Examining K-Electric's Cost of Inaction in Deploying Renewables

Whitepaper
February 2024

RENEWABLES FIRST

PRIED
Policy Research Institute
for Equitable Development

Contents

Executive Summary

K-Electric's Existing Power System	• Despite being the only vertically integrated power utility in Pakistan, K-Electric's generation fleet is entirely reliant on thermal power generation • The electricity imported from the national grid meets a little less than half of utility's total energy demand currently
K-Electric's Power Expansion Decisions – A Missed Opportunity	• K-Electric added 2,132 MW of capacity in its system since privatization in 2005. More than 95% of those additions were based on plants running on costly fuels such as RFO, HSD, RLNG etc. • The costs of RE technologies continued to decline drastically during the past decade, with the latest tariffs awarded at less than US cents 4/kWh in 2021. • Despite operating in a region with high wind and solar resources, K-Electric failed to capitalize on this opportunity.
The Cost of Lost Opportunity	• Opportunity Missed, Millions Lost: K-Electric could save USD 204 – USD 253 million in FY-22 & FY-23 by strategically adding Renewables in its generation fleet instead of extending costly PPAs. • K-Electric's inaction has left consumers burdened with the highest electricity costs reaching a staggering basket generation price of US cents 11.1/kWh
The Positive Impact of Increasing REs in K-Electric's System	• To explore the impact of adding renewables to K-Electric's system, the IGCEP 2022-31 case for K-Electric was simulated using PLEXOS that optimized 990 MW local-coal based capacity and only 1,400 MW renewables, with total system cost of **US $11.156 billion**. • However, the RF-PRIED PLEXOS model for K-Electric optimized 2,400 MW renewable energy entirely excluding local coal, with total system cost of only **US $6.647 billion**. • K-Electric has the potential to unlock savings totaling up to **US $4.51 billion** from FY 2024 to FY 2030 by taking proactive decisions on renewables additions as well as by prioritizing them over local coal.
Way Forward – A Leap from Potential to Progress	• To provide relief to inflation-stricken consumers in terms of cheaper electricity, following action points are imperative for K-Electric: 1. Cease extensions in PPAs for costly and inefficient thermal power plants 2. Ensure a consistent and efficient integration of least-cost wind and solar energy projects. 3. Refrain from incorporating expensive and environmentally hazardous coal power plant additions.

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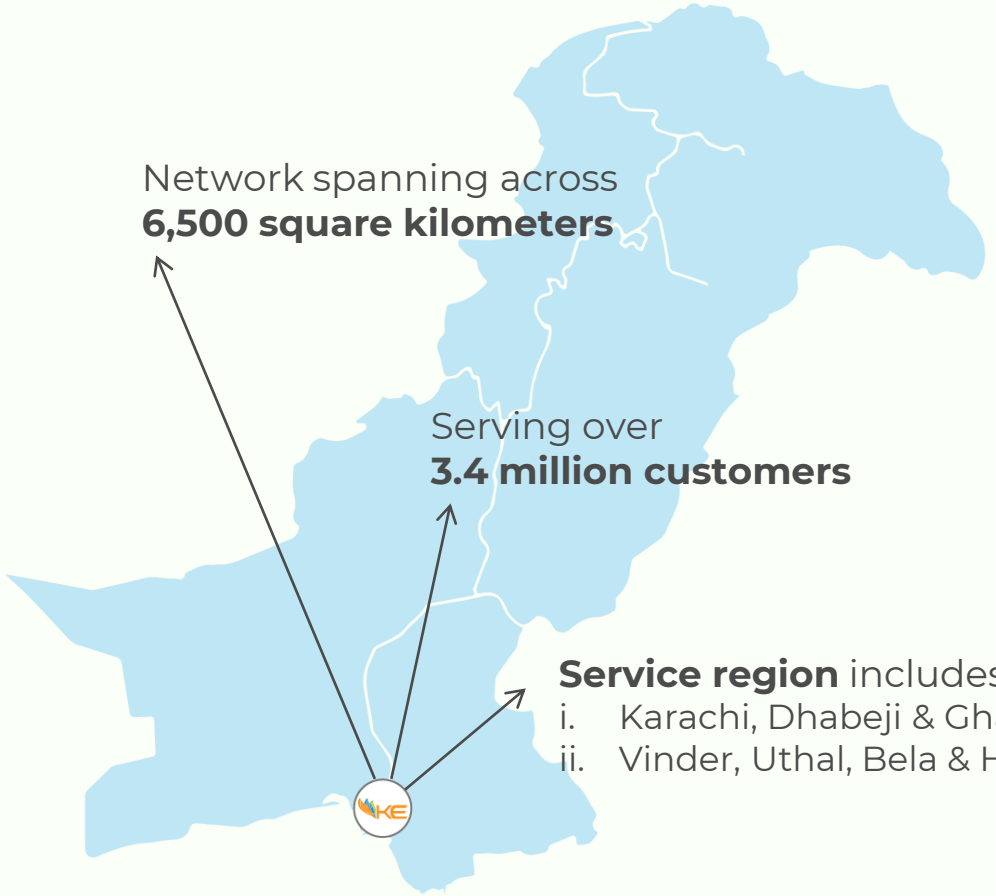
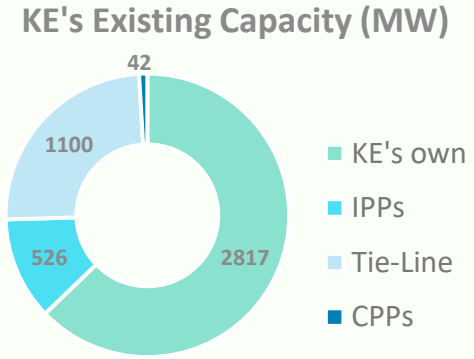
K-Electric is Pakistan's largest and only vertically integrated power utility, responsible for generating, transmitting and distributing electricity to its regulated customers



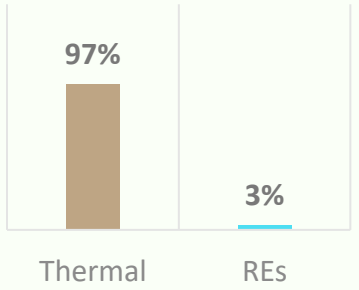
Service region includes:

i. Karachi, Dhabeji & Gharo in Sindh,
ii. Vinder, Uthal, Bela & Hub in Balochistan.



Current **total capacity** of K-Electric including import from NTDC system is **4,485 MW**.

The **Peak demand** for FY 2022 was **3,670 MW**.



The existing power system of K-Electric is dominated by **thermal power plants** constituting **97%** of the installed capacity.

