Risk-based Security Constrained Unit Commitment

A decision support system for electric operators

04 December 2015

Eng. Chiara Foglietta

chiara.foglietta@uniroma3.it

Final Workshop of URANIUM project
Models for Critical Infrastructure Protection Laboratory (MCIP lab)
Engineering Department

Università degli Studi “Roma TRE”

Agenda

Talk Aim

Traditional Unit Commitment Problem

How Integrate Risk Within Unit Commitment Problem

The Case Study

The Live Demo...

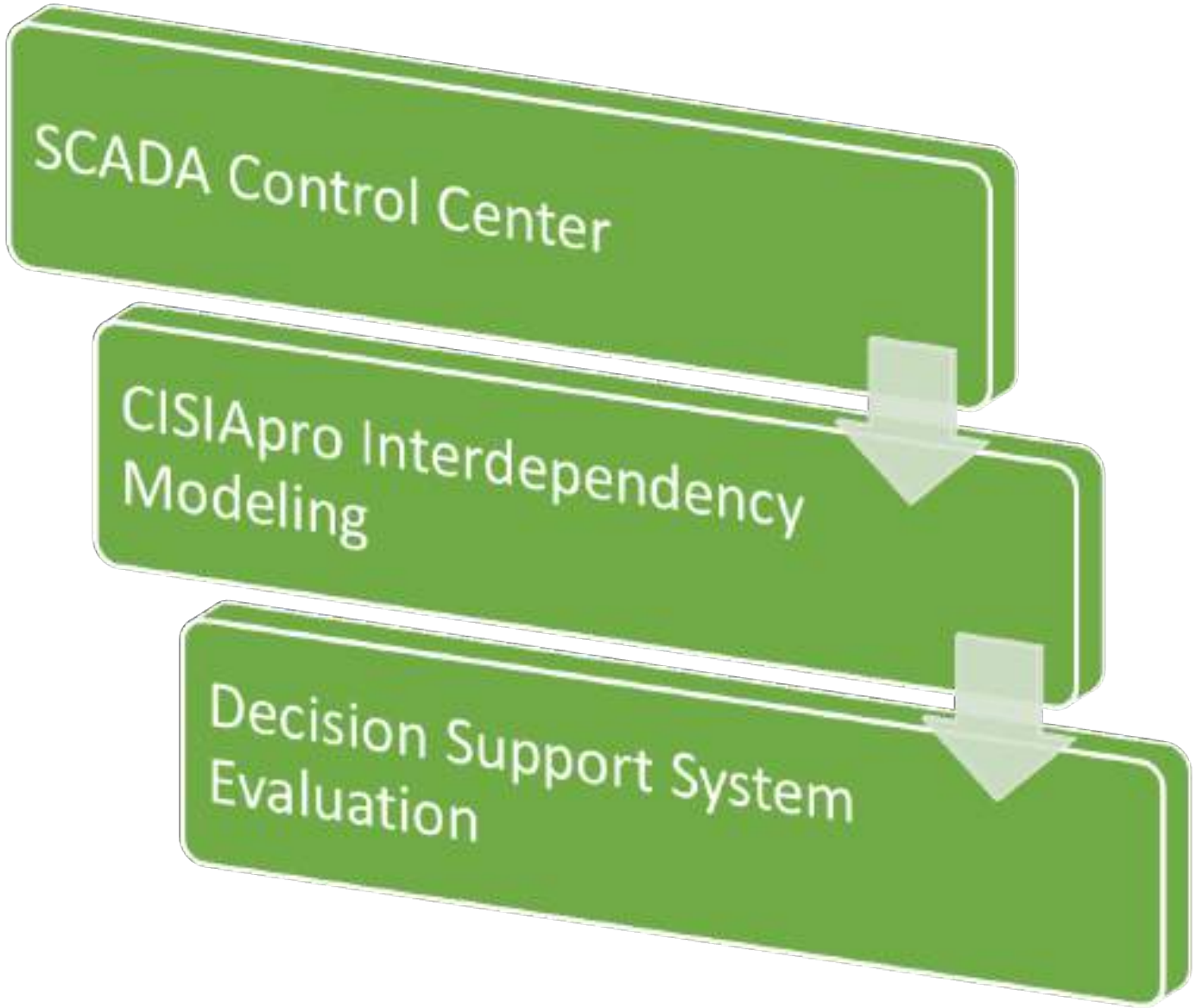
Conclusions and Future Works

Main aim of this talk

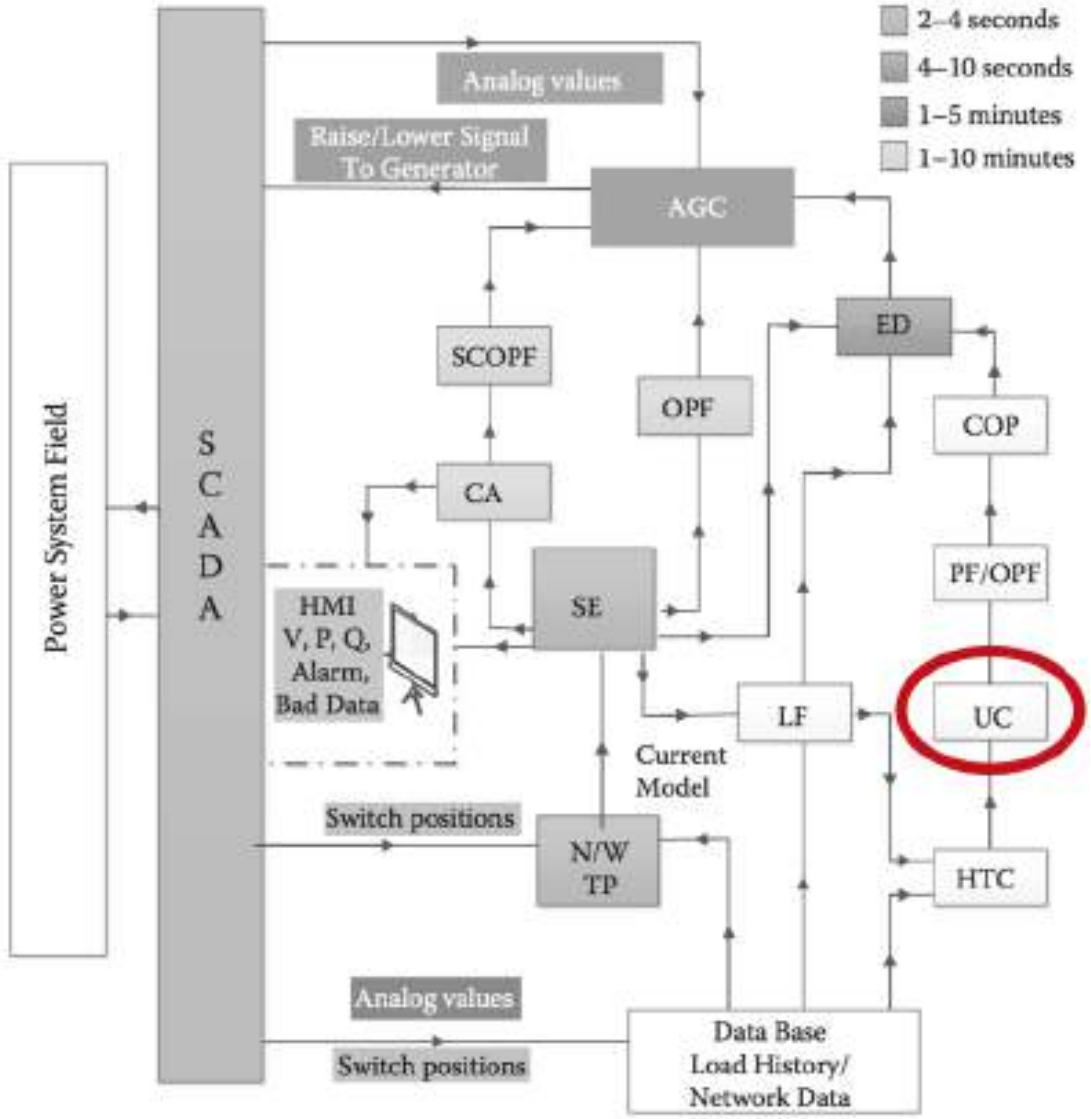
This talk presents how decisions of a single-domain operator are affected by interdependency models.

We consider a distribution smart grid and the demand-response balancing by means of the unit commitment problem.

URANIUM Information Flow



Energy Management System



Unit Commitment

The Unit Commitment (UC) calculation schedules (commits and dispatches) generator units over a given time horizon, and is extensively used in daily system operation. UC calculations over longer time-frames also fulfill critical roles in operational planning and portfolio evaluation and it aims to make power system more reliable.

