Gestão de energia através de inteligência computacional

Energy management through computational intelligence

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Framework

- **Computational Intelligence Society (IEEE)**
  - Scope:

- The Field of Interest of the Society shall be the theory, design, application, and development of biologically and linguistically motivated computational paradigms emphasizing neural networks, connectionist systems, genetic algorithms, evolutionary programming, fuzzy systems, and hybrid intelligent systems in which these paradigms are contained.

Computational Intelligence and Smart Grids

- Most CI methodologies can be applied independently of the Smart Grids deployment
  - Complex or ill-defined problems
  - Difficult optimization problems
  - Qualitative or imprecise data
  - Fast response needed
  - Addressing uncertainty

- Smart grids provide additional intelligence through bilateral communication, leading to new challenges, where CI can give specific answers
  - Combining local and centralized control
  - Creating new “outside the box” approaches

Topics

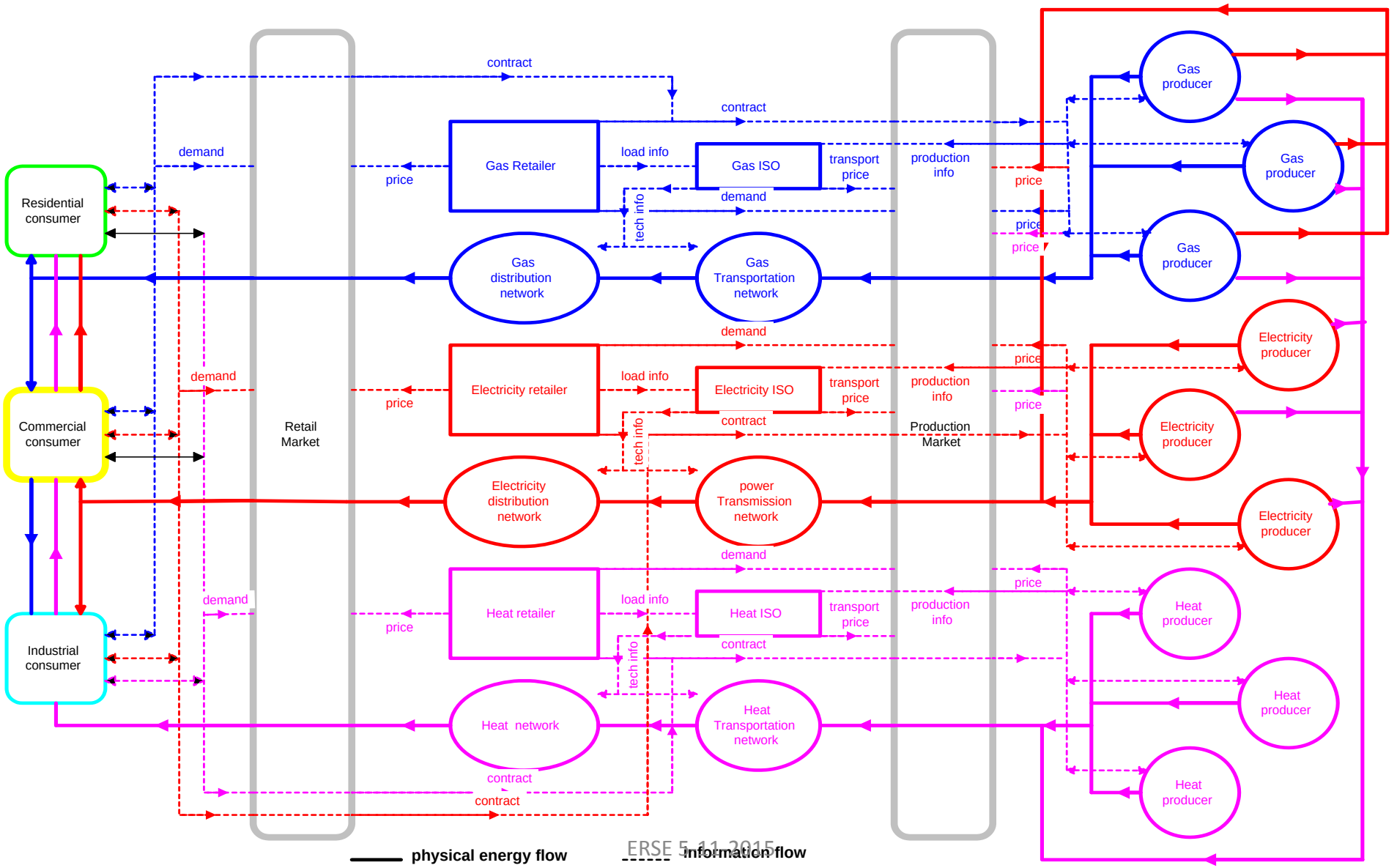
1. Agent platform > Simulation > Policy tests
2. Fuzzy inference systems > Voltage control
3. Autoencoders (ANN) > State estimation
4. Fuzzy Power Flow > Steady-state security
5. *Optimization through nature inspired methodologies*

