



Proactive Generation and Transmission Expansion Planning with storage considerations

Publishing Research Results

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OUTLINE

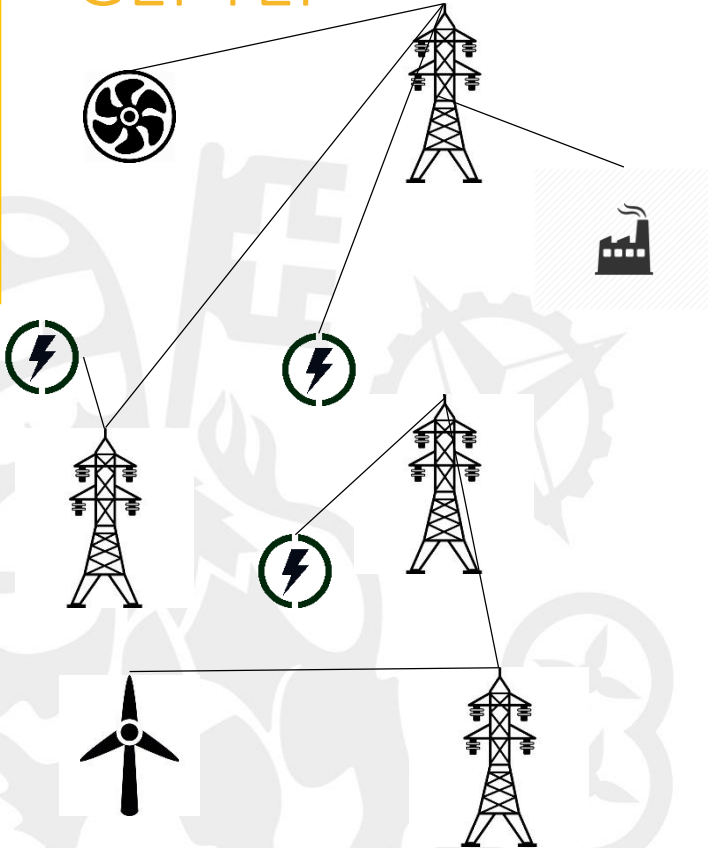
BACKGROUND

METHODOLOGY

RESULTS

SUMMARY AND FUTURE WORK

GEPTEP



Deregulated Market Environment

GENCOS

TRANSCO

← Conflicting interests →

Renewables, storage,
Distributed generation

Time Representation

Long Term
Investment
(years)

VS

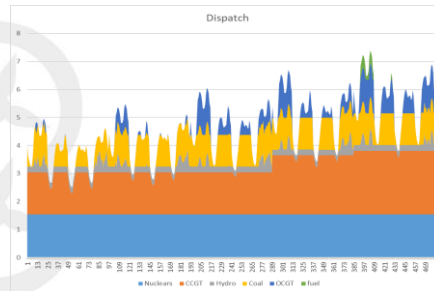
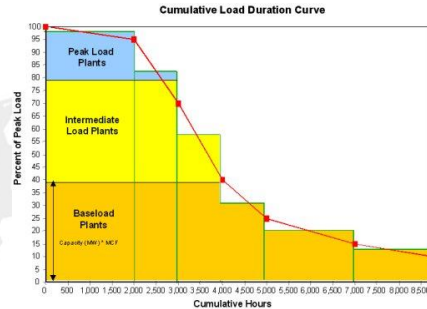
Short Term
Operation
(hours)

Load Level

System States

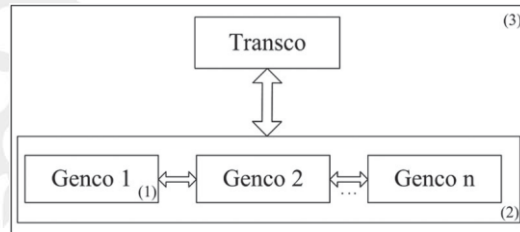
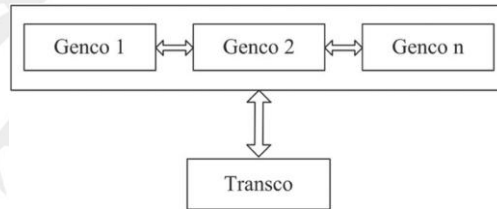
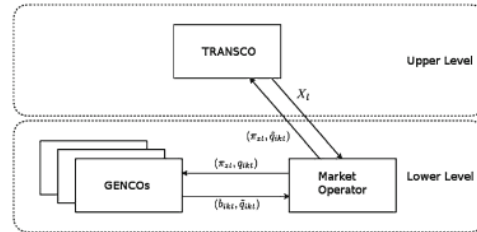
Representative Days