Source: NTDC, K-Electric

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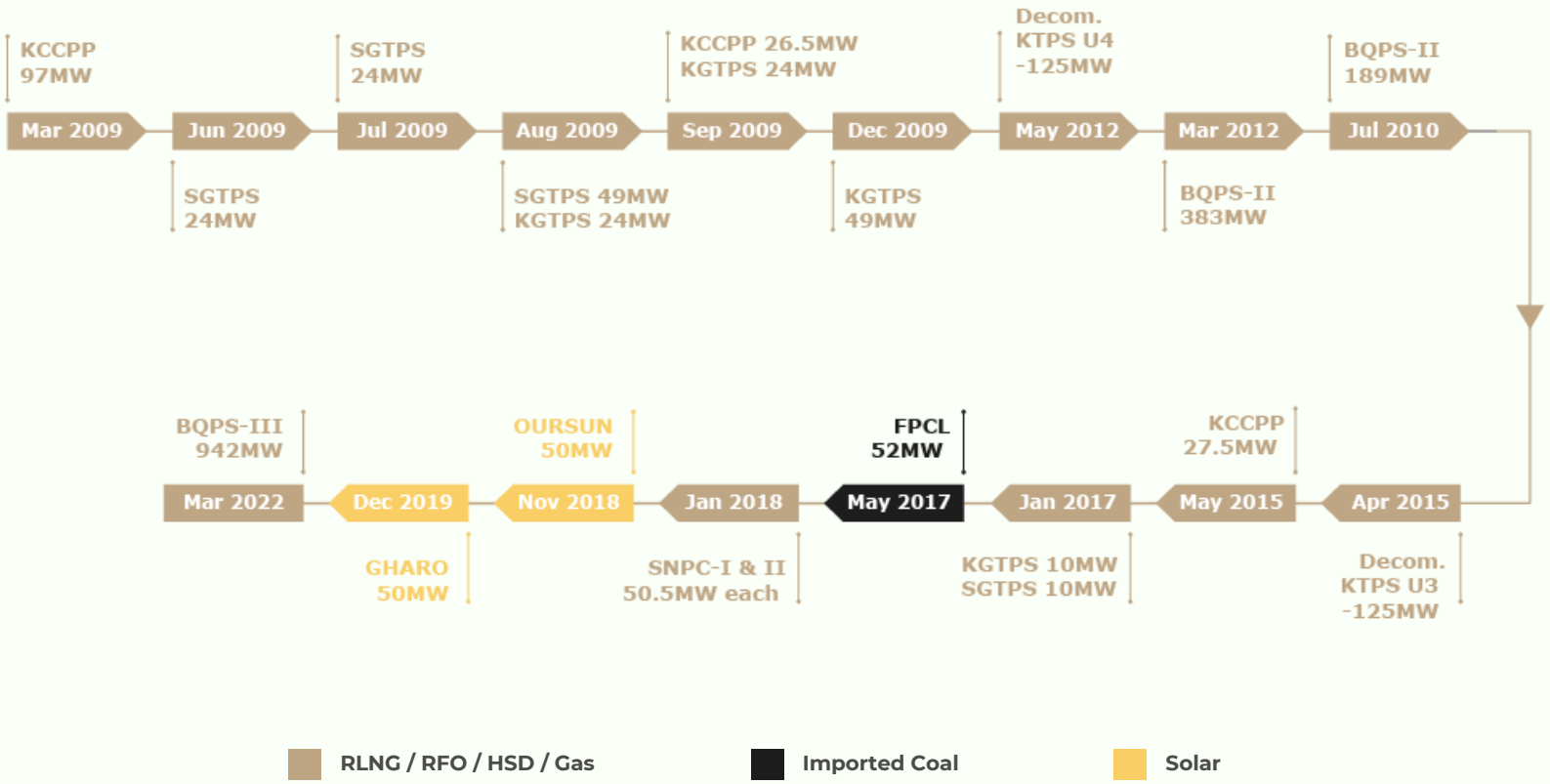
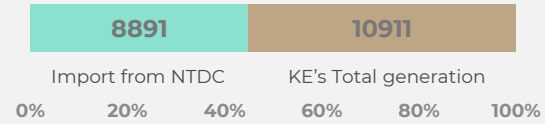
K-Electric has expanded generation capacity by about two folds since 2009, but expansion has predominantly been fossil fuel based



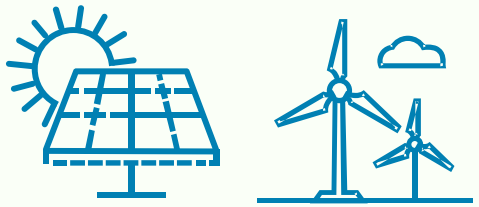
Source: K-Electric

- Since privatization until now K-Electric has invested around 474 billion rupees across the entire power value chain with a significant portion around **204 billion rupees** directed into the generation function.
- Over the last two decades, K-Electric added **2,132 MW** to its generation fleet. Surprisingly, these capacity expansions did not include significant additions of renewables – just a **100 MW** of solar PV in the IPP mode.
- KE currently shows a substantial dependency, importing around half of its 1,100 MW electricity demand from the national grid. Rest of the demand is met by KE's existing, yet costly, thermal generation fleet.

KE's Generation Mix (GWh) - FY22

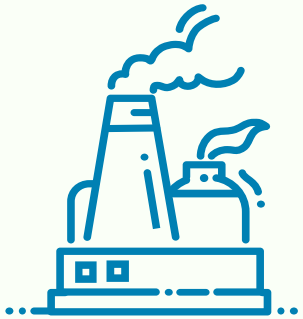


Despite being a vertically integrated utility, K-Electric's progress on renewable energy has been negligible



K-Electric operates in a region with significant wind and solar potential, yet only has 100 MW of solar capacity and no operational wind plants in its system.

Despite K-Electric's ambitious 2023 goal of achieving 30% RE by 2030, its current PAP FY24-30 projections fall short at 28%, even with hydro inclusion. Surprisingly, KE's plan lacks a target for reducing fossil fuel usage within its system.



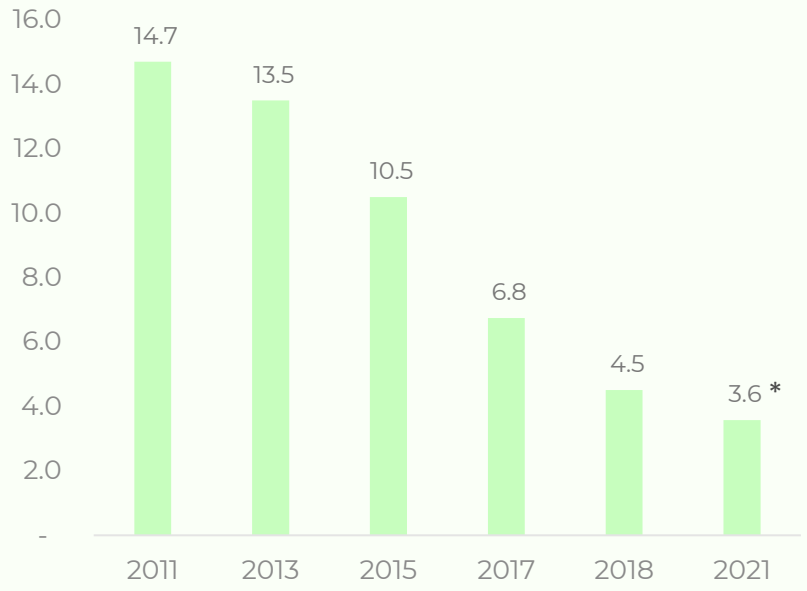
With a predominant reliance on fossil fuels in its current generation fleet, K-Electric is once again prioritizing coal projects for future capacity expansions until 2030.