Agent platform

- Competition is in energy and not only in electricity

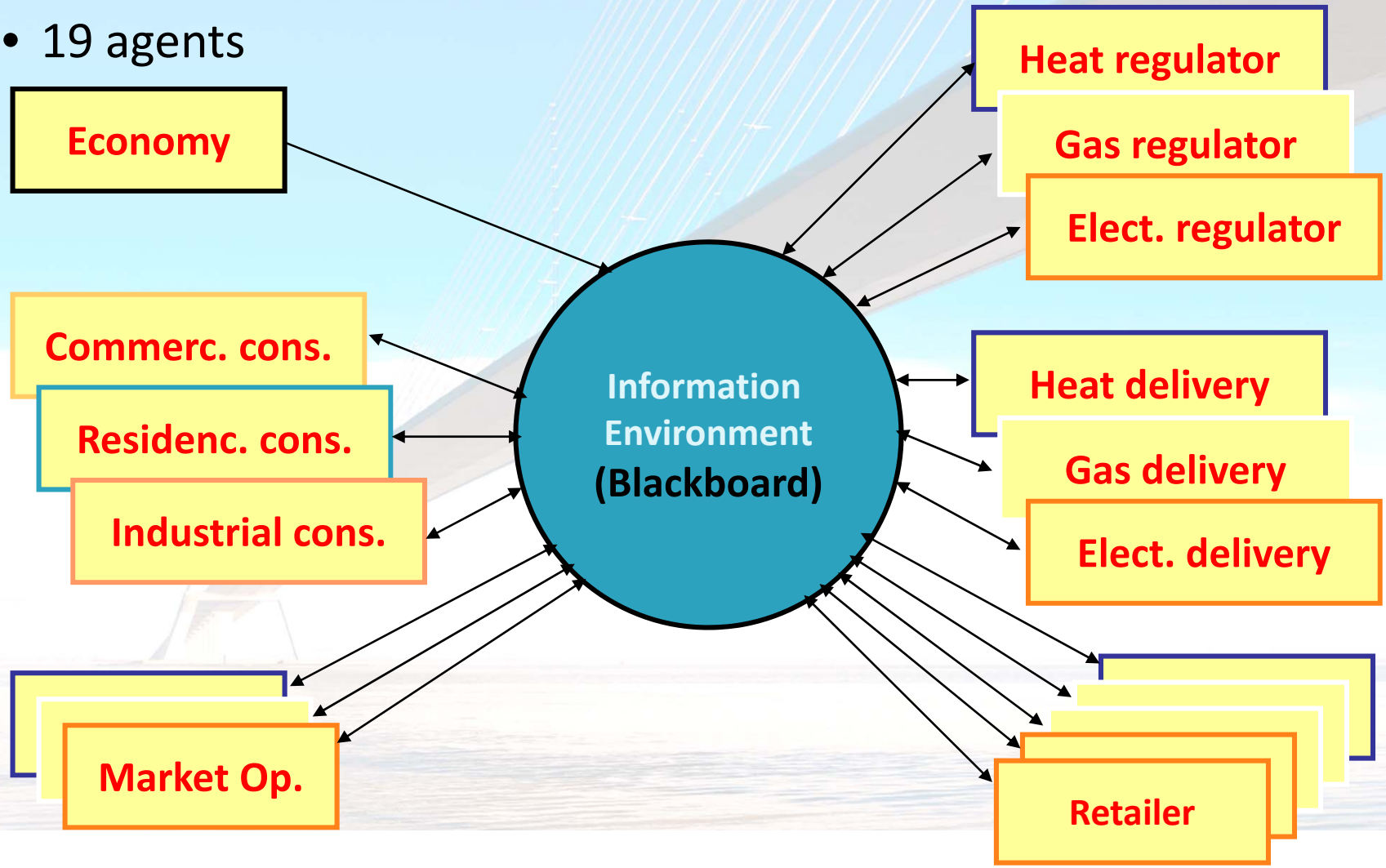
- Electricity may be generated from gas
- Heat may be generated from gas or electricity
- Physical networks may run side by side on the ground
- Consumers may opt for technologies and not only for suppliers
- Regulators must be concerned with multi-energy market interactions

