SAARC Energy Centre, Islamabad

Pakistan

THE REPORT

Webinar On "Energy System Optimization Modelling through PLEXOS® for SAARC Member States"

2nd July, 2020

Organized by

SAARC Energy Centre Islamabad

July 2, 2020

SAARC Energy Centre
697, Street 43, Sector E-11/4 (NPF),
Islamabad, Pakistan
www.saarcenergy.org

Introduction

1. SAARC Energy Centre, (SEC) successfully conducted a Webinar on "Energy System Optimization Modelling through PLEXOS® for SAARC member states" on Thursday July 2, 2020. Webinar Agenda is available at Annexure I.

2. The Webinar highlighted the most pressing topics of energy system optimization, helping decision makers and planners by providing insights into energy, environment and the associated complexities. The webinar specifically covered PLEXOS® Integrated Modelling Software, which is being used in over 300 companies across 62+ countries for the modelling, simulation, and optimization of electricity, gas and water systems. Experts from the Energy Exemplar, presented different features of the model, covering the following.

a) Knowledge of what PLEXOS® is by reviewing each use case.

b) A better understanding of what can be achieve with PLEXOS® by reviewing user's applications.

c) Insights on power system modelling best practices.

d) Awareness of the benefits of an integrated analysis approach.

e) The experts shared latest technological developments related to the above thematic areas using PLEXOS® using case studies from SAARC Member States and other countries worldwide.

Participation

3. The Webinar was registered by 141 attendees including Representative of Regional / International organizations, Academia and private sector. Experts from Energy Exemplar, joined the webinar as speakers. The list of participants is available at Annexure II.

Opening

4. Due to the COVID-19 situation and lockdown in Pakistan, SEC officials attended the webinar from their homes. Dr Tanvir Ahmad (Program Leader – Technology Transfer), opened the webinar, as the program coordinator. He briefly informed the participants about the importance of this webinar. He also introduced the speakers briefly and informed the participants about the Q&A session and procedure.

Technical Proceedings

5. The webinar hosted talks and presentations from two subject experts. The expert list is available at Annexure III. The presentation delivered during the webinar are available at Annexure IV. These presentations are also available at SEC's website http//:www.saarcenergy.org. A brief information on the content of the delivered presentation is as follows:

Presentation 1: Energy System Optimization Modelling through PLEXOS® in SAARC member states

Expert: Belen Leveroni (Business Development Executive) and Dr Dante Recalde, Lead Energy Market Analyst for the solution engineering team at Energy Exemplar

6. The presentation was started by Ms Leveroni, giving and introduction to the PLEXOS® energy modelling software. PLEXOS® is an easy to use economic software that uses mathematically based optimization techniques for energy modelling and forecasting. She also gave information about different organizations, which have used PLEXOS® to their benefits. The presentation was then handed over to Dr Dante Recalde.

7. Dr Recalde informed the participants that PLEXOS® has been the "all in one tool' for analysis from market modelling to planning. Forecasting and optimization with its perfectly designed GUI. The software can save efforts in formulating complex problems as well as significant time with its fast and flexible simulations.

8. He informed the participants that PLEXOS® is highly configurable by the user. It offers cutting edge access to some of the most advanced algorithms and modelling techniques, thus giving the use real-time simulation. The software already has 30 datasets from all over the world, including the SAARC Member States. If dataset for a specific country is not available, that can be easily built in the software.

9. PLEXOS is used extensively by transmission system operators (TSO) to optimize and analyze the impact of transmission operation and congestion costs. The ability to model optimal power flow (OPF) with losses is fully integrated with dispatch and unit commitment. The tool can be used for demand response modelling with integrated system security and adequacy.

10. Dr Recalde concluded his talk by presenting different case studies in which PLEXOS® has been used for energy forecasting and optimization. These case studies included integration of multiple renewable energy technologies into the system.

Questions & Answers

1. **What is the processing efficiency of the software and what computing requirements are required? Can the software be used in real-time systems?**

   Dr Recalde: The minimum requirements is a simple PC with Pentium 4 processor and can be easily run on a workstation. The latest version of the software allows a user to configure multiple optimizers accordingly. The software uses optimum time for energy optimization and is already in use in real-time systems.

2. **Is there any student or research version of the Software, which is free?**

   Dr Recalde: Yes, PLEXOS offers a research version of the software. The approach is not to sell the software but to make sure that the customers are empowered.

3. **Line of loss probability for Pakistani energy system mentioned in the presentation is 1%. Is this a realistic figure?**

   Dr Recalde: This was just for demonstration purpose. The software allows you to evaluate the costs to reach this 1% line of loss probability. Different scenarios can be compared using the software.

4. **Can the usefulness of pump storage be assessed using PLEXOS?**

   Dr Recalde: The software has a separate module which can be used to create and evaluate multiple scenarios for renewables integration using pump storage.

5. **What about the GHG emission using PLEXOS?**

   Dr Recalde: The software is capable of both tracking and optimizing GHG emission for different technologies and different generation possibilities. This can also include emission costs and taxes.

6. **Can PLEXOS quantify the power requirements for ancillary services?**

   Dr Recalde: Yes, PLEXOS work at frequency level. With some abstraction and simplification, best response for the batteries considering the constraints can be modelled up to one second.

7. **What kind of optimization techniques are used in the software?**

   Dr Recalde: PLEXOS uses linear systems for optimization based on mathematical modelling. A user can choose the best suitable technique according to the objective function. For the time being, a user cannot introduce their own optimization techniques into the system. However, any types of constraints can be added using the objective function or separately as required.

8. **Is there any limit on the number of variables used in the objective function and the number of constraints?**

   Dr Recalde: No, any number of variables and constraints can be used in the software. There is no limitation and this depends upon the computation requirement and resources available.

Vote of Thanks and Closing of Webinar

Dr Tanvir Ahmad, Program Leader (Technology Transfer), SEC

16. Dr Tanvir Ahmad, informed all the participants that the presentations will be available on SAARC Energy Centre's website (www.saarcenergy.org). He requested the participants to submit suggestions and comments to SEC for any further improvement of these webinars, plus they may suggest and submit any topics of their interest for arranging future webinars. The webinar was closed with special thanks to the speakers and everyone attending the webinar. .