- According to Pakistan Economic Survey FY22, Pakistan has a huge potential to generate electricity from wind with estimates reaching around 50,000 MW. The established wind corridors are in the close vicinity of K-Electric i.e., Karachi itself and Balochistan. Similarly, Pakistan also has a high potential of solar power.
- Utilizing these abundant renewable resources to generate economical power will not only bring relief to the inflation-stricken consumers but will also help K-Electric to strategically meet its goal of achieving 30% RE by 2030 and on a broader level Pakistan to meet sustainability goals.
- Unfortunately, KE remains reluctant to tap on this opportunity and planning around 50% of future capacity additions that are fossil-fuel based with already having 97% existing thermal power plants in its current fleet.

Source: K-Electric

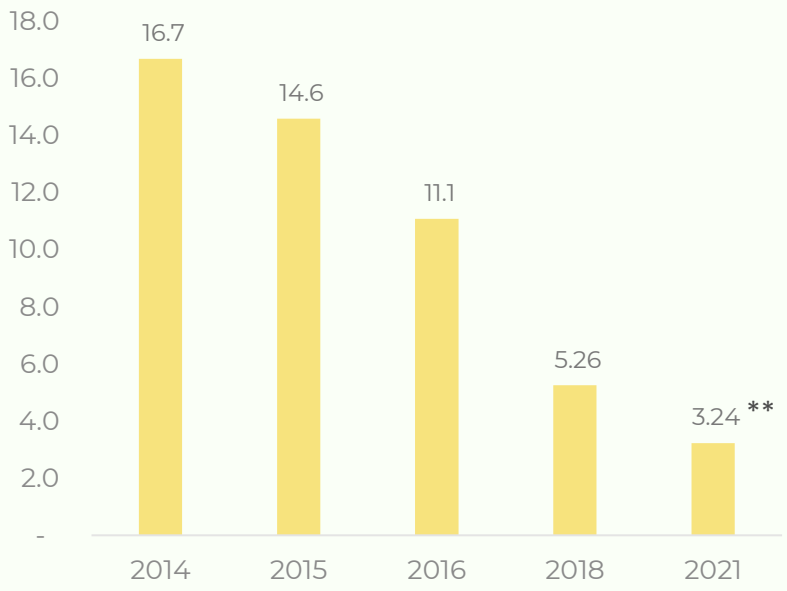
The levelized costs of utility-scale solar and wind power project have declined remarkably in Pakistan in the past decade

LCOE Trend for Wind (US ¢/kWh)



For utility scale wind projects, LCOE decreased by 76% from 2011 to 2021.

LCOE Trend for Solar (US ¢/kWh)



For utility scale solar projects, LCOE decreased by 81% from 2014 to 2021.

- The global Levelized Cost of Energy (LCOE) for utility-scale wind and solar projects has drastically decreased in the past decade, and Pakistan has also witnessed substantial cost reductions in REs.
- Levelized tariffs for wind energy have decreased by 76% from 2011 to 2021, and that of solar PV projects have witnessed 81% reduction from 2014 to 2021.
- K-Electric failed to capitalize on this opportunity and remained stuck to fuel-based power generation. This inaction led to financial losses for K-Electric and further burdened its consumers through inflated electricity costs which could have been avoided by taking timely action i.e., integrating REs.

* Awarded to Moro Power Company (Pvt.) Ltd. (MPCPL) of 24.9 MW wind power project

** Awarded to Siachen Energy Limited (SEL) of 100 MWp Solar Power Project

➢ These projects were not allowed further development due to regulatory restrictions

Source: NEPRA

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Instead of adding low-cost renewable energy, K-Electric favored PPA extensions for inefficient and low on merit order thermal power plants, further exacerbating electricity prices

K-Electric gave extension in the Power Purchase Agreements (PPAs) to two of its RFO based independent power plants: Gul Ahmed (of 136 MW installed capacity) and Tapal Energy (of 126 MW installed capacity) in 2019; and kept operating the Korangi Power Complex plants that usually lie way below in its merit order.

Their generation could have been replaced by timely induction of RE based power plants in the preceding years, that could have saved millions of dollars in total cost savings.

This cost of the lost opportunity was calculated in **two different cases**:

i. **First case:** Assessment of cost of lost opportunity assuming if the K-Electric had decided to add 200 MW renewable energy (Wind) in FY20 and FY21 each. **Six different outputs** representing the cost of the missed opportunity are calculated for this case which depends on replacement of thermal generation from K-Electric's system by the equivalent generation from these REs.

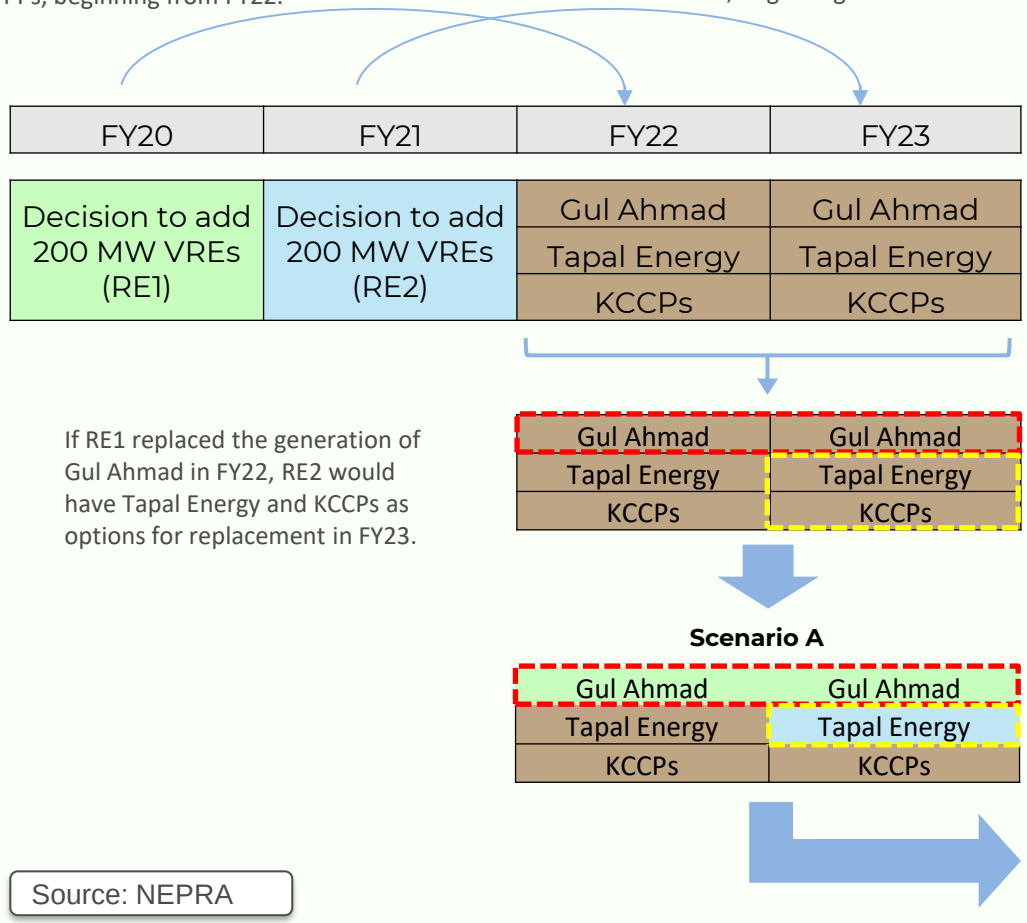
ii. **Second case:** Assessment of cost of lost opportunity assuming if the K-Electric had decided to induct in its system 200 MW renewables in FY20 and 400 MW in FY21. **Three different outputs** representing the cost of the missed opportunity are calculated for this case using the same approach.

