



# The importance of including short-term dynamics in planning models for electricity systems with high shares of intermittent renewables

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- **Low-carbon energy system:**
  - Large contribution of RES predicted, especially in the electricity sector
- **Increasing share intermittent RES:**
  - Variability supply > variability demand => increased need of flexibility (of conventional power plants)
  - Wind, PV: Seasonal and intra-daily patterns + large deviations ↔ Electricity demand



## Research Question

- What is the impact of:
  - A) TS Division/Temporal resolution
  - B) Limited technical detail

- Methodological analysis with a small TIMES model based on the Belgian electricity system
  - Single Region, No Import/export (Island operation)
  - No grid
  - Limited set of technologies
  - Base year + 4\*10-year period
  - RES targets imposed (50% in 2050)
  - 5% Capacity margin (peaking equation)
  - Linearly increasing CO<sub>2</sub>-tax

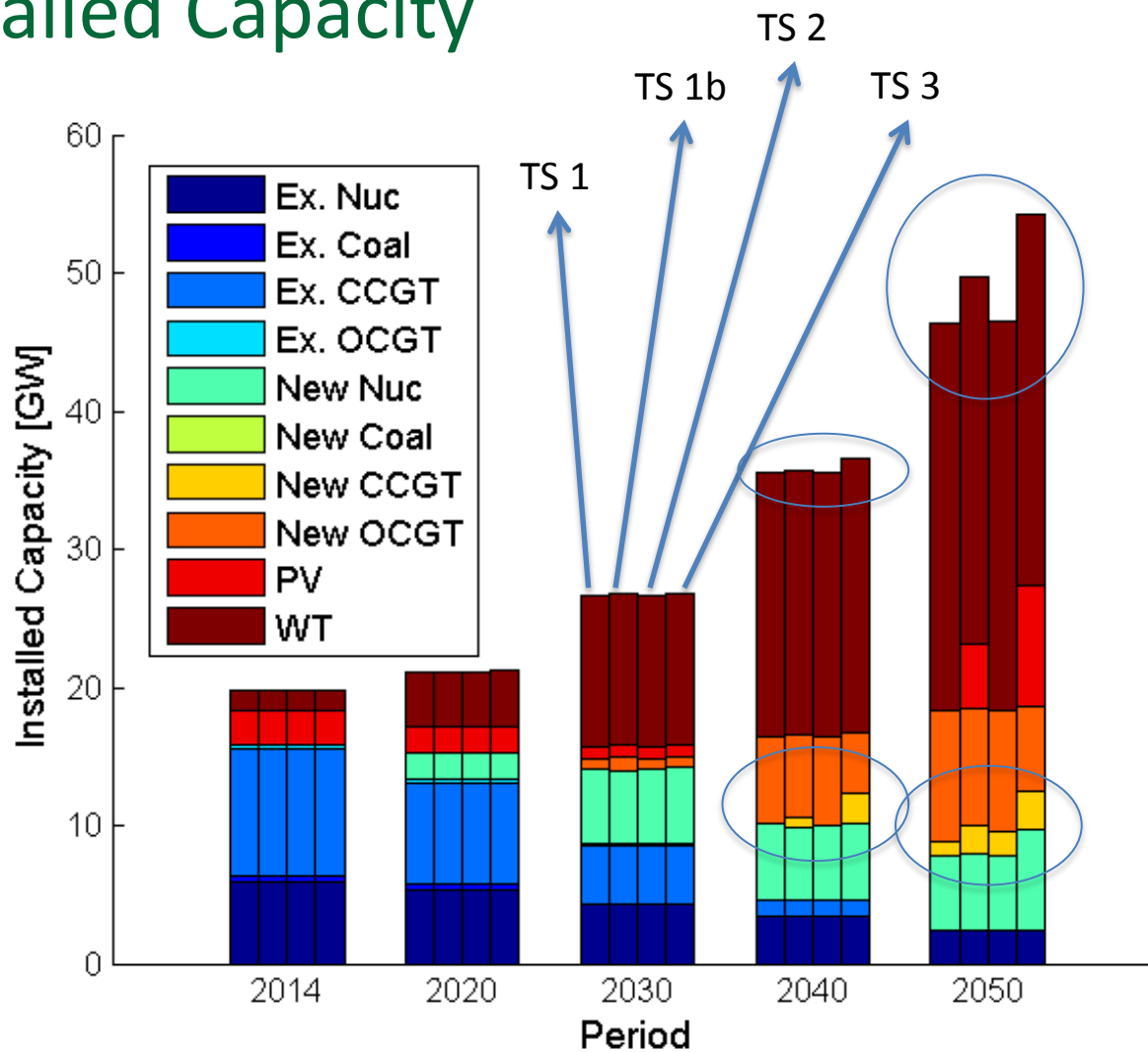


# Model Description

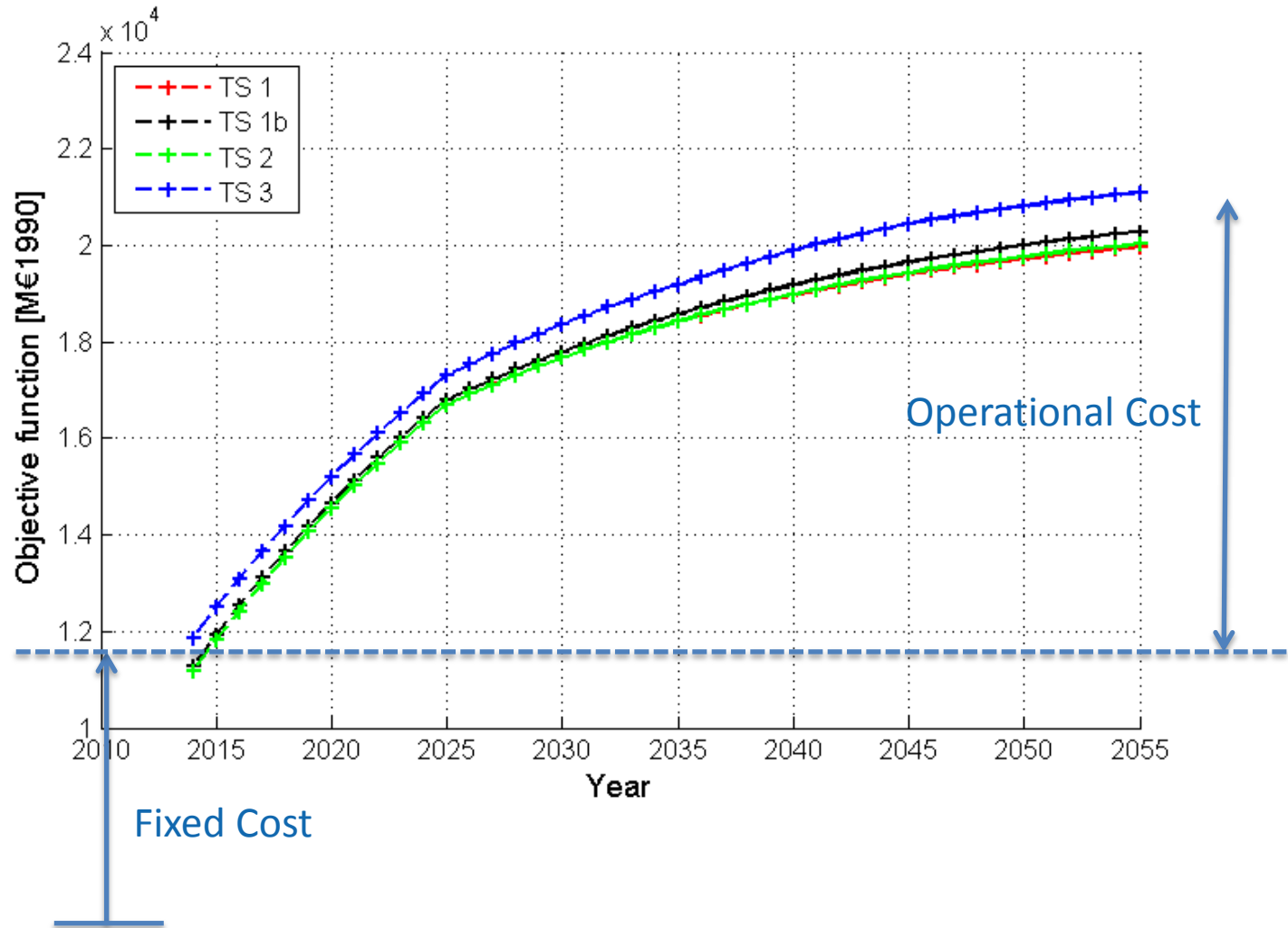
- 4 TS divisions considered:

	TS 1	TS 1b	TS 2	TS 3
SEASON	4 Seasons	4 Seasons	4 Seasons	52 weeks
WEEKLY		Day, Night, Peak	WD, Sat, Sun	7 days/week
DAYNITE	Day, Night, Peak	High Wind, Med Wind, Low Wind	24 h/day	24h/day
# TS	12	36	288	8736

- Installed Capacity



# Model Results – System Cost



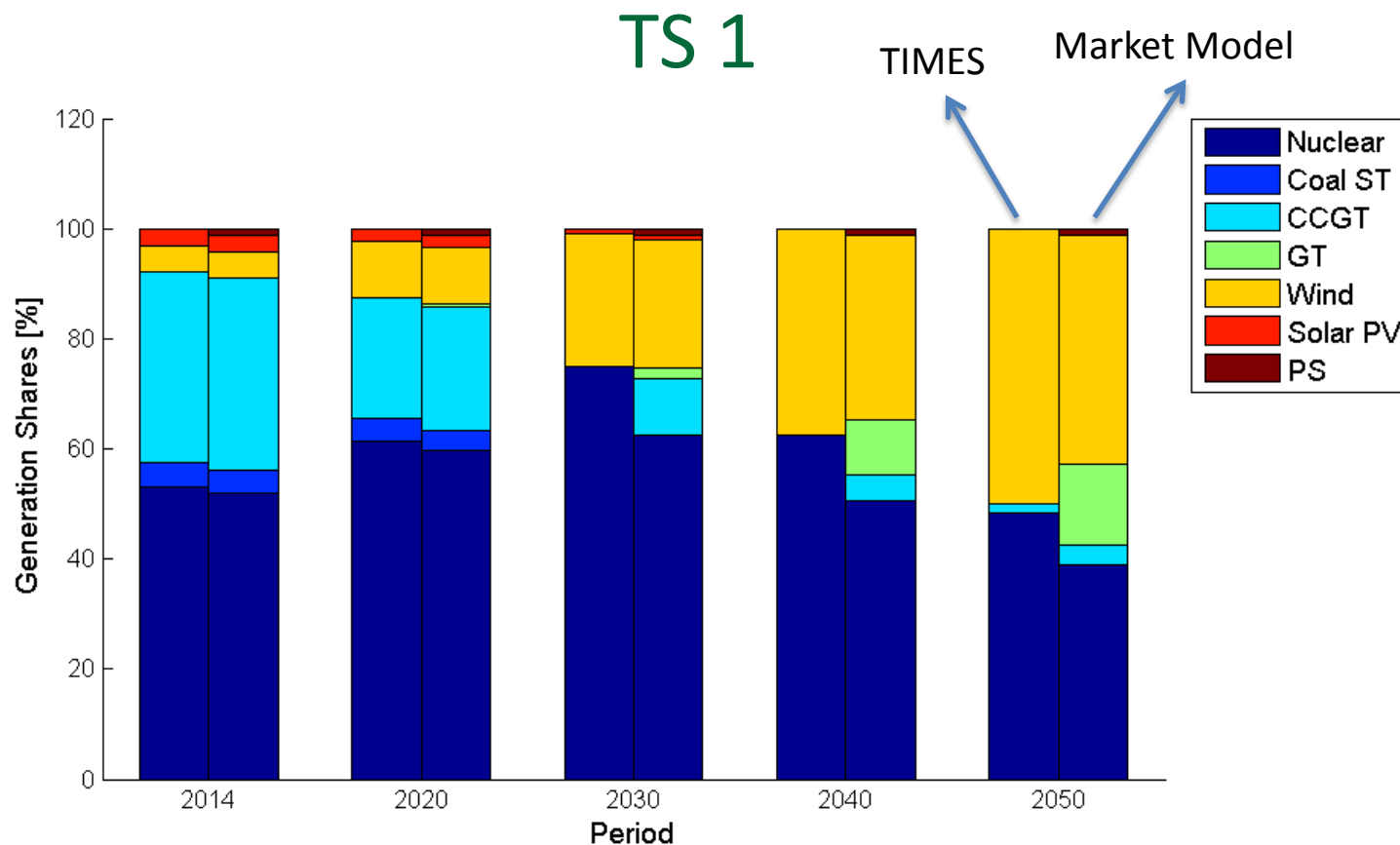


# Re-evaluate Dispatch

- Re-evaluate dispatch decisions
- MILP market model:
  - Capacity variables TIMES = input data
  - Market model:
    - Hourly resolution (8736 periods)
    - dispatch at power plant level, includes operational constraints (ramping rates, minimal generation level, minimal up and down time, etc.)
    - No operational reserves, no grids

