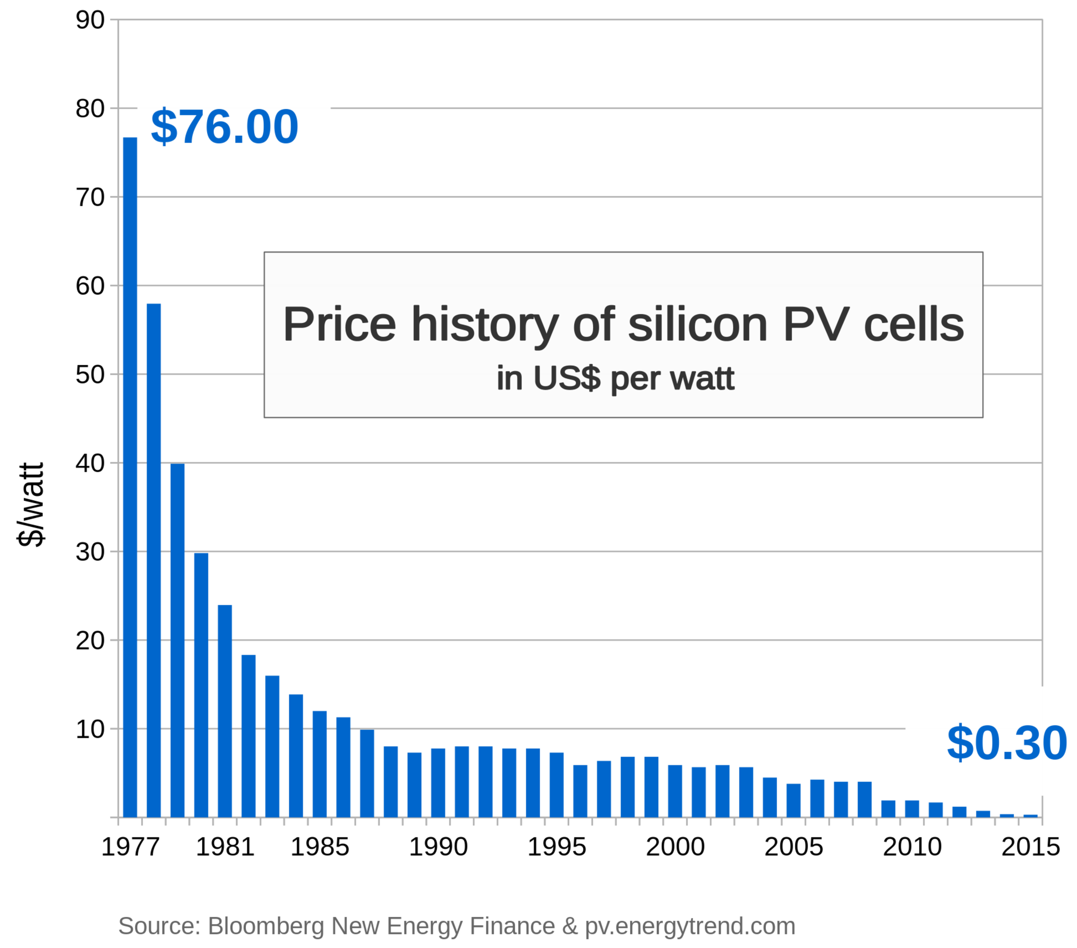
Imitative Learning for Online Planning in Microgrids

Samy Aittahar, Vincent François-Lavet, Stefan Lodeweyckx, Damien Ernst and Raphaël Fonteneau
University of Liège, Department of Electrical Engineering and Computer Science
Université de Liège

Incentives

- Load (e.g. house) proximity ;
- Drop in the cost of PV panels.



Linear dynamics

Variables

$\forall t \in \{1 \ldots T\}, \sigma \in \Sigma, T \in N :$

- $a_t^{\sigma,+}, a_t^{\sigma,-} \rightarrow$ Storage system σ actions ;
- $s_t^\sigma = s_{(t-1)}^\sigma + a_{t-1}^{-,\sigma} + a_{(t-1)}^{+,\sigma}, s_0^\sigma = 0 \rightarrow$ Storage system σ state ;
- $F_t = d_t - \sum_{\sigma \in \Sigma} (\frac{a_t^{+,\sigma}}{\eta^\sigma} + \eta^\sigma a_t^{-,\sigma}) \rightarrow$ Power cut. $d_t = prod_t - cons_t$ is the net demand. η^σ is storage system σ efficiency.

