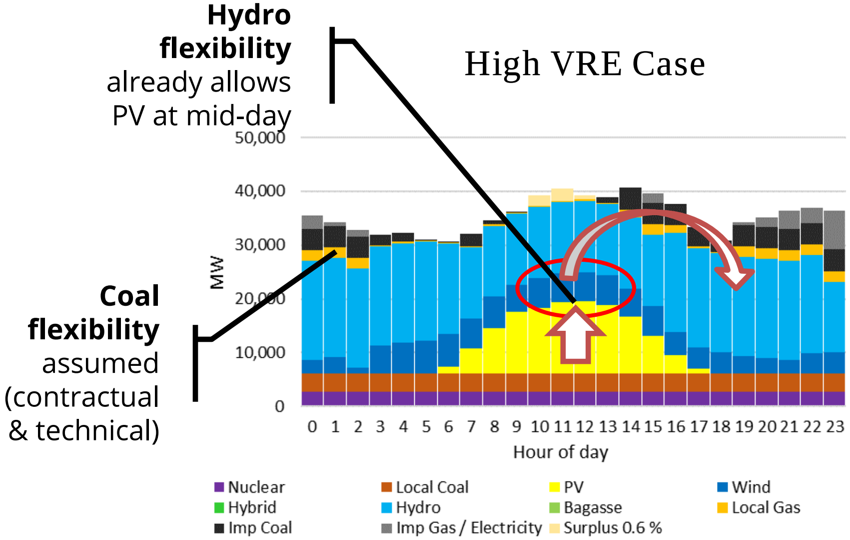


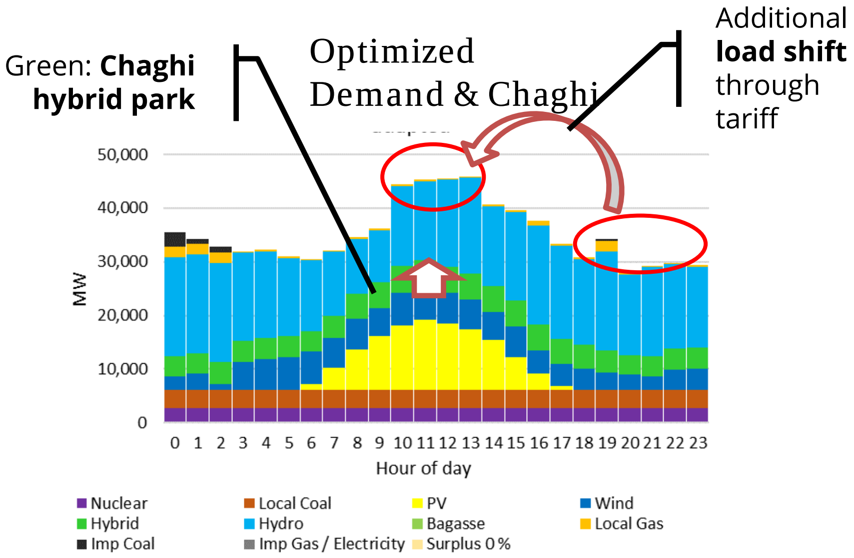


Chaghi site and HVDC connection as per *Locational Study (WB, 2020)*

Shifting Demand allows further Savings – Snapshot (July 2031)

→ Shifting load from night to day (through a „PV tariff“, i.e. lower tariff at mid-day) further fossil energy can (at night) can be replaced by VRE power (during the day).

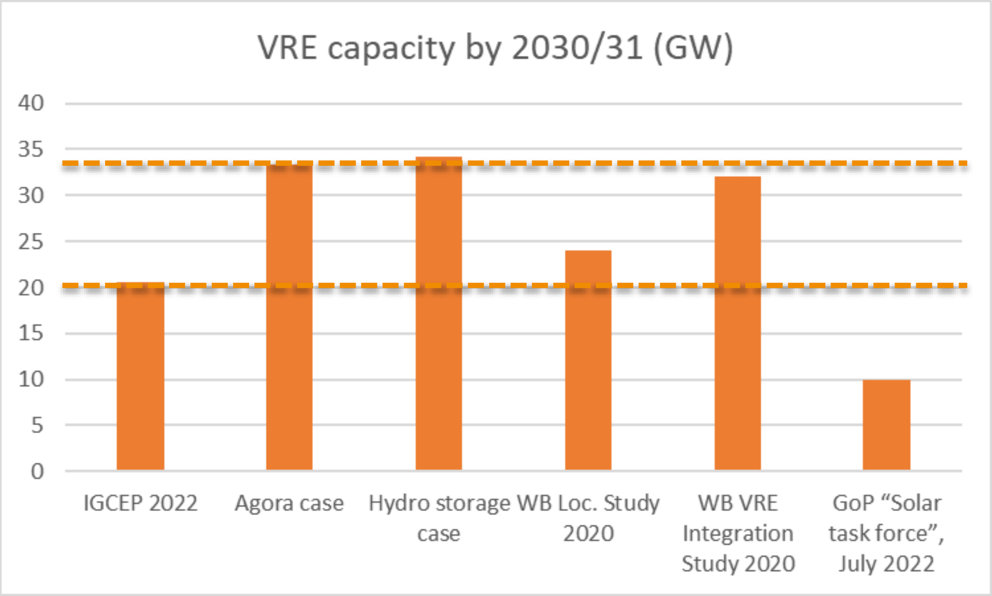




Optimized Scenario is in line with other Scenarios - IGCEP should be more ambitious

- Other studies have been done on the optimal or manageable VRE numbers for Pakistan.
- **All studies suggest higher numbers of VRE** than IGCEP 2022.
- The new GoP Solar target asks for 10 GW of PV "soon", which would be already 50% of the total PV and wind numbers for 2030 by the IGCEP.

➢ **The IGCEP 2022 numbers are moderate and should be increased.**



33 GW of VRE by 2030 – Where from?

- → 33 GW of VRE connected by 2030 does not mean that 33 GW of evacuation capacities have to be constructed in the grid infrastructure.
- → The envisaged VRE capacity is located across the country at different voltage levels, allowing the usage of existing infrastructure.
- → By 2028 (=current TSEP target year), 7+9=16 GW of VRE need to be integrated at transmission level.*)

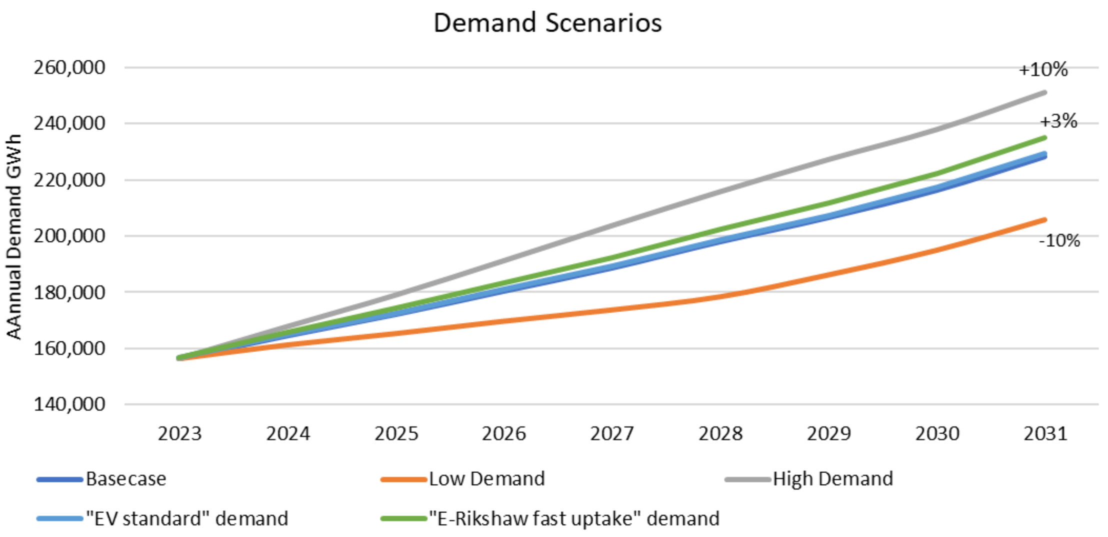
2030	Total GW installed	Where
Wind	12 GW	Chaghi, Jhimpir, others
PV	21 GW	Utility-scale: 13 GW Chaghi Park: 4 GW Feeder-based: 2 GW Net Metering: 4 GW
2028	**Total GW installed**	**Grid capacities required**
Wind	7 GW	**7 GW**
PV	14 GW	**9 GW**

*) Feeder-based and net metering plants do not require transmission grid infrastructure; furthermore, 1 GW of PV nameplate capacity are typically connected to 0.8-0.9 GW of evacuation capacity with a negligible amount of curtailment (typical inverter rating).

3. Scenario Analysis

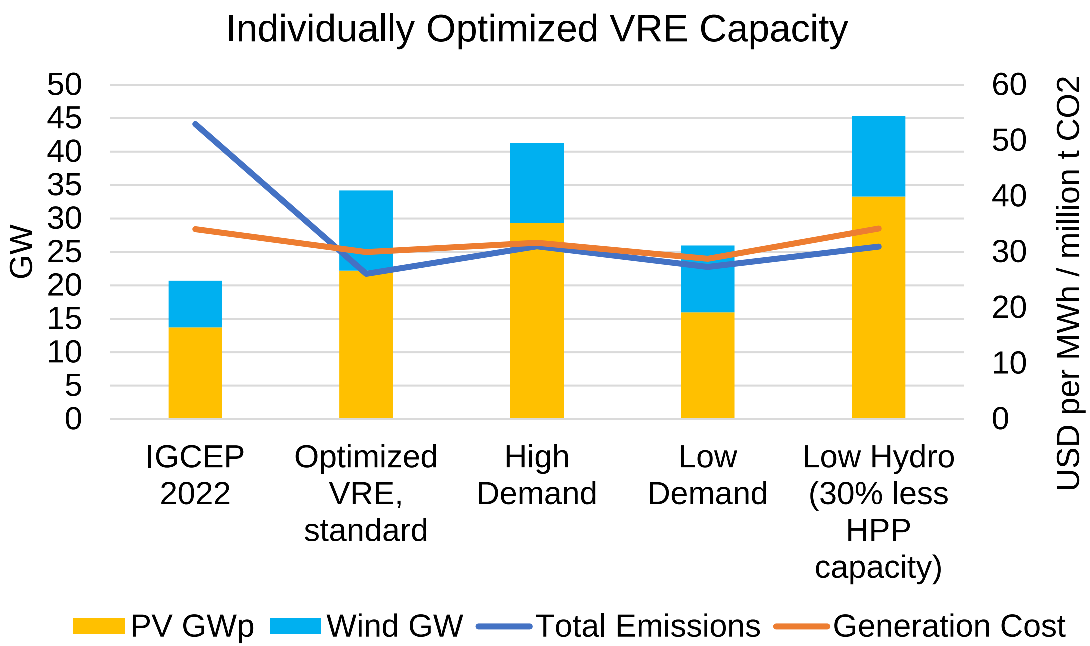
Scenario Analysis

- a) **IGCEP 2022** assumptions (base case scenario)
- b) „**High demand**“: Demand 10% higher
- c) „**Low demand**“: Demand 10% lower
- d) „**Electric Vehicle“ (EV)**
- e) „**Hydro delay**“: Hydro power (HPP) capacity in 2030 of 30% less
- f) „**Carbon cost**“: Financial scenario: Applying a carbon cost benefit



"Higher VRE" performs better across all scenarios

- For **different scenarios, different VRE capacities** are optimal.
- In any case (even for low demand, -10%), **optimal VRE is higher** than mentioned in the IGCEP 2022.
- As VRE has quick implementation time, the capacities to be tendered can be **adjusted from year to year**, if needed.
- The **5 GW Chaghi park** should be pursued for all scenarios.