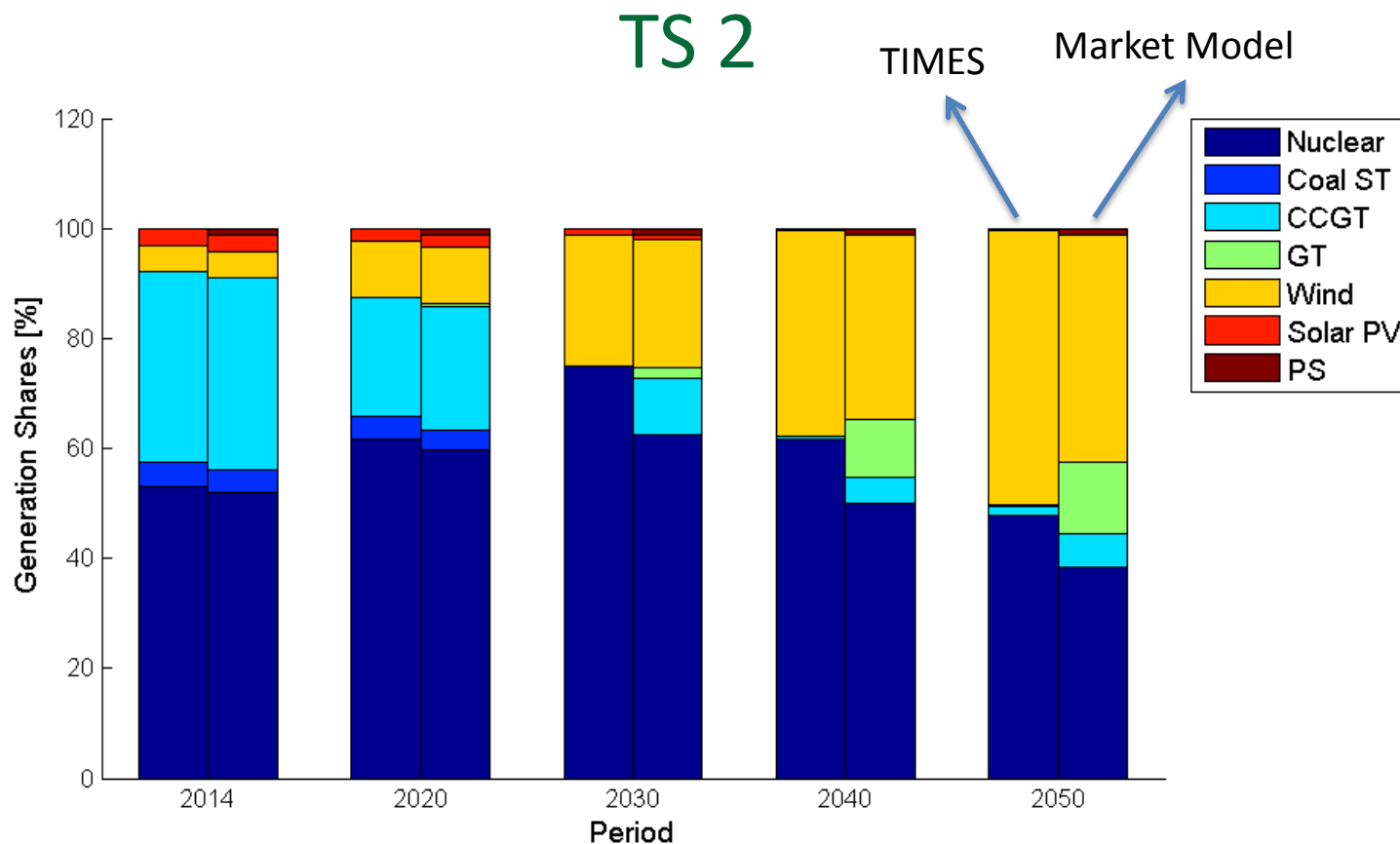


# Re-evaluate Dispatch – TS 1



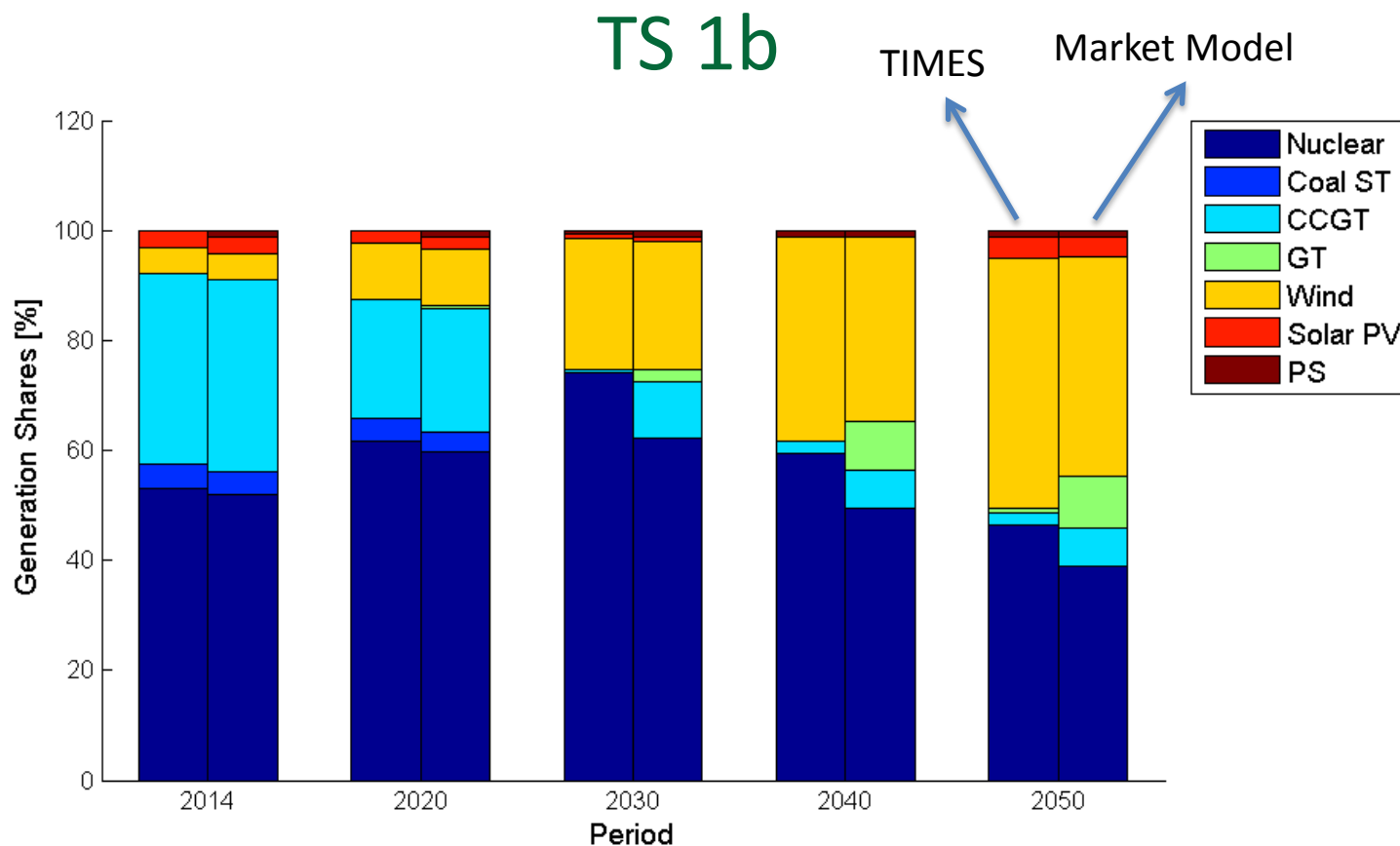
RES Target [%]:	/	12.5	25	37.5	50
Share RES [%]:	7.6	12.3	24.0	33.5	41.5