Enhanced
Representative Days



Bilevel Approaches

- Electricity Market
- Reactive
- Proactive



ONE-LEVEL GEPTP: CO-OPTIMIZATION MODEL (COM)

ONE LEVEL
CENTRALIZED AGENTE

Objective Function:

- Min ->

Line Investment
+ Generation Investment
+ Operation costs

Constraint:

- Cumulative Line investment
- Production, consumptions limits
- Line Capacities, DC flow
- Spillage, reservoir limits
- Reservoir Balance (Slow, Fast)
- Power Balance
- Cumulative generator installation

BILEVEL GEPTP PROACTIVE MODEL (PM)

UPPER LEVEL
TRANSCO

Objective Function:

- Min -> Line Investment

Constraint:

- Cumulative investment

LOWER LEVEL
GENCOS

Objective Function:

- Min-> Investment+Operation costs

Constraints:

- Cumulative investment
- Production, consumptions limits
- Line Capacities, DC flow
- Spillage, reservoir limits
- Reservoir Balance (Slow, Fast)
- Cumulative generator installation
- Power Balance

BILEVEL GEPTP: PROTACTIVE MODEL (PM)

UPPER LEVEL
TRANSCO

Objective Function:

- Min \rightarrow Line+ Gen Investment
+ Operation Costs

Constraint:

- Cumulative investment

LOWER LEVEL
GENCOS

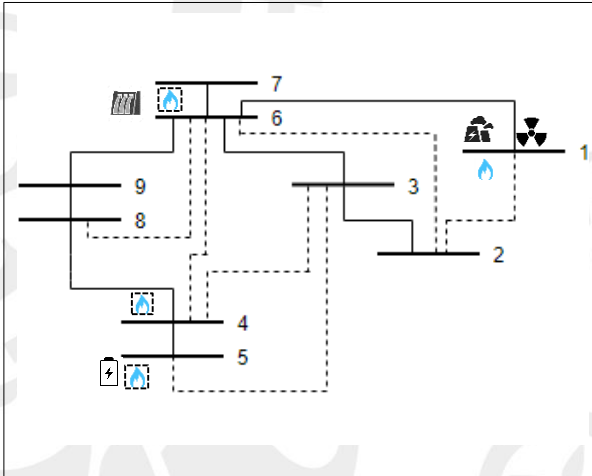
Objective Function:

- Max \rightarrow Incomes – Investment- Costs

Constraints:

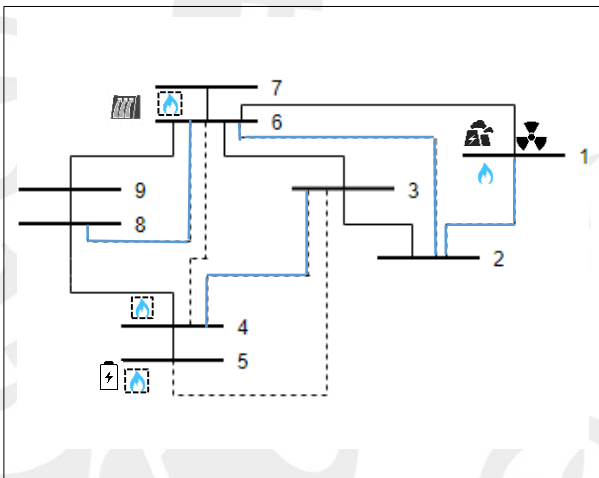
- Cumulative investment
 - Production, consumptions limits
 - Line Capacities, DC flow
 - Spillage, reservoir limits
 - Reservoir Balance (Slow, Fast)
 - Cumulative generator installation
- Power Balance