EV Market Scenario for Pakistan

- **Small EVs** like e-rikshaws can create **disruptive scenarios** if they have a business case in the transport sector, replacing diesel- or CNG-fired mini-taxis at scale:

- E.g. in Bangladesh, between 2010 and 2017, **1 million** of locally built "*easy bikes*" (=**local e-rikshaws**) got on the streets, and numbers now in 2022 are supposed to lie between 2m and 4m.[1)]

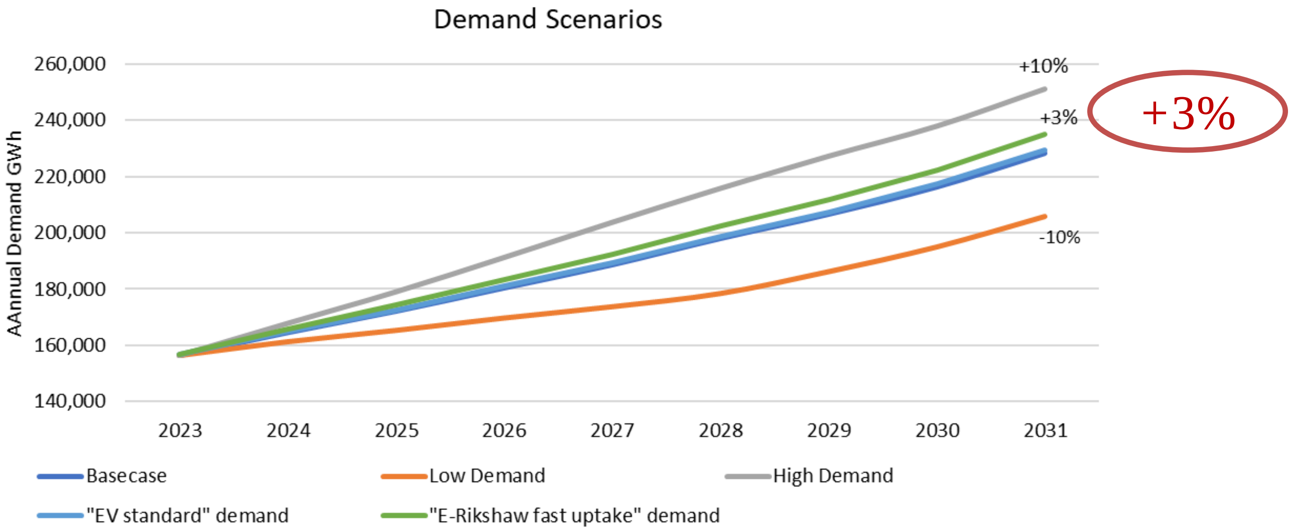
- For Pakistan, such a development could theoretically happen as well. However, local transportation in urban areas seems to be more toward **motorbikes and cars – which follow a much slower replacement curve** as they can't be built with the same cost savings.

EV illustration (Photo by Marc Heckner on Unsplash)

1) https://www.tbsnews.net/features/panorama/easy-bikes-we-them-we-them-not-352426

EV Market Scenario for Pakistan - Result

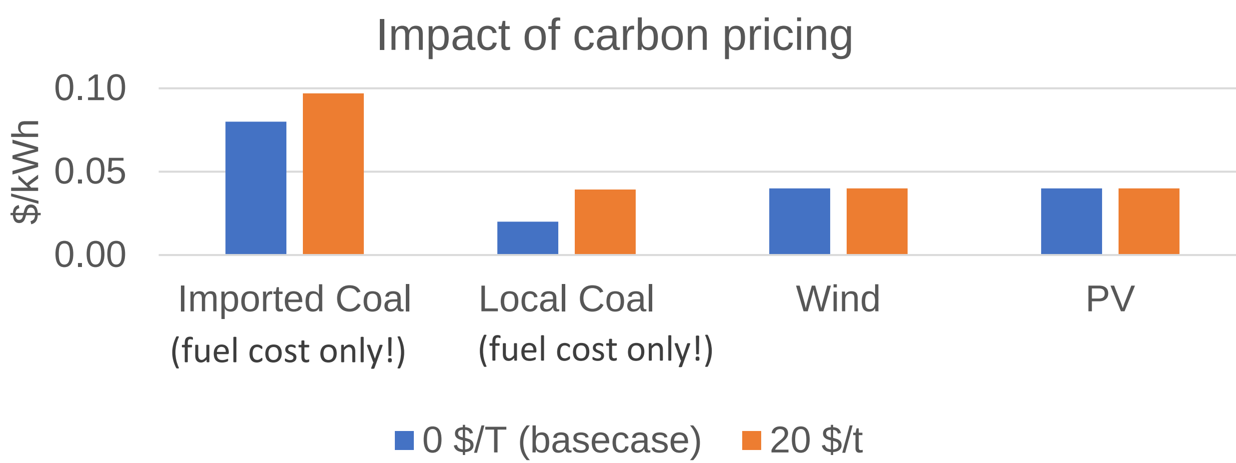
- Assuming a massive growth of e-rikshaws (like in Bangladesh since 2010), additional power demand is **not more than 1.3 GW / 6,000 GWh p.a.** (approx. 1m e-rikshaws)[1]. This equals a "+3%" increase in demand for 2031, which is negligible compared to the already discussed scenarios of ±10%.
- Assuming an standard development (i.e. starting slow) for regular EVs, for **2030, only 200 MW[2] / 900 GWh p.a.** of additional power demand is expected for EV charging (0.2m EV cars and 0.2m EV bikes), assuming a rollout starting today.



1) Assuming regular EVs with linear growth (which is much less likely) terminating at the same vehicle number by 2032 leads to very similar numbers (1.4m EV cars and 1.4m EV bikes).
2) This assumes that charging takes place evenly across 12 hours of a day (peak demand will be higher).

20 $/t CO2 of Carbon Pricing offsets Cost Gap between Local Coal (Fuel Price only!) and VRE

- International trends go toward pricing CO_2 emissions
- Even a low carbon pricing of only 20 $ per ton of CO_2 would put local coal (fuel cost only!) on par with PV and wind (in IGCEP cost assumptions).
- These cost assumptions by IGCEP are already quite favourable towards coal and probably exclude local environmental impacts etc. – if these were included in price, coal would also be more expensive.



4. Recommendations

VRE in IGCEP 2023 should be increased to 33 GW by 2030

- **Increasing VRE to 33 GW by 2030** (+60% from planned 21 GW in latest IGCEP) has high benefits and is stable under all scenarios.
- **Cost savings** of 15%
- **Emission savings** of almost 50%
- For any unexpected change in demand or others, the annual tender capacities of PV and wind can be **adjusted flexibly** in the future.
- Further savings can be achieved through *avoiding* some upcoming coal plants (further analysis needed).

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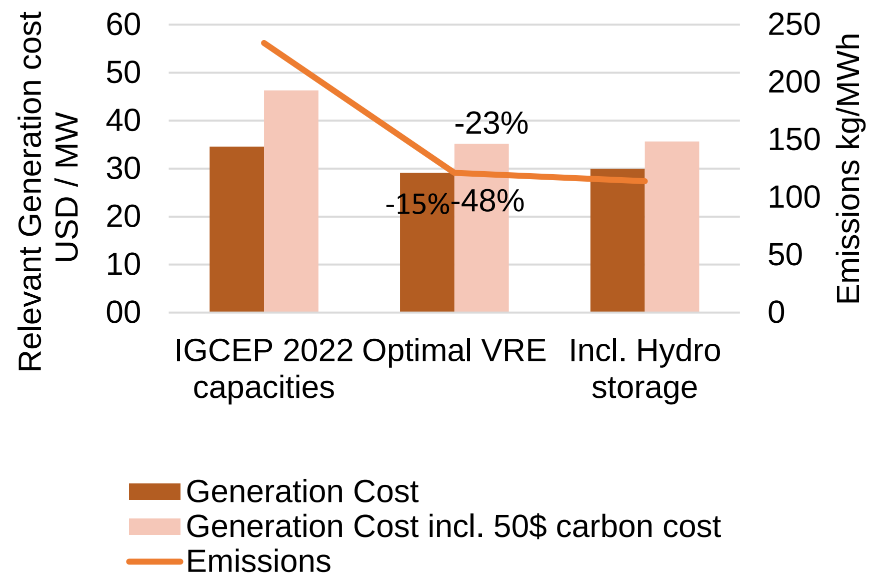
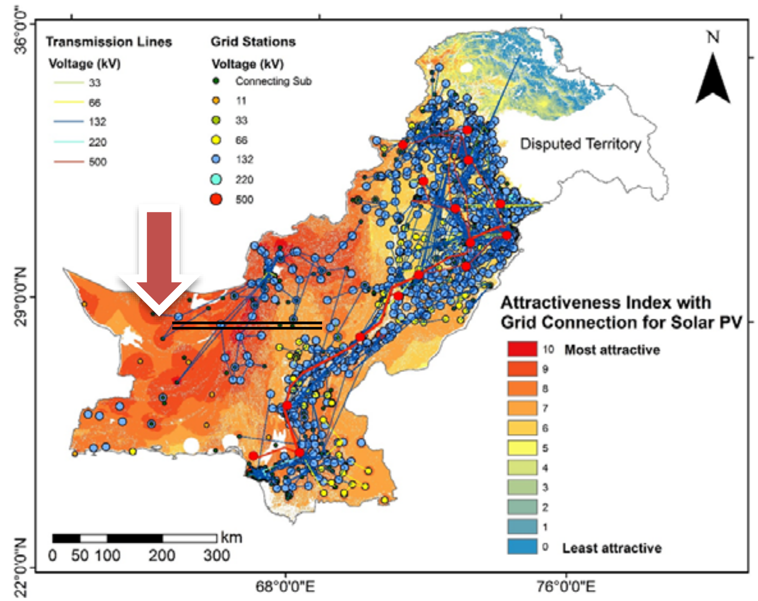


Chaghi Connection and further Infrastructure needs to be initiated immediately

- The multi-GW PV / wind location in **Chaghi region**, western Balochistan, is a cornerstone of the envisaged future VRE power suppy for Pakistan.
- A **comprehensive feasibility study** should be done for its development: Tender options (IPP, PPP) and modalities, connection to major load centers, cost and finance options; regulatory aspects, security concept.
- The implementation of an **HVDC line for Chaghi** as well as **other grid reinforcement** needs to be **initiated** at the earliest; for this; further **studies** are necessary.



Grid infrastructure and PV attractiveness index as per *Locational Study (WB, 2020)* and required HVDC link

Flexibility is Key: Hydro Power (HPP) and Flexible Coal

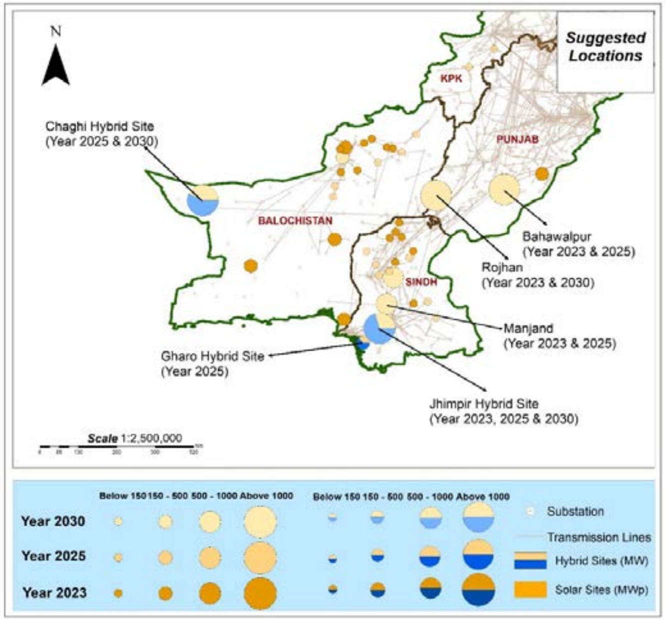
- A high amount of flexibility in dispatch is required to accommodate the high VRE amounts. Therefore:
- **Coal plants need to be operated as flexible as possible**: Contractual clauses to be questioned; technical flexibility to be integrated.
- **HPPs need to be properly studied on their dispatch flexibility** – and be operated based upon this flexibility. Every flexible kWh saves money.
- Upcoming HPPs should be planned and built with a lower basin and **reverse-pumping infrastructure**.
- **Further studies to be done** on system reserve requirements under high VRE

HPP illustration (Photo by Lode Lagrainge on Unsplash)

VRE Tender: Geographical Spread, Tender Plan, Hybrid Plants

The best sites (resulting in the lowest tariffs) for utility-scale PV and wind power have been evaluated in the Locational Study 2020 (World Bank):

- → **Tenders must be location-specific** for highest benefit. GoP should **offer specific stretches of land** which are government-owned.
- → A **reliable, year-wise tender plan** for quick competitive bidding will give investors confidence.
- → For infrastructure and cost savings, tenders should **combine solar and wind power into hybrid parks** on the same evacuation line (or same substation).



Optimal PV and wind sites as per *Locational Study (WB, 2020)*

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Annex

Value of Renewable Energy for Pakistan

Pro´s for solar and wind

- ✓ lowest LCOE
- ✓ no fuel cost nor supply risk
- ✓ lowest CO_2 emissions over lifetime
- ✓ low supply chain risks
- ✓ low development time
- ✓ decentralized technology, i.e. at current penetration levels, no grid reinforcement are needed

The variability of solar and wind need to be managed:

- Decentralized development
- Hydro power dispatch can compensate fluctuation of solar and wind without any additional CO2 (depending on seasonal availability)
- Where needed, gas plants can also help in compensating dispatch.