Annexures

Annexure-I

Agenda for Webinar

"Energy System Optimization Modelling through PLEXOS® for SAARC Member States"

Thursday July 2, 2020

Time Slot	Contents
1400 – 1405	Introduction
1405 – 1510	Energy System Optimization Modelling through PLEXOS® in SAARC member states 1. *Belen Leveroni* *Business Development Executive @Energy Exemplar* 2. *Dr Dante Recalde* *Lead Energy Market Analyst for the solution engineering team at Energy Exemplar*
1510 – 1525	Q & A
1525 – 1530	Closing of Webinar

Information for the participants:

1. All times mentioned in agenda are according to Pakistan Standard Time (PST). The participants from other Member States may attend Webinar by following their own national time. The time conversion for all Member States is given below for reference:

Country	Afghanistan	Bangladesh	Bhutan	India	Maldives	Nepal	Sri Lanka
Local time	(PKT-00:30)	(PKT+01:00)	(PKT+01:00)	(PKT+00:30)	PKT	(PKT+00:45)	(PKT+00:30)

2. The participants can ask questions to presenters by typing questions or clicking to the raised hand option into the Attendees pane of the main window of GotoWebinar software. You may send in your questions at any time during the presentations; we will collect these and address them during the Q&A session at the end of each session.

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Annexure-III

List of Presenters\ Resource Persons

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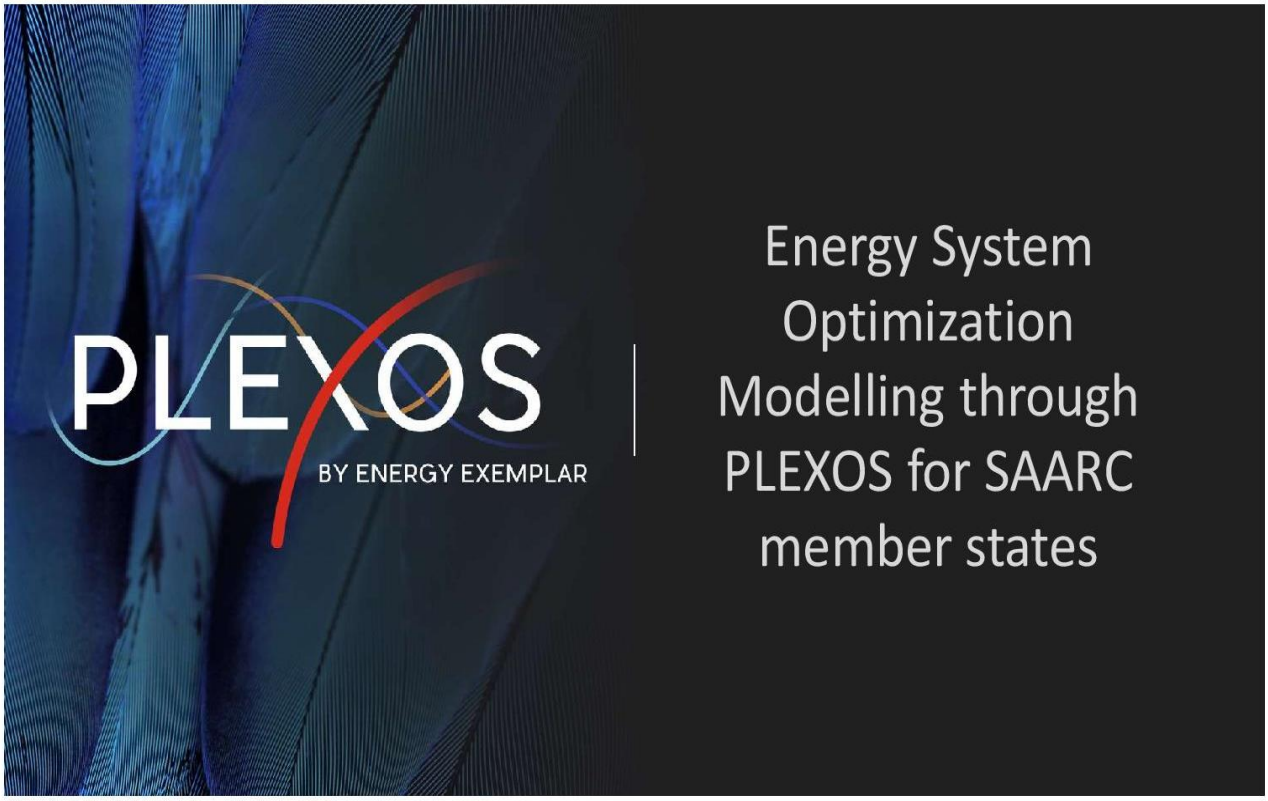
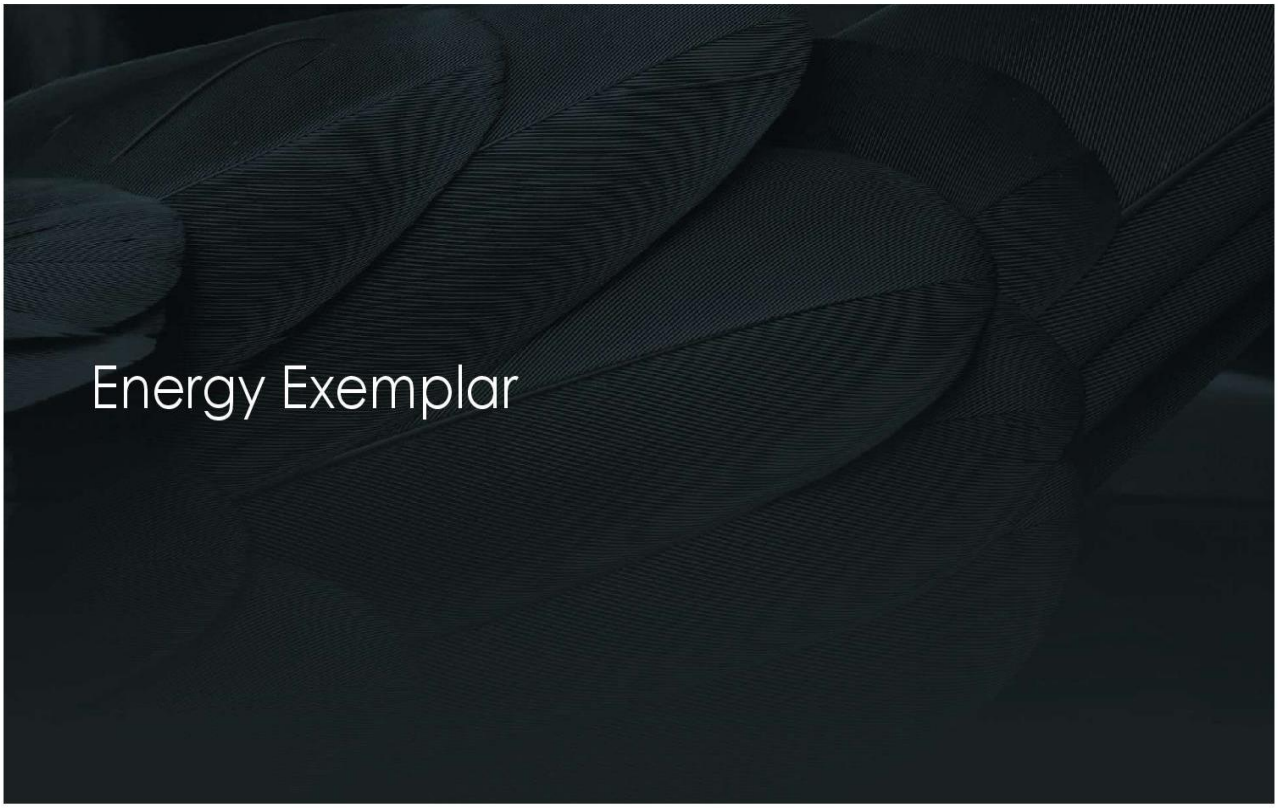

PLEXOS
BY ENERGY EXEMPLAR
Energy System Optimization Modelling through PLEXOS for SAARC member states


Energy Exemplar

Why Energy Exemplar?