Complexity of interactions



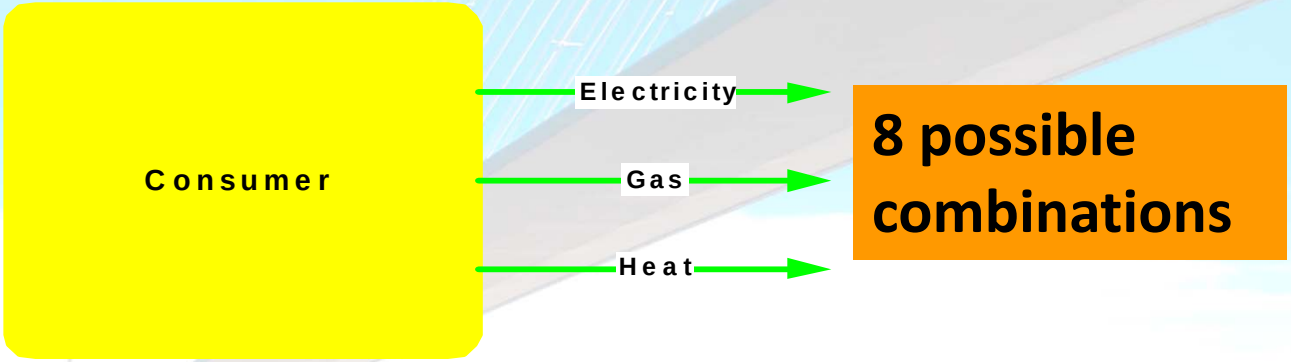
A model for the retail market

- 19 agents



Consumer Group Agent

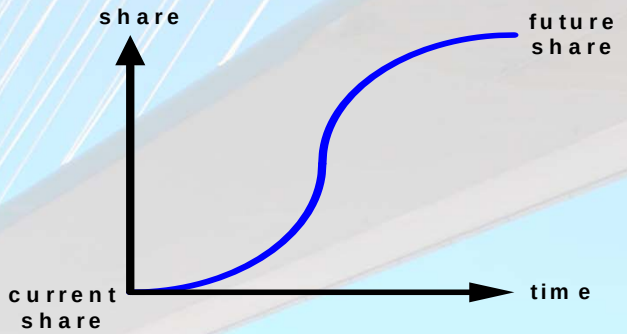
- Price Sensitivity Model
- Consumer Classifier