# Re-evaluate Dispatch – TS 2



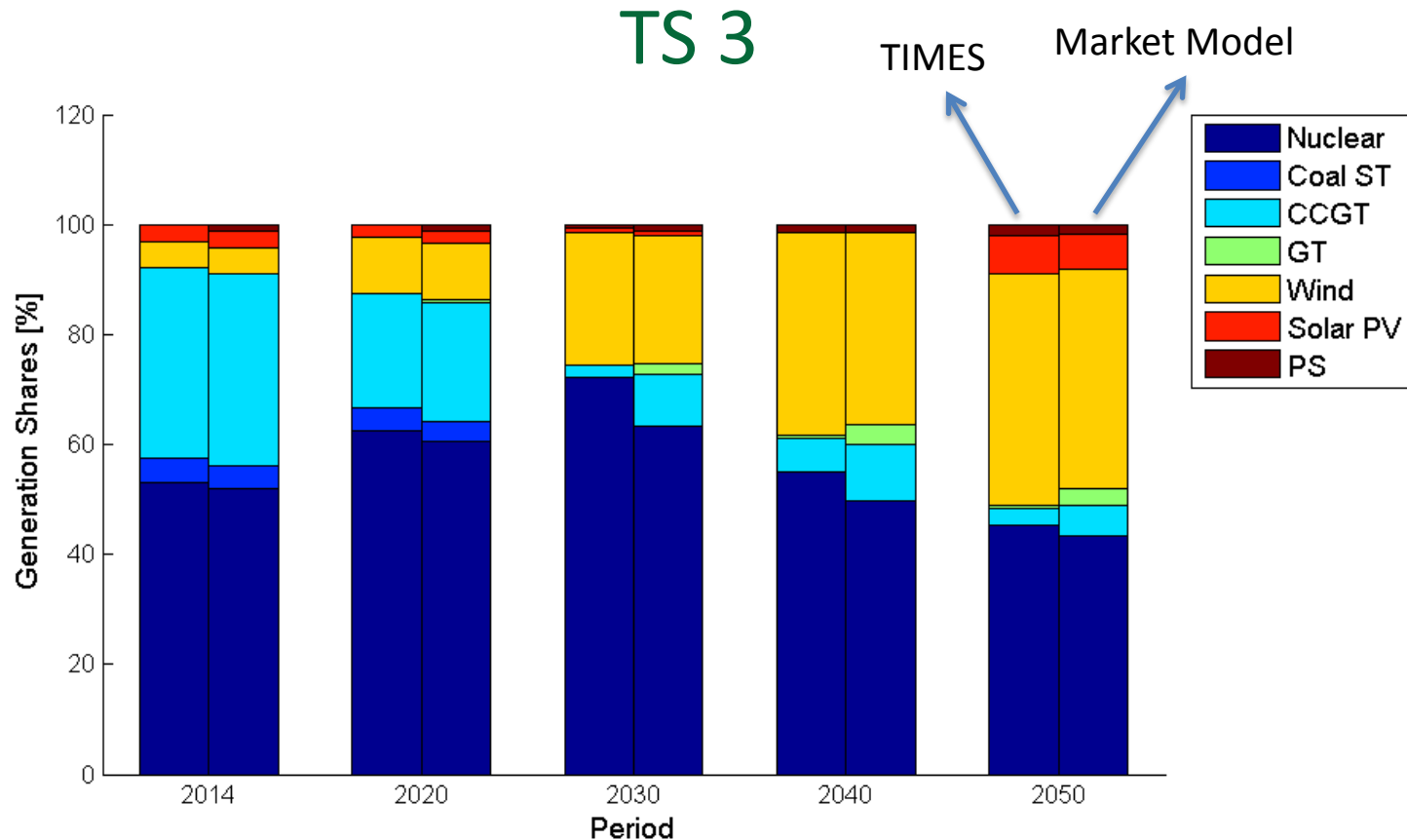
RES Target [%]:	/	12.5	25	37.5	50
Share RES [%]:	7.6	12.3	24.0	33.5	41.5

# Re-evaluate Dispatch – TS 1b



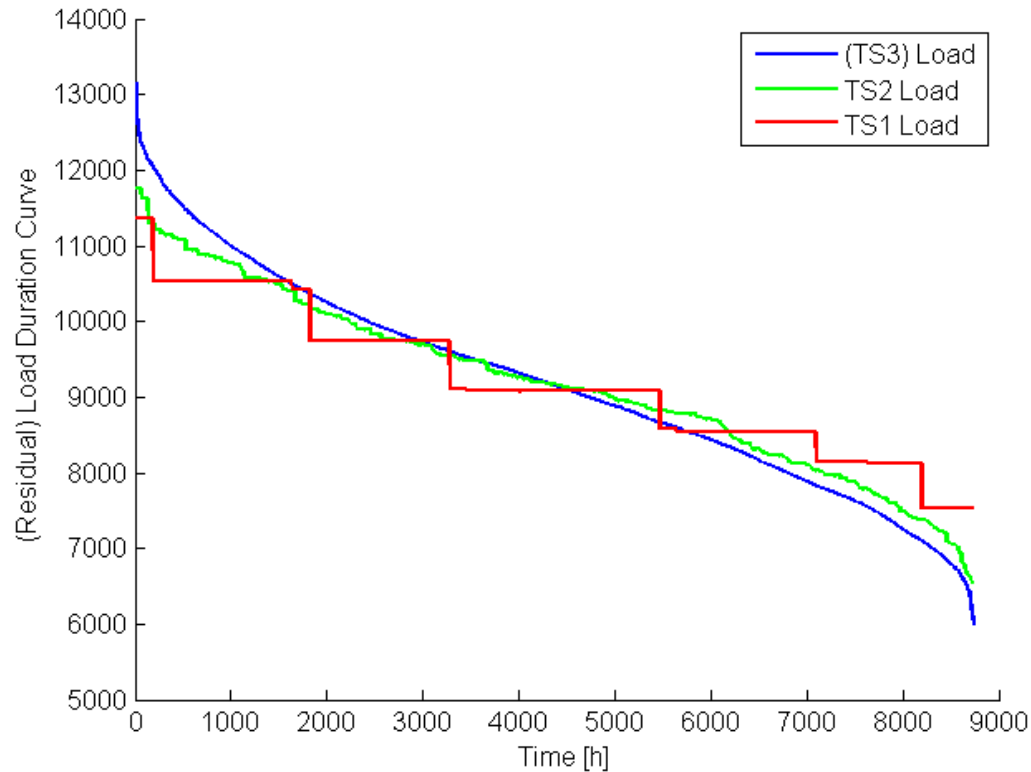
Year	Model	RES Target [%]	Share RES [%]
2014	TIMES	/	7.6
2020	TIMES	12.5	12.3
2030	TIMES	25	24.0
2040	TIMES	37.5	33.6
2050	TIMES	50	43.4
2050	Market Model	50	43.4

# Re-evaluate Dispatch – TS 3



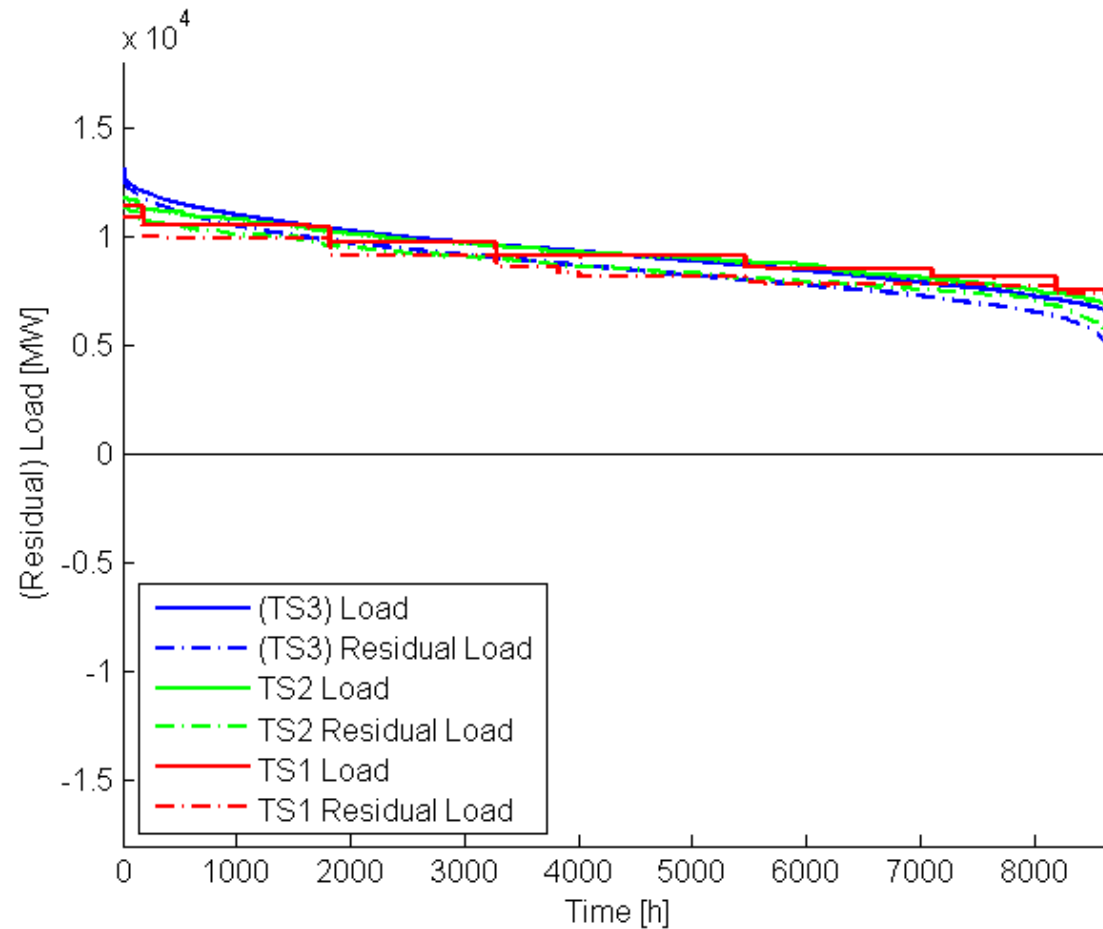
RES Target [%]:	/	12.5	25	37.5	50
Share RES [%]:	7.6	12.3	24.0	34.9	46.5

