Modelling Electricity Generation: Comparing Results From a Power Systems Model and an Energy Systems Model

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Overview

Context

- ❑ Why and What
- ❑ TIMES models generator
  - Irish TIMES model
- ❑ PLEXOS for power system
  - PLEXOS Ireland model

Methodology

- ❑ Modelling approach
- ❑ Scenarios
- ❑ Phase 1
- ❑ Phase 2

Results

Conclusions

Why and What?

Why

- ❑ Increase resolution of simulation
- ❑ Evaluate system adequacy
- ❑ Explore the impact of increasing shares of variable energy
- ❑ Test the role of storage and interconnection

What

TIMES
Energy Systems Model Generator

soft-link

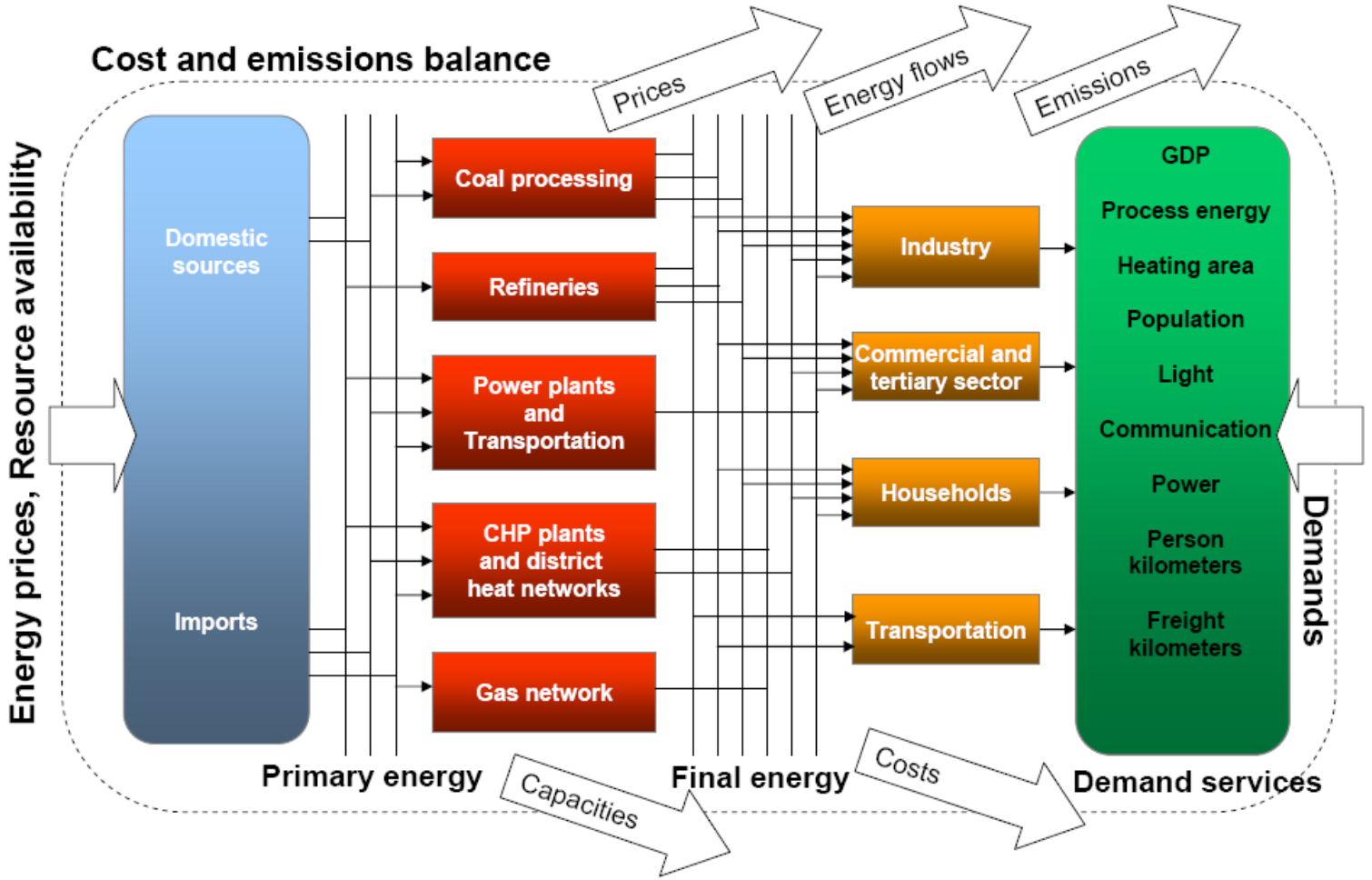
PLEXOS
For Power Systems

TIMES model generator

TIMES (The Integrated MARKAL-EFOM System):

- Hosted by *Energy Technology Systems Analysis Program* (ETSAP), an Implementing Agreement of the *International Energy Agency* (IEA)
- Economic model generator for local, national or multi-regional energy systems
- Linear programming bottom-up technology rich model
- Integrated model of the entire energy system
- Prospective analysis on medium to long term horizon (20-100 years)
- Demand driven (exogenous) in physical units
- Partial and dynamic equilibrium (perfect market)
- Optimal technology selection
- Minimize the total system cost
- Environmental constraints
- Energy and emission permits trading
- Price-elastic demands

TIMES model



Remme U. 2007 *Overview of TIMES: Parameters, Primal Variables & Equations.* Proc. ETSAP Workshop November 2007 Brazil.

Irish TIMES (2009-2011)

- TIMES energy systems model for Ireland
- Developed by UCC from the extraction of *Pan European TIMES (PET[36])* model
- Horizon: 2005 – 2050
- Build scenarios to inform energy & environmental policy
- Provide technology rich pathways

http://ww.ucc.ie/en/serg/energypolicy/projects/irishtimes/

PLEXOS for Power Systems

- First release in 2000
- Commercial power system model with solutions based entirely on mathematical optimisation:
  - Linear Programming (LP)
  - Mixed Integer Programming (MIP)
  - Stochastic Optimisation (SO) (MISO)
- Used worldwide by all types of customers
- Free for academic users

ENERGY EXEMPLAR
Power Market Simulation & Analysis Software

Analysis tools in PLEXOS

- **LT Plan** – Optimal investment
- **PASA** – Maintenance
- **MT Schedule** – Decomposition
- **ST Schedule** – Chronological