Mathematical Formulation
Objective Function

The generic unit commitment problem can be formulated as an optimization problem where the objective function is:

$$\sum_{i=1}^{NG}\sum_{t=1}^{NT} FC_{it}(P_{it}) + MC_{it}(P_{it}) + ST_{it} + SD_{it}$$

where

- $MC_i(P_i)$ is the maintenance cost;
- ST_{it} is the start-up cost;
- SD_{it} is the shutdown cost;
- $FC_{it}(P_{it})$ is the function cost of the generator i at time period t depending on the actual power production P_{it} and it is usually a quadratic curve

$$FC_{it}(P_{it}) = a_i \cdot P_{it}^2 + b_i \cdot P_{it} + c_i$$

with a_i, b_i and c_i as cost coefficients.

Padhy, Narayana Prasad. "Unit commitment-a bibliographical survey." *Power Systems, IEEE Transactions on* 19, no. 2 (2004): 1196-1205.

Mathematical Formulation
Constraints

The optimization problem is subject to several constraints. The most common are:

- Maximum and minimum output limits on generators

$$P_{it}^{\min} \leq P_{it} \leq P_{it}^{\max}$$

- Limit on the production ramp rate ∇P_{it}

$$\nabla P_{it} \leq \nabla P_{it}^{\max}$$

- Power balance

$$\sum_{i=1}^{NG} (U_{it} \cdot P_{it}) \leq D_t^f$$

where U_{it} is the up/down status of the unit i and D_t^f is the forecast demand during time period t

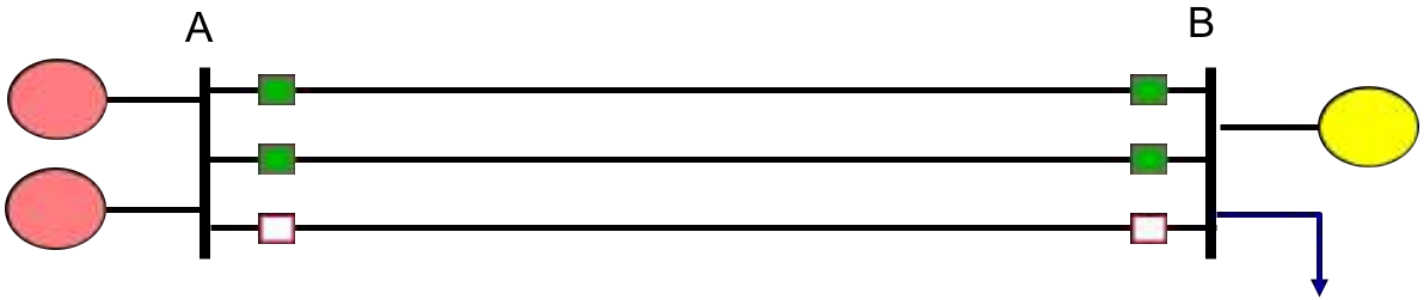
Padhy, Narayana Prasad. "Unit commitment-a bibliographical survey." *Power Systems, IEEE Transactions on* 19, no. 2 (2004): 1196-1205.

Security-Constrained Unit Commitment

Transmission network may have an effect on the commitment of units:

- Some units must run to provide voltage support
- The output of some units may be limited because their output would exceed the transmission capacity of the network

In order to consider failures on the electric branches (i.e., lines), we need to consider also the topology of the power grid with the maximum capacity of each branch: if the capacity of a line is zero, the line is damaged.



