



University of
Strathclyde
Engineering

Influence of the Emission Trading Scheme on the Generation Trade Strategy

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Context

- General Objectives
- Introduction of the AMES Power Market Framework
- Formulation to enable ETS constraints and trading
- Results
- Future work

General Objectives

To investigate the influence of the Emission Trading Scheme on the Generation Trade Strategy

- See how the generation react when limited by the emission allowance
- Study the influence on individual GenCo strategy changing when enable the emission trading
- Investigation the outcomes of the electricity markets under the GenCos changing

AMES Wholesale Power Market Framework

- The model is using the agent-based approaches
- Stochastic award/profits chasing based reinforcement learning
- Flexible power system building
- Open source JAVA software

AMES Wholesale Power Market Framework

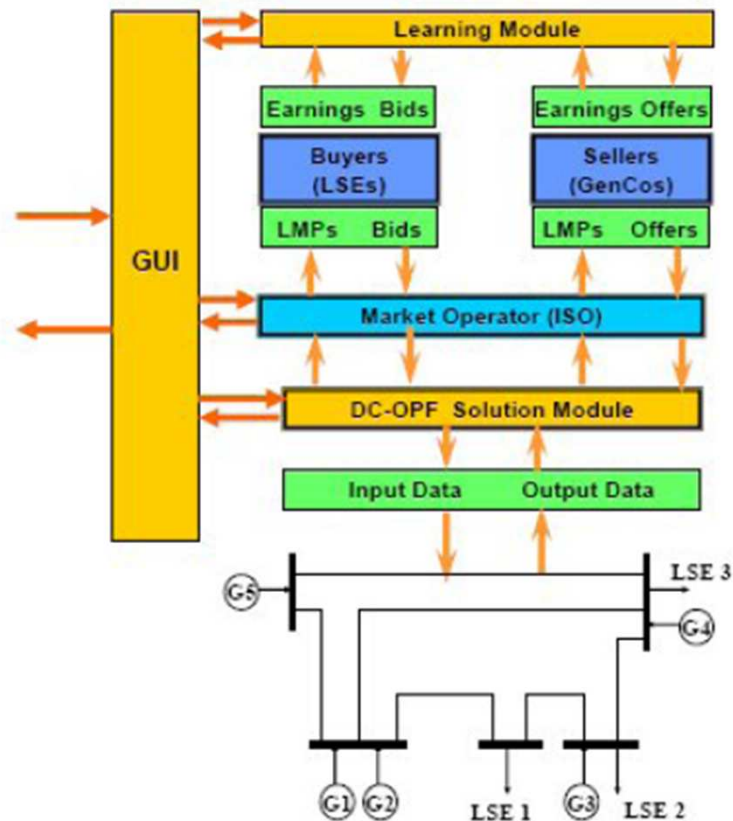
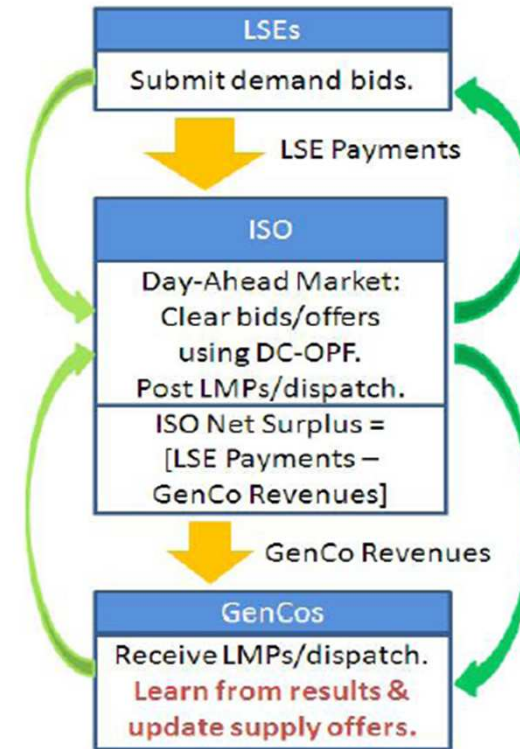


Illustration of AMES dynamics on a typical day D in the absence of system disturbances or shocks for the special case of a 5-bus grid