Analysis tools in PLEXOS

LT Plan – Optimal investment

PASA – Maintenance

MT Schedule – Decomposition

ST Schedule – Chronological

Modelling features

- Short timeframe
- High resolution (hourly/half-hourly)
- Key generation constraints and costs:
  - **Min Stable Level**: the minimum megawatt possible when unit is “on”
  - **Start Cost**: cost of getting a unit from “off” to MSL
  - **Fuel Cost**: cost of operating once “on”
  - **Min Up Time**: hours unit must stay up once committed
  - **Min Down Time**: hours unit must stay down after de-commitment
  - **Ramping**: maximum change in MW output
  - **Emission production constraints**
  - **Resource constraints**: fuel, hydro, wind
  - **Taxes**
- Overall objective is maximise welfare

PLEXOS Ireland

PLEXOS expertise in Ireland

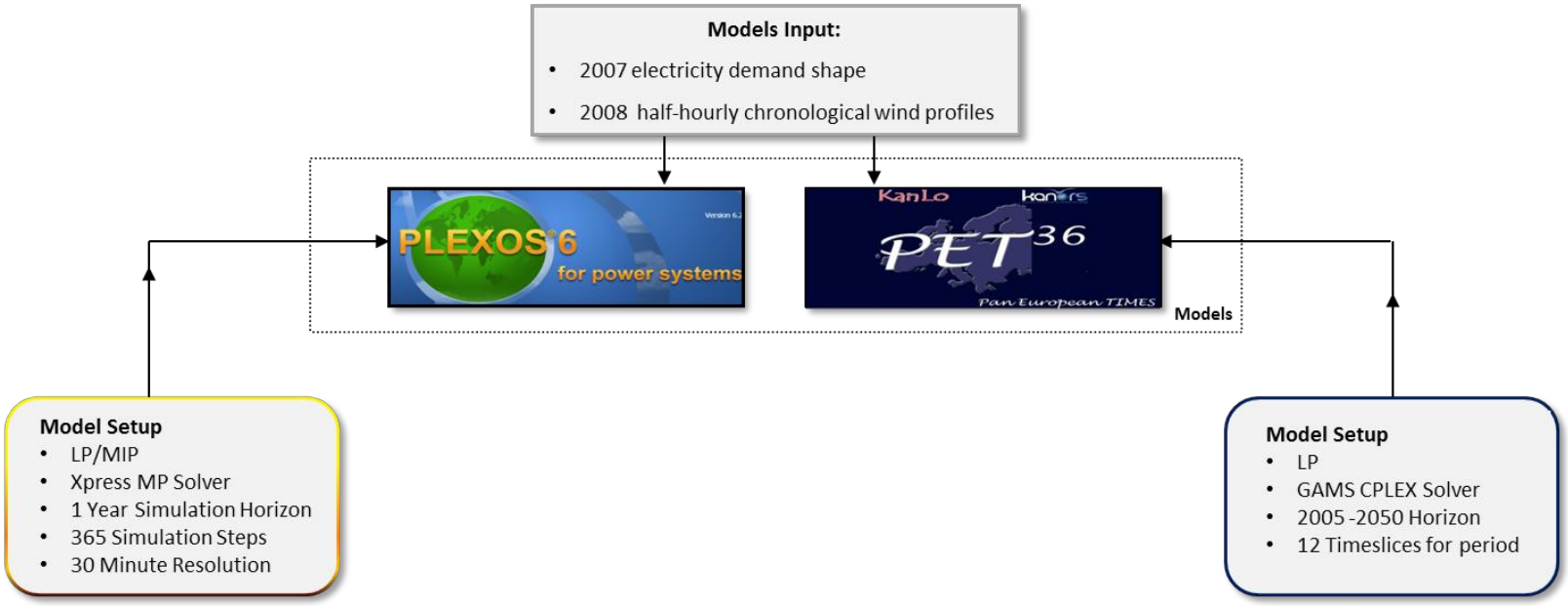
- PLEXOS have been used to validate and model the Irish Single Electricity Market (SEM)

PLEXOS-Ireland model

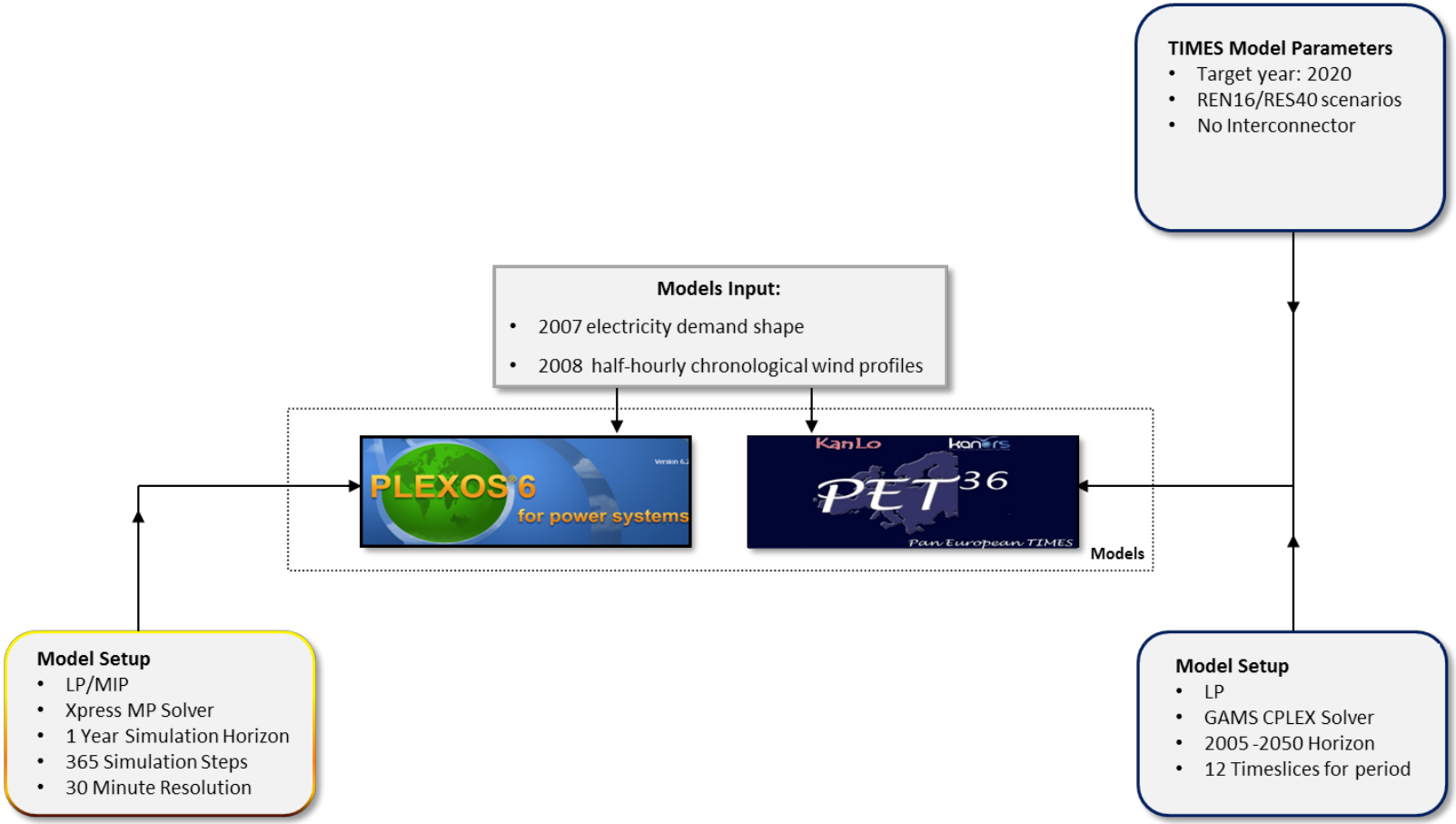
- Initially developed by CER in Ireland to validate electricity market in Ireland
- Expanded by UCC to 2020 and beyond
- Model Includes:
  - All conventional and non-conventional Generation Plant
  - Technical and Economic characteristics of each plant
  - Renewable generation (12 regions)
  - Fuel costs and carbon costs
  - Interconnection to Great Britain
  - Mixed Integer Model at 30 minute resolution
  - Outage and Maintenance schedules