Including Risk Evaluation

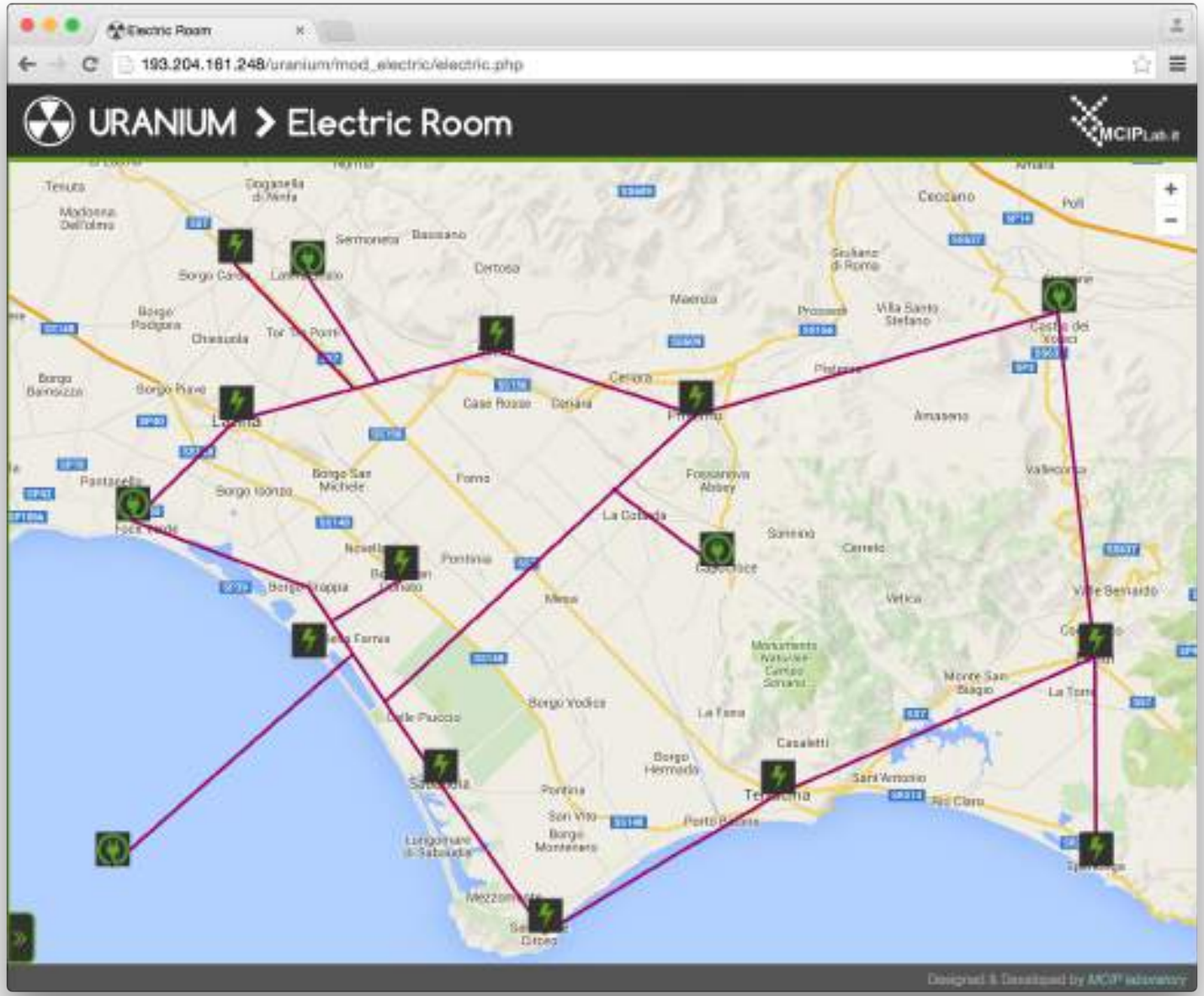
The risk has been introduced within the objective function:

$$\sum_{i=1}^{NG}\sum_{t=1}^{NT}(FC_{it}(P_{it}) + MC_{it}(P_{it}) + ST_{it} + SD_{it}) \cdot (2 - op\ level)$$