- Share shifting

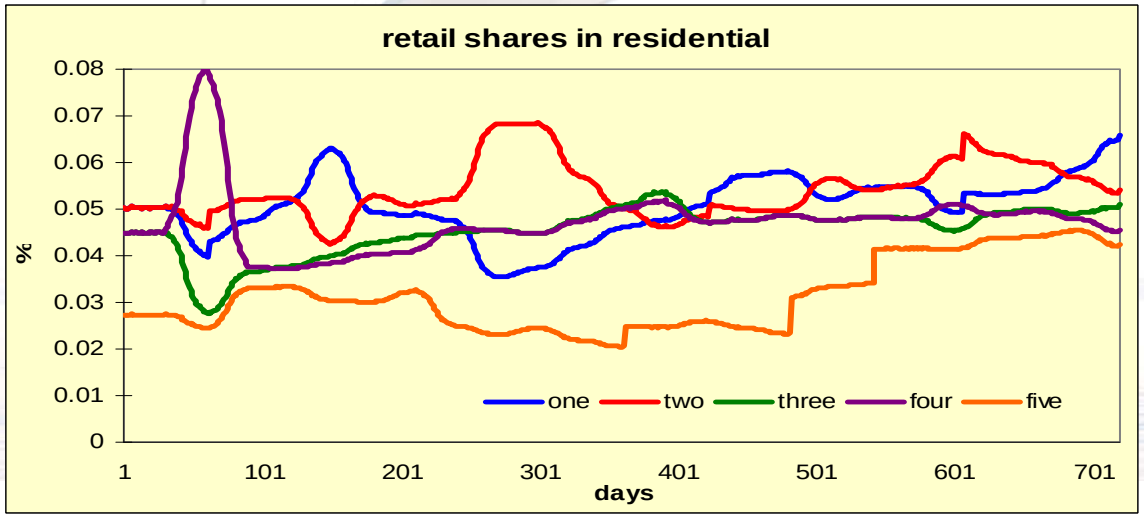
Consumer Group Agent

- Economic feasibility check



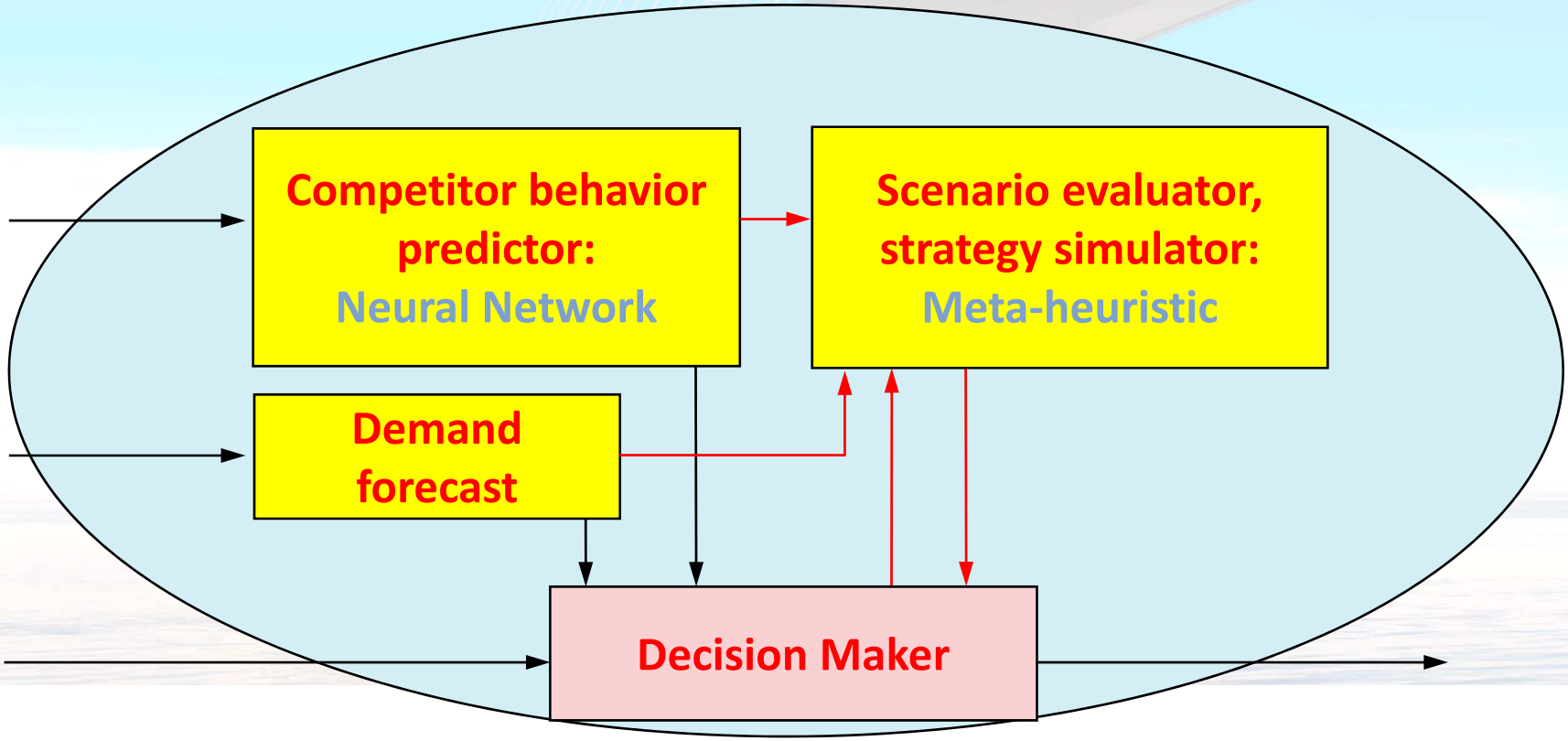
- Smoothing demand shift

- Transform energy group share into energy consumption and market share



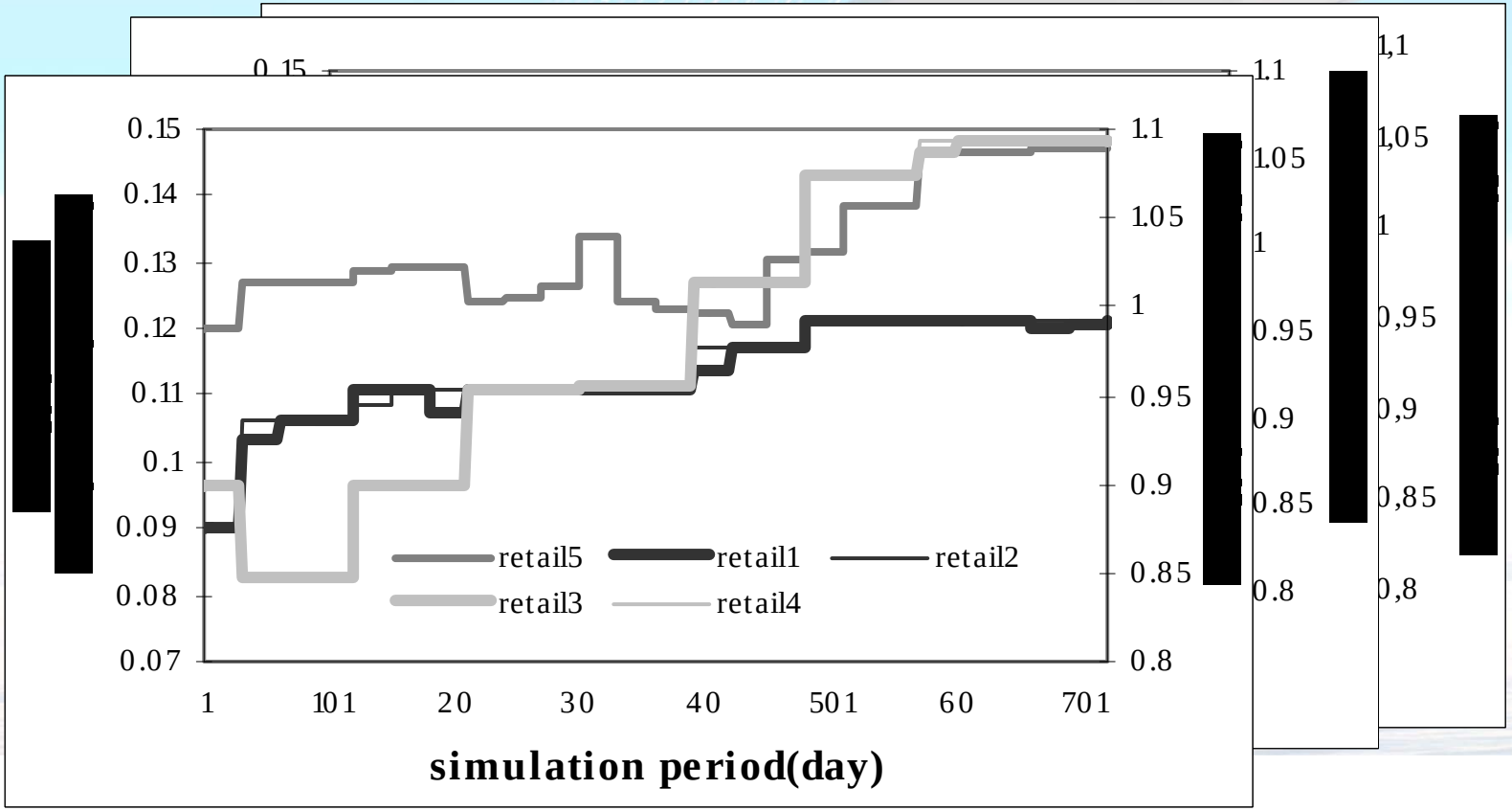
Inside a Retailer Agent