Methodology

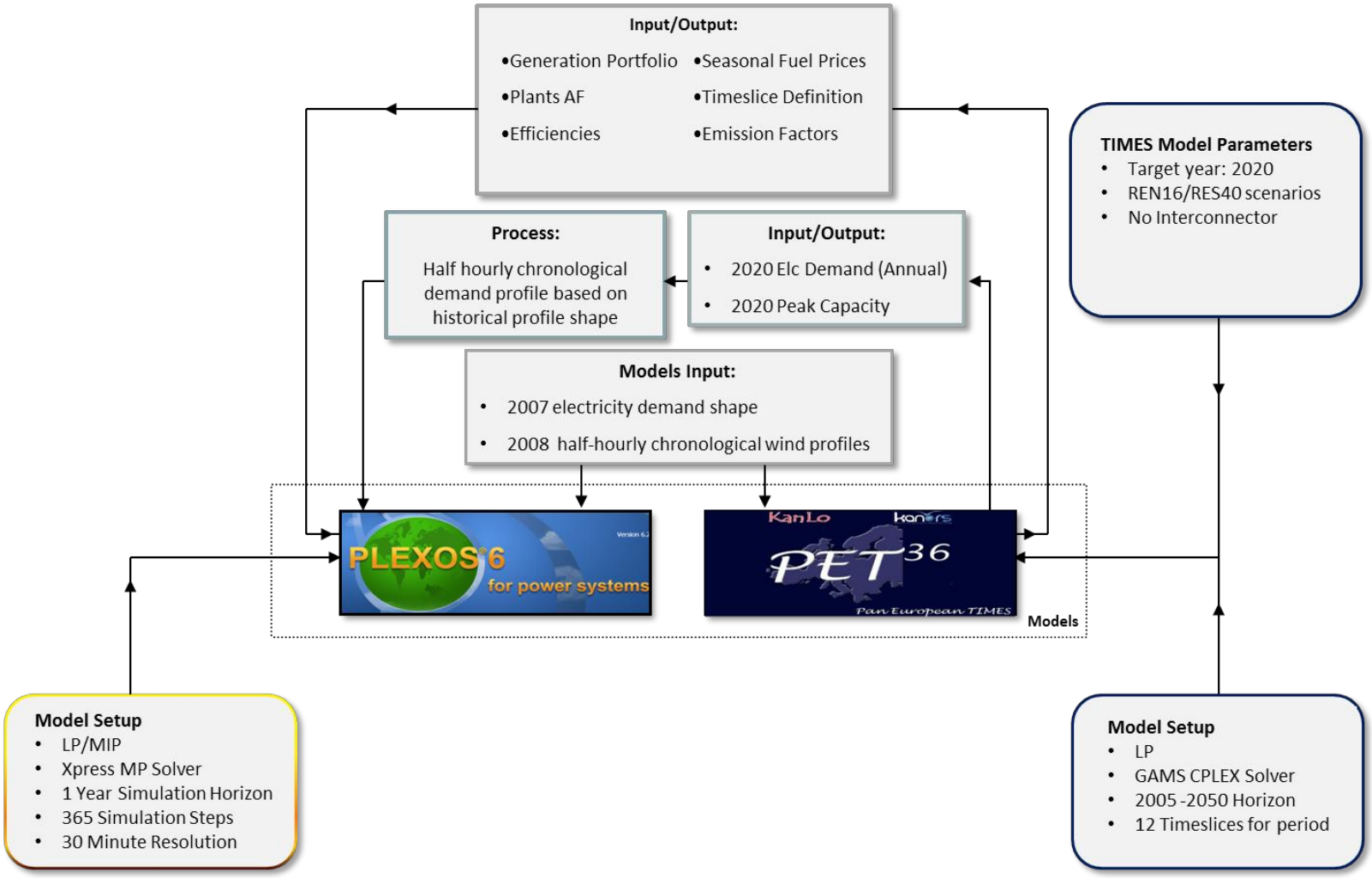
Methodology



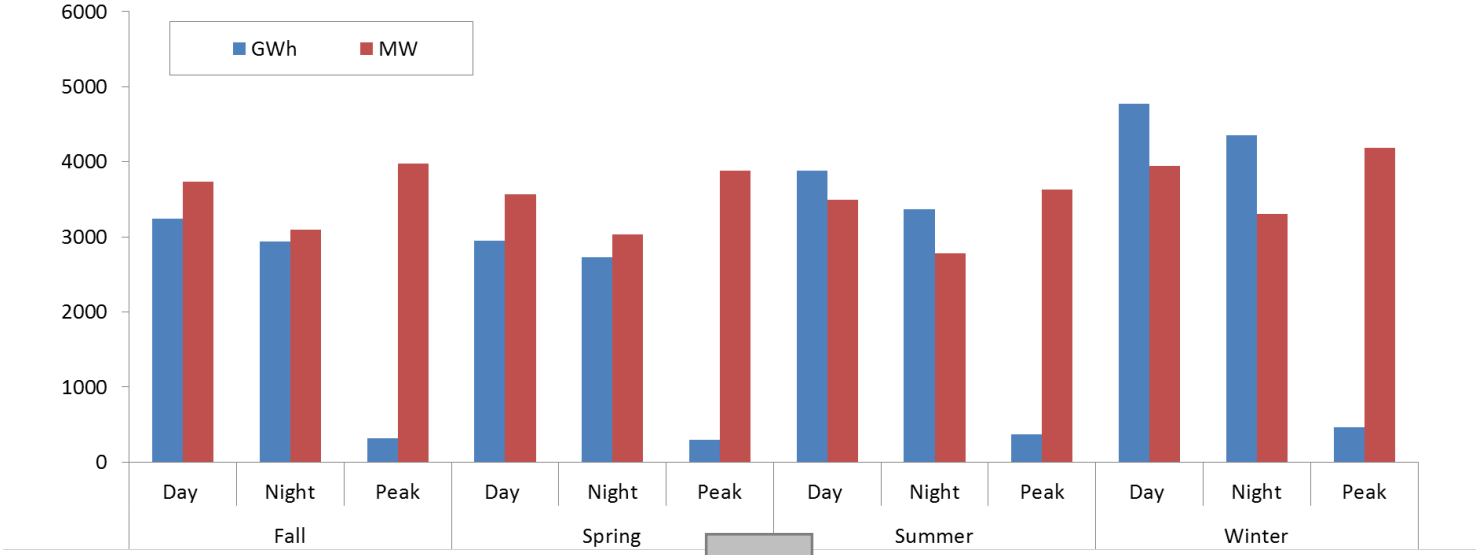
Methodology

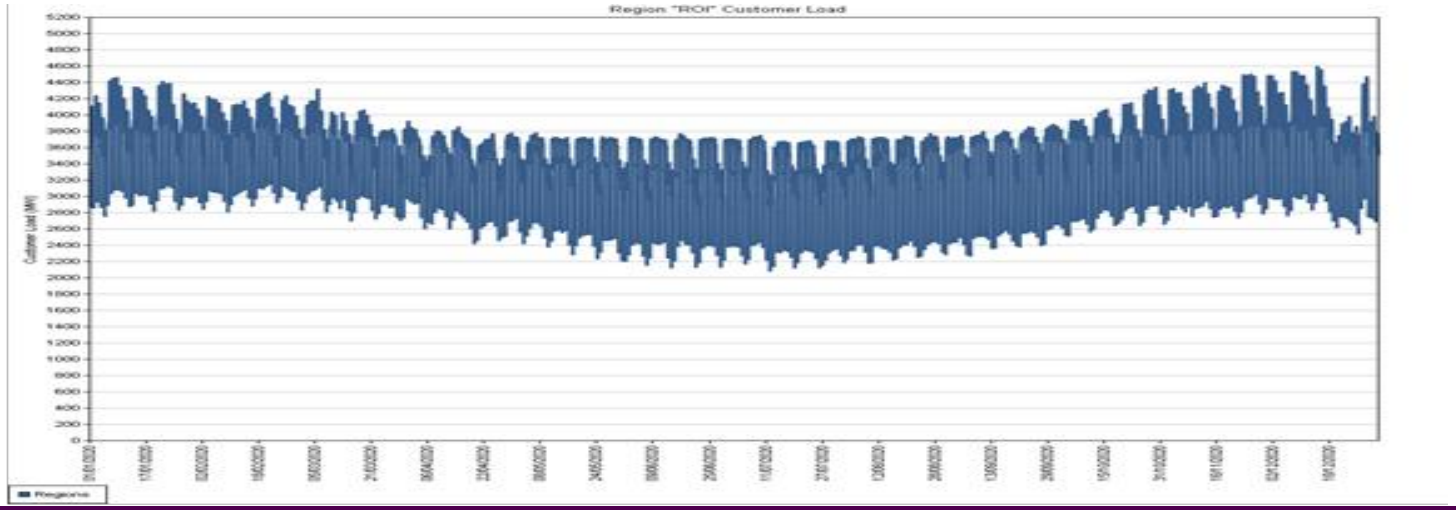