AMES day-ahead energy market activities during each day D

Formulation

Objective function:

$$\sum_i^I [A_i P_{gi} + B_i P_{gi}^2] + \pi_p \left[\sum_{1 m \in BR} \delta_m^2 + \sum_{km \in BR, k \geq 2} [\delta_k - \delta_m]^2 \right] + \sum_i^I Em_{bi} \pi_{bi} - \sum_i^I Em_{si} \pi_{si}$$

With respect to:

$$P_{Gi}, i=1, \dots, I; \delta_k, k=2, \dots, K; Em_{bi}, Em_{si}, i=1, \dots, I$$

Subject to constraints:

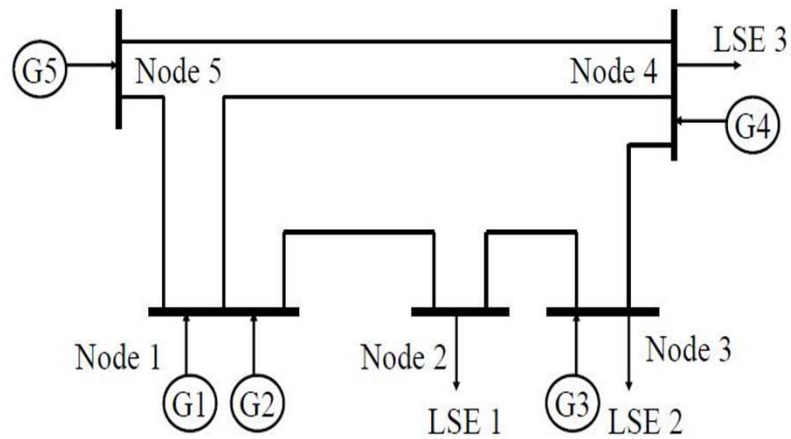
$$\sum_{i \in I_k} P_{Gi} - \sum_{km \text{ or } mk \in BR} B_{km} [\delta_k - \delta_m] - \sum_{j \in J_k} P_{Lj}$$

$$-B_{km} [\delta_k - \delta_m] \geq -F_{km}^U, \quad B_{km} [\delta_k - \delta_m] \leq F_{km}^U$$

$$P_{gi} \geq P_{gi}^L, \quad -P_{gi} \geq -P_{gi}^U$$

$$Em_i = e_i C_i(P_{gi}), \quad Em_i + Em_{bi} - Em_{si} \leq EA_i, \quad \sum_i^I Em_{bi} - \sum_i^I Em_{si} = Cons$$

Simulation



	atBus	A(£/MWh)	B(£/MWh ²)	LowCap(MW)	UpCap(MW)	Fcost(£/h)	EmcCoe(Ton/\$)	EA(Ton)	Pb(£/Ton)	Ps(£/Ton)
GenCo1	1	14	0.005	0	110	56.9	0.021	800	13.5	15
GenCo2	1	15	0.006	0	100	0.11	0.008	800	11	17
GenCo3	3	25	0.01	0	520	2267.53	0.055	100	14	16
GenCo4	4	30	0.012	0	200	5.19	0.055	800	13.5	16.5
GenCo5	5	10	0.007	0	600	1391.16	0.057	100	12.5	17