1. Market Leader since 1999. **350+ clients in 62+ countries**
2. No consulting. We're **focused on our platform**.
3. **24x6 support worldwide**
4. Strong **investment in development**
5. **Social gateway** to a global community
    1. Network at User Group Meetings
    2. Adopt Best Practices
    3. Enjoy the knowledge transfer

Energy Exemplar

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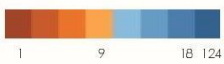
Energy Exemplar footprint

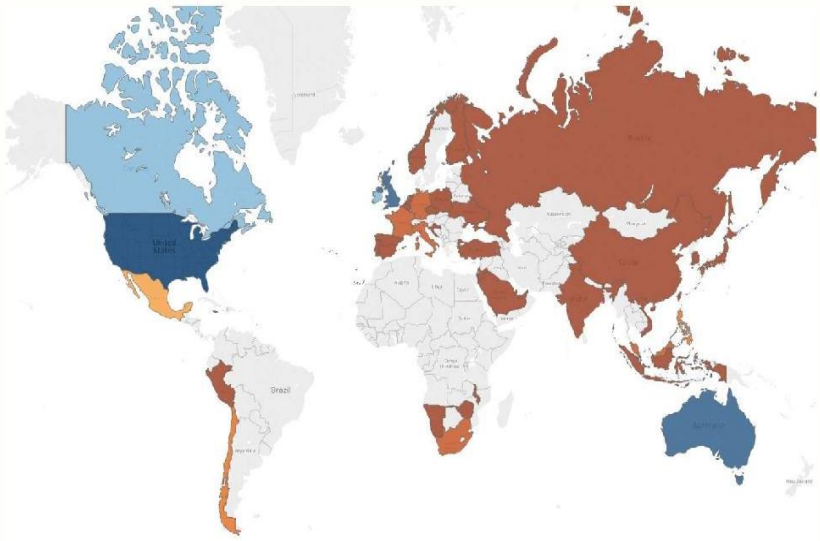
1,700 users at over 350 companies in 62 countries

Clients by Region:



Clients by Segment:

Utilities:	97
Consultants:	44
Power Producers:	39
Researchers:	28
Regulators:	21
TSOs:	14
ISOs:	13
Traders:	5
Energy Analysts:	4
International Institutes:	3



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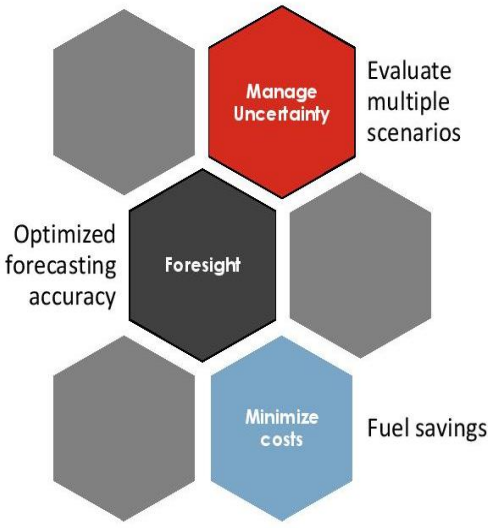
Asia Pacific Customers

AEMO
synergy
origin
CLP 中電
Energy for Brighter Tomorrows
TENAGA NASIONAL
SN ABOITIZ POWER GROUP
SESB
sarawak energy
电力规划设计总院
ENERGY MARKET AUTHORITY
POSOCO
EVNNLDC
ElectraNet
AboitizPower
EREA
MERALCO

Energy Exemplar

5

Why optimization?



Is your existing approach optimal enough?