- According to IGCEP benchmarks, a wind power plant of 200 MW capacity can generate about 736 GWh in a year. Similarly, annual generation of a 200 MW hybrid power plant (3:1, wind to solar) is about 650 GWh.
- According to the NEPRA's State of industry Report, Gul Ahmed and Tapal Energy generated between 670 GWh to 710 GWh and 620 GWh to 750 GWh in the last five years, respectively. Likewise, the Korangi Power Complex plants have generated about 667 GWh in FY 2022 on open and combined cycle modes.
- Therefore, an RE plant (Wind) of 200 MW capacity could (& can still) replace the generation of any of these three thermal power plants without compromising system operations.

K-Electric's inaction on renewable energy has costed its consumers up to US 204 million dollars in the FY 2022 and FY 2023 alone

The 200 MW REs added in FY20 have option for replacing the (equivalent) generation of one of the three thermal PPs, beginning from FY22.

Similarly, the 200 MW REs added in FY21 have option for replacing the (equivalent) generation of one of the remaining two thermal PPs, beginning from FY22.



REs added in FY20 (replaces thermal generation for FY22 & FY23

REs added in FY21 (replaces thermal generation for FY23

Thermal generation (to be replaced)

If RE1 replaced the generation of Gul Ahmad in FY22, RE2 would have Tapal Energy and KCCPs as options for replacement in FY23.

In the first scenario, we assume that RE1 starts replacing Gul Ahmad's generation from FY22, and RE2 replaces Tapal Energy's generation in FY23. This would have saved 204 million US dollars for K-Electric.

Savings = US $204.03 Million

Source: NEPRA

Note:

- A two years lead (development) time for the REs has been considered while doing calculations.
- RE1 is the 200 MW of renewables coming into the system of K-Electric in FY22 as a result of the decision taken in FY20 (i.e., after 2 years of lead / development time).
- Similarly, RE2 is the 200 MW of renewables coming into the system of K-Electric in FY23 as a result of the decision taken in FY21.

K-Electric's inaction on renewable energy has costed its consumers up to US 204 million dollars in the FY 2022 and FY 2023 alone

FY20	FY21	FY22	FY23
Decision to add 200 MW VREs (RE1)	Decision to add 200 MW VREs (RE2)	Gul Ahmad Tapal Energy KCCPs	Gul Ahmad Tapal Energy KCCPs

REs added in FY20 (replaces thermal generation for FY22 & FY23

REs added in FY21 (replaces thermal generation for FY23

Thermal generation (to be replaced)

Scenario A

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

Savings = US $204.03 Million

Scenario B

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

Savings = US $192.31 Million

Scenario C

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

Savings = US $201.66 Million

Scenario D

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

Savings = US $187.89 Million

Scenario E

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

Savings = US $178.27 Million

Scenario F

Gul Ahmad	Gul Ahmad
Tapal Energy	Tapal Energy
KCCPs	KCCPs

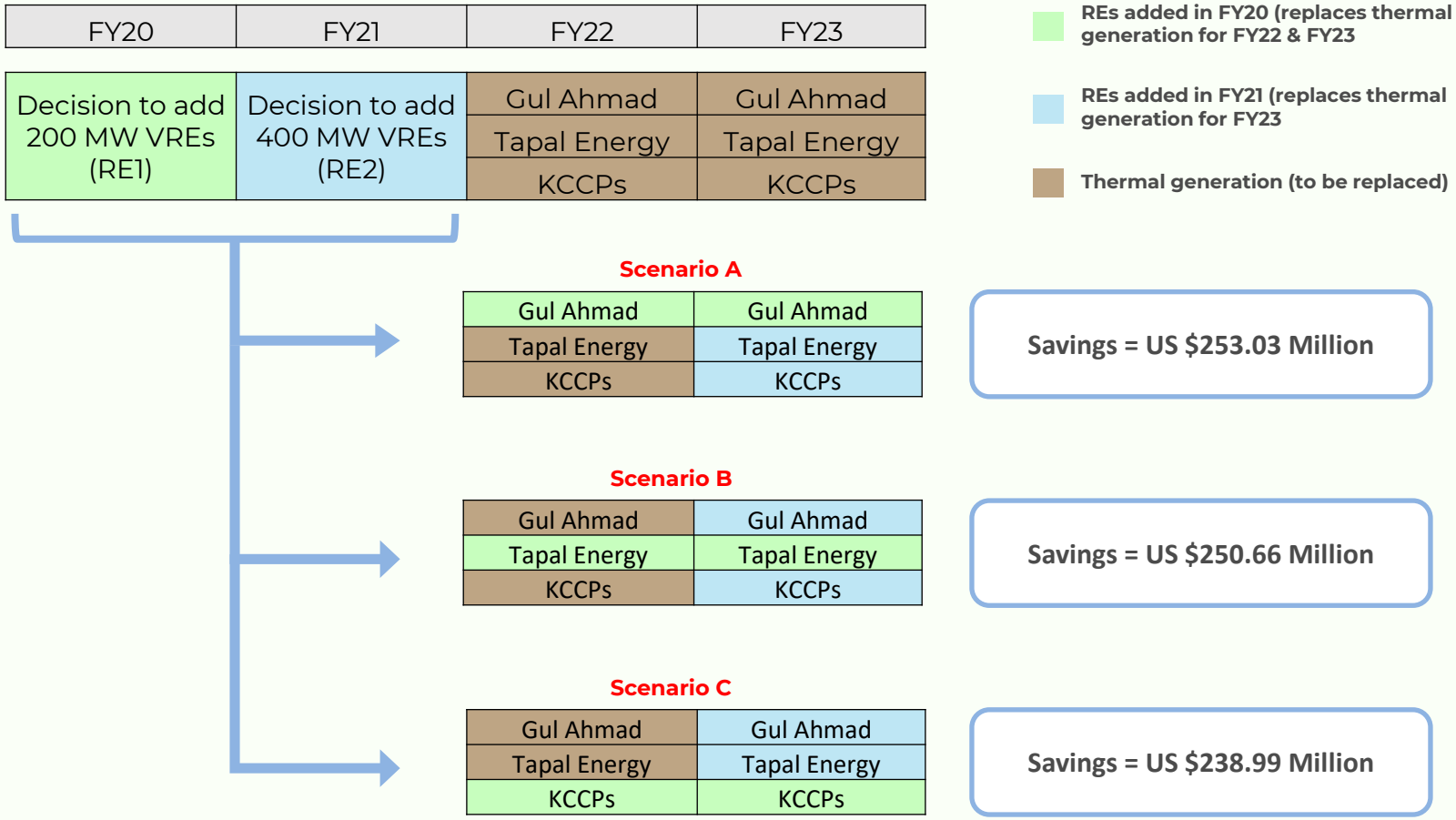
Savings = US $176.22 Million

Source: NEPRA

First Case::

- For all six scenario outputs in the first case, RE1 (200 MW REs added in FY20) could replace the generation of one of the three thermal plants for two years (FY22 & FY23).
- RE2 could replace the generation of any of the remaining two thermal power plants for FY23.
- Each scenario thus represents the savings of adding 400 MW REs in K-Electric's system to replace the equivalent thermal power generation in FY22 and FY23 combined.
- The findings of the first case show that K-Electric could have saved up to US $204.03 million in two fiscal years by adding 400 MW of REs in its system.