Results

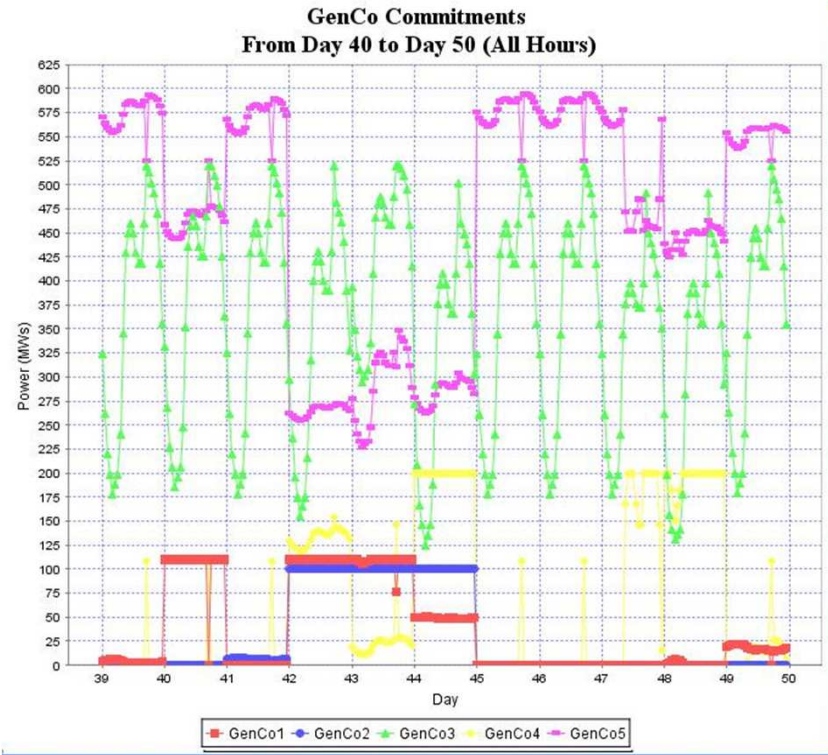
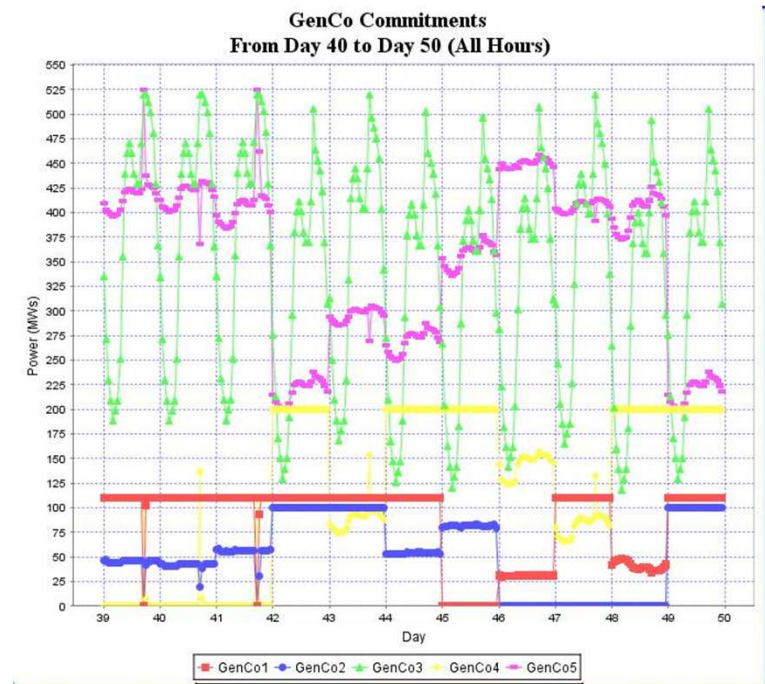
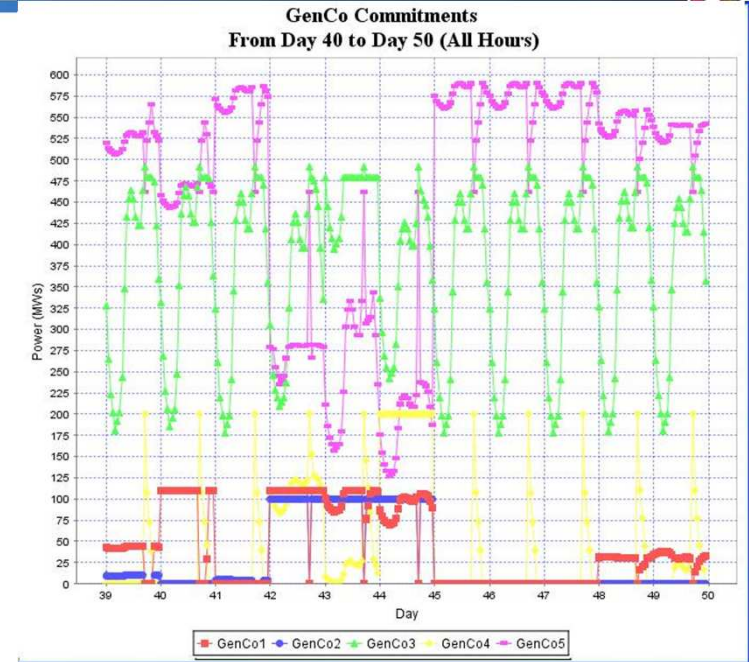