Energy Exemplar

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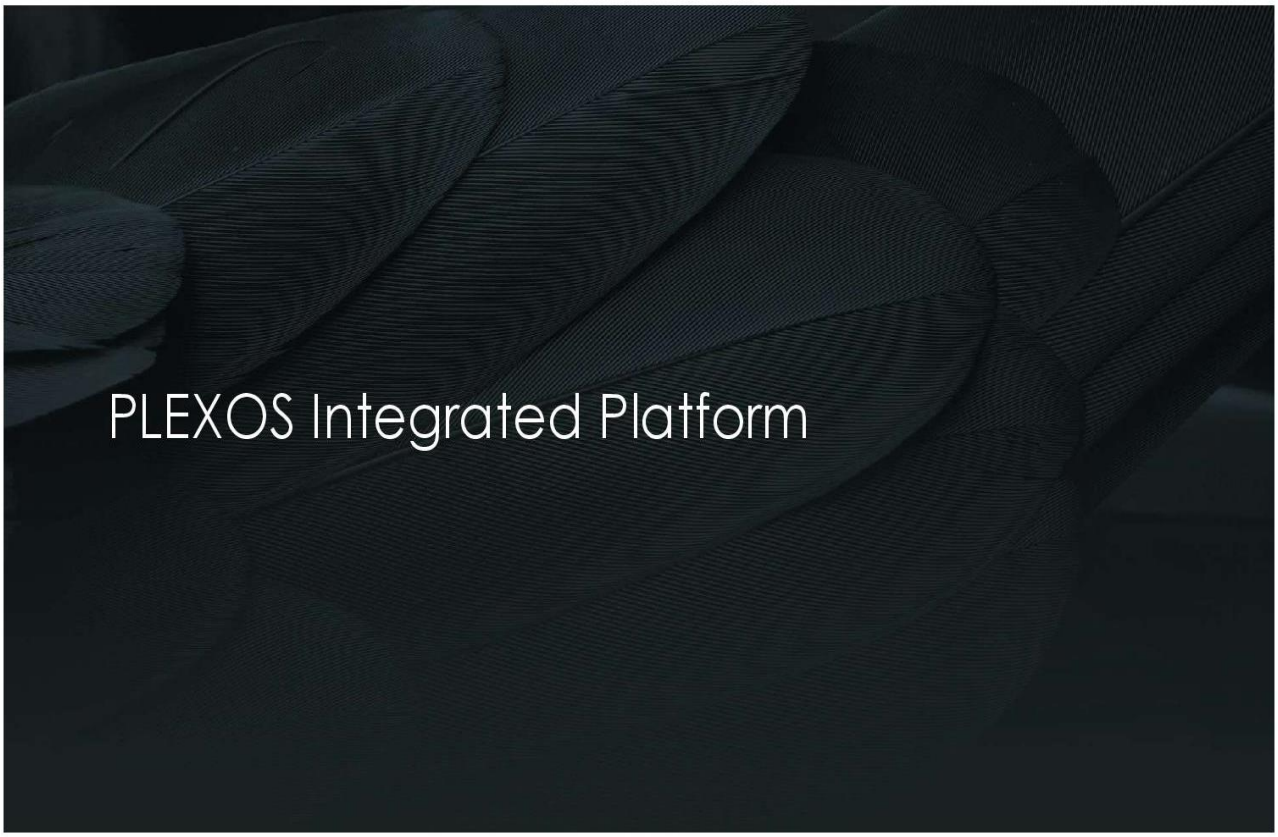
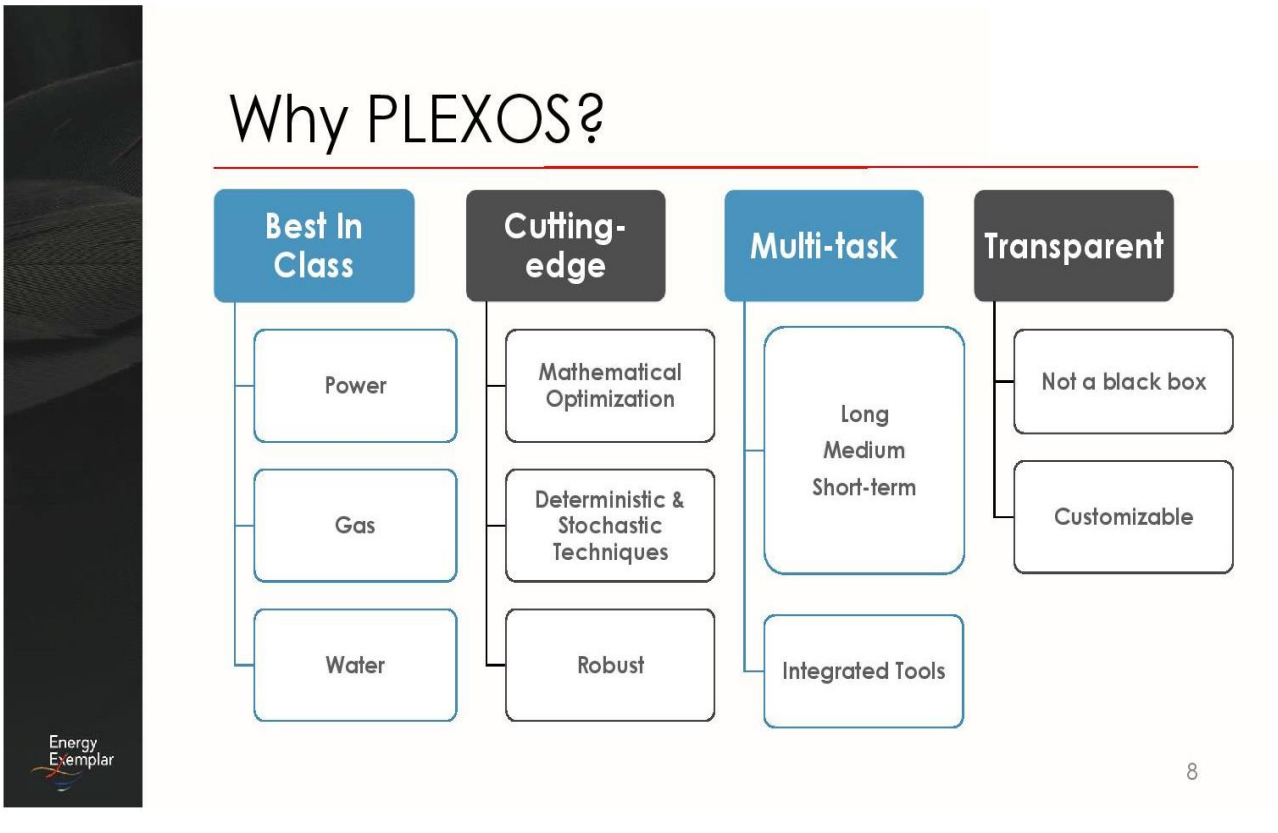
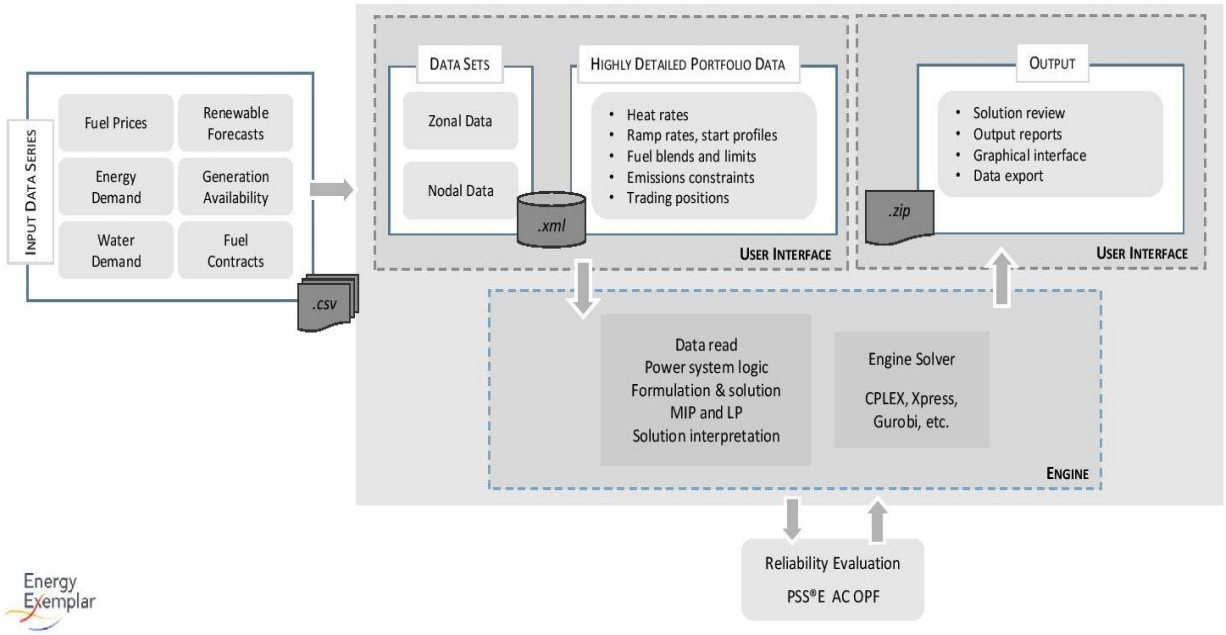