# Residual Load Duration Curve (RLDC)



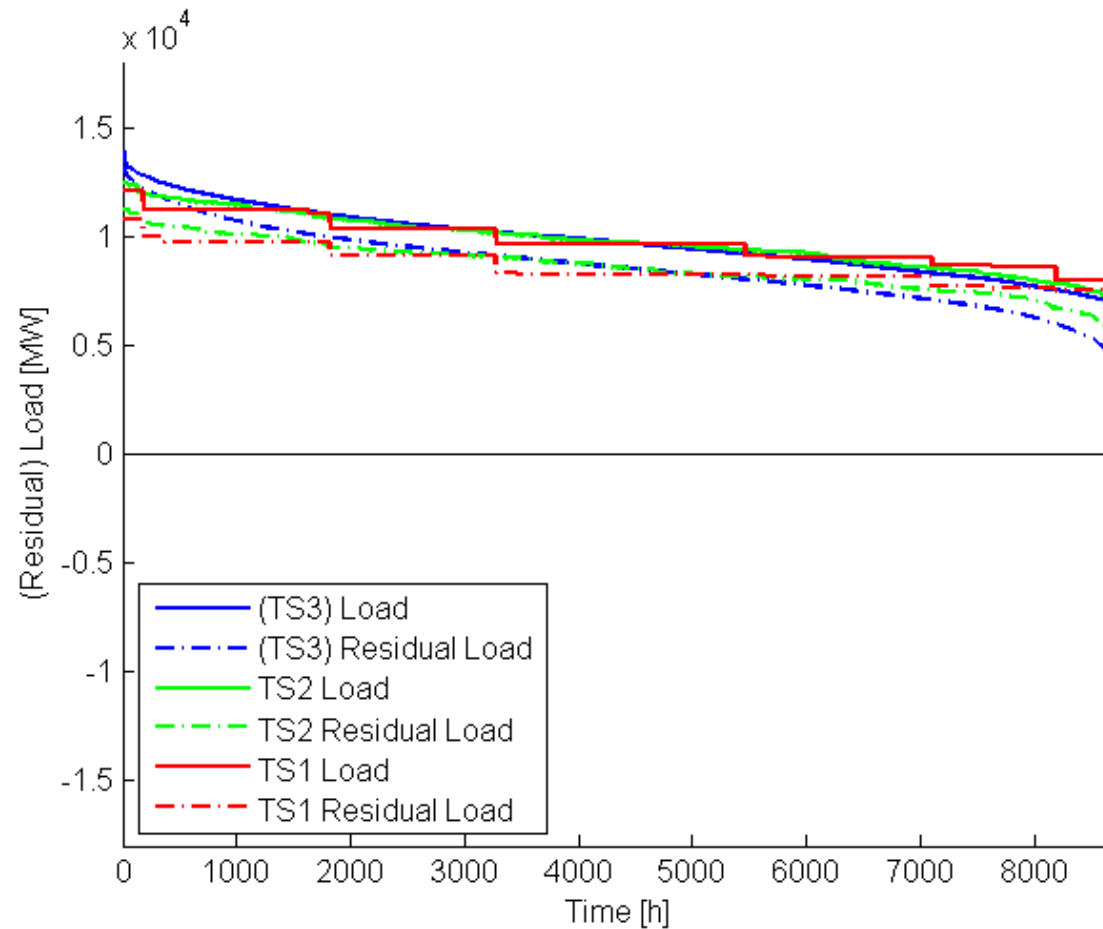
# Residual Load Duration Curve (RLDC)

- 2014: 1.5 GW Wind, 2.5 GW PV



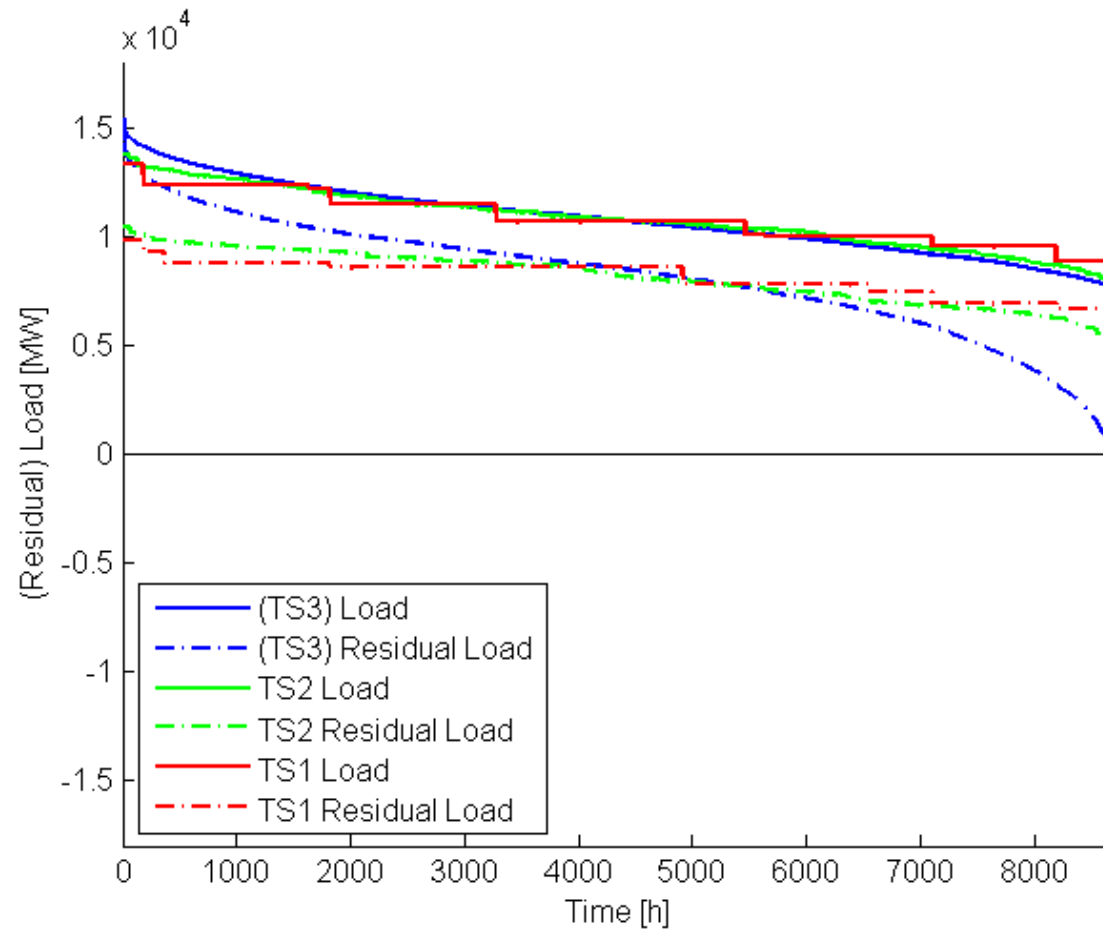
# Residual Load Duration Curve (RLDC)