CASE 2



- 9 Demand Nodes
- 5 generators (1 Hydro)
- 1 year (8764 hours)
- 4 RP (4 days)
- 6 Candidate Lines
- 3 Candidate Generators
- 1 Genco per Node

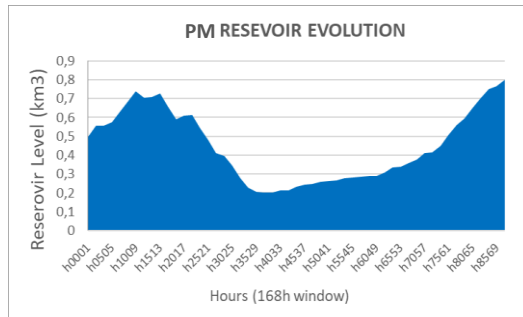
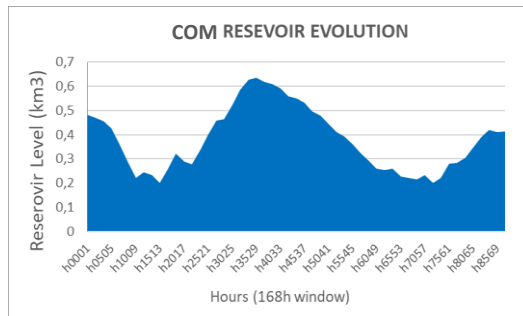
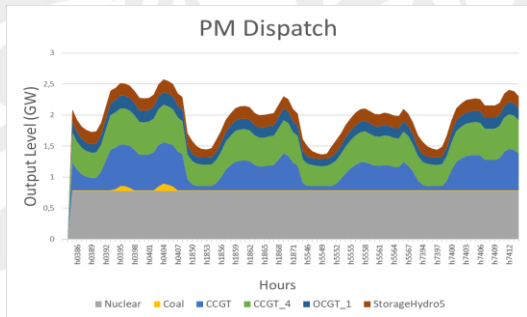
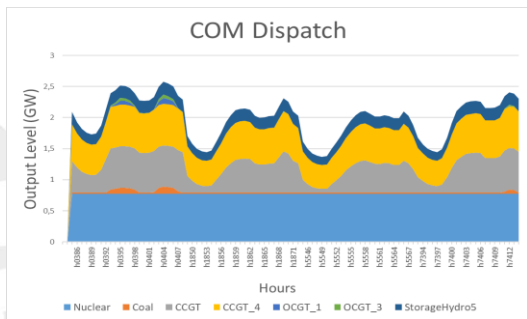
Investment Plan



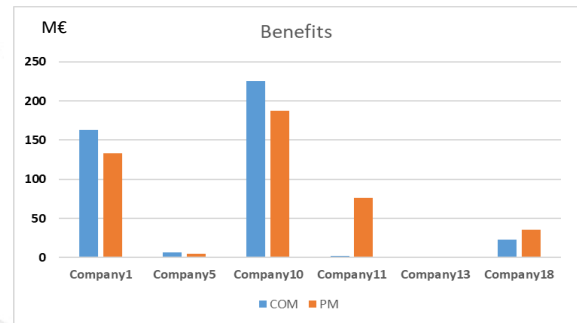
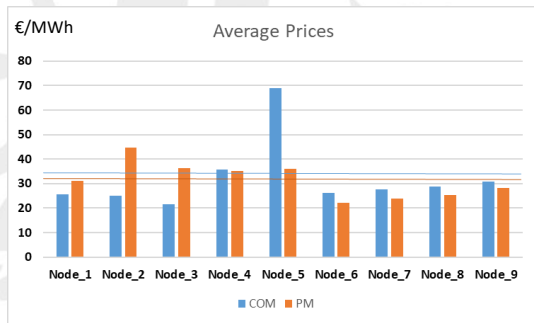
	Lines Built	Investment (M€)
COM	(1-2), (3,4), (6,2), (6,8)	40
PM	(1-2), (3,4), (6,2), (6,8)	40

	Generation Company (Unit, Node)	Generation Expansion (MW)	Total Investment Cost (M€)
COM	(CCGT_4, 4)	667.5	133
	(OCGT_1, 5)	95.23	12.4
PM	(OCGT_3, 6)	57.30	7.50
	(CCGT_4, 4)	599.7	119.9
	(OCGT_1, 5)	208.8	27.15

Results



Benefits



Total Benefits COM = 421 M
Total Benefits PM = 436 M

SUMMARY AND FUTURE WORK



We propose a bilevel geptep model that includes analysis of storage management using a enhanced representative framework.