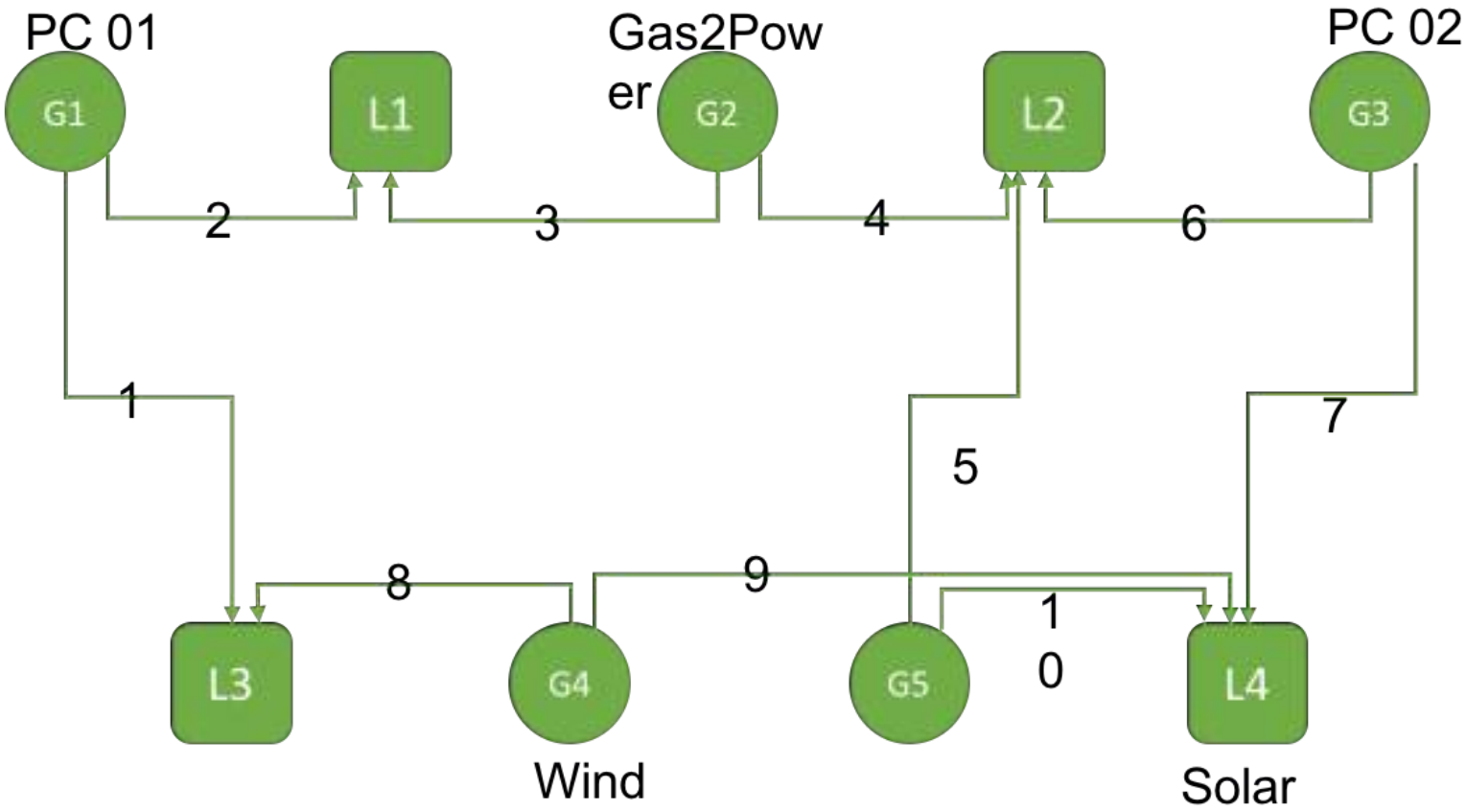
where $FC_{it}(P_{it}) + MC_{it}(P_{it}) + ST_{it} + SD_{it}$ is the traditional formula of the objective function.