- A retailer defines its market policy as a function of data input from the Environment Agent and from internally predicting and simulating the market



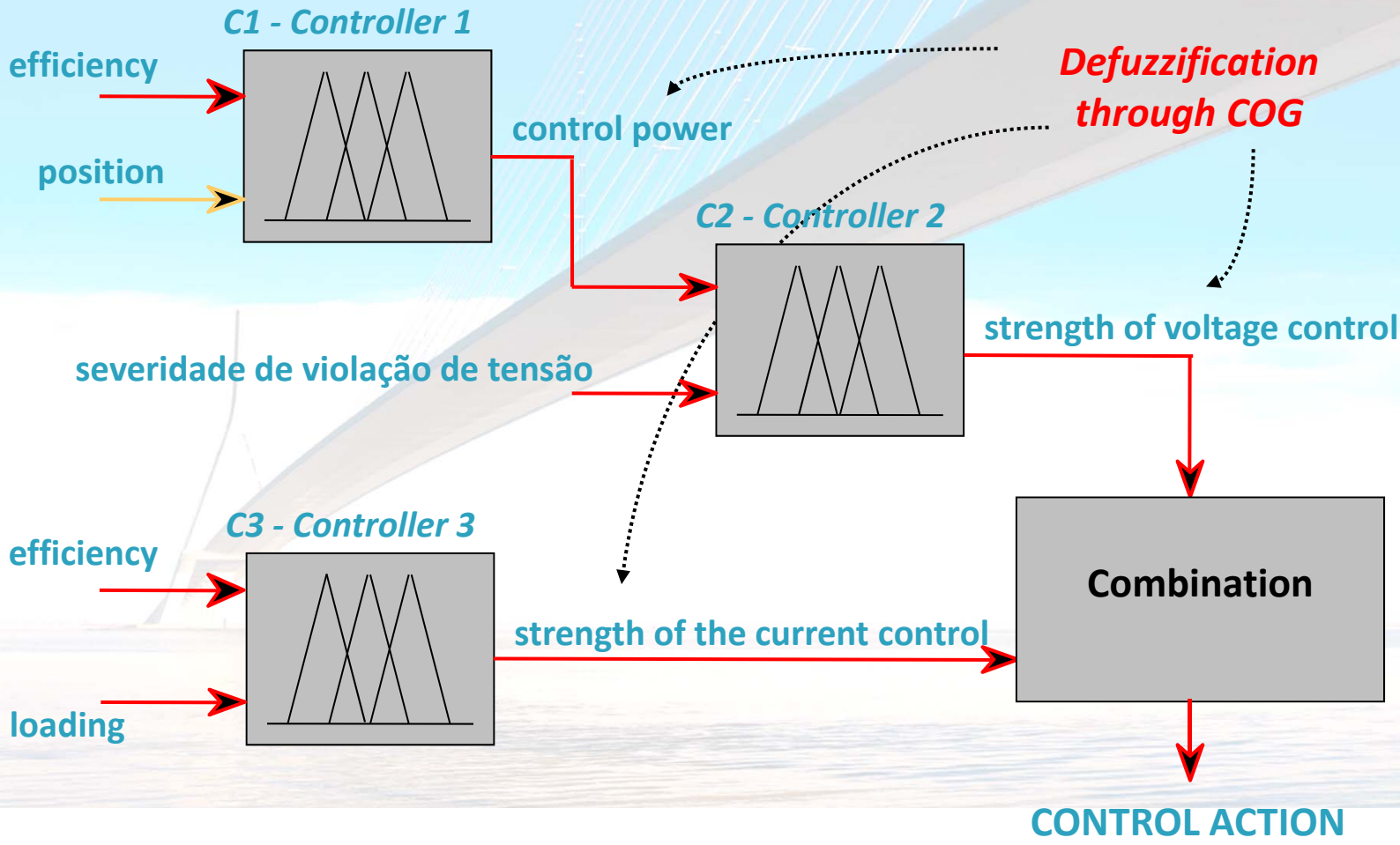
Example of simulation results

- **Prices in residential consumers**
- **Prices in commercial consumers**
- **Prices in industrial consumers**