Strategic Options evaluated

The following strategic options are evaluated:

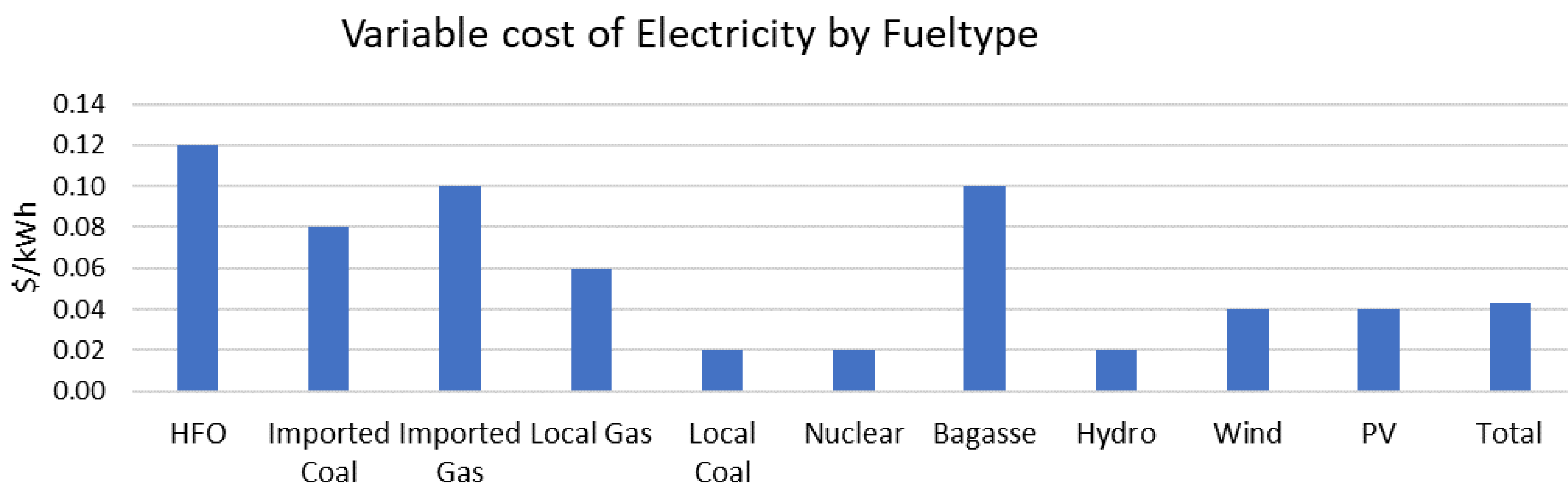
1. **IGCEP 2022 (base case)**
2. **Optimized VRE proposal**
   - **Increased VRE** capacities (allowing curtailment)
   - **Development of Chaghi** (Balochistan) as a 5 GW hybrid (solar + wind) park, connected to Punjab **=>** HVDC line
   - **Inducing some load shift** from night to day (= time-of-use tariffs)
   - **Optimized hydro power dispatch** (more flexibility)
3. **„Hydro storage"**: Same as (2) **+** using additional pump storage capacity for new HPP plants **=>** using excess energy

Methodology for the IGCEP-based Scenarios

- Capacities and cost of **IGCEP 2022 defines baseline**
- The focus of the analysis is the final year, the **fiscal year 2030/2031**
- Starting point for all scenarios is the **hourly electricity generation** data by fuel type as per IGCEP 2022
- Impact of **higher VRE Share** than IGCEP
- Results are **input for the IGCEP 2023** scenarios
- Min/Max monthly output numbers (GW) of each fuel type maintained
- Decision-relevant costs → **only variable costs for any fuel-based technology**; for VRE, full costs (CAPEX+OPEX) → conservative approach

Relevant Cost

- As per IGCEP 2022*), only variable costs (i.e. fuel costs for thermal plants) are considered.
- New wind and solar are assumed at 4 $ct / kWh (levelized CAPEX + OPEX), which is in line with the final IGCEP 2022**) assumptions.



*) Instead of individual numbers, average numbers are used for each technology for simplification.
**) As per presentation by NTDC on 12th October, 2022

Chaghi development

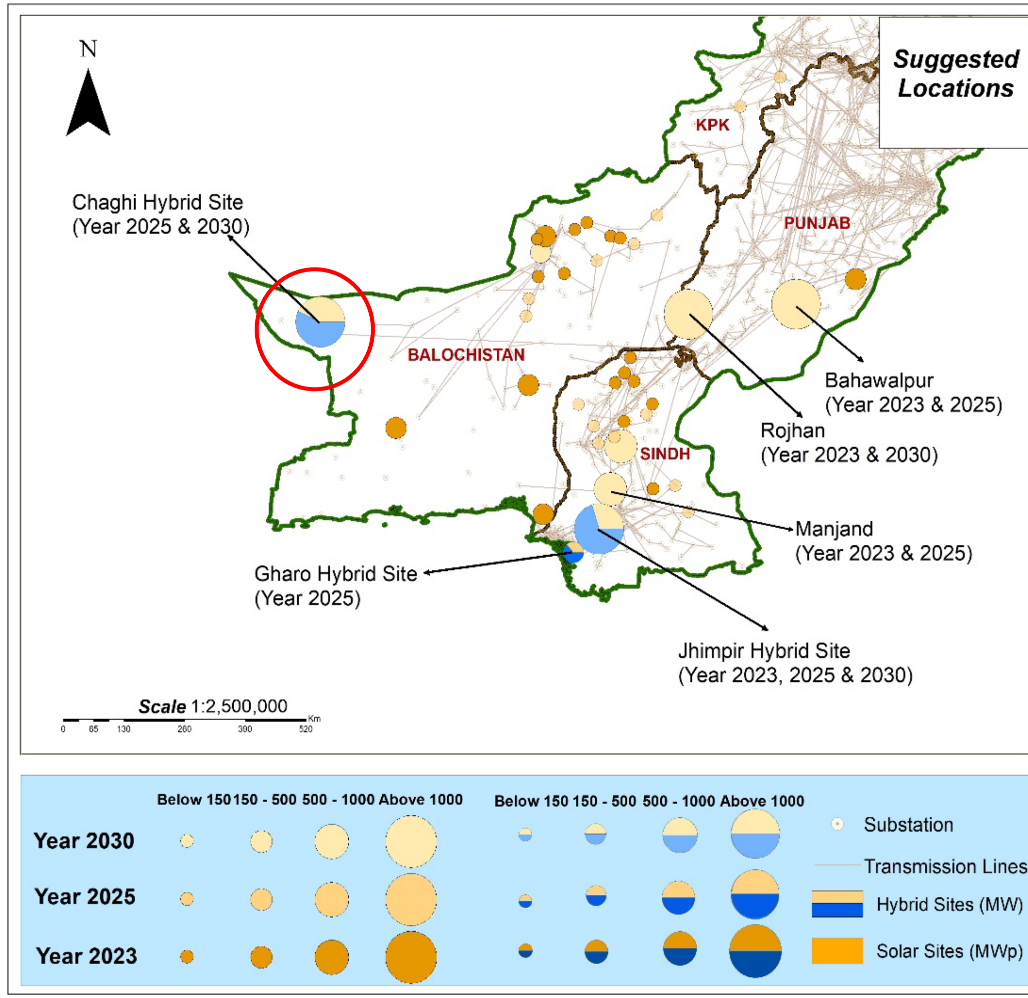
The 2020 VRE Locational Study (World Bank):

Chaghi area ideal for a PV-Wind hybrid plant development.

Ideal Wind and irradiation resource and complementary

65% utilisation of a dedicated HVDC line estimated

Additional cost of the 5 GW HVDC line compensated by the low production cost of Wind and PV at this location



Suggested VRE plant locations as per WB Locational Study

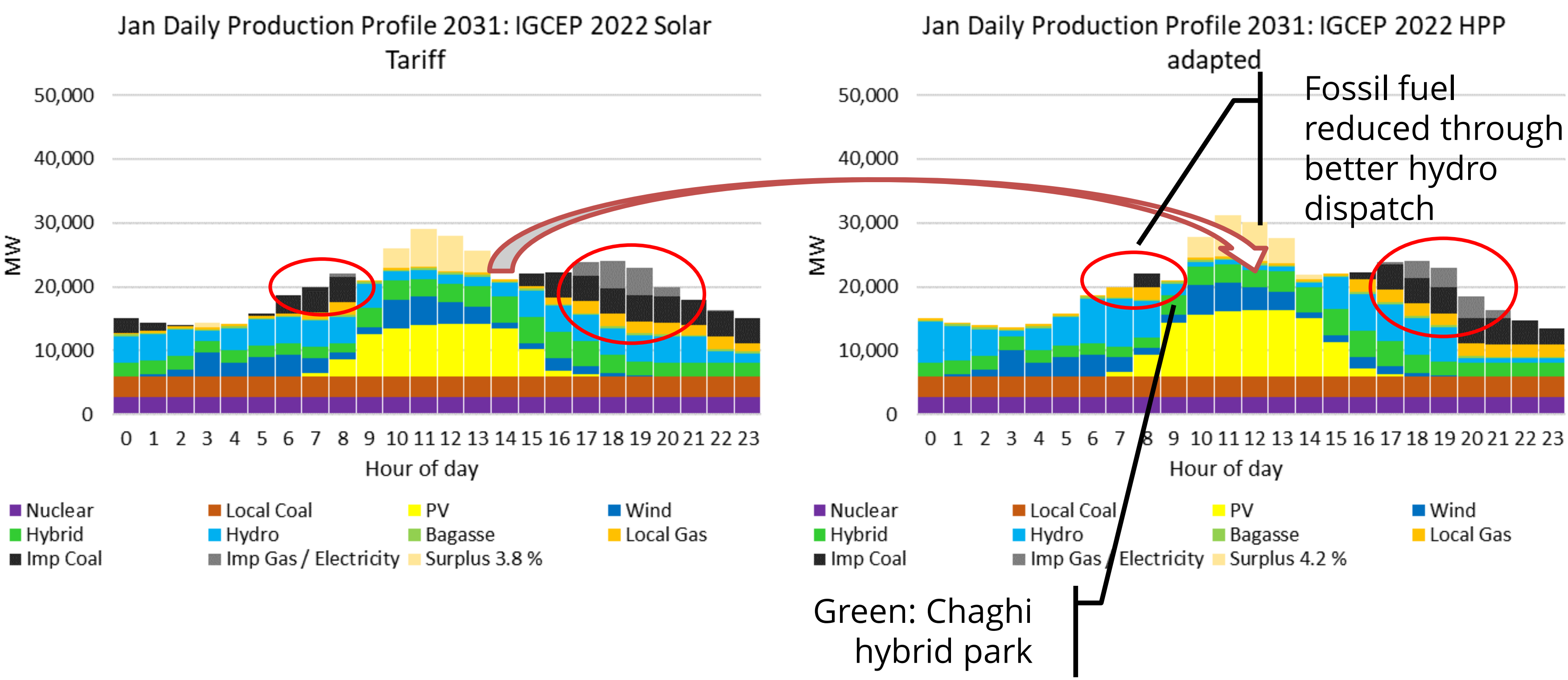
Optimization of VRE Proposal

For the optimized VRE case, the following adaptations to the IGCEP 2022 case have been considered:

- **Increased VRE (PV + wind)** capacities (allowing curtailment) – optimized through modeling
- Development of **Chaghi** (Balochistan) as a **5 GW** hybrid (PV + wind) park, connected to Punjab → HVDC line
- Including some **load shift from night to day** (adapted time-of-use tariffs; max of 20% night load)
- **Optimized hydro power dispatch** (when available & needed)