Timely and more aggressive action on renewable energy by K-Electric could have resulted into even more cost savings for its consumers



Source: NEPRA

Second Case::

- For all three scenario outputs in the second case, RE1 (200 MW REs added in FY20) could replace the generation of one of the three thermal plants for two years (FY22 & FY23).
- RE2 could replace the generation of the remaining two thermal power plants for FY23.
- Each scenario thus represents the savings of adding 600 MW REs in the K-Electric's system to replace the equivalent generation of thermal power plants in FY22 and FY23 combined.
- The findings of the second case show that K-Electric could have saved up to US $253.03 million in two fiscal years by adding 600 MW of REs in its system.

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A PLEXOS based model has been developed to assess the viability of K-Electric's generation expansion choices

Model inputs

Data:

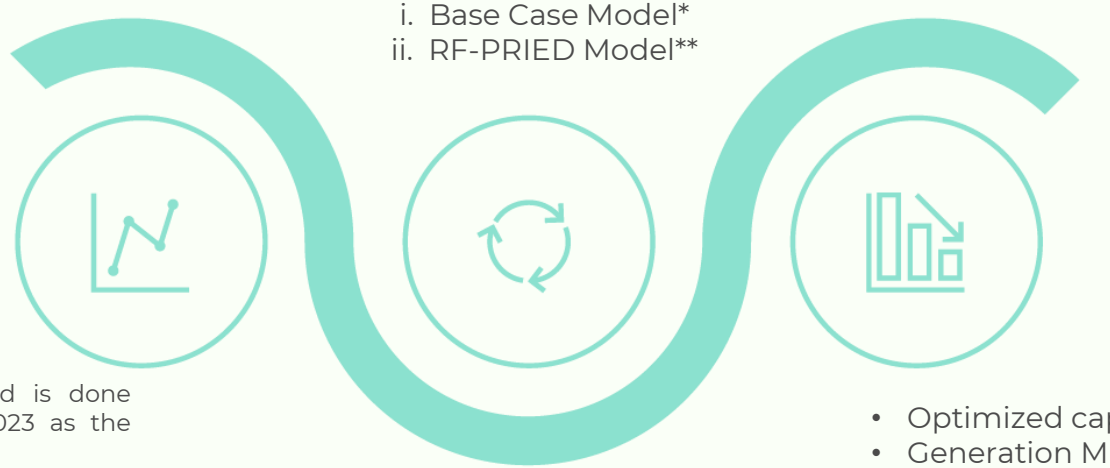
- Fuel Prices
- Demand Forecast
- Plant Parameters
- Operational constraints

Assumptions:

- Backward projection of demand is done through PLEXOS considering 2023 as the base year.
- Build Cost of a candidate Coal Power Plant has been updated as per procedure defined in NEPRA's upfront tariff determination for coal projects.
- Fuel parameters of local coal have also been updated to reflect current market conditions.
- No minimum guaranteed offtake has been considered for the candidate power plants.
- A minimum guaranteed offtake of 75% for BQPS-III and 50% for SNPC plants has been considered.
- Project development time of 2 years has been considered for solar and wind projects, and 4 years has been considered for thermal (coal) power projects.

Simulations:

i. Base Case Model*
ii. RF-PRIED Model**



PLEXOS Model

Optimization with technical, operational and economic constraints

Model outputs

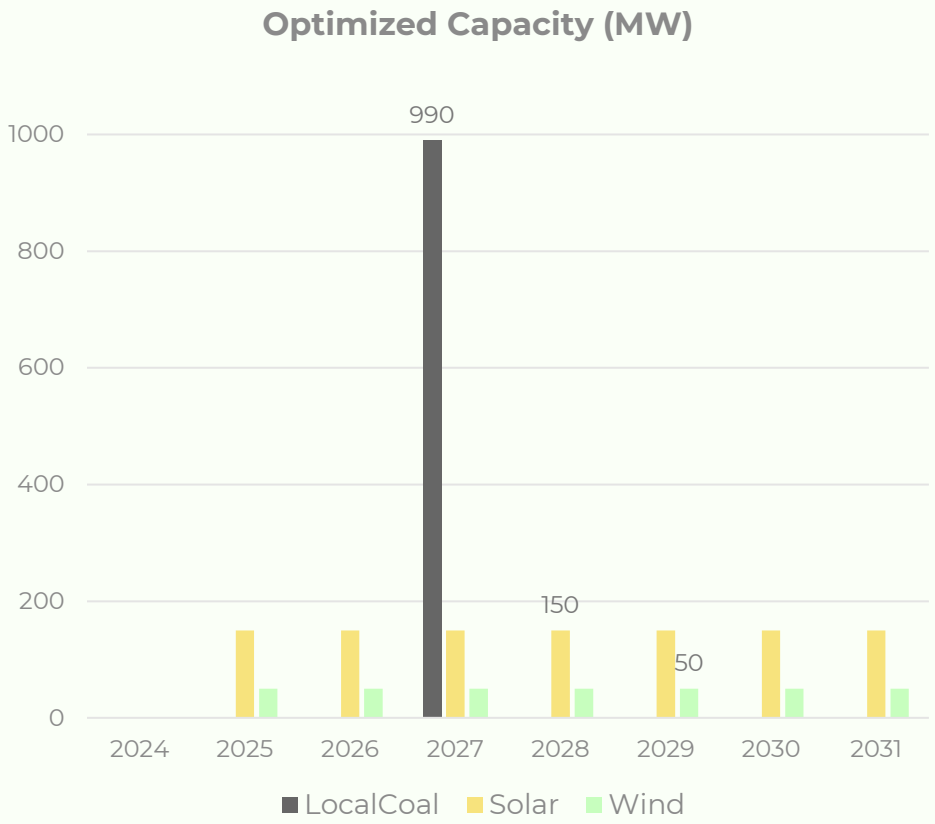
- Optimized capacity
- Generation Mix
- Generation costs
- Fuel costs
- Capacity factors
- Network adequacy
- System flexibility

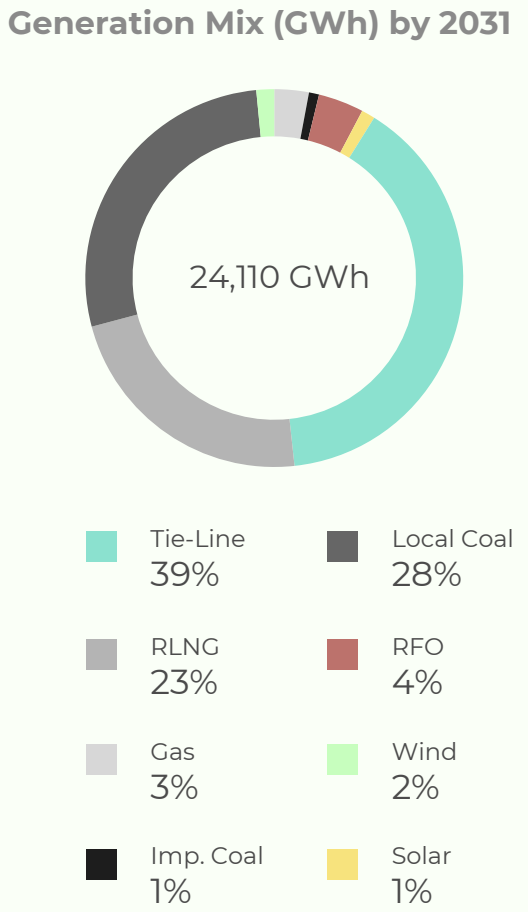
* Base case was prepared by considering similar set of constraints & assumptions to replicate the IGCEP optimizations for K-Electric, with a small difference of indicative 82 MW of hydel, which was not considered for our analysis.