PLEXOS Integrated Platform

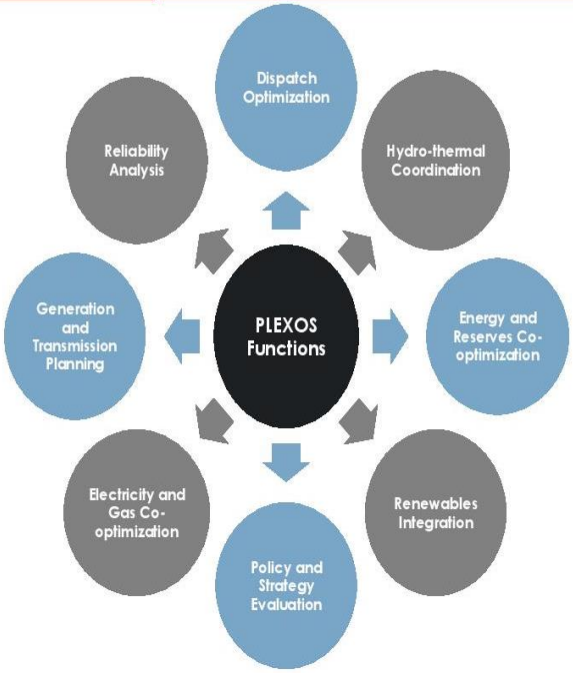

Why PLEXOS?
Best In Class
Power
Gas
Water
Cutting-edge
Mathematical Optimization
Deterministic & Stochastic Techniques
Robust
Multi-task
Long
Medium
Short-term
Integrated Tools
Transparent
Not a black box
Customizable
Energy Exemplar
8

How PLEXOS works?



Energy Exemplar

PLEXOS Main Applications



Energy Exemplar

10

PLEXOS® Integrated Energy Model

Why single engine?

- Collaboration among institutions
- Co-optimize across use cases
- Performant for the most complex problems
- Role based UI

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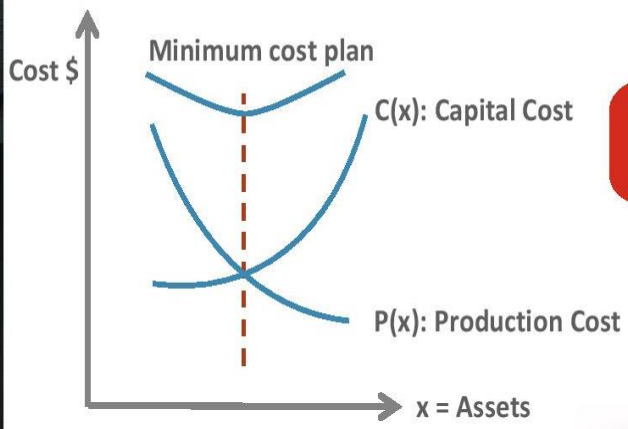
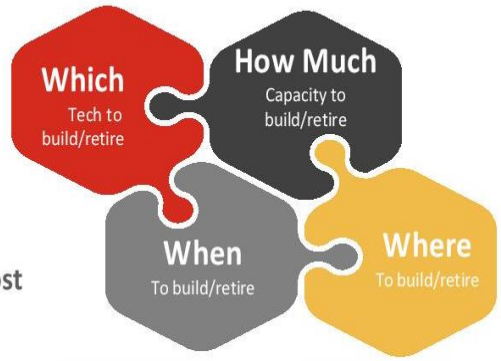
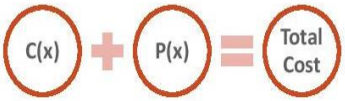
12

PLEXOS® Long-Term Planning





MIP Objective: Minimize NPV of capital & production



Energy Exemplar

14

Indicative Generation Capacity Expansion Plan (IGCEP 2047)

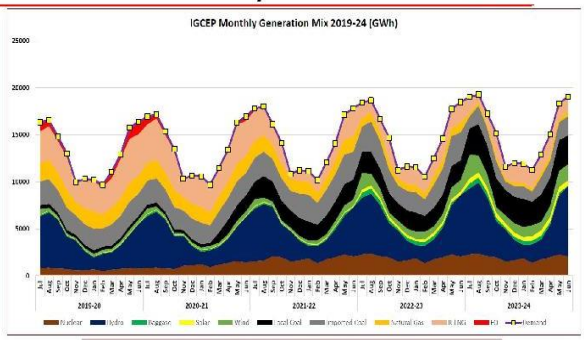
Objectives:

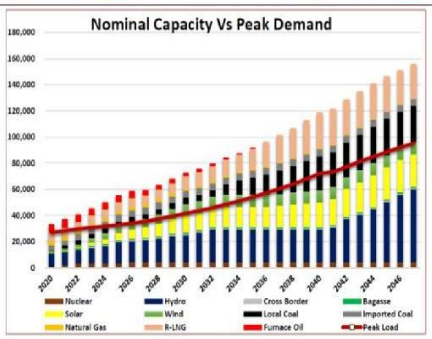
Identify new generation requirements by capacity, fuel technology and commissioning dates on year-by-year basis;

Satisfy the Loss of Load Probability (LOLP) not more than 1% year to year;

Cater for the long-term load growth forecast and reserve requirements; and

Provide a least cost optimal generation expansion plan for development of hydroelectric, thermal, nuclear and renewable energy resources to meet the expected load demand up to the year 2047





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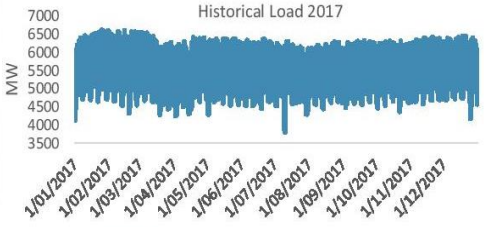
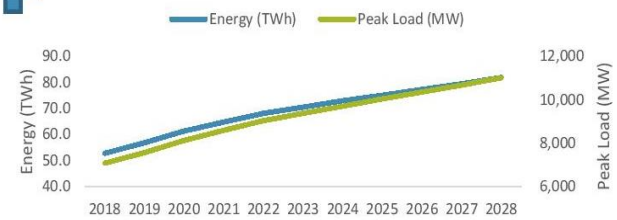
Load Forecasting