URANIUM Case Study

The power grid



URANIUM Case Study
The topology



URANIUM Case Study

The load profile

Terna

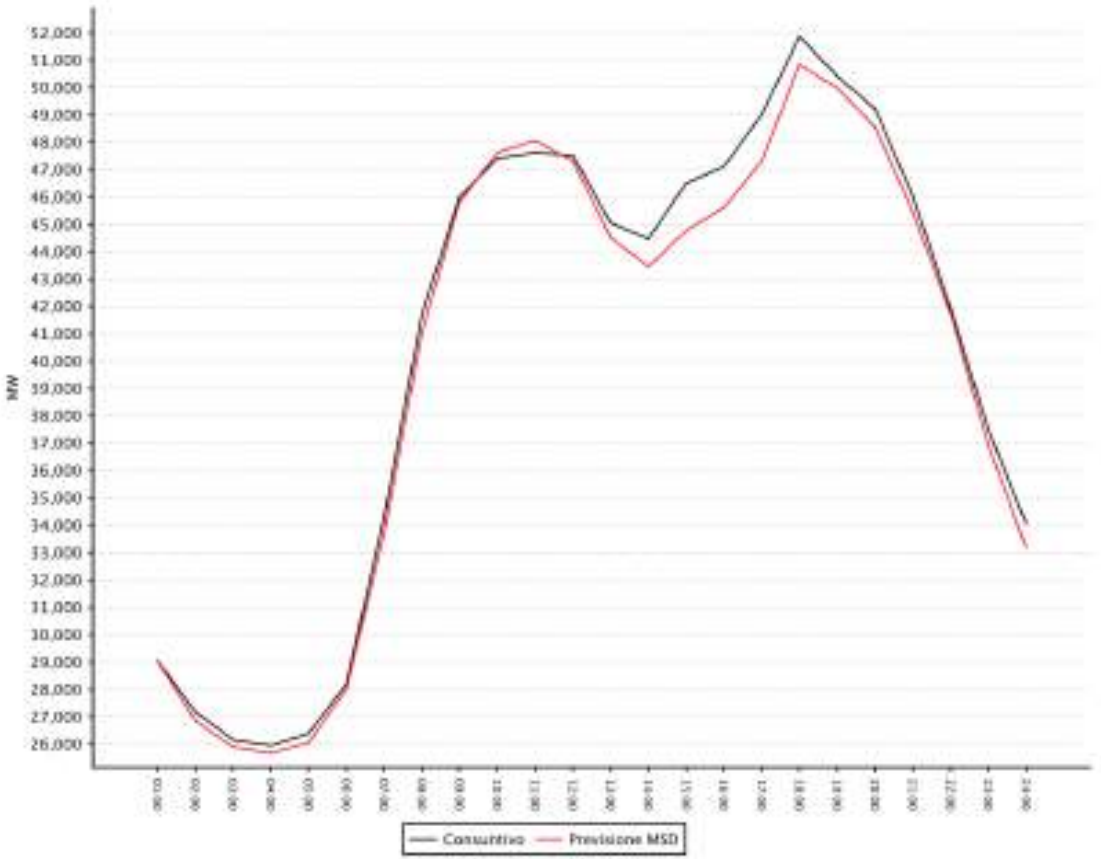
Report Storico Previsione 100%

Giorno di previsione : 02/12/2015 ITALIA

ORA	CONSUNTIVO	PREVISIONE
01:00	29,058	29,090
02:00	27,182	26,858
03:00	26,166	25,895
04:00	25,949	25,663
05:00	26,390	26,050
06:00	28,186	28,002
07:00	34,273	33,892
08:00	41,692	41,023
09:00	46,003	45,817
10:00	47,410	47,624
11:00	47,618	48,052
12:00	47,535	47,316
13:00	46,051	44,513