Methodology

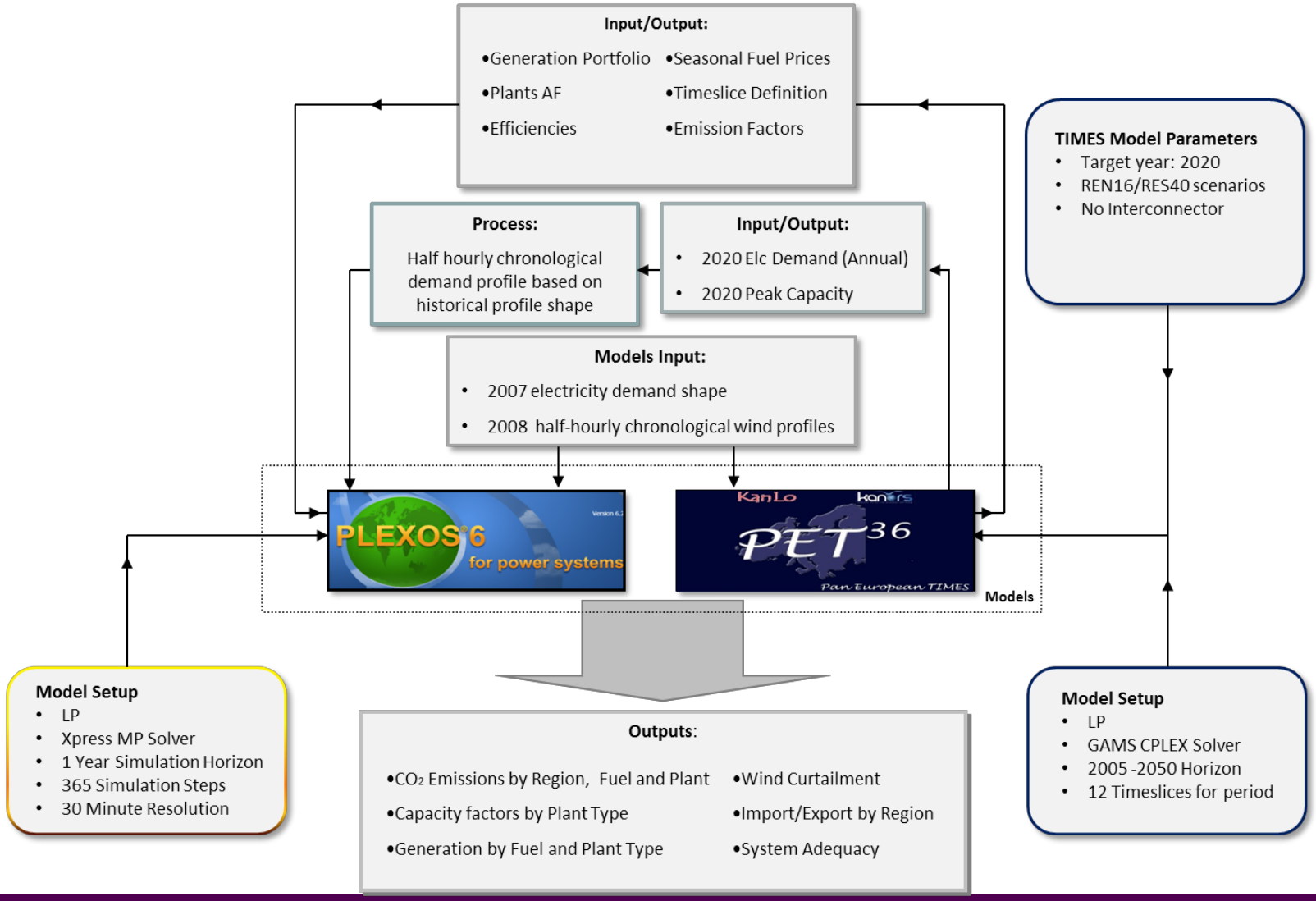


Electricity Demand

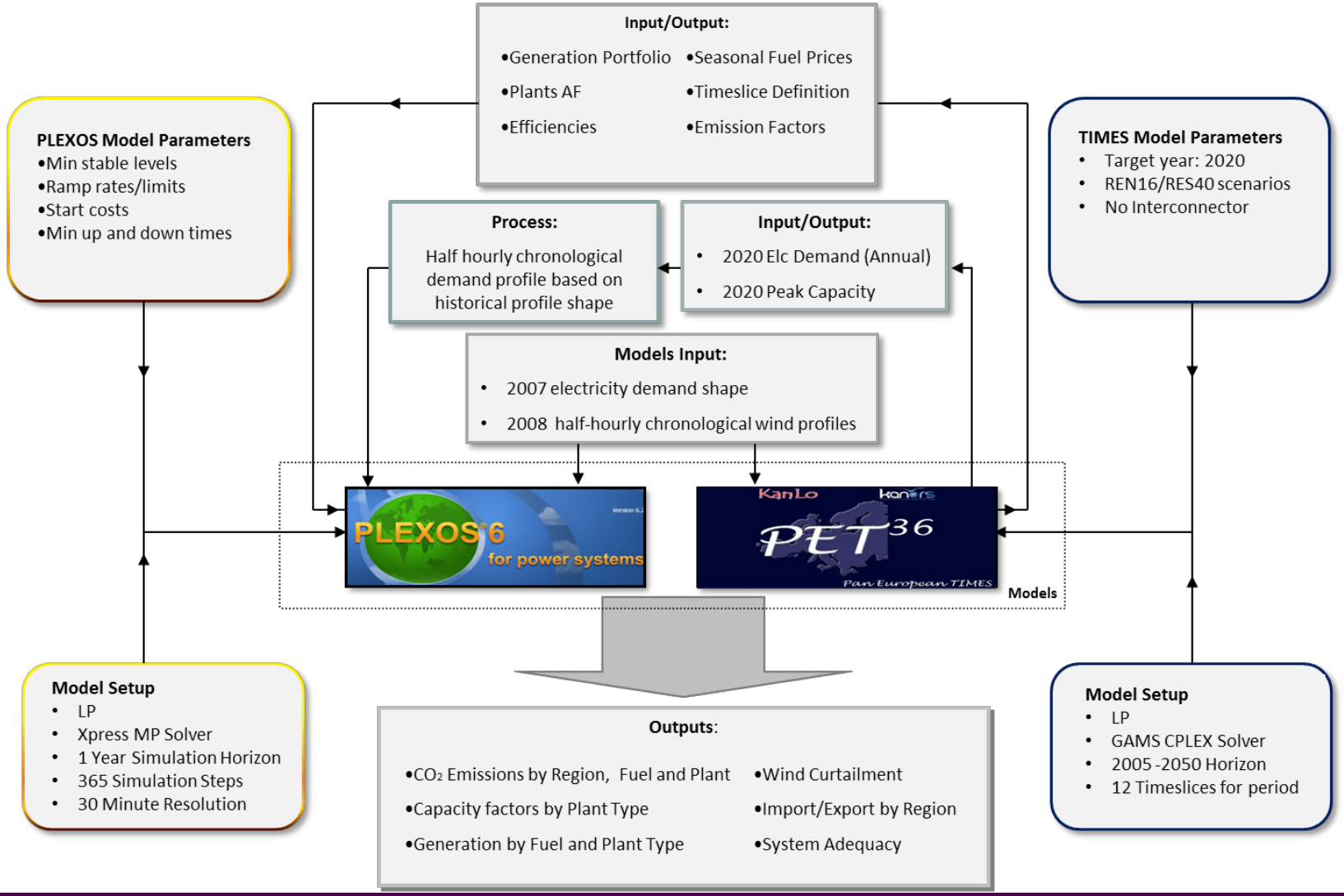




Methodology Phase-1