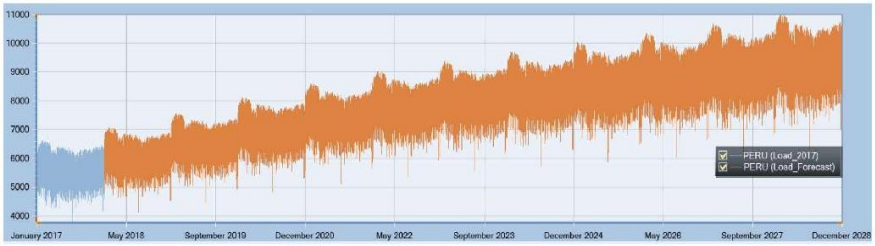
Base Load Profile



Peak and Energy Forecast



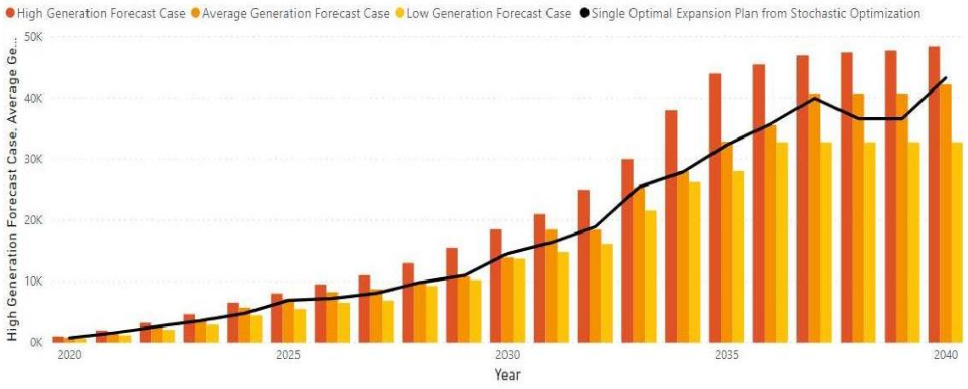
Forecasted Load Profile



16

Renewable Energy Integration

PLEXOS® Stochastic Optimization considers **multiple renewable profiles** to deliver **a single optimal build decision**.



Uncertainty doesn't disappear
...it's just accounted for properly

Energy Exemplar

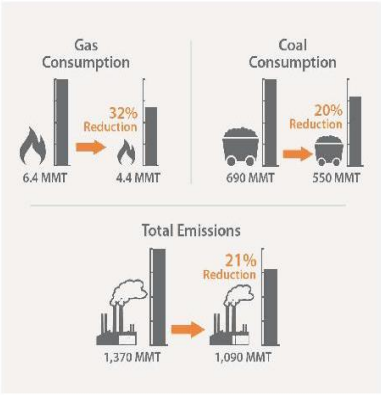
17

GREENING THE GRID: Pathways to Integrate 175 Gigawatts of Renewable Energy into India's Electric Grid

SCENARIO NAME	SOLAR (GW)	WIND (GW)	DESCRIPTION	PURPOSE
No New RE	5	23	Wind and solar capacities installed as of 2016	Establish a baseline to measure impact of adding new RE to the system
20S-50W	20	50	Total installed capacity as targeted in Green Energy Corridors & National Solar Mission	Evaluate changes to power system planning and operations to meet near-term targets
100S-60W	100	60	Current Government of India target for 2022	Evaluate changes to planning and operations to meet the official target of 175 GW RE
60S-100W	60	100	Solar and wind targets reversed in comparison to official target	Understand differential impacts of wind versus solar on need for system flexibility
150S-100W	150	100	Ambitious RE growth	Evaluate how needs for system flexibility would change under a higher wind and solar build-out

A 175-GW RE target by 2022 that places greater emphasis on wind over solar (60 GW wind, 100 GW solar), achieves higher RE capacity factors

Higher RE penetration levels brings benefits of reduced fuel consumption and lower CO^2 emissions.



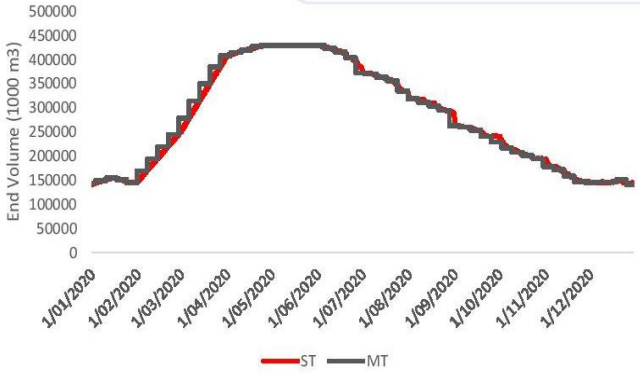
Energy Exemplar

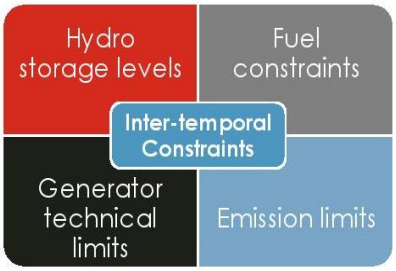
18

PLEXOS® Medium Term Planning

LT Plan → MT Schedule → ST Schedule

Decompose inter-temporal constraints that would otherwise be too long for ST Schedule





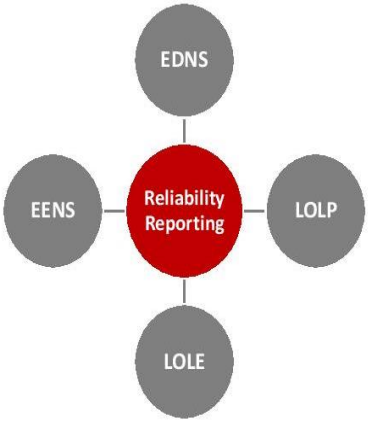
Energy Exemplar

20

System Security and Maintenance Planning

Projected Assessment of System Adequacy (PASA) is a simulation phase that focuses on the balance of supply and demand in the medium term. The functions of the PASA simulation phase are:

- To schedule maintenance events of any asset (transmission lines, generators, gas pipelines).
- Allocate outages events
- Compute reliability statistics such as:



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21

Hydro Optimization

Multiple phase simulation (Long – Medium – Short)	Ensures optimal use of storage down to chronological level
Cascading networks	Major and minor storages and junctions Natural inflows and spillways and canals
Constraints	Minimum releases for environment Operational constraints and hydro generation efficiency
Monte Carlo or Stochastic Optimisation	Multistage stochastic optimisation for better modelling of storage release policies under uncertainty