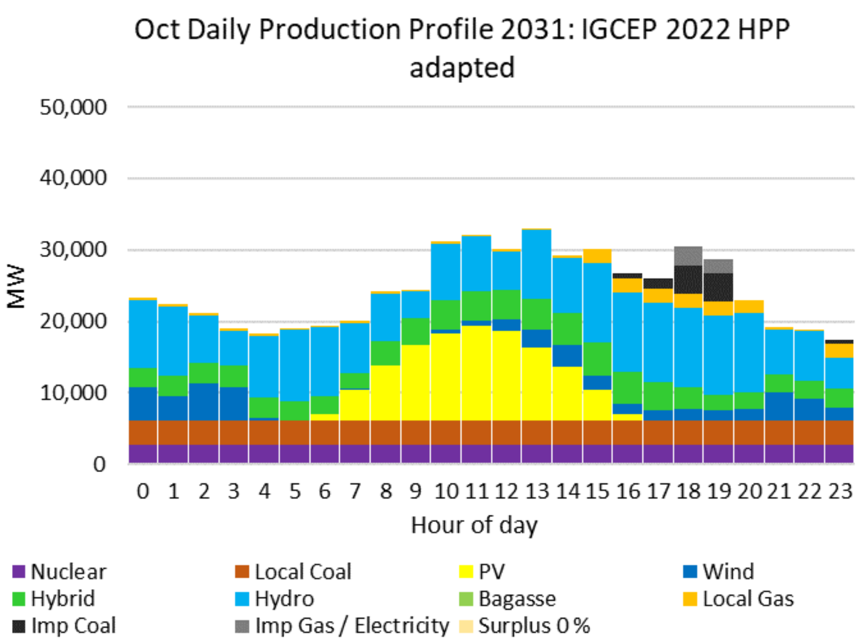
Snapshot January 2031 Optimised Option

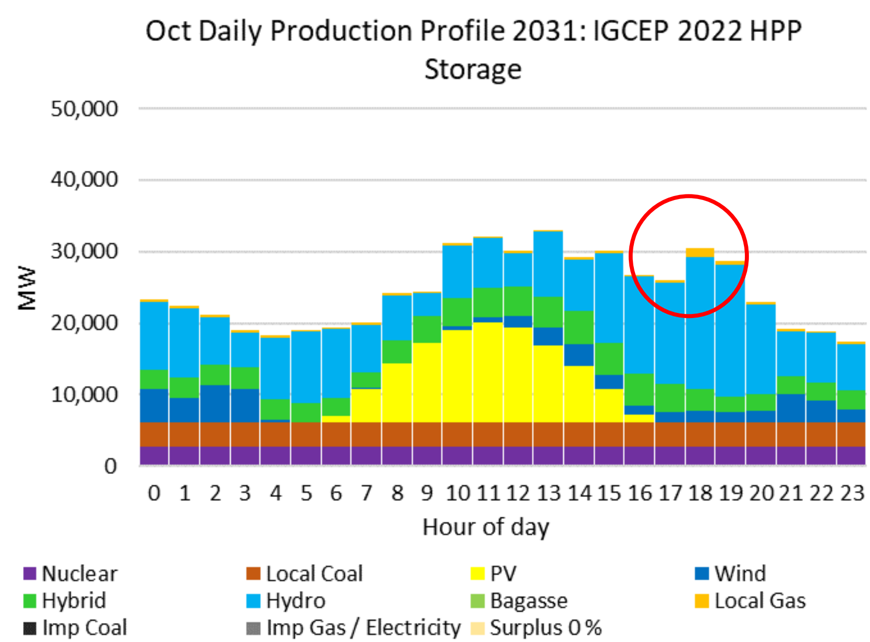
- Hydro power is used more flexibly to balance the VRE.
- Surplus during mid-day is reduced.



Optimization of VRE with Hydro Storage

- Non summer months: surplus VRE pump water for usage later in the day
- **Hydro storage**: utilisation of only 20% of the time => more cost than savings
- CAPEX relatively high but allows for much more flexibility





Scenarios Analysis – Intro

As the plan looks 10 years into the future, it is certain that some future assumptions will materialize differently. For this, a scenario (or „sensitivity") planning is done.

⇒ A good proposal should be **optimal** or at least **robust for different future scenarios.**

⇒ The „**base case scenario**" is that demand and additional plants develop as per **IGCEP 2022** planning.

⇒ **Flexible implementation:** Decisions should be made early enough but as late as possible to reduce uncertainty of evaluation criteria

Scenarios Analysis - Overview

a) IGCEP 2022 assumptions (**base case** scenario)

b) „**High demand**“: Demand 10% higher

c) „**Low demand**“: Demand 10% lower

d) **„Electric Vehicle“ (EV)**

e) „**Hydro delay**“: Hydro power (HPP) capacity in 2030 of 30% less

f) „**Carbon cost**“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

Scenarios Analysis – Demand Variation

a) IGCEP 2022 assumptions (base case scenario)

b) „**High demand**“: Demand 10% higher

c) „**Low demand**“: Demand 10% lower

d) „Electric Vehicle“ (EV)

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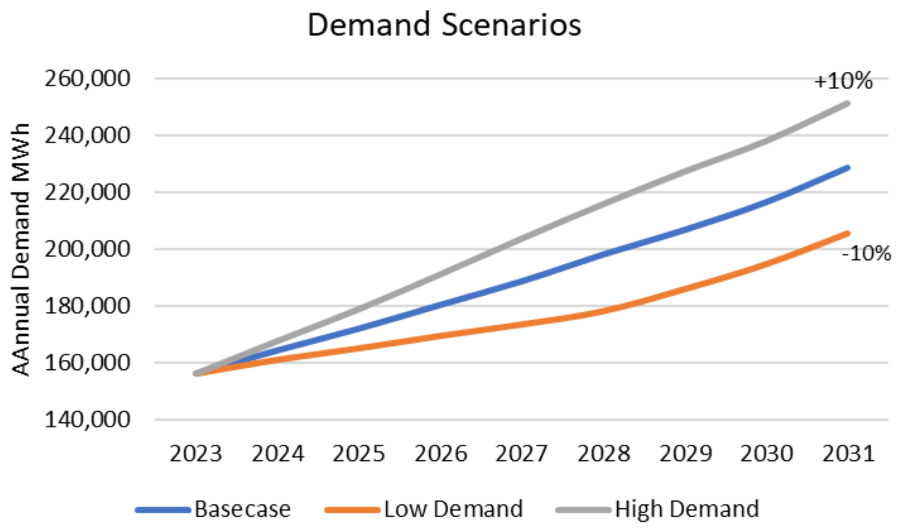
f) „Carbon cost“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

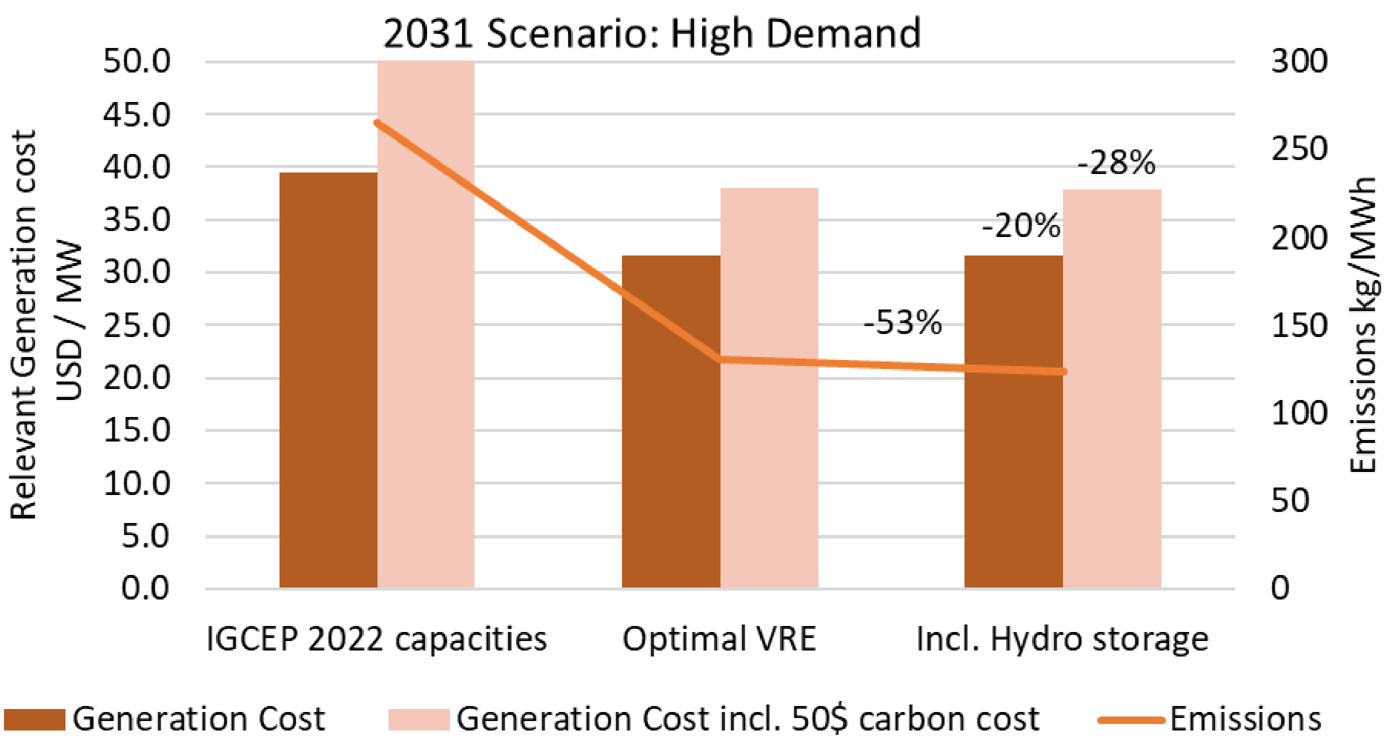
IGCEP 2022: Demand Forecast Until 2031

- The demand forecast is related to the GDP development and altered +/-10% in scenarios b) and c).
- A low demand leads to (thermal) generation overcapacity and VRE face higher curtailment.
- A high demand can lead to demand-supply gaps, leading to high cost import cost. Solar and wind plants can help to close this gap.



„High Demand“ Scenario

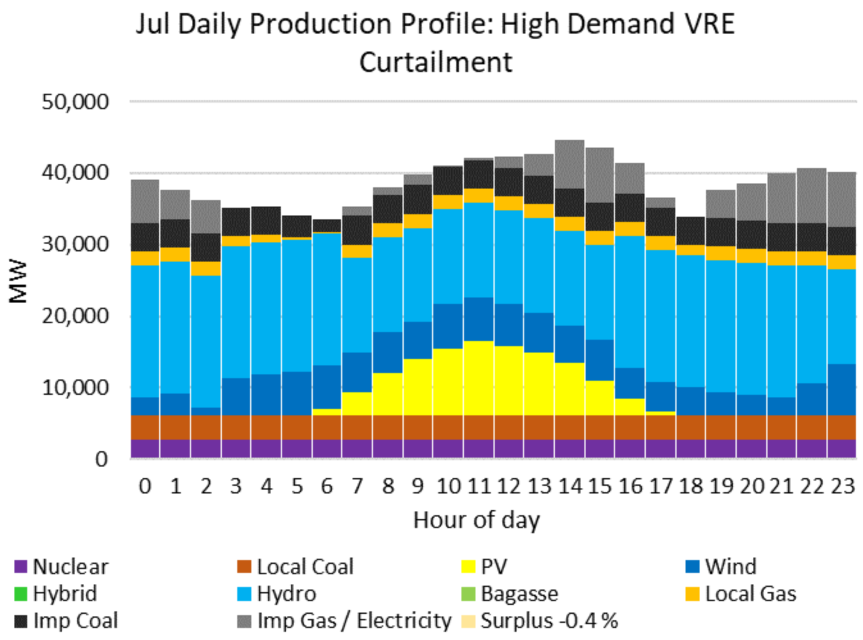
- No need for more fossile generation;
- 5 GW solar-wind park at Chaghi is required
- „PV tariff“ helps reducing the mid-day curtailment

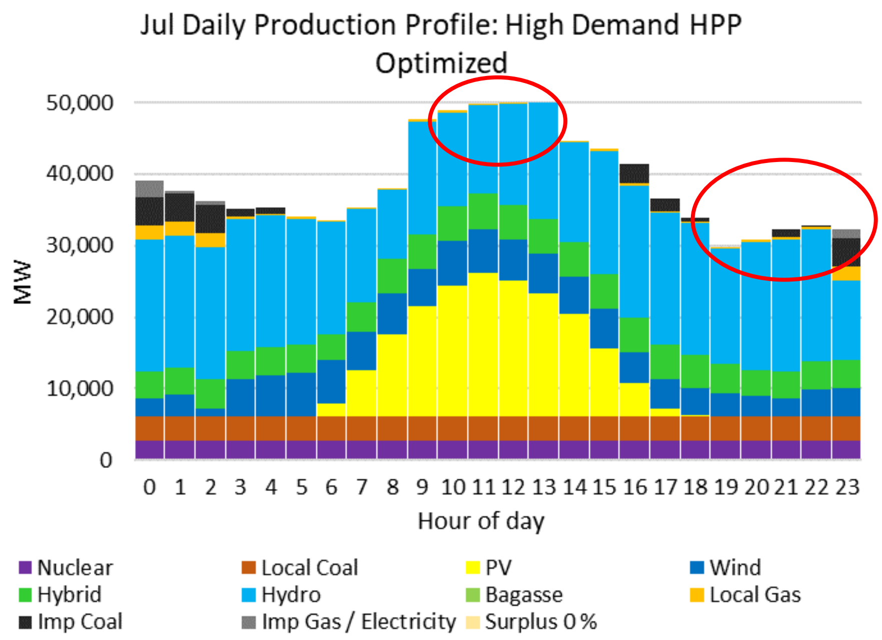


	IGCEP 2022 capacities	Optimal VRE	Incl. Hydro storage
PV GWp	**13.7**	**29.3**	**29.3**
Wind GW	**7.0**	**12.0**	**12.0**