* For the RF-PRIED model, PLEXOS had additional 200 MW of solar and wind capacity for each year, as candidate options to optimize based on the least-cost criteria beginning from FY24.

- Strategic Integration of Renewable Energy offers substantial future savings for K-Electric.
- Opportunity Missed, Millions Lost: Demonstrated earlier, K-Electric could have saved approximately $204 to $253 million in just two years. It is imperative to assess the potential for additional savings in the coming years by transitioning to REs.
- RF-PRIED has developed a PLEXOS-based model for this study. In this model, we analyzed the capacity expansion for K-Electric by removing the yearly cap on REs. We introduced more solar and wind power plants as candidate options, allowing PLEXOS to optimize based purely on the least-cost criteria.

Putting a cap on REs from FY24 to FY30 shows an unnecessary reliance on local coal in K-Electric's base case for capacity optimization



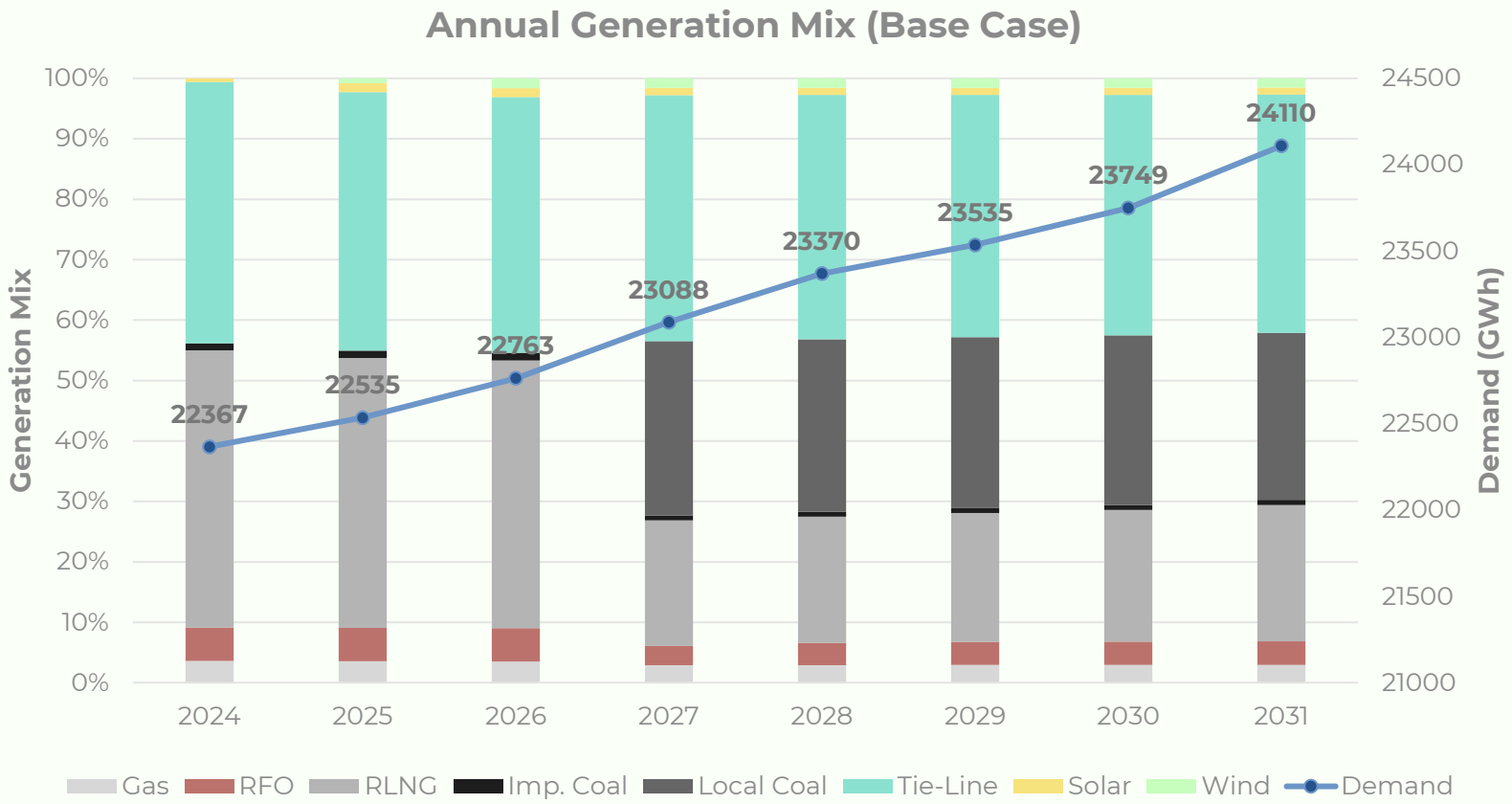


- The time horizon for the study is kept same as in the IGCEP i.e., from FY24 to FY30.
- In the base case, a 990 MW of local coal-based capacity is optimized in the system due to a cap of 200 MW put on the maximum capacity build in a year for the REs.
- This leaves a limited room for the REs, as only 1,400 MW capacity is optimized, which includes 1,050 MW solar and only 350 MW wind energy.
- Moreover, K-Electric's system shows heavy reliance on existing as well as future optimized thermal sources of power generation (Local Coal, RLNG etc.) in the long run.
- For year 2031, only 3% of total annual energy required to serve electricity demand is generated using the 1,500 MW of (existing and future optimized) wind and solar capacity altogether.

Source: NTDC (IGCEP)

* The Tie-Line capacity is considered as 1100 MW throughout the study horizon.

The cap on REs from FY24 to FY30 limits the shares of supply from wind, solar and Tie-Line in the total generation mix due to reliance on local coal



- The assumption for the Tie-Line capacity between NTDC and K-Electric is 1,100 MW till FY24, and up to 2,050 MW on pro rata basis from FY25 till the end of the study period.
- The generation cost for the electricity imported by K-Electric from the national system through the Tie-Line is $32.77/MWh, and it was calculated using the data from NEPRA's State of Industry report.
- In the simulated IGCEP base case, the supply from the local coal limits the shares of wind, solar and Tie-Line supply in the total generation-mix.

