



Proactive Generation and Transmission Expansion Planning with storage considerations

Publishing Research Results

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OUTLINE

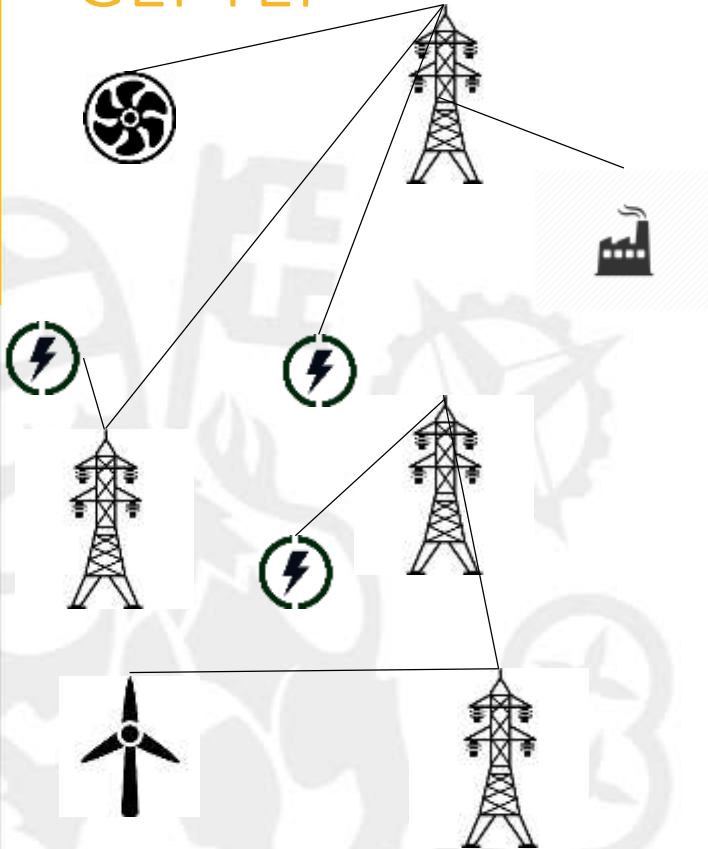
BACKGROUND

METHODOLOGY

RESULTS

SUMMARY AND FUTURE WORK

GEPTEP



Deregulated Market Environment

GENCOS

TRANSCO

Conflicting interests

Renewables, storage,
Distributed generaiton

Time Representation

Long Term
Investment
(years)

VS

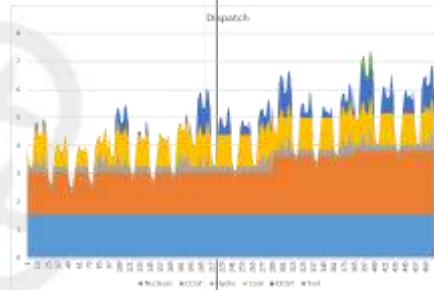
Short Term
Operation
(hours)

Load Level

System States

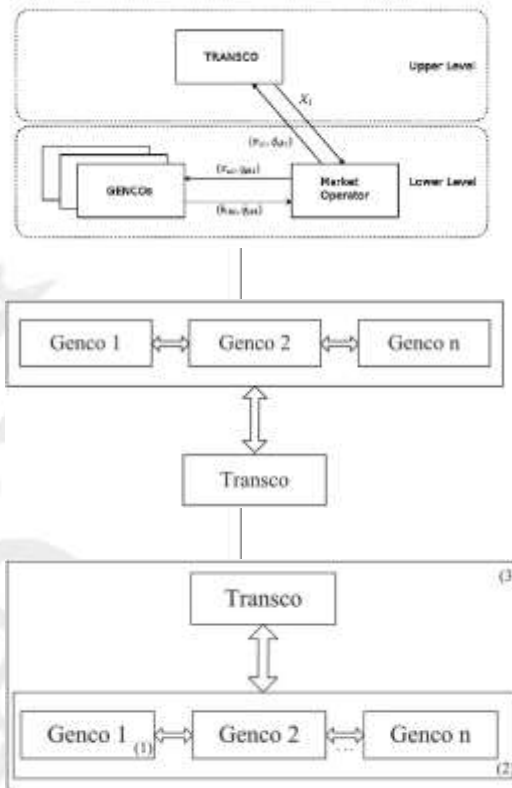
Representative Days

Enhanced
Representative Days



Bilevel Approaches

- Electricity Market
- Reactive
- Proactive



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

ONE LEVEL
CENTRALIZED AGENTE

Objective Function:

- Min \rightarrow

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 GEPTEP: PROTACTIVE MODEL (PM)

UPPER LEVEL
TRANSCO

Objective Function:

- Min \rightarrow Line+ Gen Investment
+ Operation Costs

Constraint:

- Cumulative investment

LOWER LEVEL
GENCOS

Objective Function:

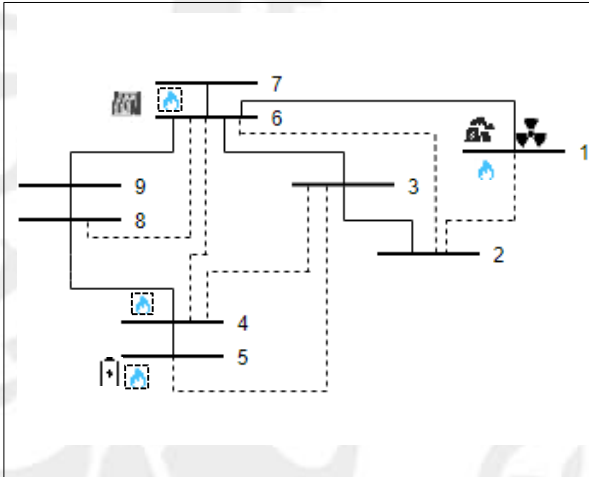
- Max \rightarrow Incomes – Investment- Costs