„High Demand“ Scenario - Details

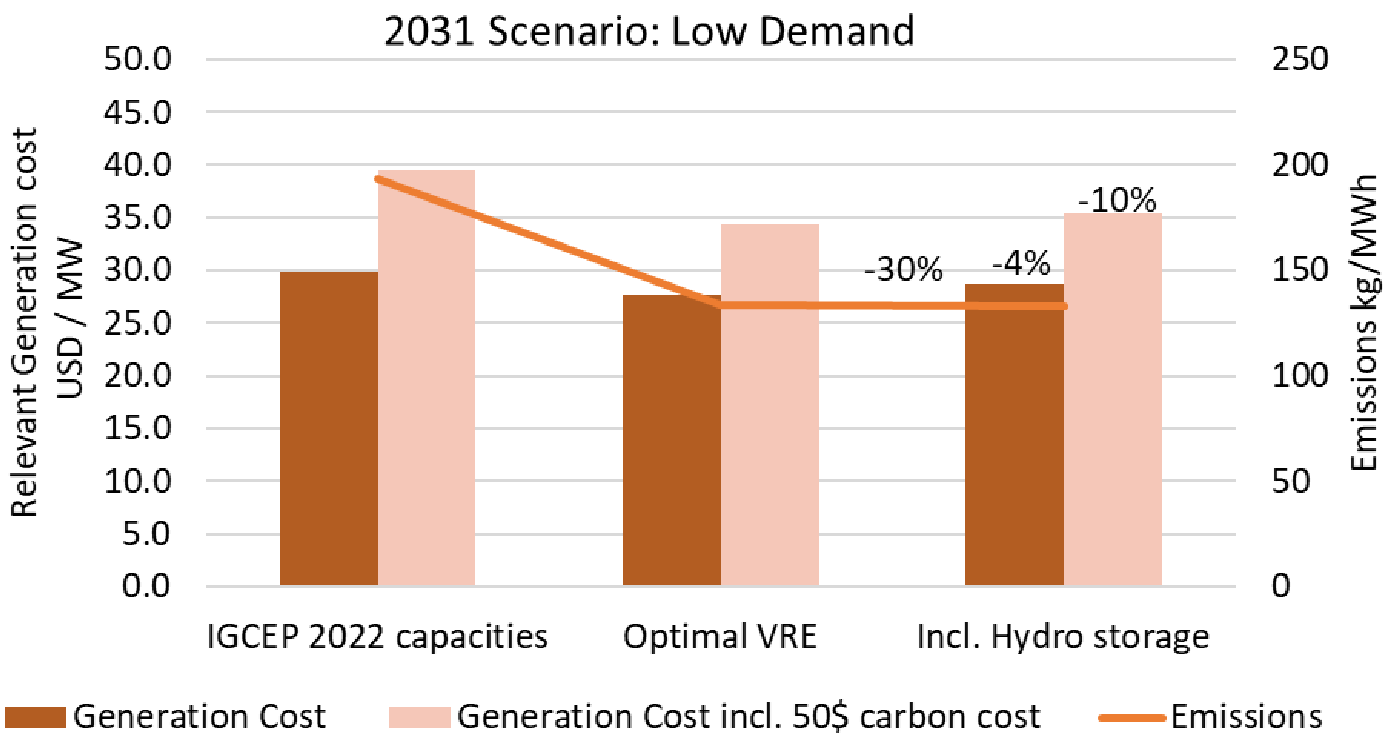
- Summer months would need to be analysed in more detail for grid stability, as RE would reach >80% mid days.
- Reducing peak demand through higher energy efficiency in cooling applications and/or HPP storage would be beneficial





„Low Demand“ Scenario

- Average cost of electricity is reduced due to lower peak demand and merit order.
- The optimal PV and wind capacity for this scenario are lower, totalling 26 vs 33 GW.
- The Hybrid Chaghi park should still be pursued



PV GWp	**13.7**	**16.0**	**16.0**
Wind GW	**7.0**	**10.0**	**10.0**

Scenarios Analysis – EV Development

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b) „High demand“: Demand 10% higher

c) „Low demand“: Demand 10% lower

d) „Electric Vehicle“ (EV)

e) „Hydro delay“: Hydro power (HPP) capacity in 2030 of 30% less

f) „Carbon cost“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

EV Market Scenario for Pakistan

- Some Pakistani manufacturers have launched into the EV market; however, percentage in sales remains low.
- The **impact** on the VRE scenarios of **EV charging** in terms of total GW for charging (same for TWh required) is therefore **rather negligible** until 2030.
- **EV could also bring benefits** to the grid if regulated well: Parking EVs as a decentralized battery backup for the grid

EV illustration (Photo by Fer Troulik on Unsplash)

EV Market Scenario for Pakistan

- **Small EVs** like e-rikshaws can create **disruptive scenarios** if they have a business case in the transport sector, replacing diesel- or CNG-fired mini-taxis at scale:
- E.g. in Bangladesh, between 2010 and 2017, **1 million** of locally built “*easy bikes*” (=**local e-rikshaws**) got on the streets, and numbers now in 2022 are supposed to lie between 2m and 4m.[1)]
- For Pakistan, such a development could theoretically happen as well.
- However, local transportation in urban areas seems to be more toward motorbikes and cars – which follow a much slower replacement curve as they can’t be built with the same cost savings.

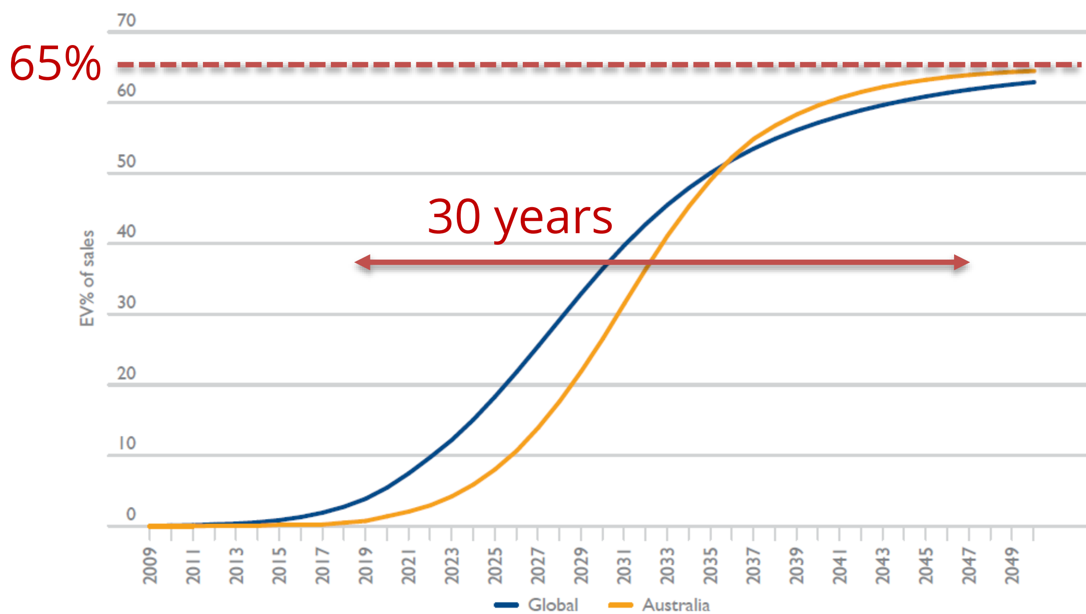
Photo by Marwan Ahmed on Unsplash

1) https://www.tbsnews.net/features/panorama/easy-bikes-we-them-we-them-not-352426

Impact of Electric Vehicles (EV) Market in Pakistan

- **Starting point:** "How will a potential transformation to EV in Pakistan impact the demand scenarios?"
- **Insight 1:** Replacement of fossil-fueled cars through EVs in a new market happens slowly.
- **Insight 2**: GoP needs to actively remove barriers, otherwise, EV market will grow even more slowly.

Figure A.1 Global and Australian predicted EV sales as a percentage of annual new passenger vehicle sales



Source: Report by Australian Gov. on EV modelling in 22 countries
https://www.bitre.gov.au/publications/2019/bitre-report-151:

An EV Market Scenario for Pakistan

Assumptions taken for scenario:

- ➢ Consumption benchmark: 8.30 kWh energy consumption per car per day on average [1)]
- ➢ Pakistan vehicle fleet:10m cars in 2019; motorcycles: fleet also around 10m [2)]
- ➢ Final value assumed at 70% of EV within 40 years (by 2062) (values higher than 70% might be unrealistic in countries with remote areas like Pakistan)

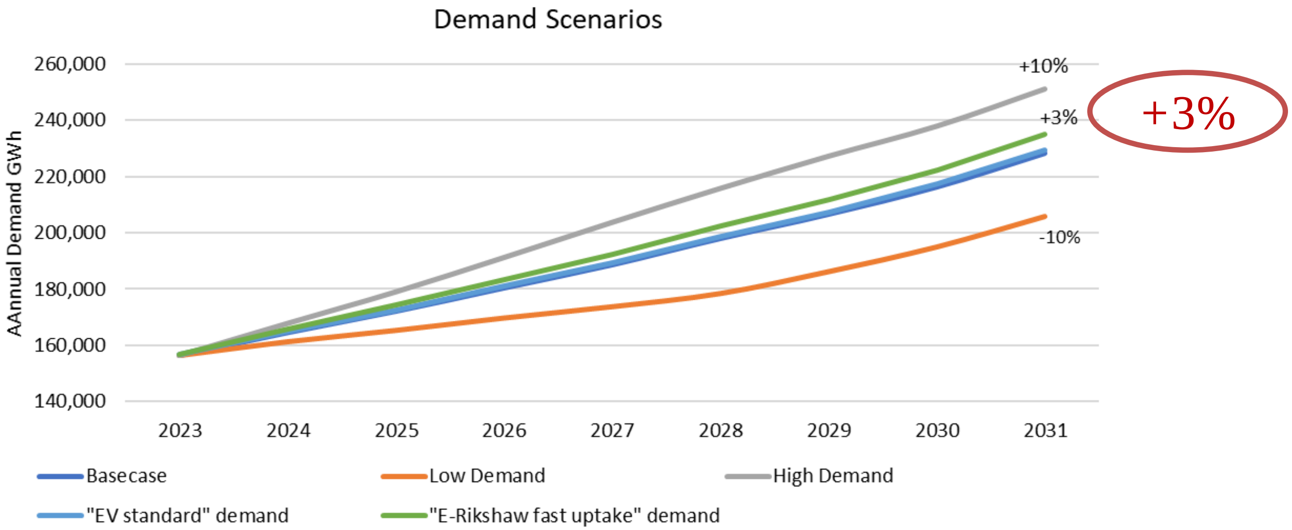
Photo by myenergi on Unsplash

- ➢ Assumption on charging infrastructure: Charging takes place evenly across 12h out of 24h per day (very rough assumption)

1) See numbers from https://www.iea.org/reports/electric-vehicles
2) Based on approx. 1m sales of motorcycles p.a. – assumed average lifetime 10 years. Consumption assumed at 40% of cars.

EV Market Scenario for Pakistan - Result

- Assuming a massive growth of e-rikshaws (like in Bangladesh since 2010), additional power demand is **not more than 1.3 GW / 6,000 GWh p.a.** (approx. 1m e-rikshaws)[1]. This equals a "+3%" increase in demand for 2031, which is negligible compared to the already discussed scenarios of ±10%.
- Assuming an standard development (i.e. starting slow) for regular EVs, for **2030, only 200 MW[2] / 900 GWh p.a.** of additional power demand is expected for EV charging (0.2m EV cars and 0.2m EV bikes), assuming a rollout starting today.



1) Assuming regular EVs with linear growth (which is much less likely) terminating at the same vehicle number by 2062 leads to very similar numbers (1.4m EV cars and 1.4m EV bikes).
2) This assumes an even charging across 12 hours - peak charging could be more than that.