Fuzzy control of voltage / reactive power

- Basic idea – cascading Mamdani controllers

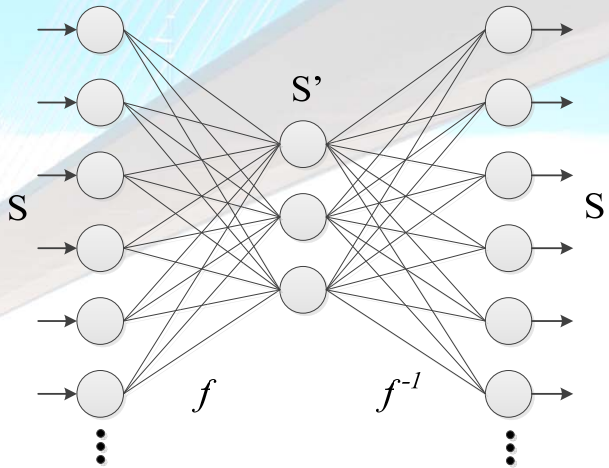


Fuzzy control of voltage / reactive power

- Relevant parameters
  - SEVERITY of the operating limit violation
    - The controller will try to eliminate the most severe violation (minmax optimization)
  - EFFICIENCY of the control action
    - The controller will try to use the control action with foreseen greater impact
  - AVALABILITY of the control action
    - The controller will tend to use at each moment the more available actions while trying to maintain all the variables within the admissible band and not in its limits

The Concept of Autoencoder

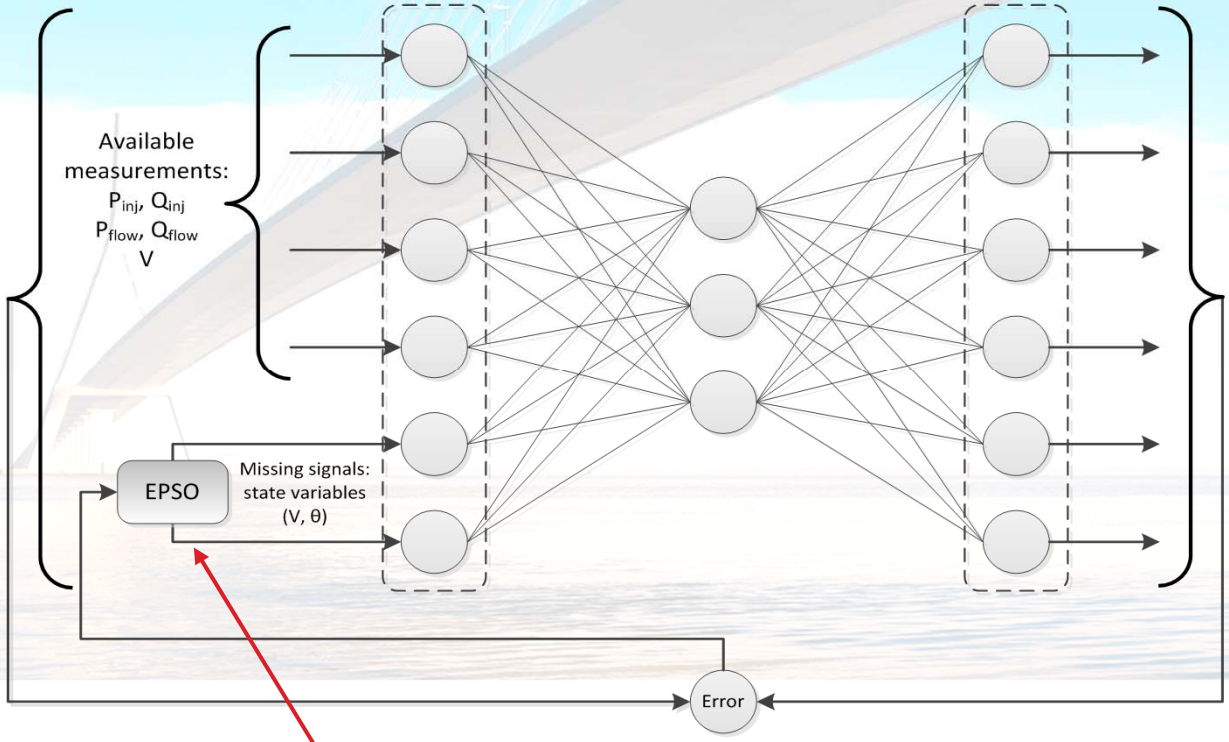
- Auto-associative neural networks (AANN) or autoencoders are feedforward neural networks that are built to mirror the input space S in their output → the size of its output layer is always the same as the size of its input layer.



- An autoencoder is trained to display an output equal to its input. With adequate training learns the data set pattern and stores in its weights information about the training data manifold.