Constraints:

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

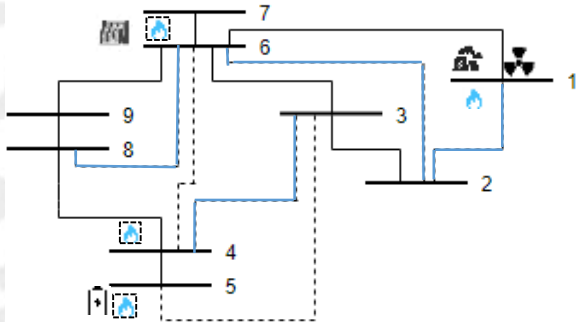
- Power Balance

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

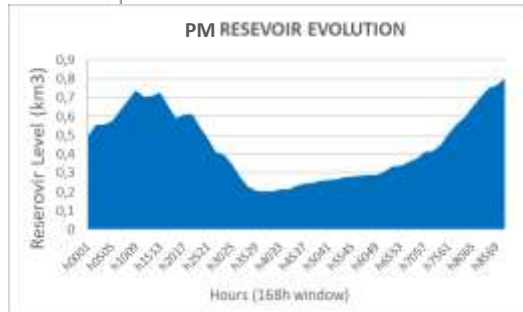
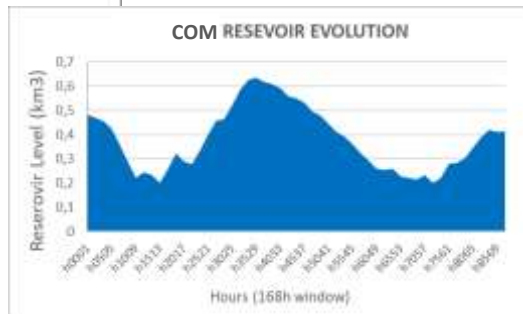
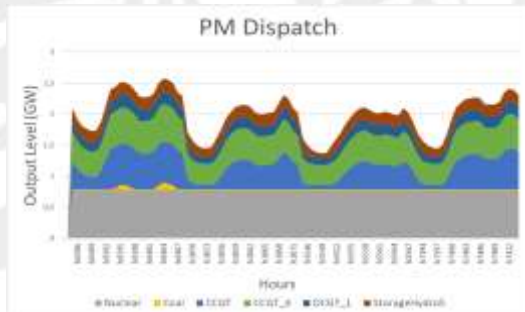
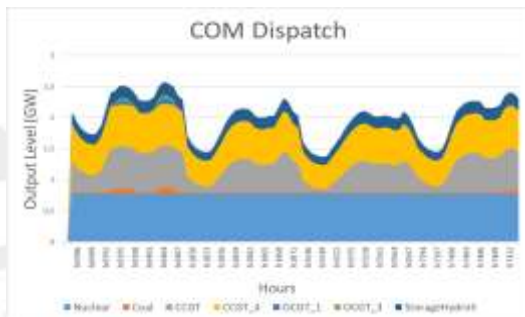
Investment Plan



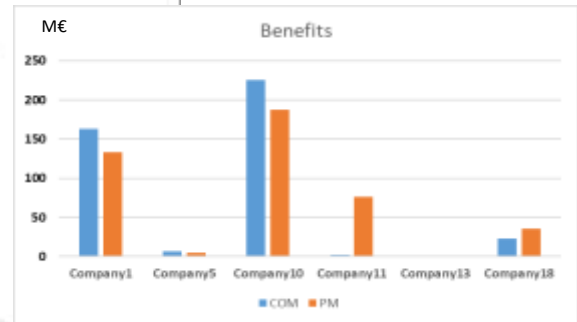
	Lines Built	Investment (M€)
COM	(1-2), (3,4), (6,2), (6,8)	40
PM	(1-2), (3,4), (6,2), (6,8)	40

	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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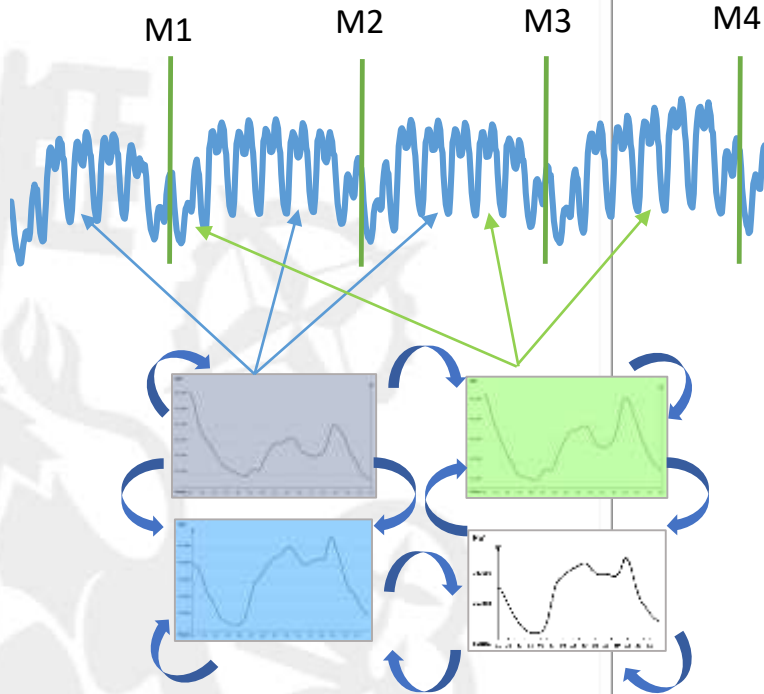


THANK YOU

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