Is it shown that including a strategic framework to analyze competition in GEPTep models can yield conterintuitive results compared to a co-optimization framework .



Storage Investment

Complete dual formulation

Integrate Linearized Losses

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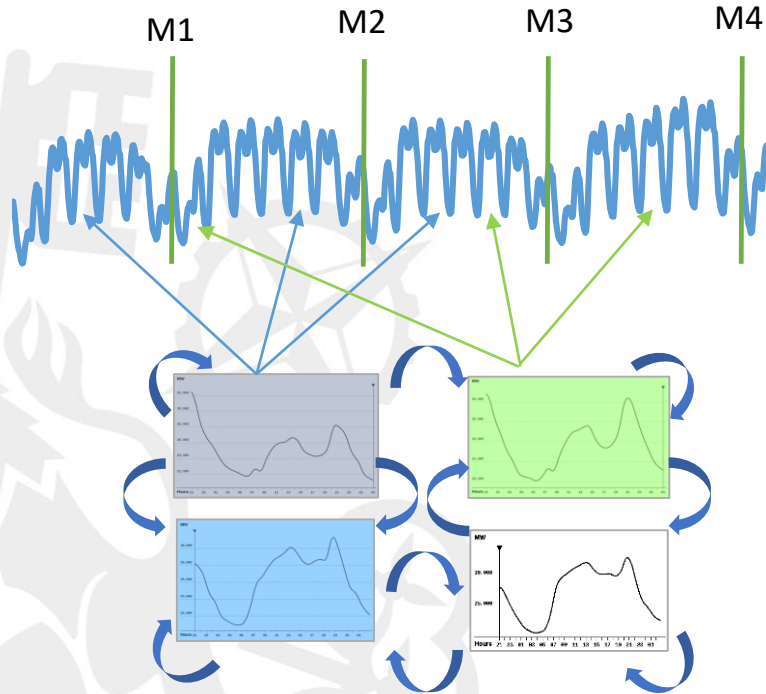


THANK YOU

References

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REPRESENTATIVE PERIODS



Storage Equations

- INTRADAY

$$\begin{aligned}
 & vLevel_{yphfd} \\
 &= vLevel_{y,p-1,h,d} + vLevel_{y=0,p=1,h,d} + pInflow_{yphfd} - vSpill_{yphfd} \\
 &- \frac{vProd_{yp\ hfd}}{pProd fct_{h_f}} + \frac{vCon_{yphfd}}{pProd fct_{h_f}} : \psi_{yphd} \quad \forall h_f \in GED, p < pf, \\
 &\forall yphd,
 \end{aligned}$$

- INTERDAY

$$\begin{aligned}
 & vLevel_{yphd} \\
 &= vLevel_{y,p-M,h,d} + vLevel_{y=0,p=1,h,d} \\
 &+ \sum_{p'}^p \sum_{p''} \left(pInflow_{yp''hd} - vSpill_{yp''hd} - \frac{vProd_{yp''hd}}{pProd fct_h} + \frac{vCon_{yp''hd}}{pProd fct_h} \right) \\
 &: \psi'_{yphd} \quad \forall h \in GED, p < pf, \quad \forall yd,
 \end{aligned}$$

with $p' = p - M + 1$ and $p'' \in H(p', p'')$

REPRESENTATIVE PERIODS

Representative Periods with Transition Matrix and Cluster Index

We include the **transition matrix and cluster index** ideas of System States Models into the representative periods, so that it is possible to link chronological information among the representatives such as storage levels or unit commitments