Objective function (operational costs)

Levelized Cost of Energy :

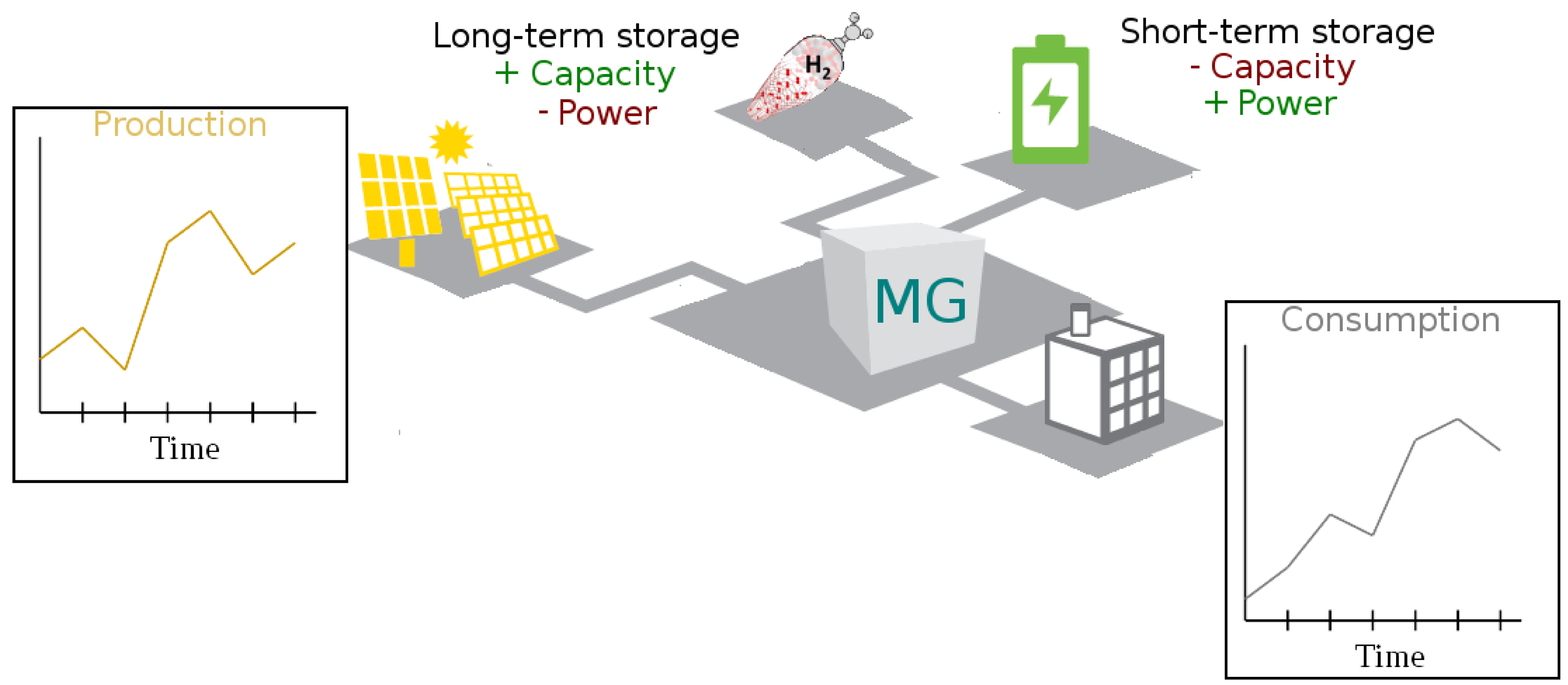
$$LEC = \frac{\sum_{t=1}^{T} \frac{-\sum_{\psi \in \Psi} k_t^\psi F_t^\psi}{(1+r)^{y'}} + I_0}{\sum_{y=1}^{n} \frac{\epsilon_y}{(1+r)^y}} \quad \text{where}$$

- $I_0 \rightarrow$ Initial investment cost ;
- $k_t^\psi F_t^\psi \rightarrow$ Cost of consumption not met for load $\psi \in \Psi$ at time $t \in \{1 \ldots T\}$.

Linear programming

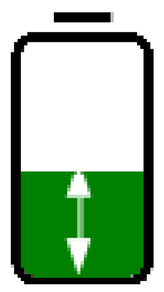
Minimization of objective function with contraints related to the dynamics $\rightarrow$ Optimization of planning strategies given a complete scenario.