- 2020: 4.0 GW Wind, 1.9 GW PV



# Residual Load Duration Curve (RLDC)

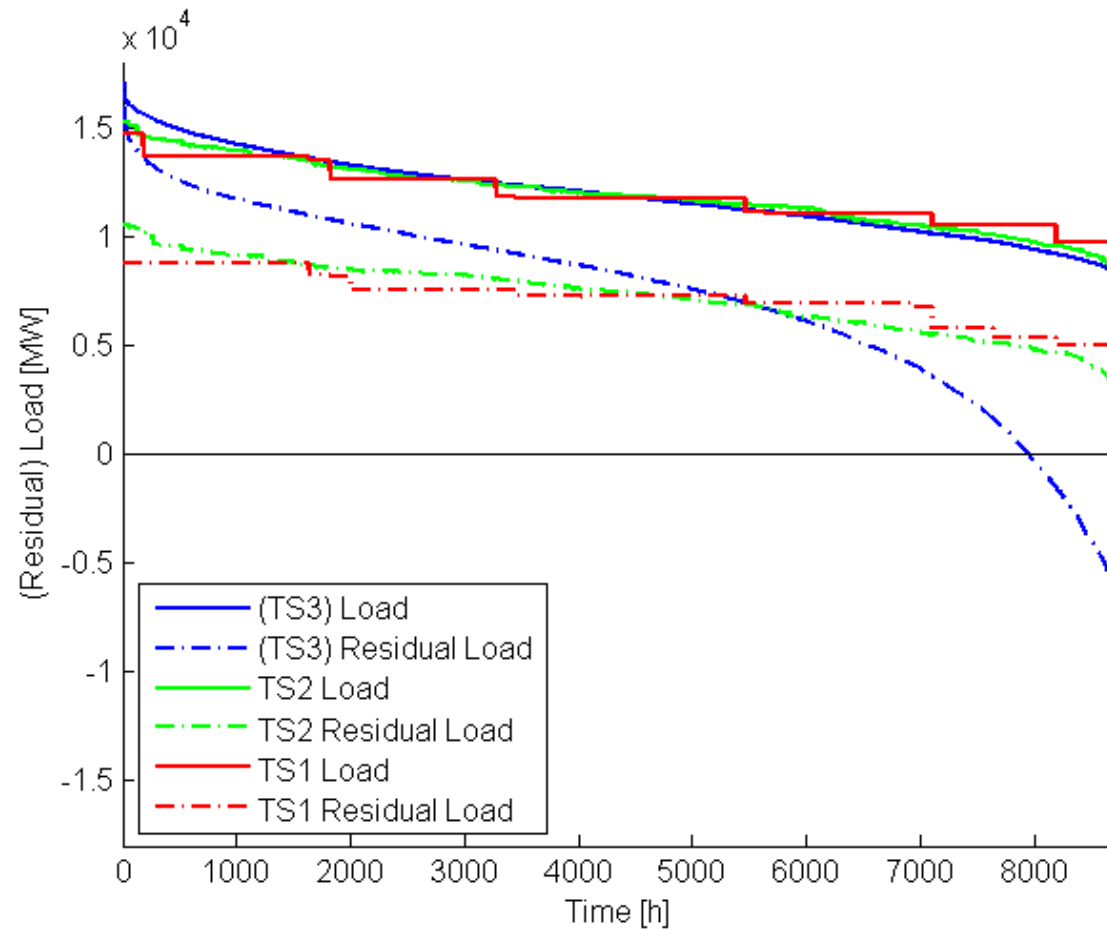
- 2030: 11.0 GW Wind, 0.9 GW PV





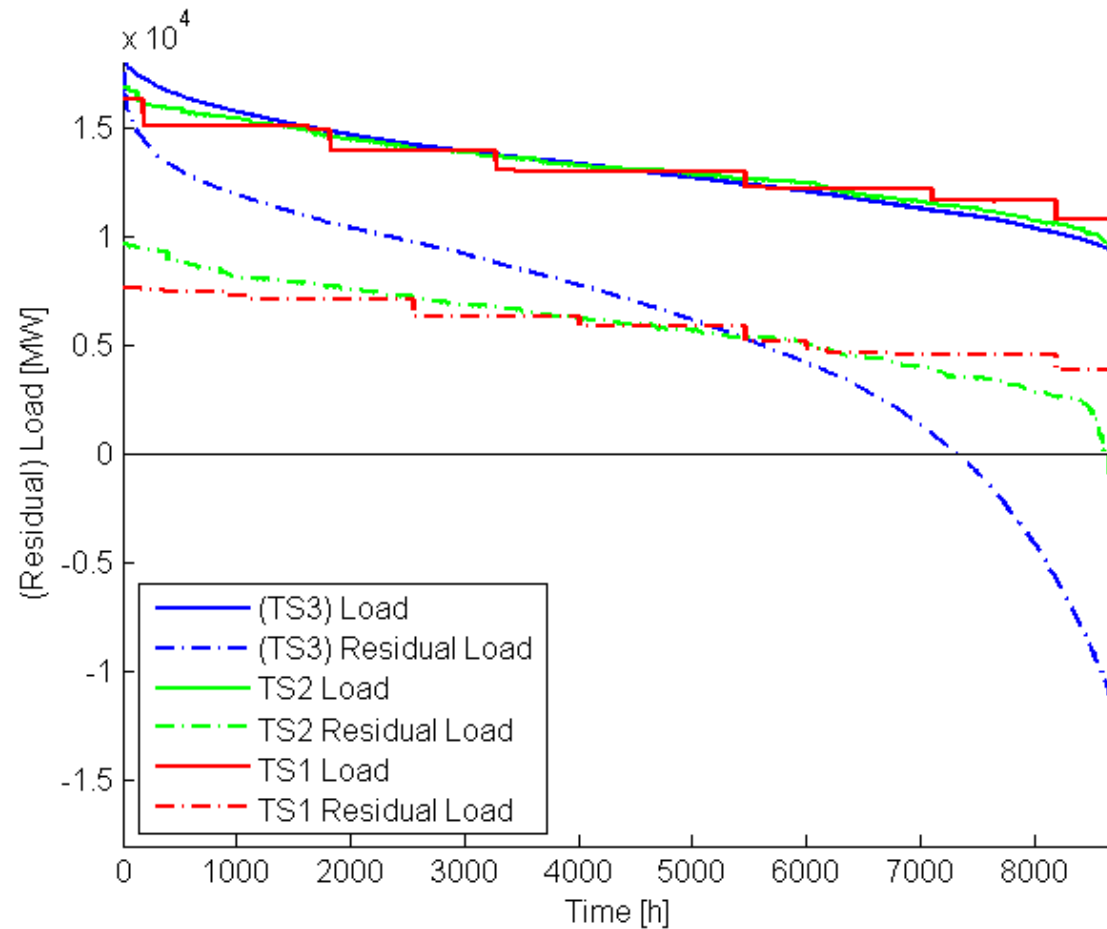
# Residual Load Duration Curve (RLDC)