Scenarios Analysis – Hydro Delay

a) IGCEP 2022 assumptions (base case scenario)

b) „High demand“: Demand 10% higher

c) „Low demand“: Demand 10% lower

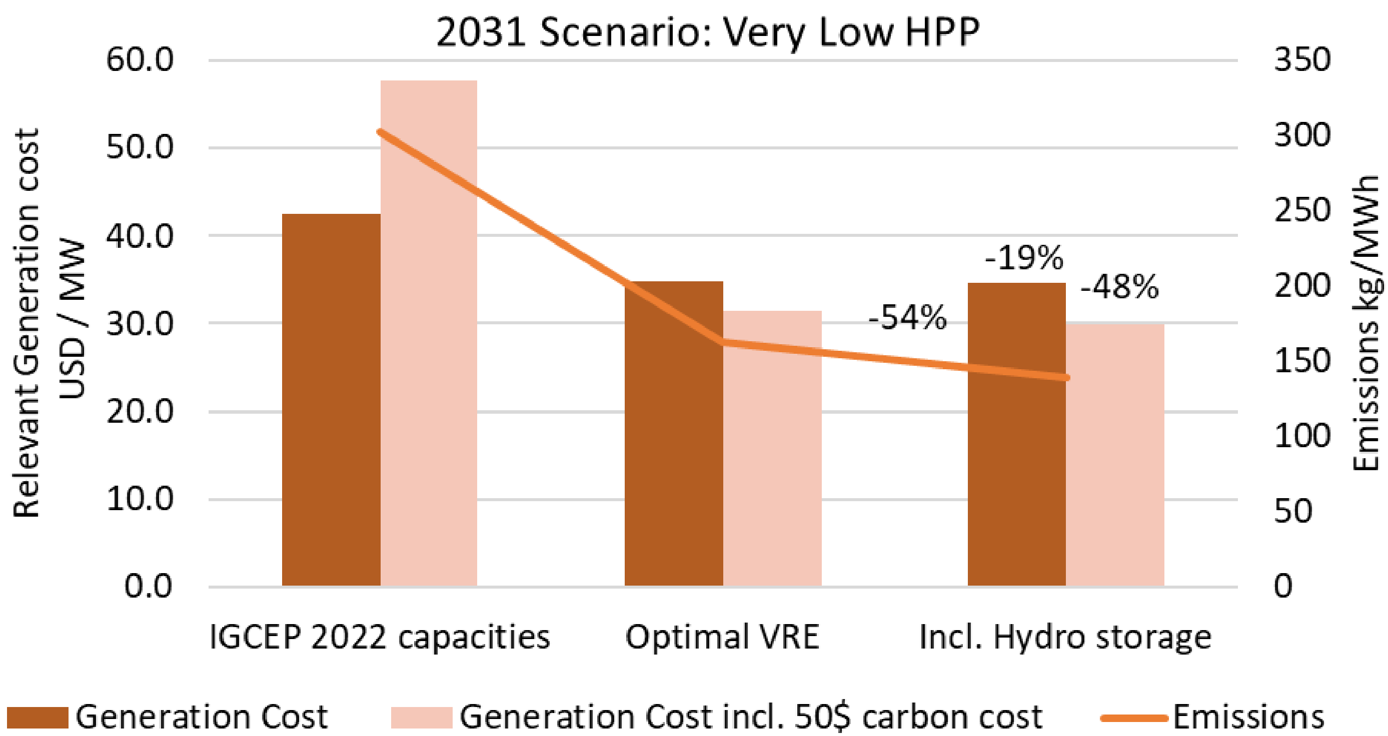
d) „Electric Vehicle“ (EV)

e) „Hydro delay“: Hydro power (HPP) capacity in 2030 of 30% less

f) „Carbon cost“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

„Hydro Delay“ Scenario

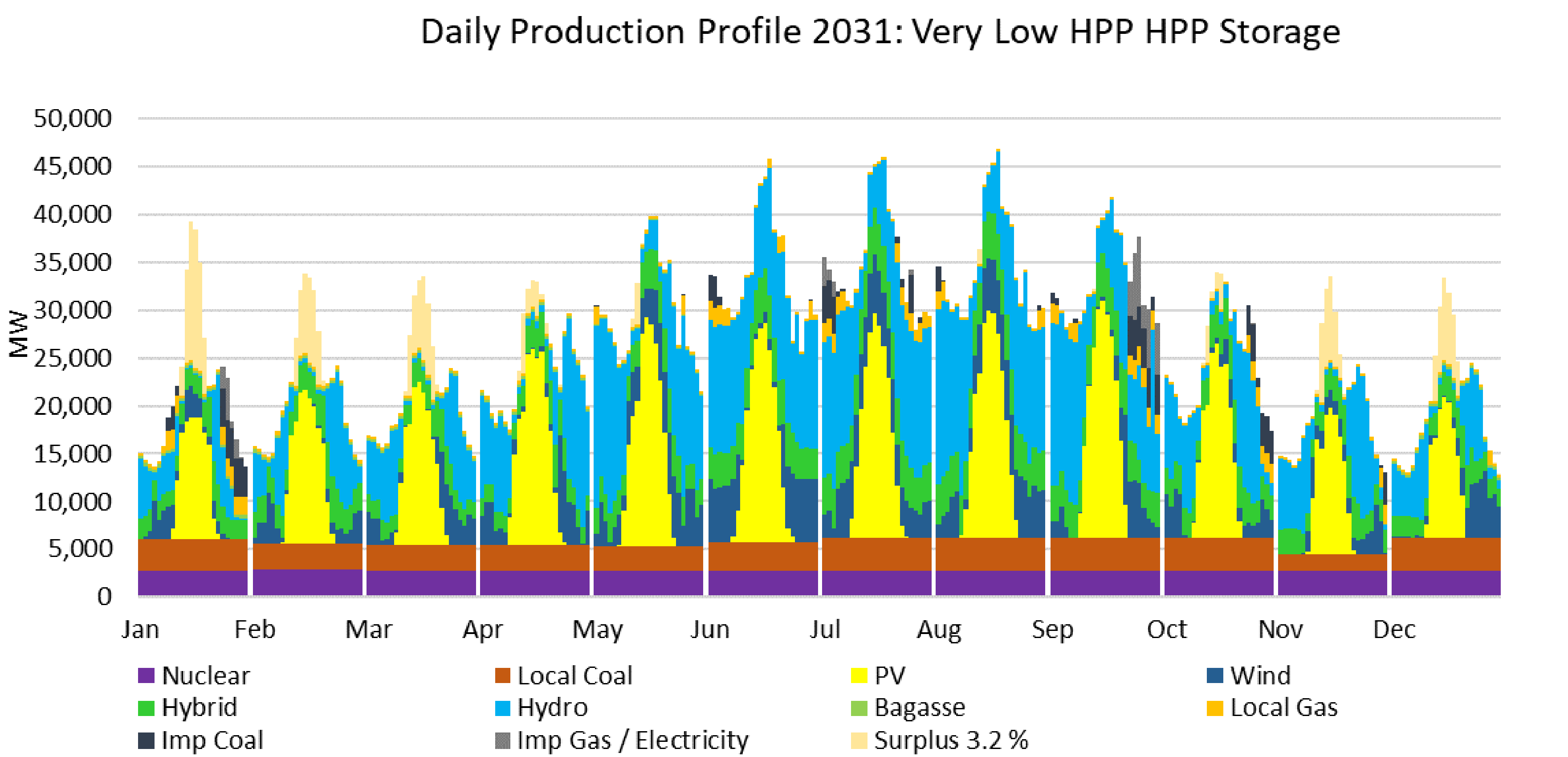
- Extreme (but not unlikely) scenario of 30% less hydro power by 2031
- The cost of electricity and co2 emissions increase due to use of coal and gas
- Doubling VRE capacity offset this risk, HPP pumped storage important for grid stability



PV GWp	**13.7**	**29.3**	**33.3**
Wind GW	**7.0**	**12.0**	**12.0**

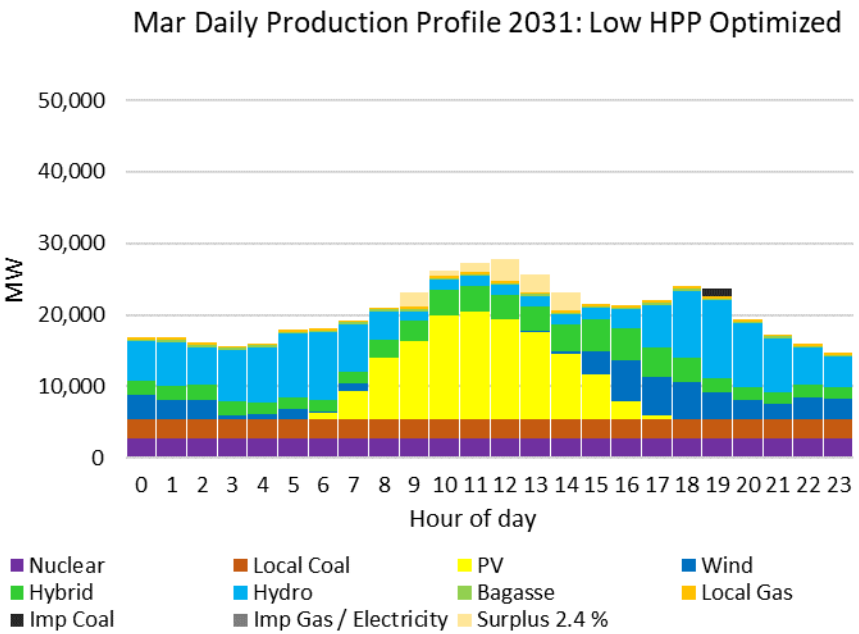
„Hydro Delay“ Scenario – Optimized

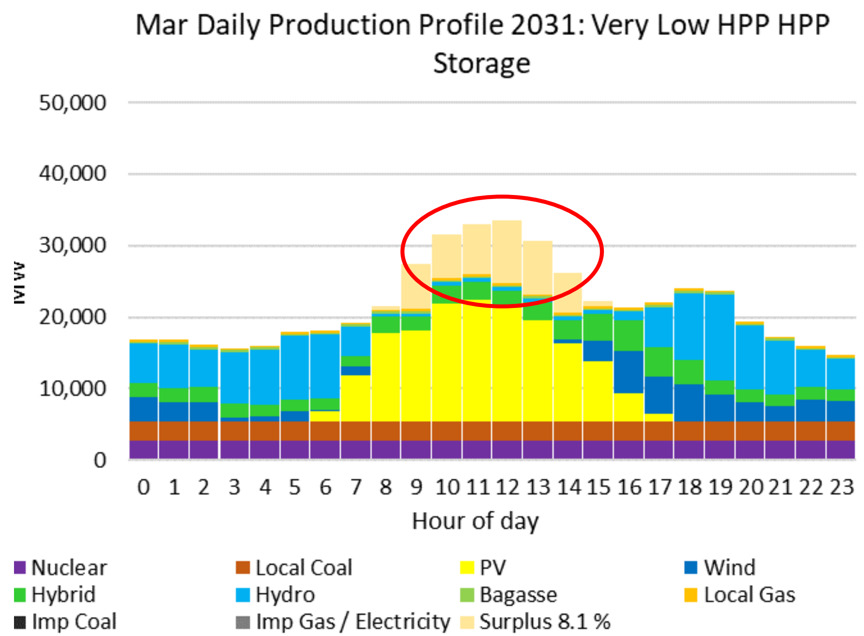
- Simlar to high Demand Scenario but even more dependent on VRE
- Challenge of grid stability in summer, HPP storage is additional grid stability value
- High curtailment in winter



Hydro Delay - Details

- In the „low hydro“ case (-10%), PV can substitute missing volumes, however, by accepting curtailment. (Here: a day in March)
- The „very low hydro“ scenario (-30%) has some 3.2% annual energy curtailment or export opportunity.
- In some months up to 8% curtailment





Scenarios Analysis – Carbon Cost

a) IGCEP 2022 assumptions (base case scenario)

b) „High demand“: Demand 10% higher

c) „Low demand“: Demand 10% lower

d) „Electric Vehicle“ (EV)