Source: NTDC (IGCEP)

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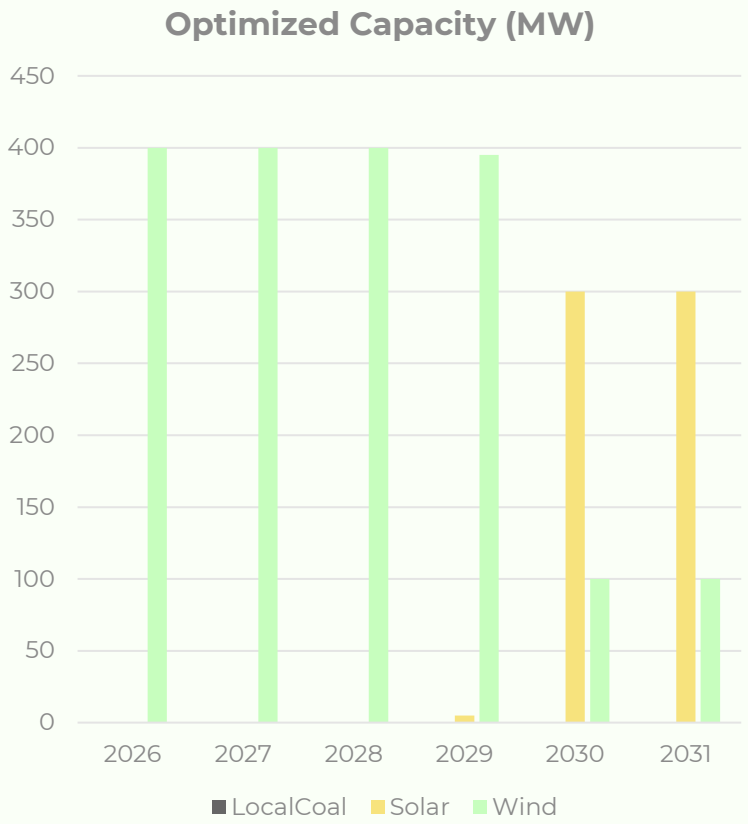
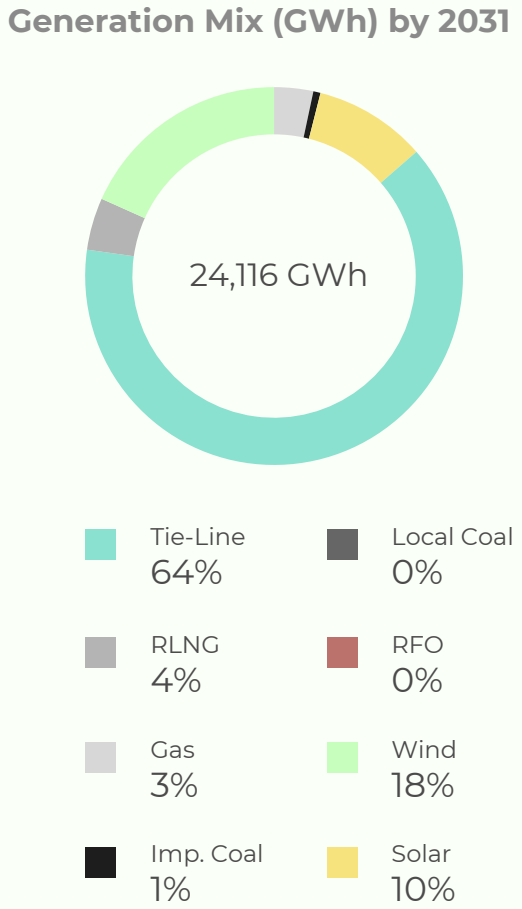
Removing cap of 200 MW renewable energy per annum optimizes no coal and 2,400 of renewables during the time horizon of the study



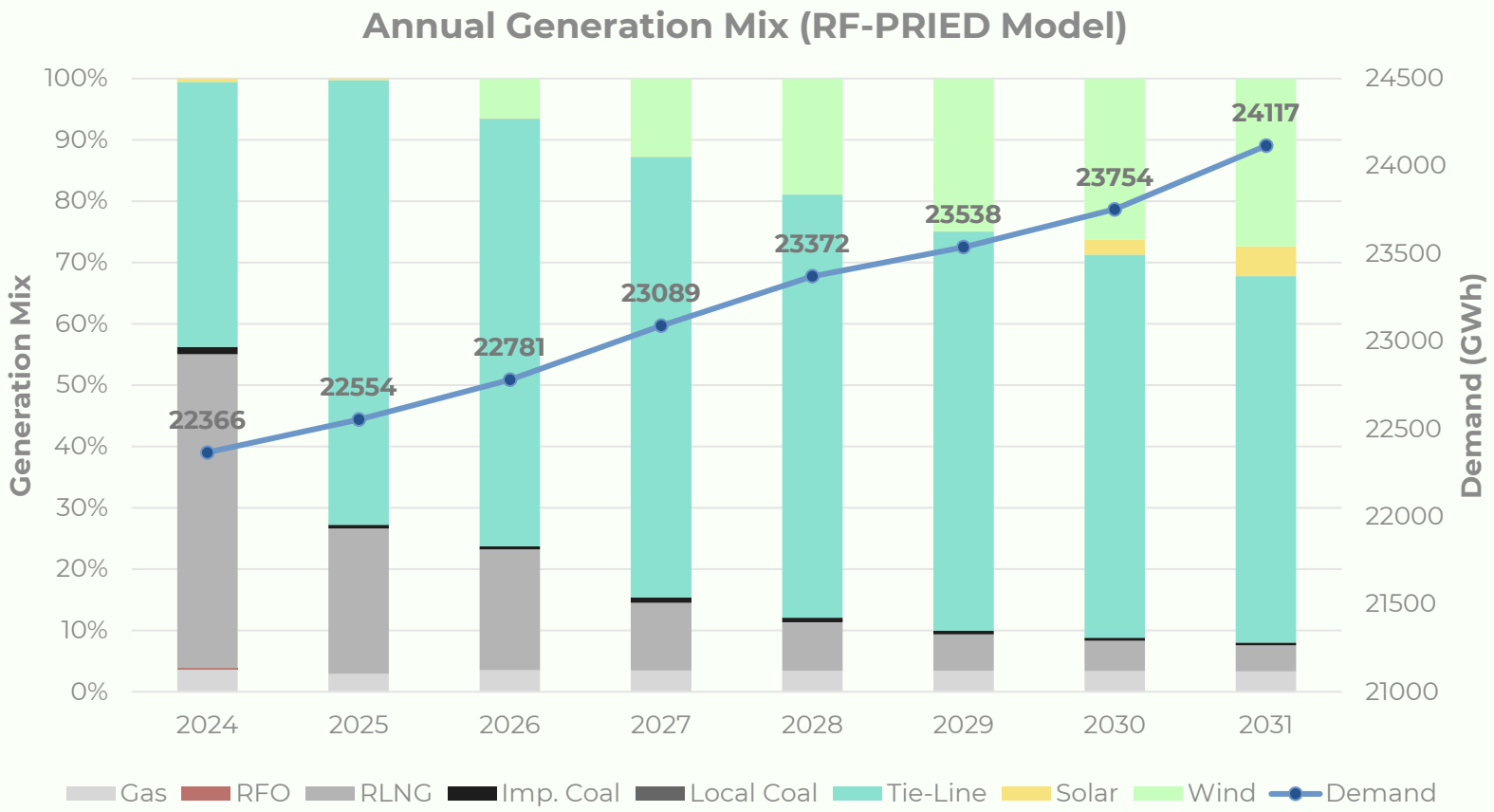
The share of wind in the optimized capacity is more than solar owing to its consistent daily generation profile as compared to solar.