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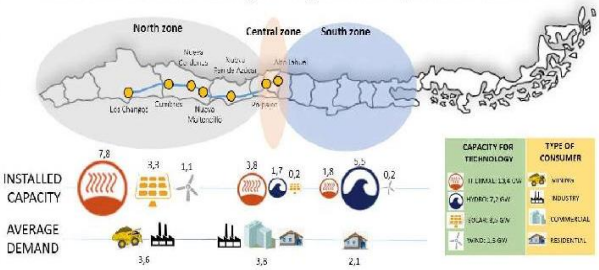
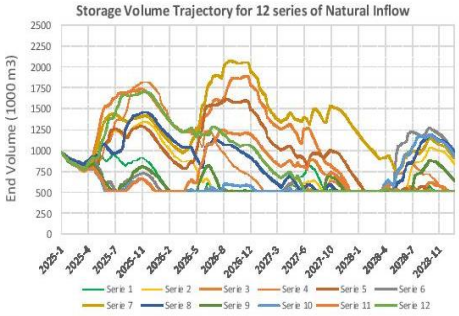
22

Hydro Operation and Planning

COORDINADOR ELÉCTRICO NACIONAL

2 interconnected systems connected through a 1,700 MVA 2x500 kV line consisting in a system of 3,200 km extension





Challenges:

1) **Transmission**: High congestions in the transmission lines due to large supply of solar energy in the north to serve high demand in the central zone

2) **Cycling:** Increase in startups between 16 and 21 hours (Solar gen decrease) and shutdowns between 6 and 12 hours (Solar gen increase).

3) **Ramping**: High ramping requirements with solar generation increase/decrease.

4) **Hydro constraints:** Highly complex irrigation constraints.

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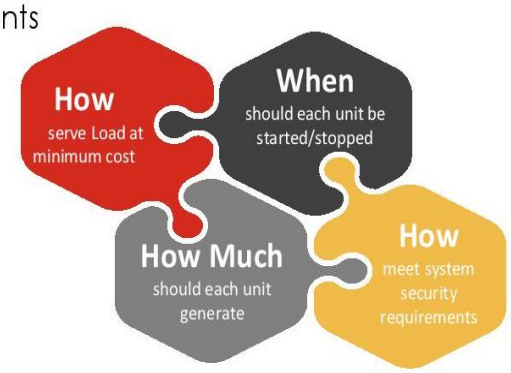
23

PLEXOS® Short Term Formulation

Minimize: Operational Costs + Start-up/Shutdown Costs
(Maximization of societal benefits)

Subject to: Energy balance
Technical limits
System security requirements



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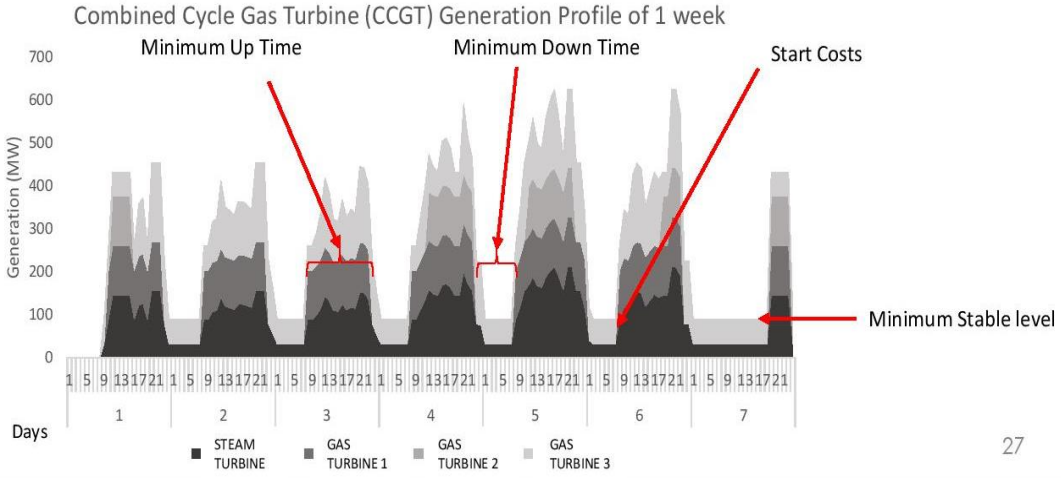
Dispatch Optimization

Mixed Integer Programing | Over 300+ Unit Commitment properties | Constraints modelling | Resolution down to 1-second



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27

Reduce Fuel Costs

CLP 中電

1. PLEXOS unit commitment algorithms work to minimize costs subject to constraints
2. CLP has many fuel constraints
    1. Coal port and different mix ratios for coal plant in Hong Kong
    2. Nuclear imports from China
    3. Gas supply contracts with max daily quantity, take or pay etc.
3. CLP has different technologies like steam turbines, CCGTs and GTs
    1. Over 300 UC properties in PLEXOS emulate life like dispatch
4. CLP has an emissions constraint for Hong Kong
    1. The PLEXOS constraint class allows almost any constraint to be applied
    2. The PLEXOS conditional class is like setting up "if" statements in excel
    3. The PLEXOS variable class allows relationships to be assigned
5. These features together with Mixed Integer Programming emulate the real world.
6. Very significant savings are achieved

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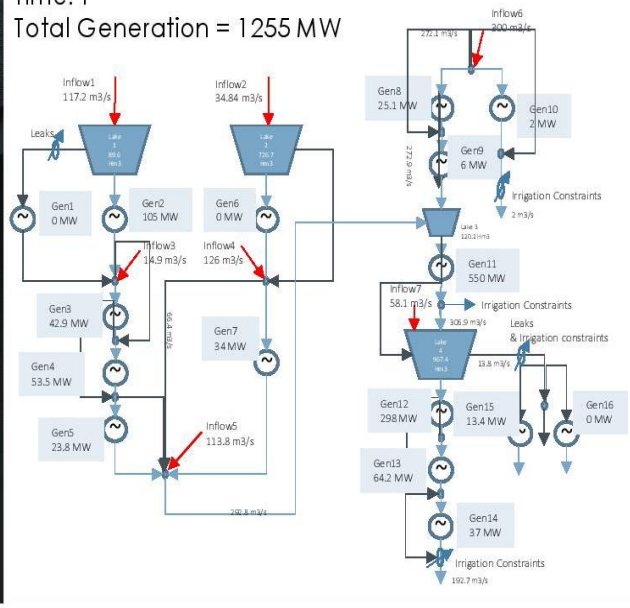
28

Cascading System Optimization

Time: t
Total Generation = 1255 MW



- Generators flow water from their Head Storage to their Tail Storage or 'to the sea'.
- A Waterway flows water from one Storage to another
- As the water runs downstream in a cascade system, there is also a loss of potential energy during the trajectory which can be handle with PLEXOS

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29

Transmission Modelling

- Transmission operation
- Transmission Expansion Planning
- Security Constrained Economic Dispatch (SCED)
- 'N-x' Contingency Analysis
- Congestion Costs
- Transmission aggregation and Network reduction
- PSSE Power Flow Raw Data file Importer