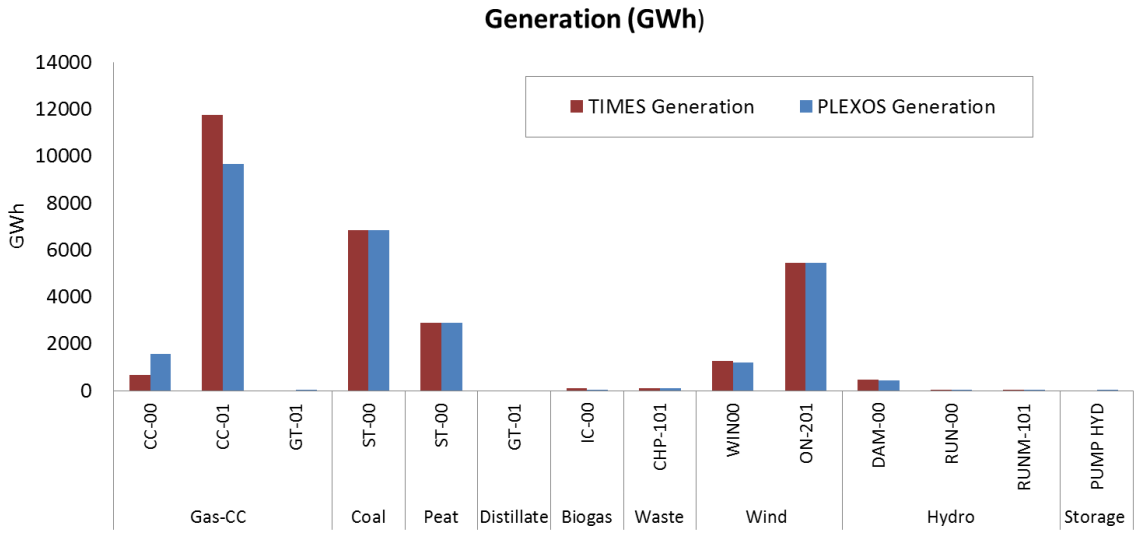
Methodology Phase-2

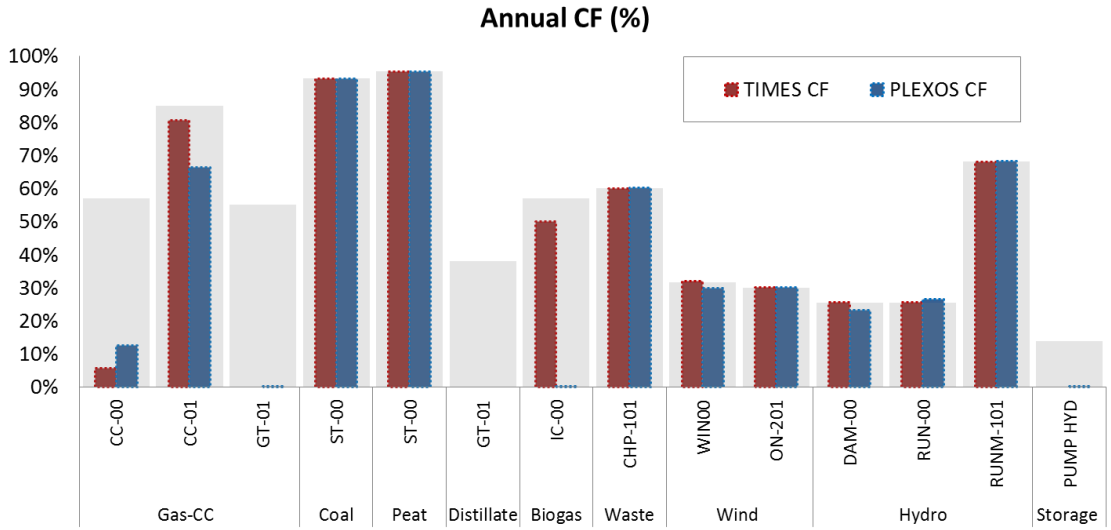


PASA Reliability indexes

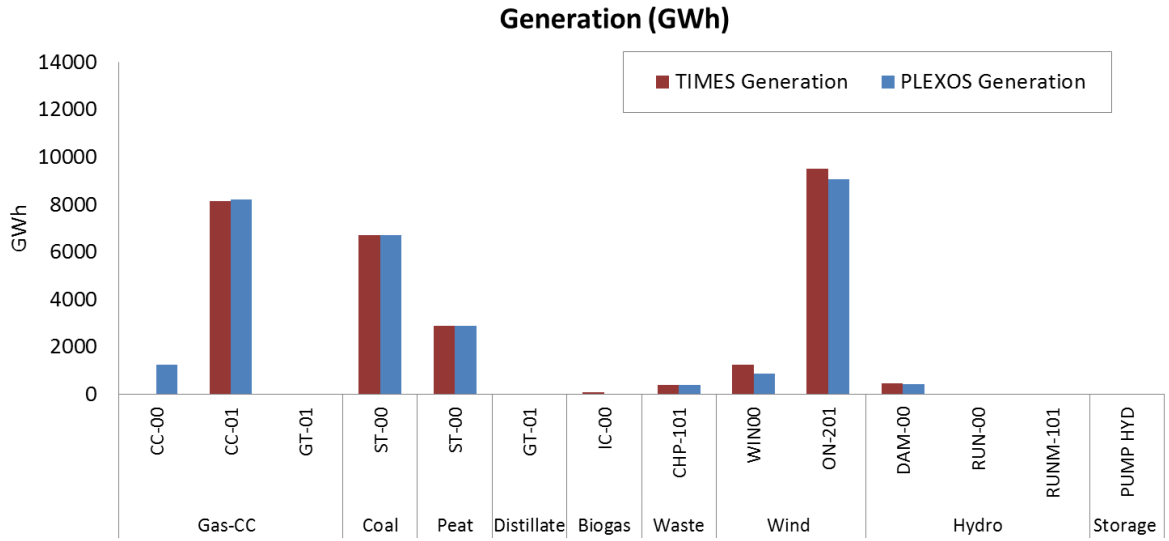
	REN16	RES40	unit
Capacity Reserves	614.3	614.3	MW
Capacity Reserve Margin	13.21	10.13	%
EENS	253.3	1382.9	MWh
EDNS	0.03	0.16	MW
LOLE	0.07	0.35	days
LOLP	0.02	0.10	%