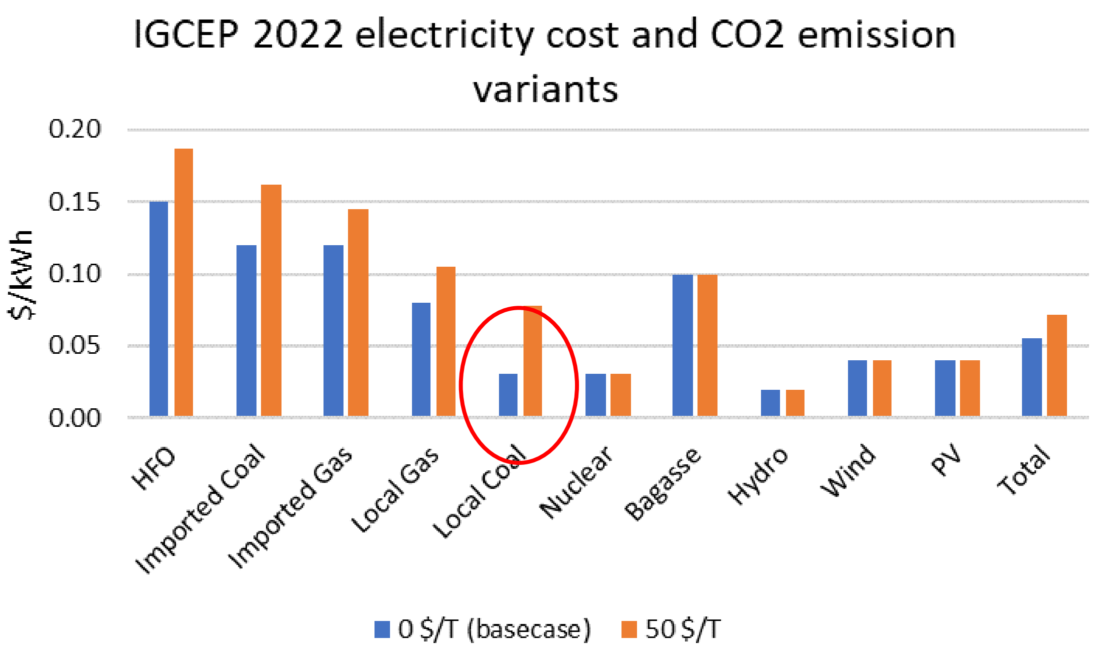
e) „Hydro delay“: Hydro power (HPP) capacity in 2030 of 30% less

f) „Carbon cost“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

Longer-Term Carbon Cost

- CO_2 emissions are likely to get penalized in medium term future
- If cost of carbon were priced especially local coal would be affected

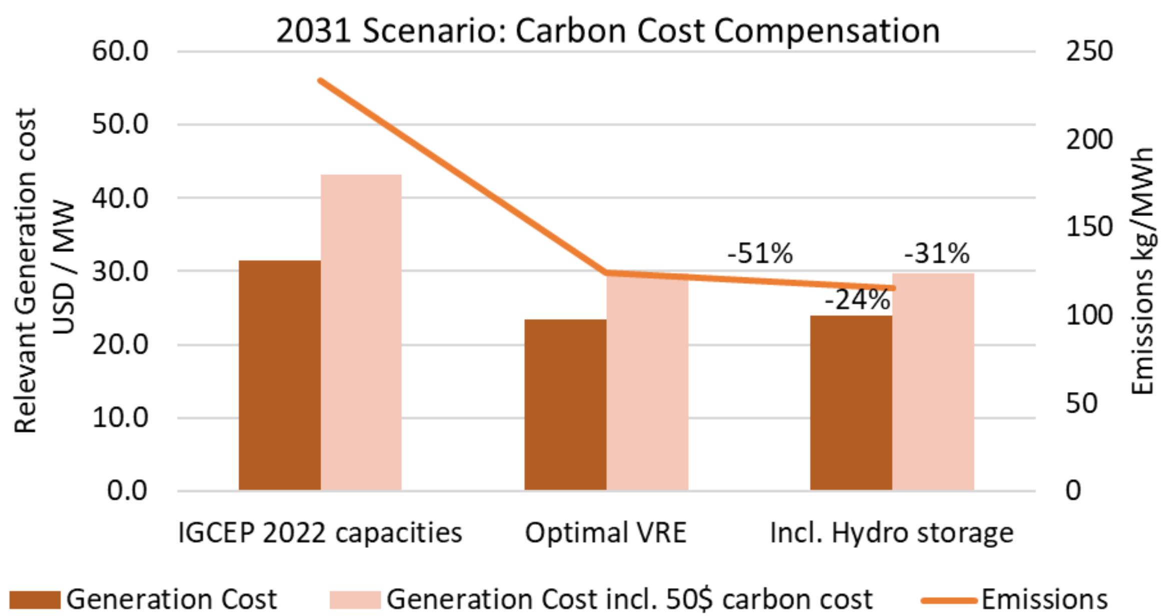
	g/kWh
HFO	735
Imported Coal	850
Imported Gas	500
Local Gas	500
Local Coal	966
Nuclear	0
Intercon	500
Bagasse	0
Hydro	0
Wind	0
PV	0



*) The same effect would make wind and PV accordingly cheaper if international credits can be obtained for these emission savings.

Longer-Term Carbon Cost Compensation

- In this Scenario it is assumed Pakistan will get a compensation for offsetting CO_2 emissions ~ 50 USD/T
- Due to lower cost, a slightly higher share of PV than in basecase is optimal



PV GWp	**13.7**	**22.2**	**24.2**
Wind GW	**7.0**	**12.0**	**12.0**

Scenarios Analysis – Distributed Generation

a) IGCEP 2022 assumptions (base case scenario)

b) „High demand“: Demand 10% higher

c) „Low demand“: Demand 10% lower

Additional “scenario”: Distributed Generation (DG)

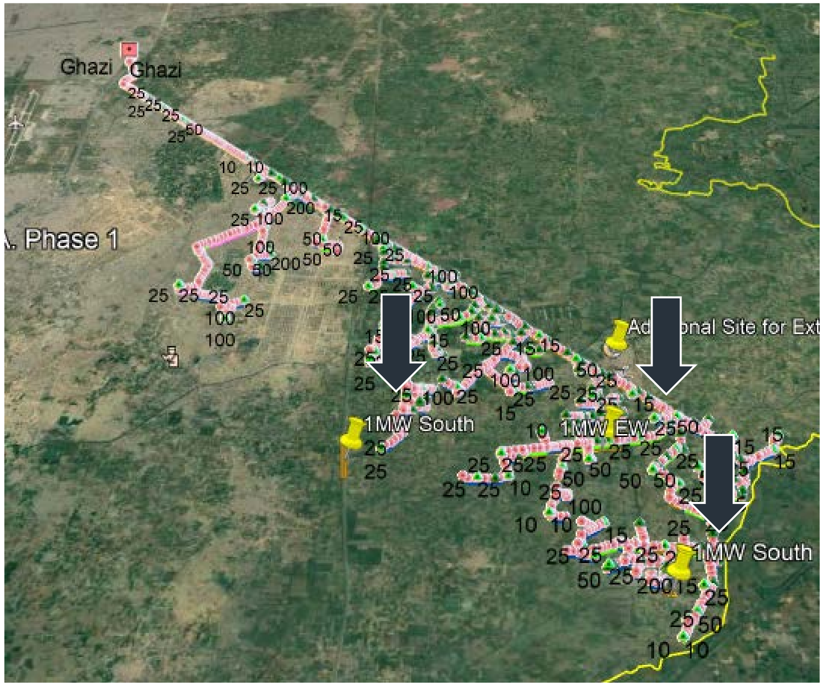
d) „Electric Vehicle“ (EV)

e) „Hydro delay“: Hydro power (HPP) capacity in 2030 of 30% less

f) „Carbon cost“: Financial scenario: Applying a carbon cost benefit of 15 USD/MWh for VRE (~ 50 $ per of CO_2 savings)

Role of Distributed Generation (DG) I

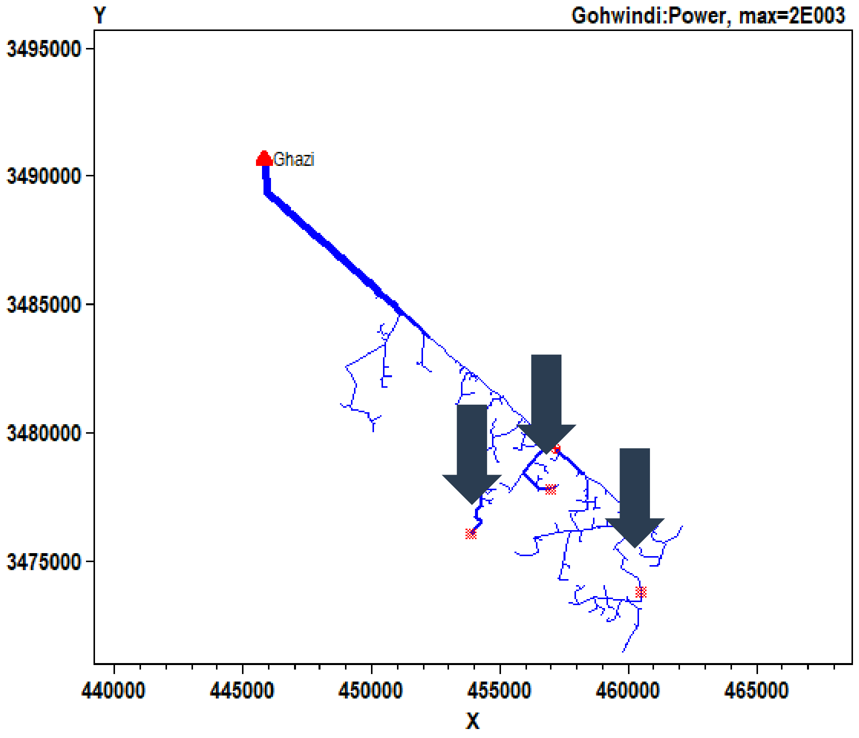
- **GoP** has already committed to pursue **DG as a strategy**
- Feed-in **tariff** must be **slightly higher** than for large-scale PV (no economies of scale; higher development costs)
- **NTDC/IGCEP** has estimated a total of **2 GW of PV DG for the next 3 years** (called “Solar Feeder” in IGCEP) to be possible
- In the analysis here, DG capacities are included in the general PV numbers: 2 GW of the total 12 GW / 21 GW (depending on case) would come from DG, the rest through utility-scale PV plants.



Therefore: “DG” is therefore not a scenario by itself but rather a detail to the presented PV numbers.

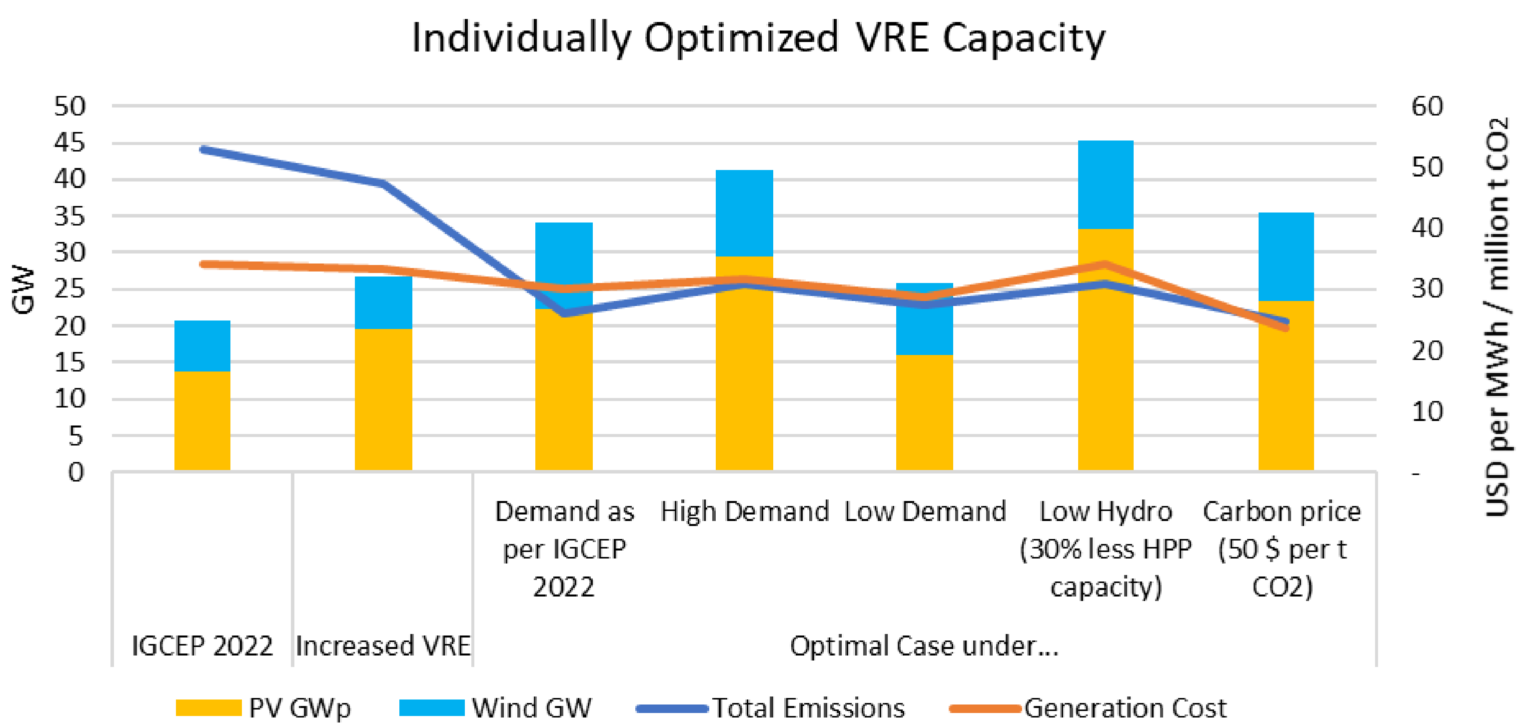
Role of Distributed Generation (DG) II

- **Distributed generation (DG)**, i.e. PV plants of the lower MW-scale feeding into the distribution grid (11kV), has **specific advantages**:
  - Decrease losses on remote feeders
  - Improve voltage levels on remote feeders
  - Through decentral implementation, reduce the power fluctuations through local weather events
- However, DG also has the following **challenges and downsides**:
  - Land development required for each site individually, increasing costs
  - Grid impact and permission to be resolved locally; requires a very streamlined process