- No thermal capacity is optimized in the system when the cap of 200 MW capacity build per year for the REs is removed.
- Solar and wind are consistently optimized throughout the study period based on the least-cost criteria. A total of 2,400 MW capacity is optimized for REs, which includes 1,200 MW solar and wind energy each.
- A major shift in K-Electric's system's reliance is observed towards the power generated by wind, solar, and electricity imported from the NTDC system, as more RE candidate options are introduced in the model for optimization based on least cost criteria.
- The generation fuel mix becomes more diversified. For year 2031, solar and wind collectively supply 28% of the total generation and 38% of installed capacity.

* The Tie-Line capacity is considered as 1100 MW till FY 2024, and 2050 MW onwards as per PAP (FY 2024-30)

The shares of supply from REs and Tie-Line increase significantly in the total generation mix due to removal of local coal & RLNG from K-Electric system



- The share of cheap electricity import from NTDC system witnesses a substantial increase in the energy-mix, rather than building new local coal plants. For year 2031, the Tie-Line supplies 64% of the total generation.
- The overreliance of the K-Electric's system on the supply from national grid raises multiple concerns including the affordability of electricity generated by K-Electric's own system, as well as the inefficient planning decisions by the utility.
- Considering the factors discussed above, there is a critical need for a specialized research study. This study will thoroughly investigate the implications of the supply from the national grid to K-Electric through the Tie-Lines.

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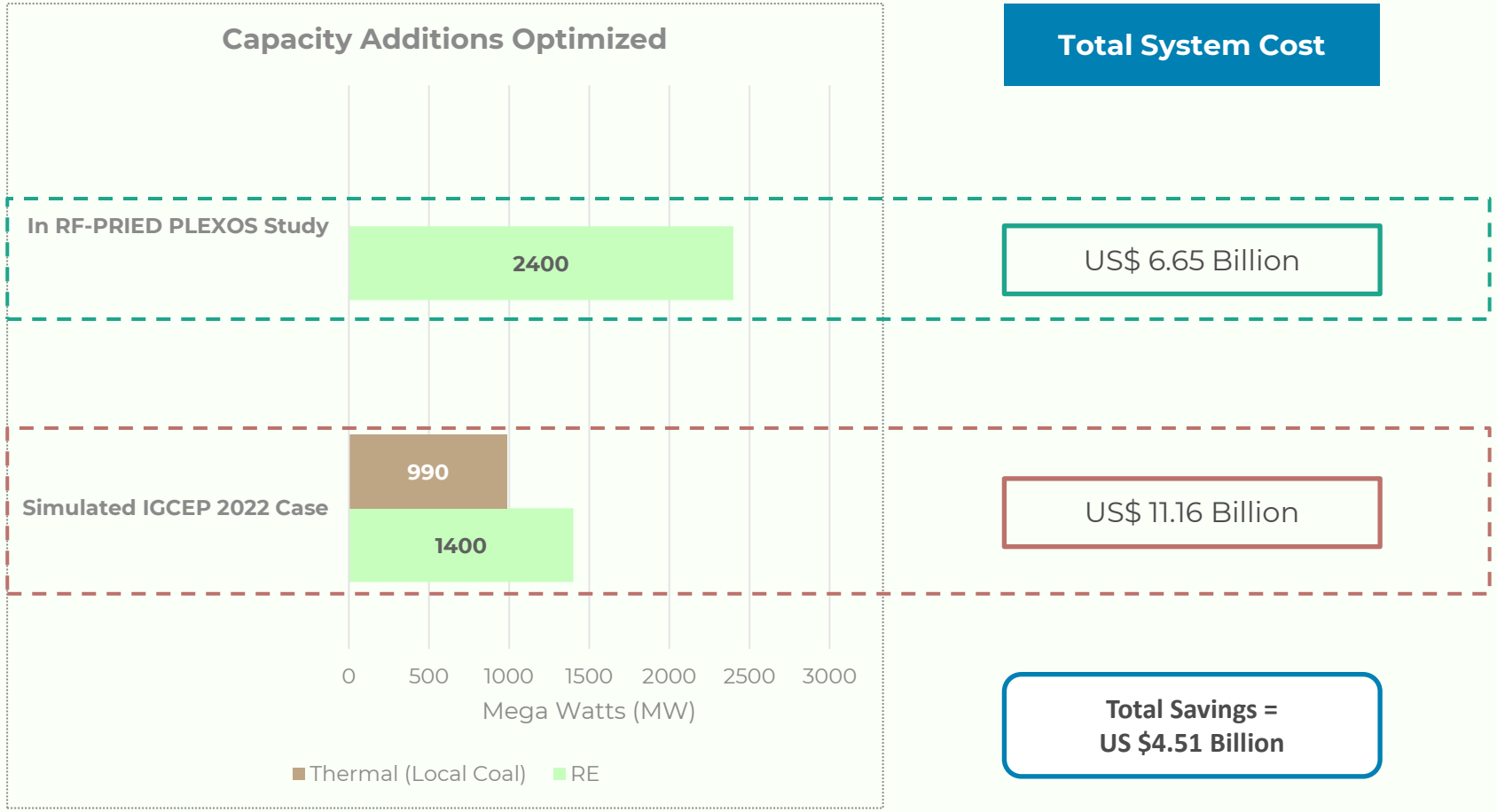
K-Electric can save 4.51 billion US dollars billion from FY24 to FY30 by proactively adding renewable energy into its system



Total System Cost

US$ 6.65 Billion

US$ 11.16 Billion

Total Savings = US $4.51 Billion

- Now, there is a dire need for K-Electric to think and act proactively, learning from past mistakes. As discussed earlier, K-Electric missed the opportunity to save millions of USD in the past by granting extensions to costly Power Purchase Agreements (PPAs). K-Electric must now take proactive actions to avoid such costs in the future, preventing an overburden on its consumers. As suggested by our model, K-Electric can achieve substantial savings of up to 4.49 billion USD in the future by making timely decisions on renewable energy integration.
- These additional savings can be allocated to other vital purposes, such as enhancing transmission capabilities and upgrading infrastructure. These investments will contribute to providing economical and reliable power to end consumers.

*** Total System Cost** includes fixed and variable operations and maintenance costs, capacity charges, and fuel costs.

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Way Forward: A Leap from Potential to Progress

To provide relief to inflation-stricken electricity consumers of Karachi in terms of affordable electricity, following action points are imperative for K-Electric:

- ✓ Cease extensions in the Power Purchase Agreements (PPAs) of expensive and inefficient thermal power plants
- ✓ Ensure a consistent and efficient integration of least-cost Renewable energy projects i.e., Wind and Solar
- ✓ Avoid incorporating fossil-fuel based thermal power generation in its fleet that is costly and environmentally hazardous
- ✓ Uphold its commitment of adding 30% renewables in its generation fleet by 2030 to achieve sustainability targets

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Thank You

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