14:00	44,478	43,454
15:00	46,498	44,787
16:00	47,111	46,618
17:00	49,012	47,288
18:00	51,860	50,836
19:00	50,410	48,974
20:00	49,220	48,564
21:00	46,034	45,453
22:00	41,933	41,748
23:00	37,501	36,936
24:00	34,049	33,181
Totale:	970,604	957,369

Elaborazione effettuata sulla base di dati di previsione di esercizio

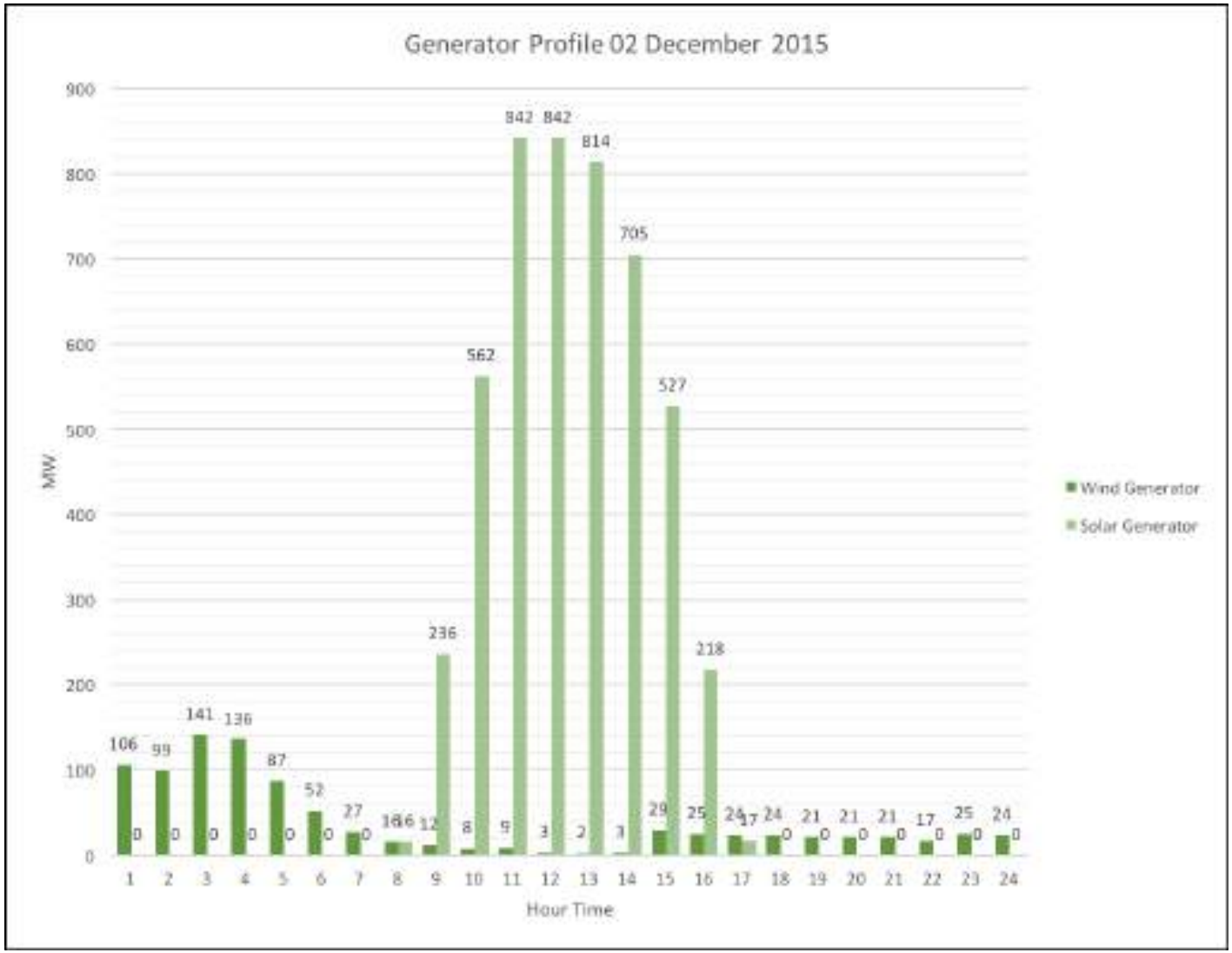
Scostamento alla Potenza Massima :	1.97%
Scostamento alla Potenza Minima :	1.10%
Scostamento Assoluto Medio Potenza :	1.34%
Scostamento Energia :	1.36%