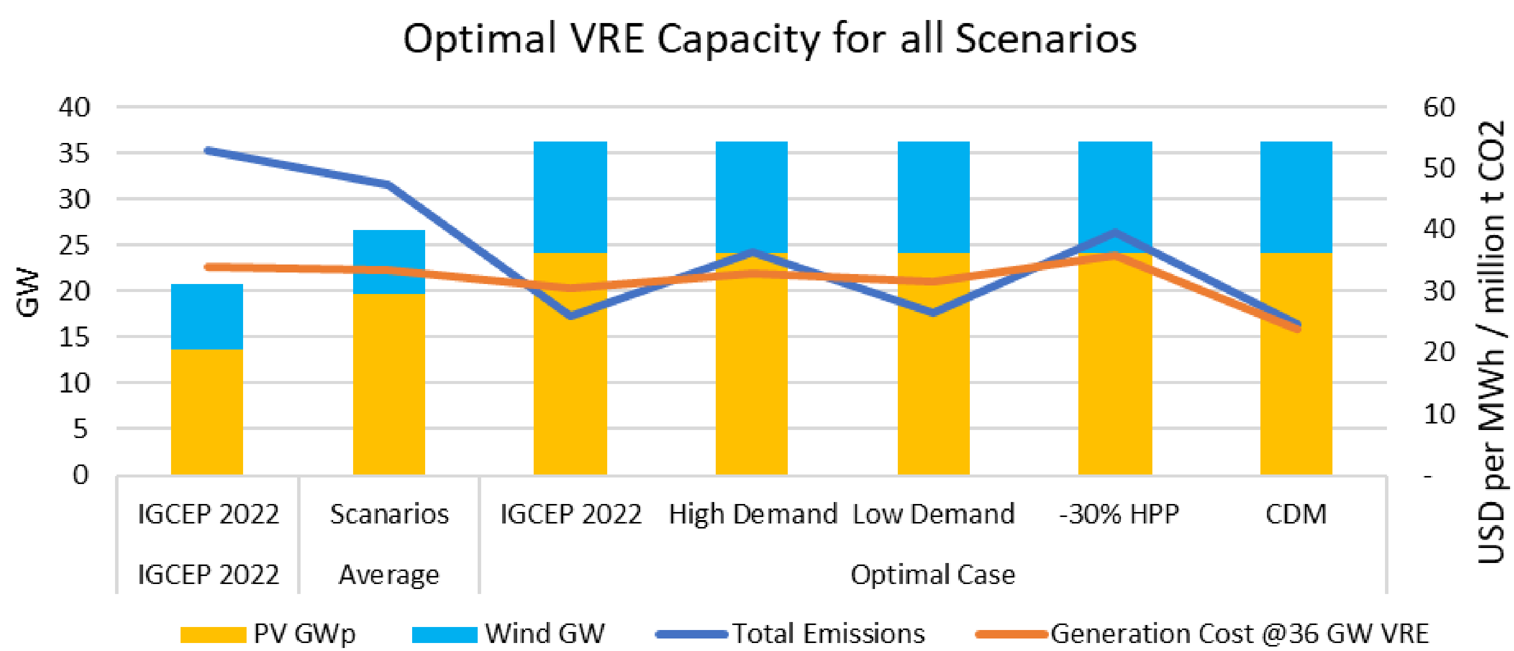
Conclusion: Scenario Analysis Summary

- All optimal cases replace much more gas and coal with VRE by 2031
- Base case scenario cost reduce by 13% and CO_2 emissions by 50%



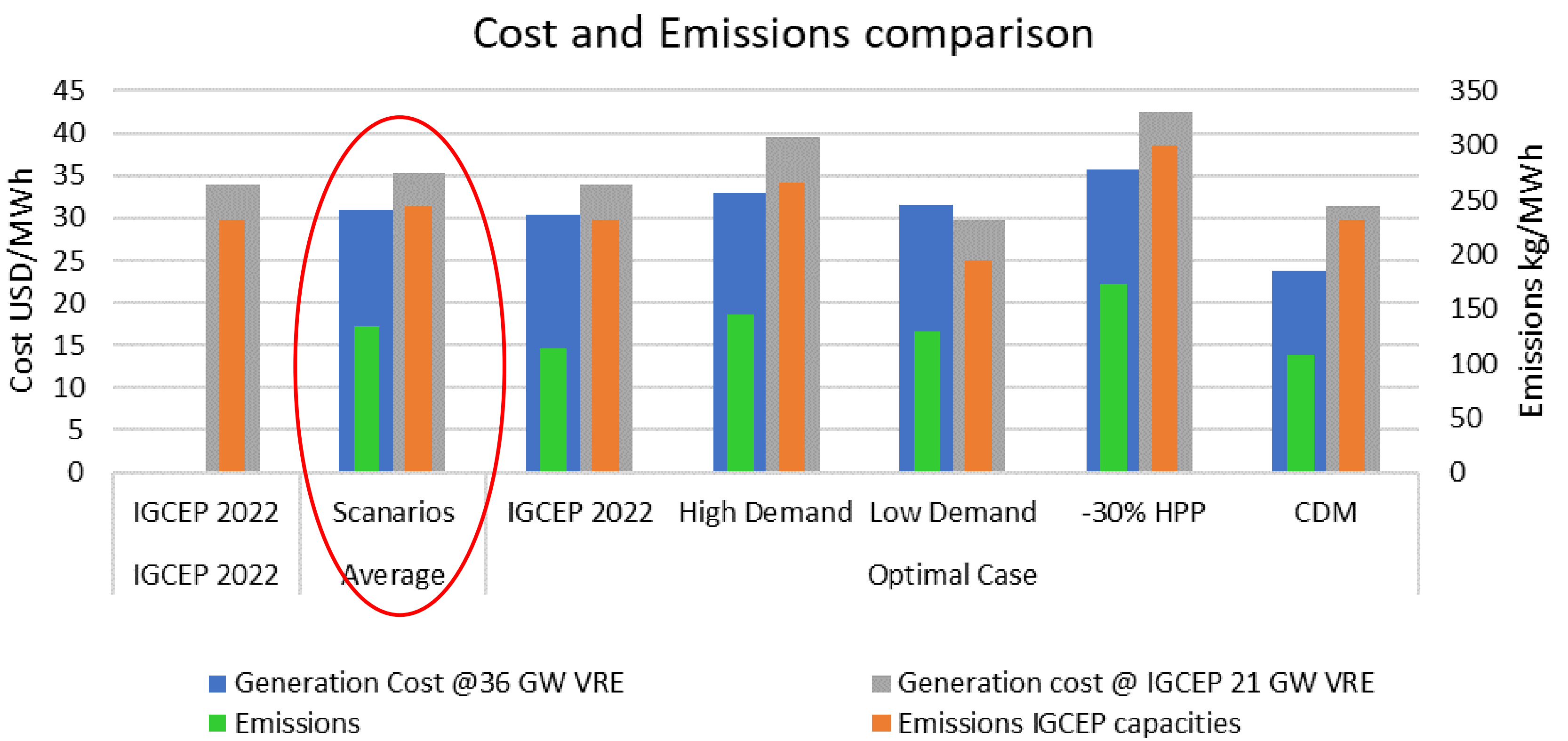
Conclusion: Scenario Risk Evaluation

- Realistic lowest cost VRE capacity is 22.5 GWp PV and 12 GW Wind
- The fixing of VRE capacity for all scenarios has a small cost effect



Conclusion: Scenario Analysis Conclusion

- The proposed optiaml VRE share (36 GW VRE) has **lower emissions** (green vs. orange) than IGCEP case (base case, 21 GW VRE) for all scenarios in 2030.
- The proposed optimal VRE share **reduces average cost by 13%** (blue vs gray) and **average emissions by 45%.**



Recommendations on VRE tender process I

- The recommendation of this analysis is to **add significant new solar** (21 GW) and **wind** plants (12 GW) **by 2030**.
- This, of course, means **significant new installations every year** (average: **2.5 GW solar, 1.5 GW wind** p.a.).
- The focus therefore needs to be to **unlock new installations at scale**.

Photo by Thomas Reaubourg on Unsplash

Recommendations on VRE tender process II

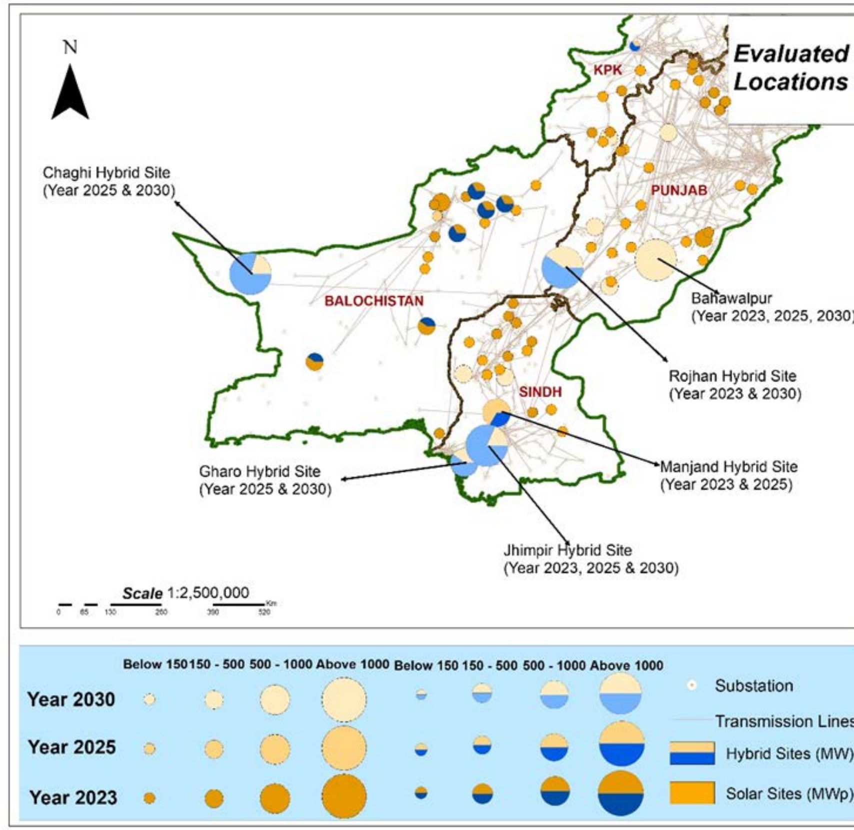
- GoP plans are to implement these next installations through **competitive bidding** (IPP PPA mode, reverse auctioning).
- **Factors for a successful bidding process** will be:
  - **Transparency** and clear process for tender
  - Building a reliable **pipeline** of upcoming tenders (e.g. a commitment to tender 2.5 GW / 1.5 GW solar/wind per year)
  - Ensuring **reliable payment** to producers (no default / dispute)

Photo by Caspar Rae on Unsplash

Recommendations on VRE tender process III

Tenders should be **location-specific**: The best sites (resulting in the lowest tariffs) for utility-scale PV and wind power have been evaluated in the *Locational Study 2020 (World Bank)*.

- The ranking of these best sites should be updated and developed further into a **year-wise tender plan** for quick competitive bidding.
- GoP should **offer specific stretches of land** which are government-owned
- In order to make best use of infrastructure**,** tenders should **combine solar and wind power into hybrid parks** on the same evacuation line (or same substation)



Optimal PV and wind sites as per *Locational Study (WB, 2020)*