Fully off-grid microgrid

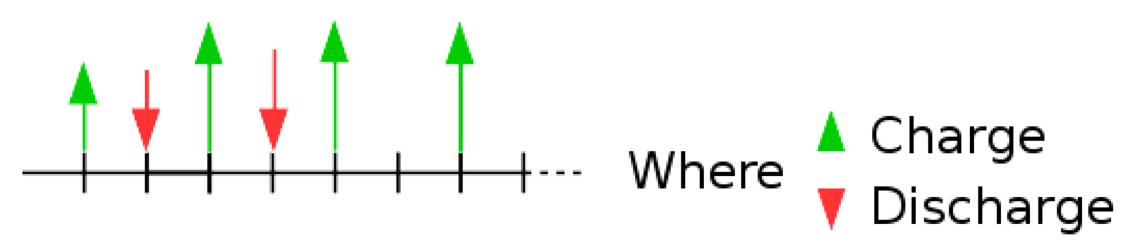


For each storage systems included in the microgrid :

State system variable

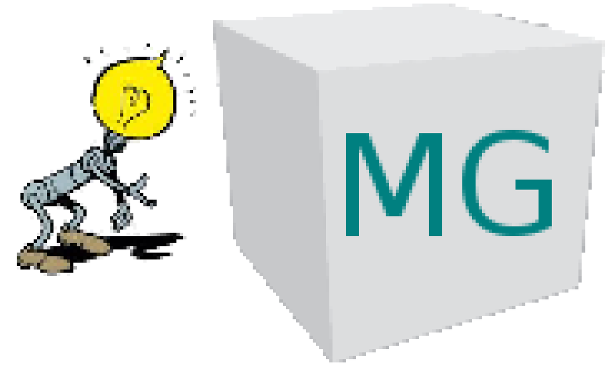


Decision making process



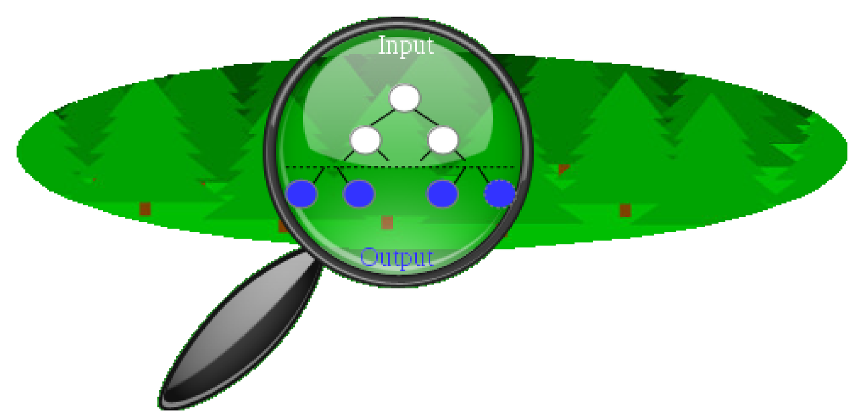
Challenge : Real-time balancing of several storage systems under uncertainties.

Goal



Automated extraction of smart online planning agents using imitative learning.

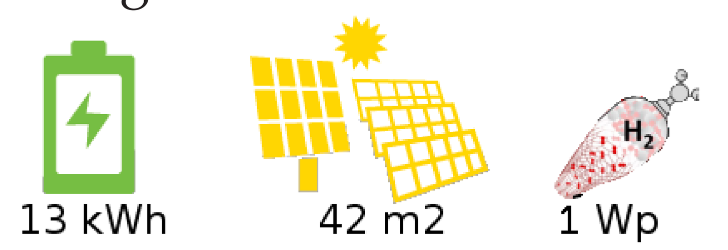
Learning structure



Forest of regression binary trees.

Data

- Annual solar irradiance in Belgium ;
- Daily consumption pattern (18 kWh) ;
- Microgrid size.



Results

Discharge/recharge storage systems in increasing order of efficiency.