The Concept of Autoencoder

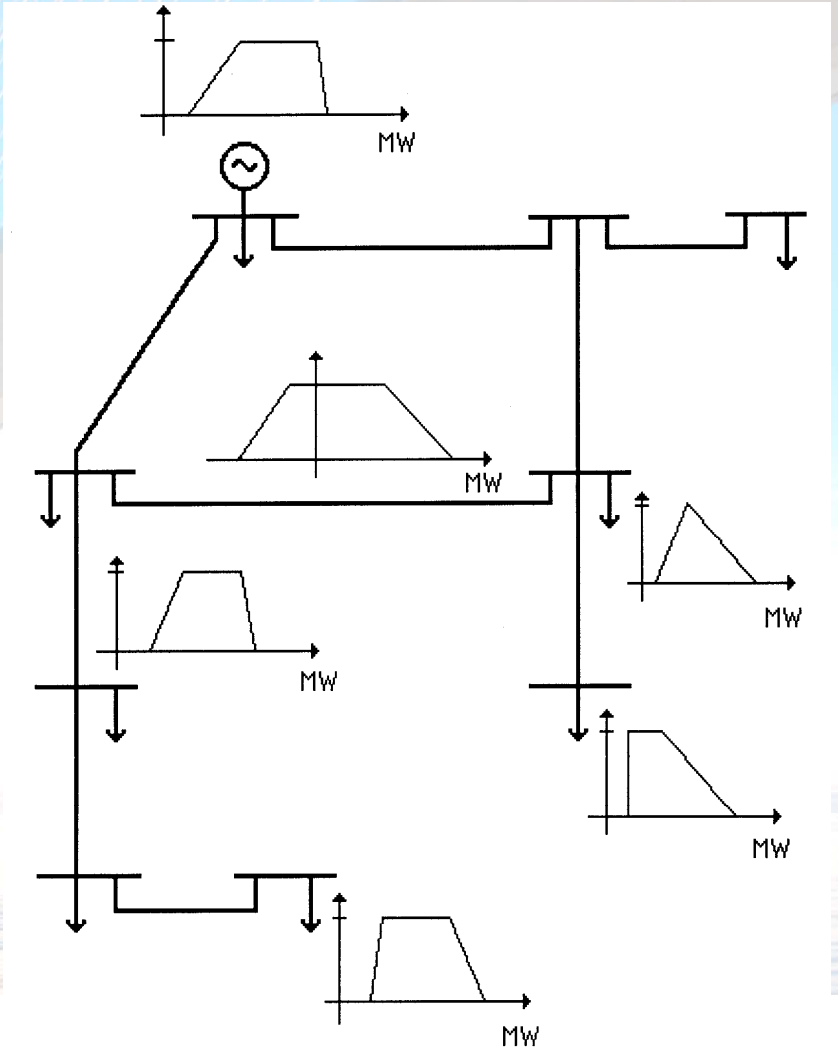
- If an incomplete pattern is presented, the missing components may be replaced by random values producing a significant mismatch between input and output
  - A search may be conducted by an optimization algorithm



Nature inspired optimization methodology

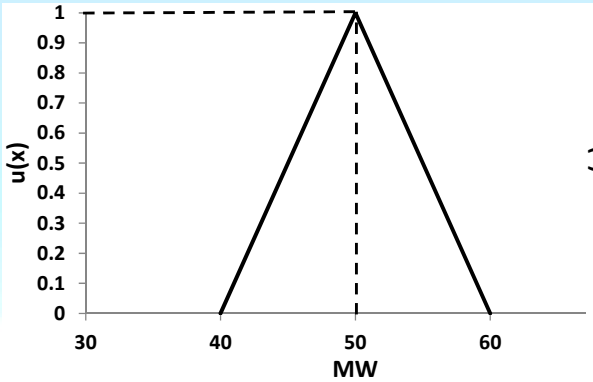
Fuzzy Power Flow

- A way of understanding the influence of load and generation uncertainties in the main state variables of a power network
  - Voltages
  - Branch Flows
- FPF deals with imprecise or qualitative declarations
- Risk indices are produced to help the Decision Makers

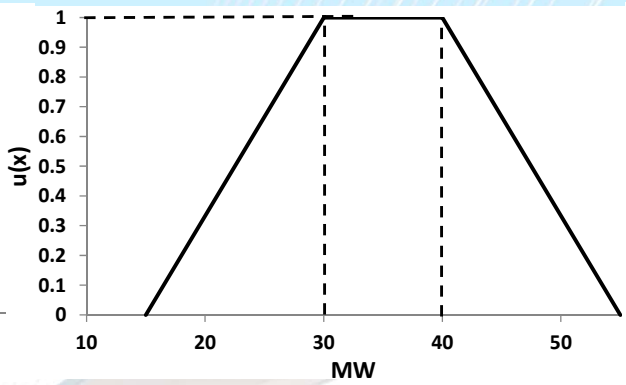


Fuzzy Power Flow

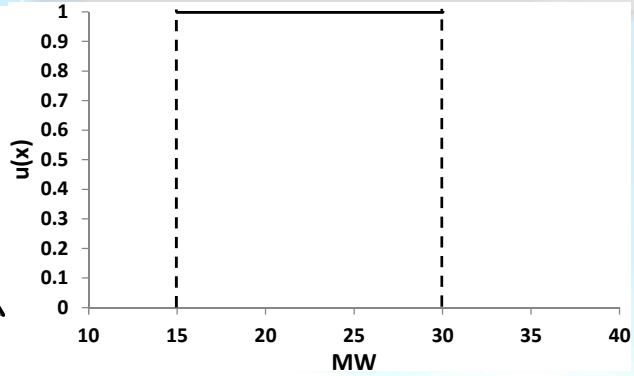
- Fuzzy numbers for generation and load (active and reactive)