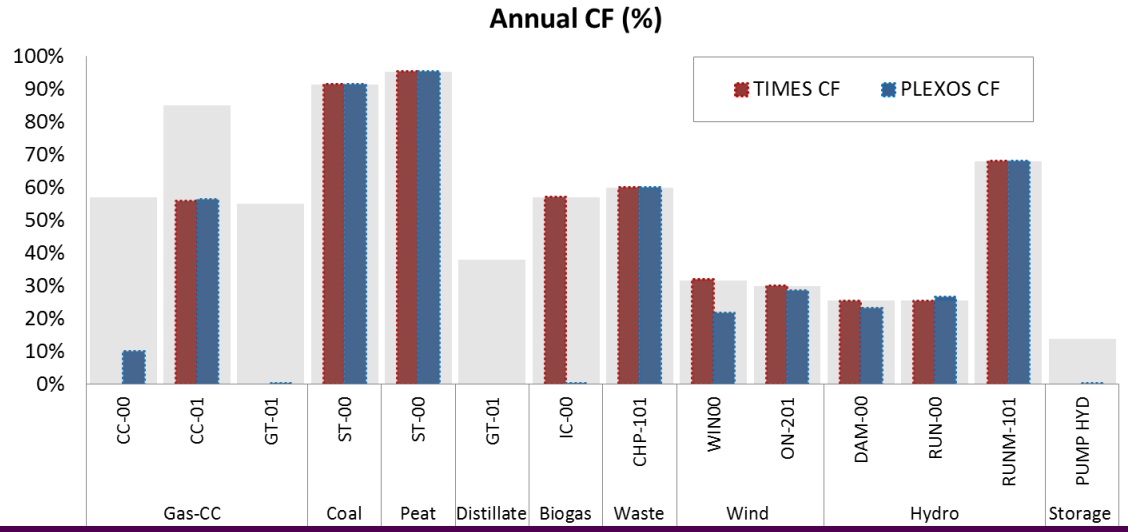
Phase 1: REN16



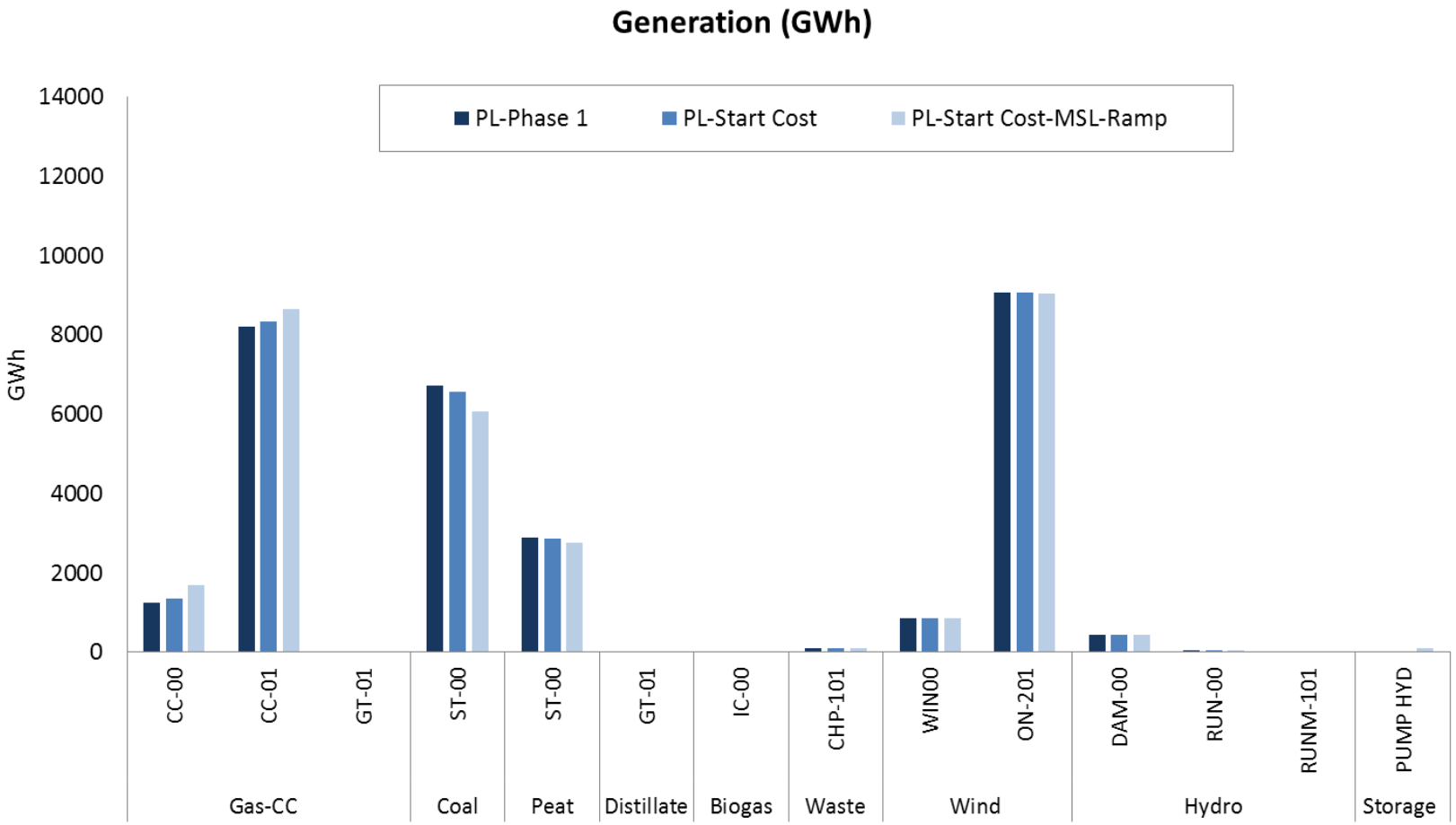


Phase 1: RES40

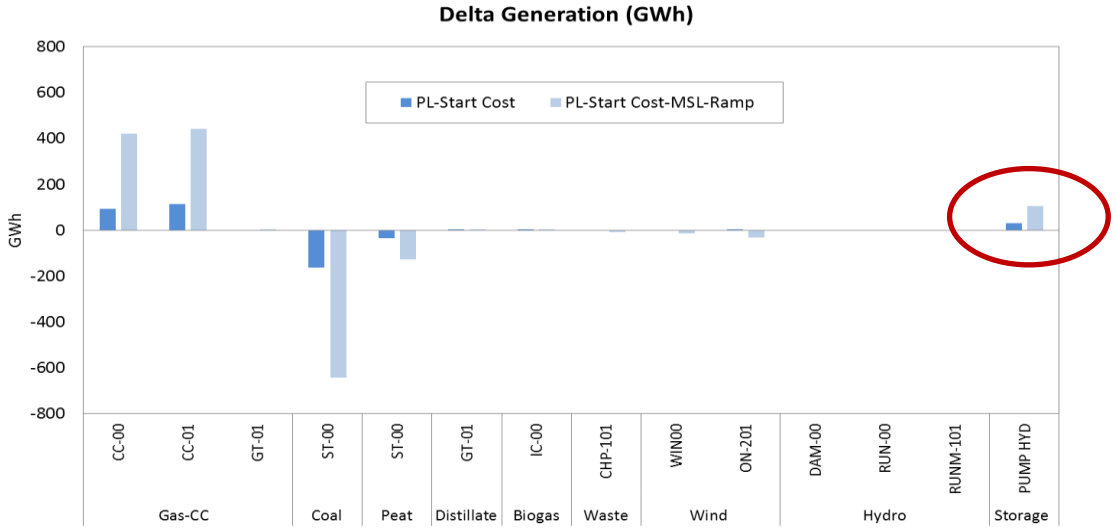


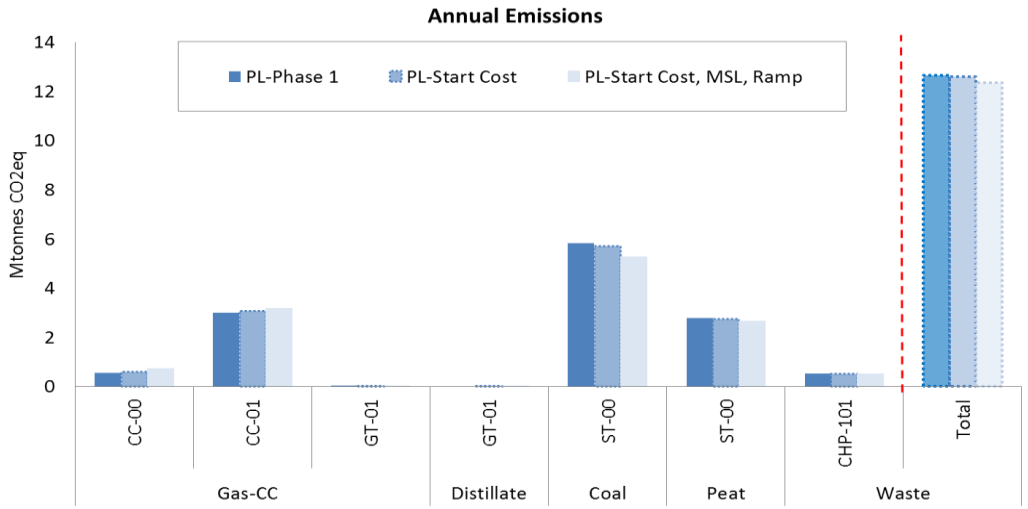


Phase 2: RES40



Phase 2: RES40

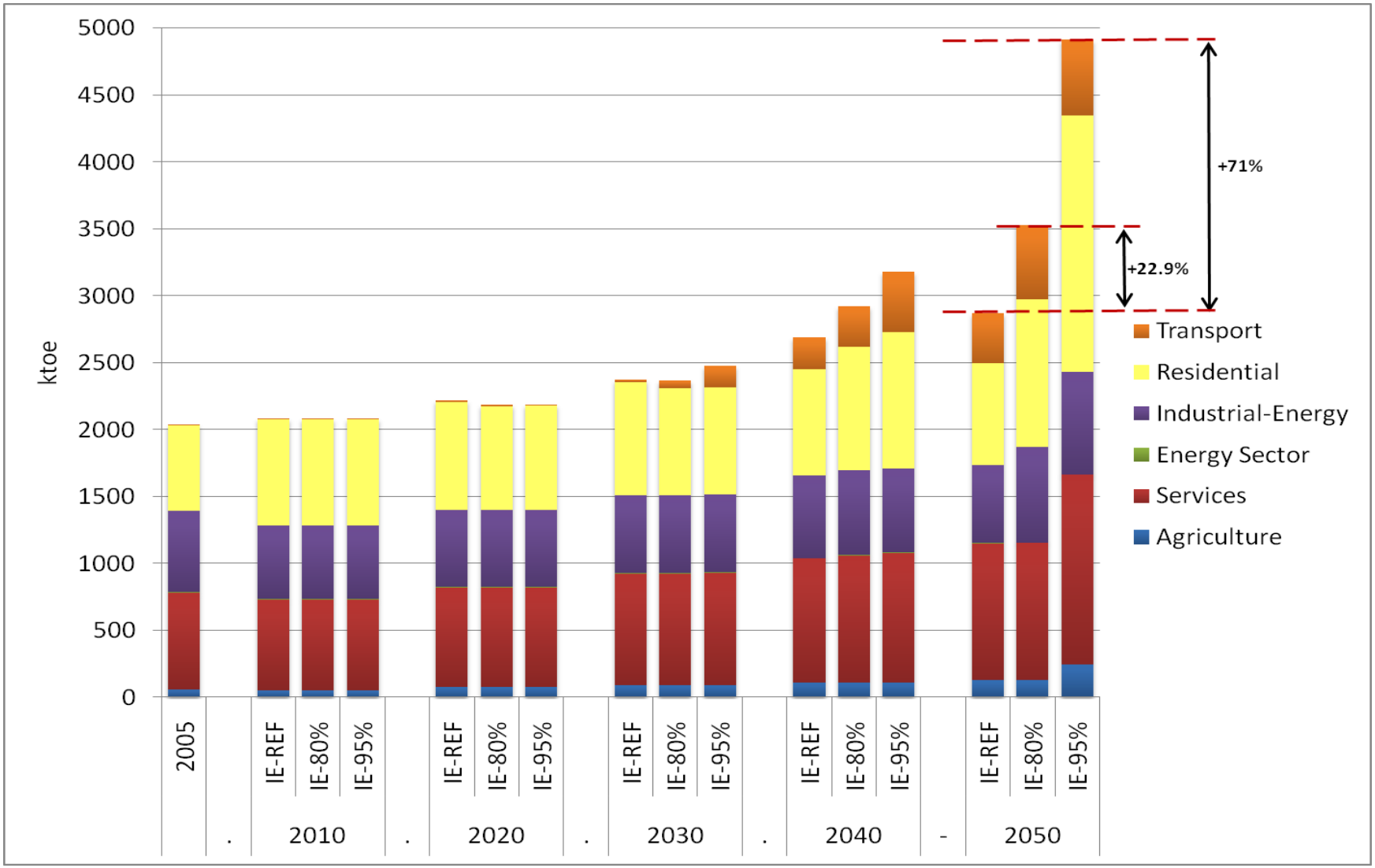




Interim Conclusion

- Development of soft-linking models could represent an important added value in terms of improving electricity generation modelling
- Delivers high resolution simulations for target years of peak hours demand, highly variable generation, storage and interconnections
- Some of soft-linking evaluation could feedback into hard-linking

Next Steps


5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
ktoe
+71%
+22.9%
Transport
Residential
Industrial-Energy
Energy Sector
Services
Agriculture
2005
IE-REF
IE-80%
IE-95%
2010
2020
2030
2040
2050

Next Steps

Electrification of heating

- Irish TIMES shows strong electrification in RSD and SRV

Development of Electric Vehicles

- Impact of scheduling EV charging on electricity demand

High shares of variable load generation

- Irish TIMES shows 80% of RNW generation by 2050 (mostly wind)

Storage & Interconnections

- Explore in detail the role of Storages, Interconnections and Smart Grids

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