Figure left top: Original Commitment Learning

Figure Right Top: Under Emission Constraints Only

Figure Right Bottom: Enable the Emission Trading

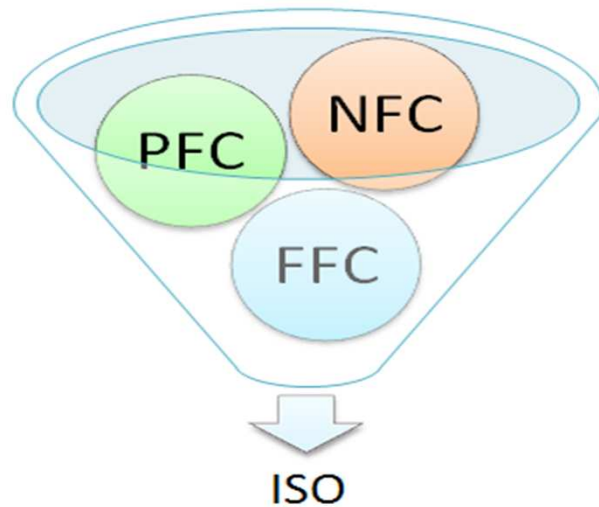


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Discussion

- Adding emission constraints will limit the large generation production but how to price when the large scale generation should run to maintain the stability and security of the system
- How to avoid the increase of the electricity price for the consumers
- Decision making on the Emission Allowance (depending on type or the production)

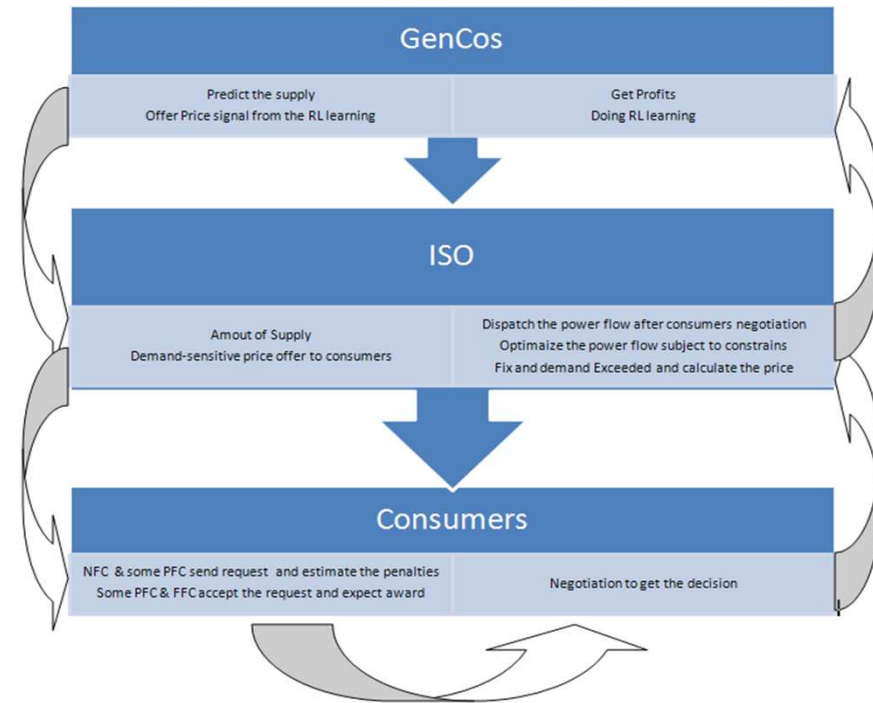
Future Work



The New Structure Relationship between Consumer Agent and ISO

Implementation of the consumers negotiation

- None-Flexible Consumer(NFC)
- Partly-Flexible Consumers (PFC)
- Fully-Flexible Consumers (FFC)



The process for the ideal load-follows-supply process from the original AMES Test Bed

- In the ahead-day market, let the generation calculate the supply and offer the price.
- In the real-time market, the large-scale generation will be used to follow the more or less load request could not be accepted

Future Work

Model Improvement and Development	Supply Side Implementation	Demand Side Implementation	Comment or Achievements
Original model	Agent-based generation	Fixed or price sensitive demand	Get the formulation and structure from the original model
Extension original model	Agent-based generation with emission allowance constraints	Fixed or price sensitive demand	Familiarize the original programming and publish the results
Implement the consumers	Fixed or sensitive supply	Three group of agent-based consumers	Invert the procedure and both side of the implementation and publish the results
Final model completion	Agent-based generation with emission allowance constraints	Three group of agent-based consumers	Integrate the software above and writing report