Load about 50 MW

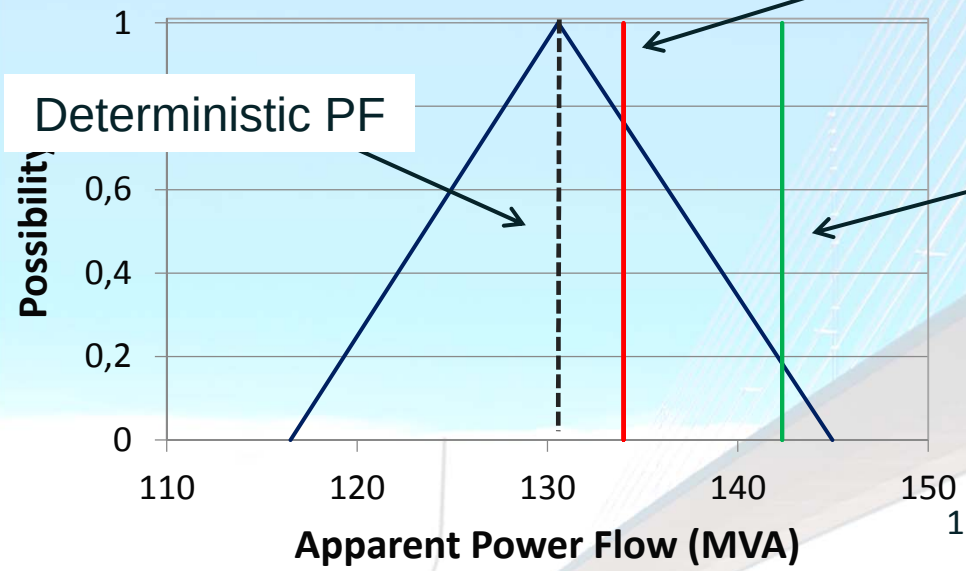


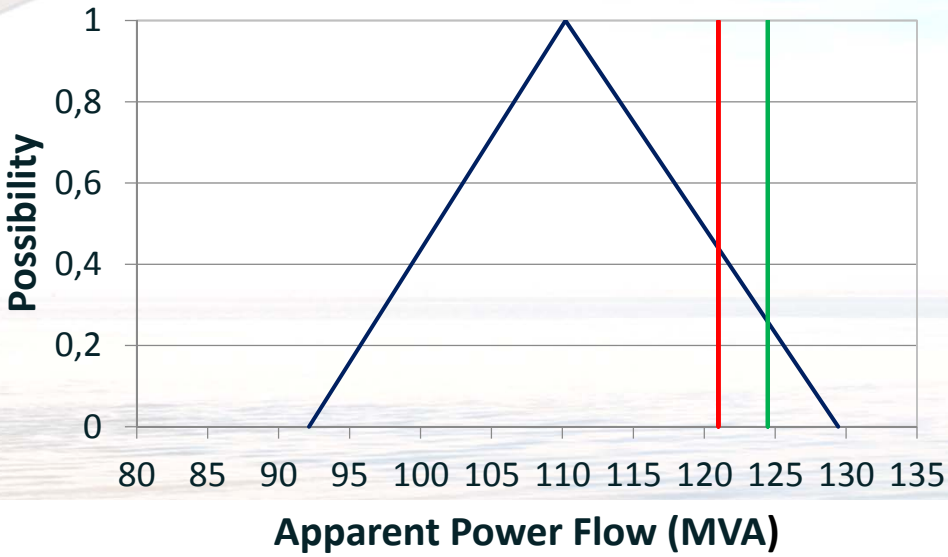
Load more or less between 30 and 40 MW



Load between 15 and 30 MW

Illustrative Results





Congestion

Deterministic	Classified as Positive	Classified as Negative
Positive	3882	127
Negative	241	1032415

Fuzzy	Classified as Positive	Classified as Negative
Positive	3922	87
Negative	919	1031737

Final remarks

- Computational intelligence methodologies may bring new (effective) answers to **old** and **new** problems
- An agent platform may be very useful for testing policies
  - e.g. Imposing a minimum period before changing prices tend to lower the prices
- Dealing with uncertainty is crucial, but the associated decision issues should not be ignored
  - The best forecast is the one that leads to more effective results
- Computational intelligence approaches are well established now: *"Primeiro estranha-se, depois entranha-se"*