Single Line Diagram (SLD) allow users to review nodal connection

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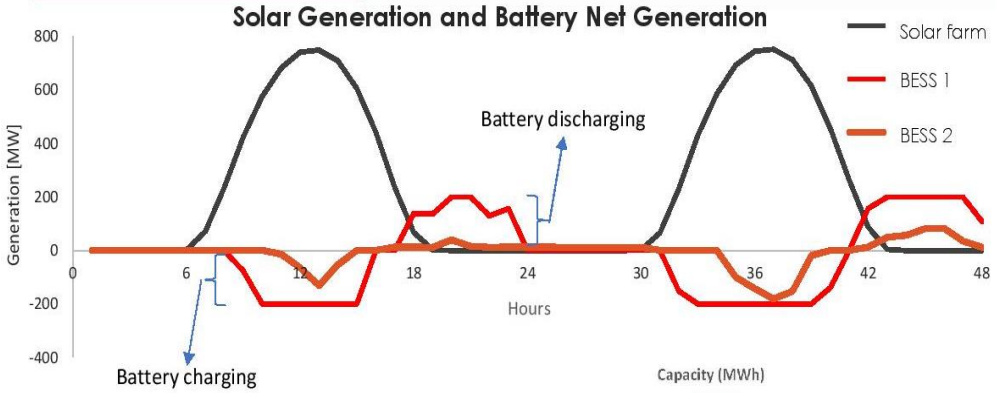
30

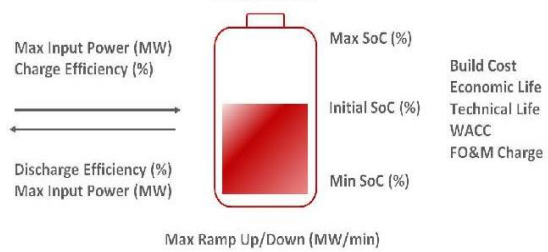
Battery Energy Storage System



Built in best in class battery models

BESS technical and economic representation

Represent all types of energy storage technologies



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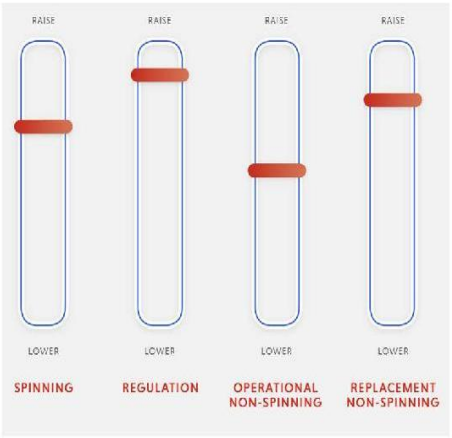
Ancillary Services Modelling

Model any class of ancillary service

Static and/or Dynamic requirement for the service

Define generators to provide reserve

- What price and hence cost was imposed by reserve?
- Which generators and / or interruptible load provide reserves?
- How reserve costs were allocated to generators?



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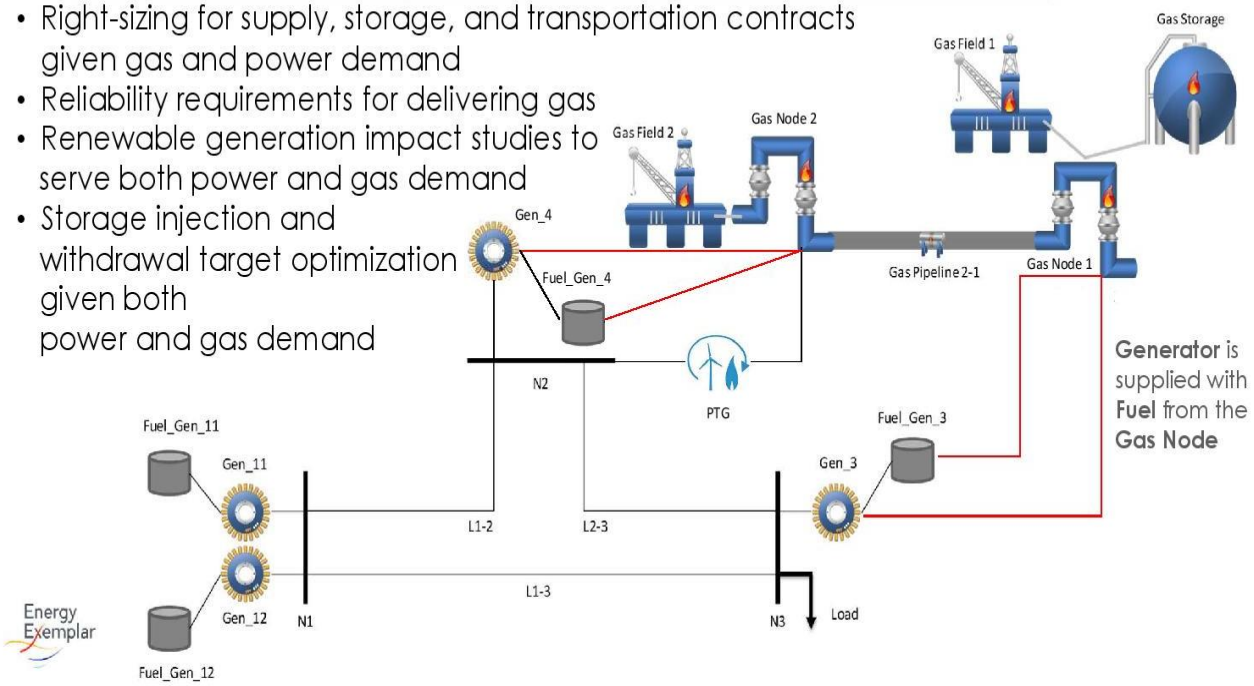
33

Electricity and Gas Co-optimization

- Right-sizing for supply, storage, and transportation contracts given gas and power demand
- Reliability requirements for delivering gas
- Renewable generation impact studies to serve both power and gas demand
- Storage injection and withdrawal target optimization given both power and gas demand



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Integrated Strategic Optimization

- High & low renewable penetration scenarios impact on gas demand
- Impacts of nuclear & coal retirements to the gas demand
- Increasing carbon price impact on merit order between gas and coal
- Modelling the injection of Biomethane or Hydrogen into the gas system
- Power (excess wind power)to Gas Production (Hydrogen) Scenarios
- Scenario Analysis- Electricity & Gas

entsog european network of transmission system operators for gas

entsoe Reliable Sustainable Connected european network of transmission system operators for electricity

PLEXOS SIMULATION SOFTWARE

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35

Concluding Remarks

PLEXOS BY ENERGY EXEMPLAR

- Better knowledge
- Accurate foresight
- A confident direction
- Optimal operation

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36

Thank you for your kind attention

Do not hesitate to contact us if you have any question or want to know more about our solutions.

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37