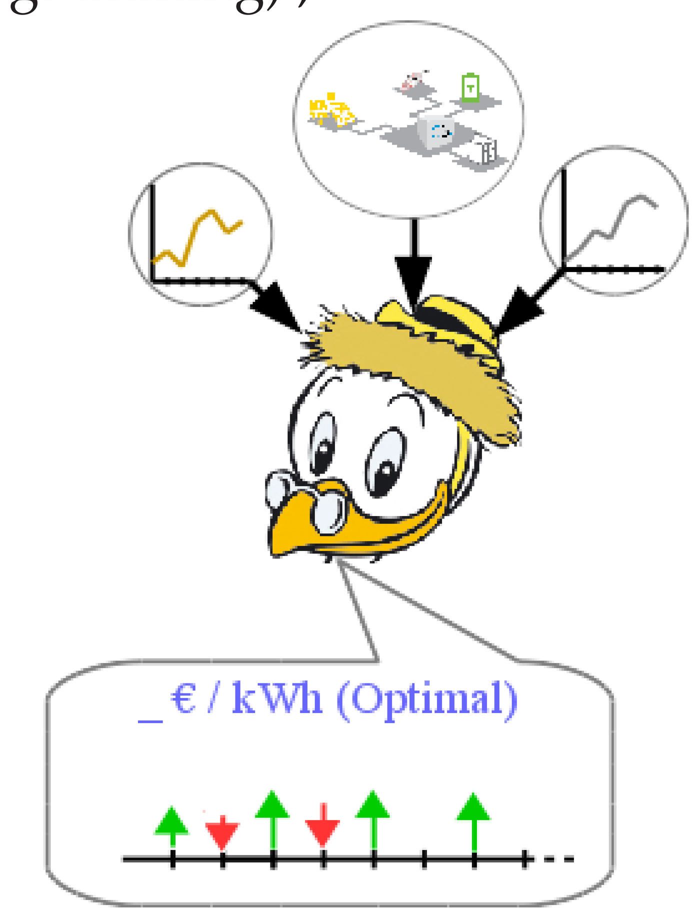
LEC (€/ kWh) :

Expert	Agent	Novice
0.32	0.42	0.6

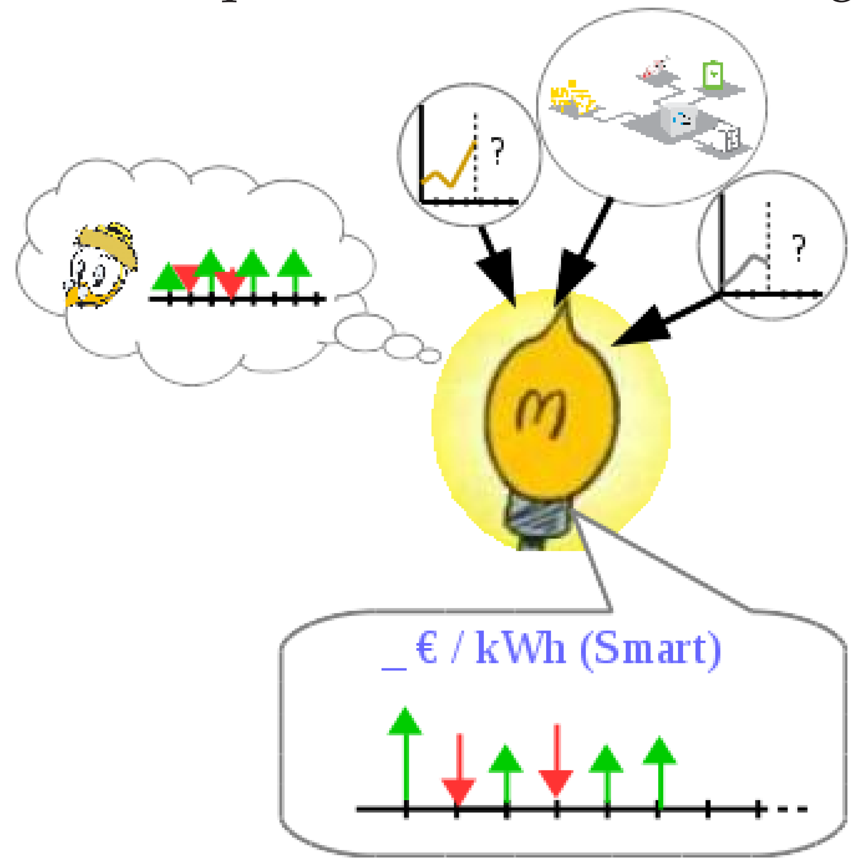
Imitative Learning

Principle : learning near-optimal behavior with optimal sequences of actions.

- Compute optimal sequences of actions from production and consumption scenarios (linear programming) ;



- Build smart online planning agent with optimal sequences (machine learning).



Future work

- Benchmarking of others machine learning structures/algorithms ;
- Testing on others microgrids (e.g. connected on main network) ;
- Transfer learning (i.e. adaptation of an existing strategy for new microgrids).