- 2040: 20.0 GW Wind, 0 GW PV

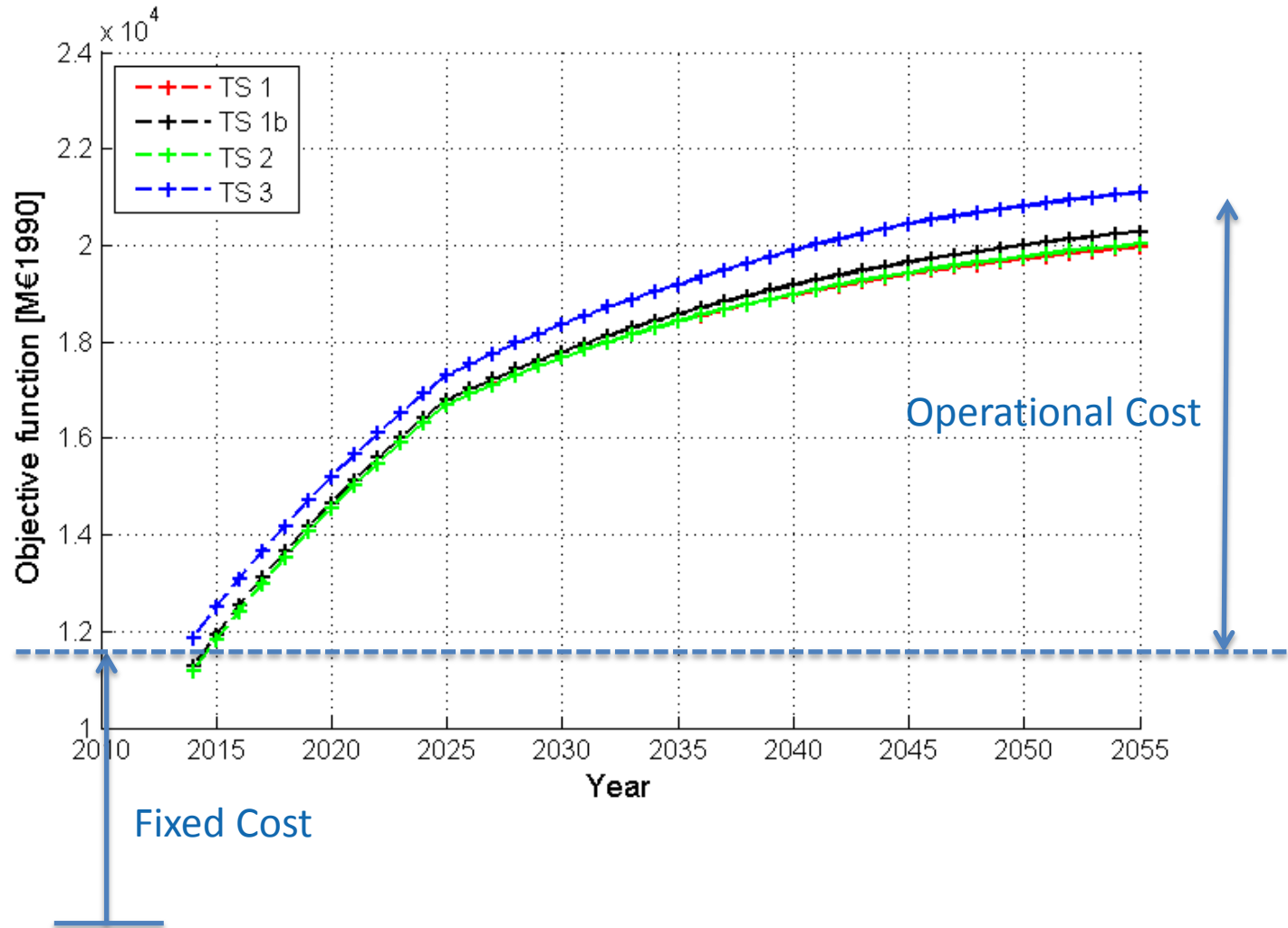


# Residual Load Duration Curve (RLDC)

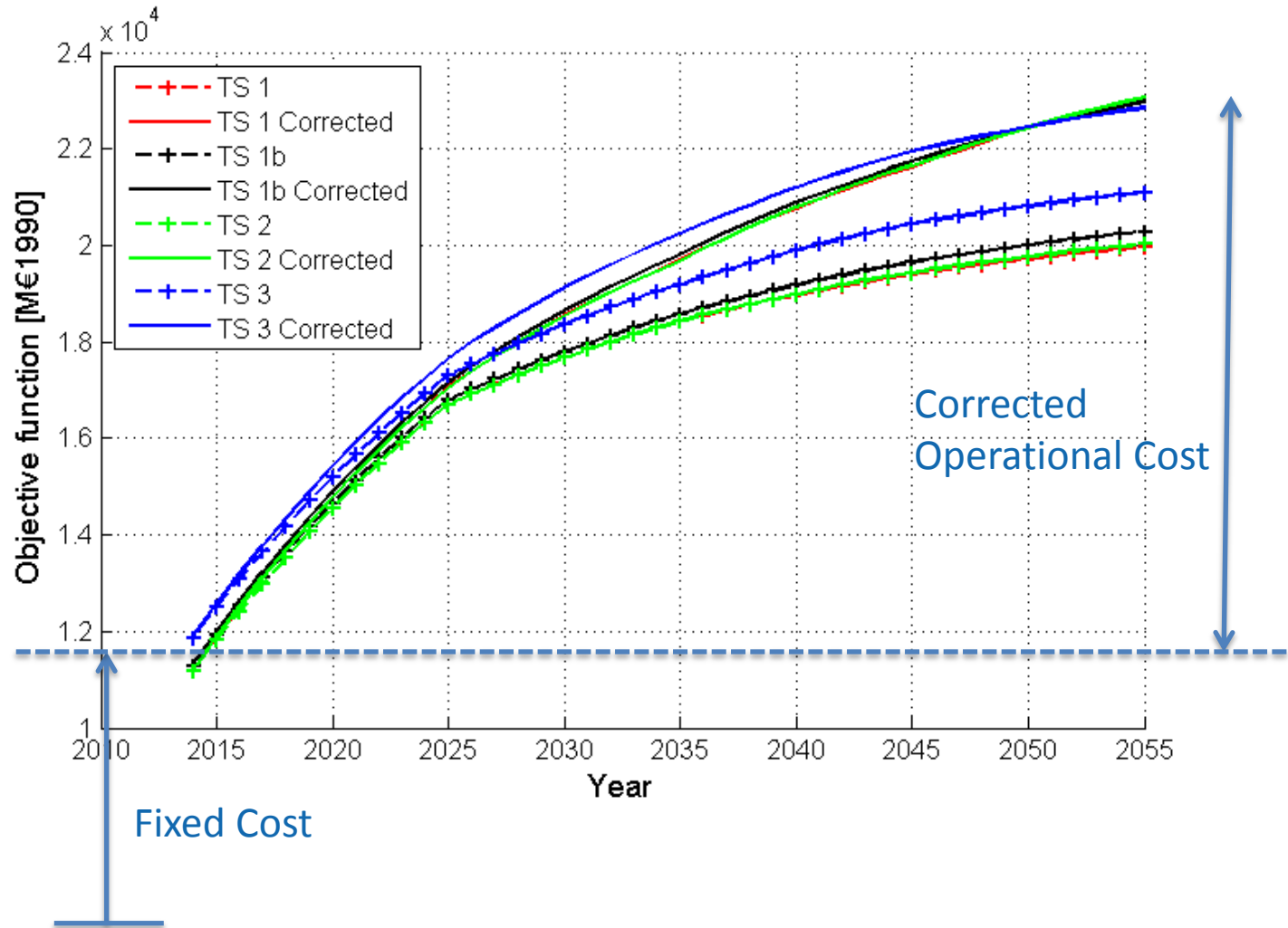
- 2050: 26.9 GW Wind, 8.8 GW PV



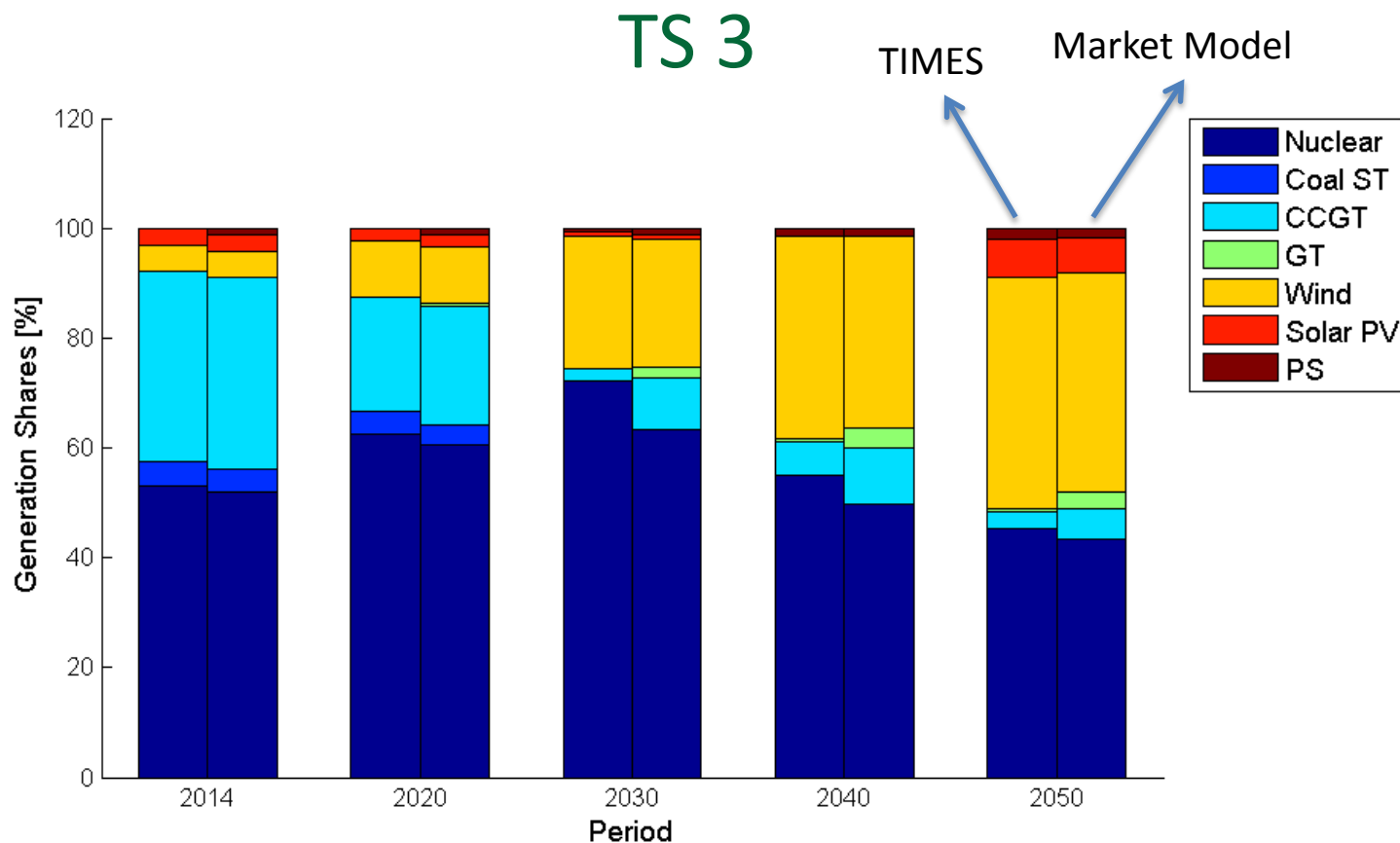
# System Cost



# System Cost - Corrected



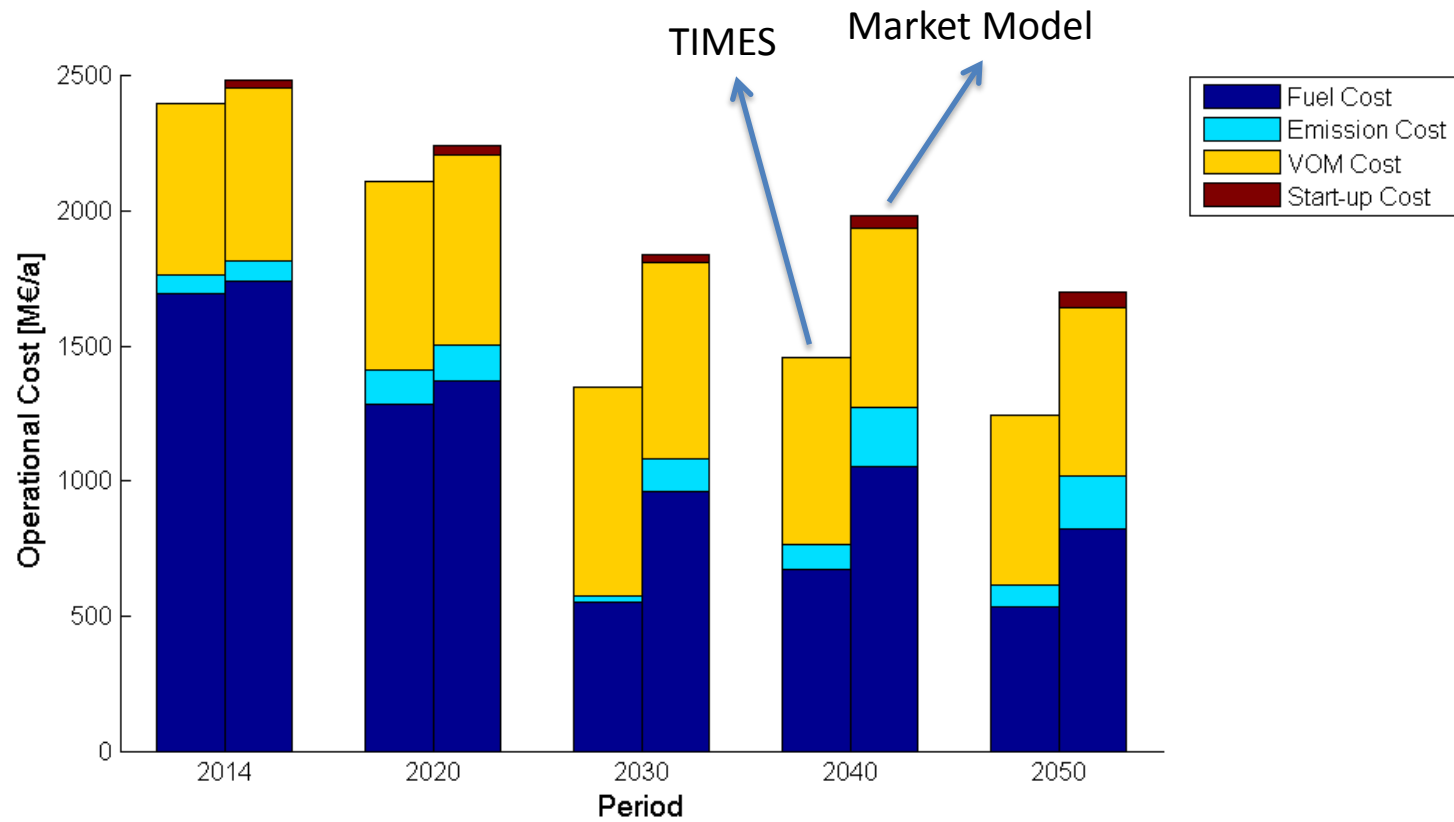
# Re-evaluate Dispatch – TS 3



RES Target [%]:	/	12.5	25	37.5	50
Share RES [%]:	7.6	12.3	24.0	34.9	46.5

# Impact Operational Constraints

## TS 3



- 1) Use Time Slices:
  - classical division of TS based on seasonal, daily or intra-daily fluctuations can not be justified
- 2) Operational Constraints of power plants:
  - Can have a significant impact (dependent on power system)

# Questions?

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- Generation