from http://www.terna.it/it-it/sistemaelettrico/dispacciamento/datiesercizio/datigiornalieri/confronto.aspx

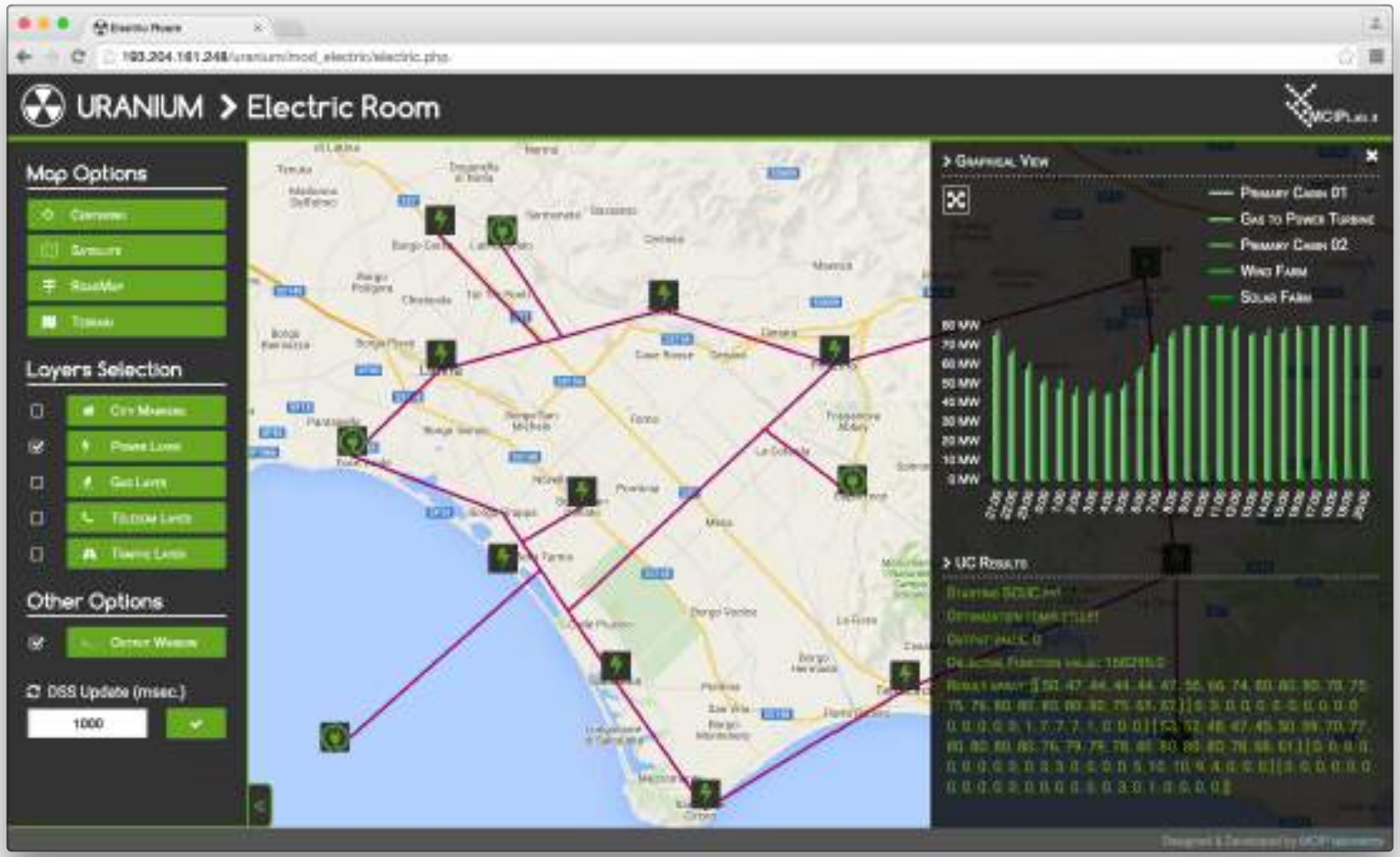
URANIUM Case Study

The generator profile

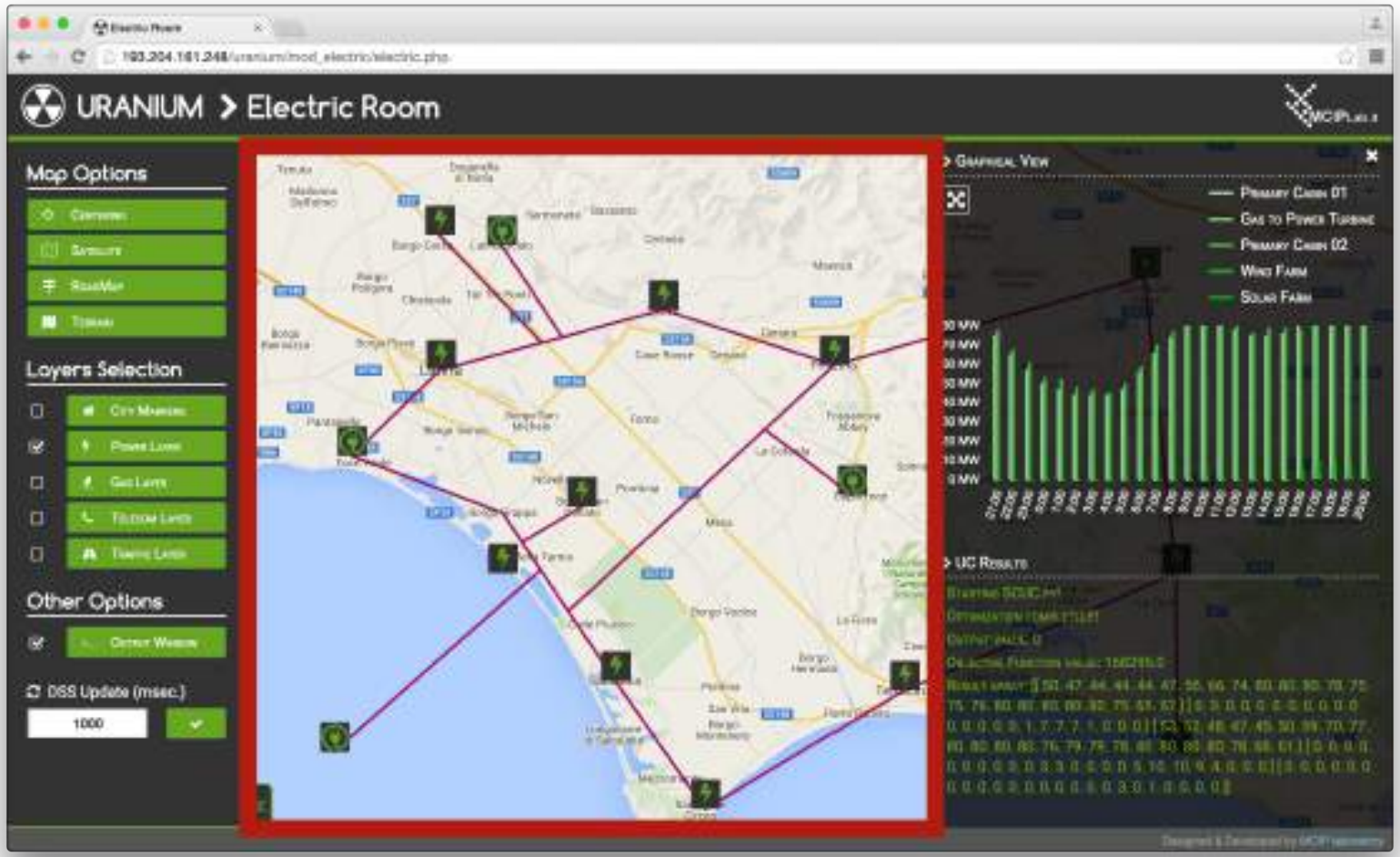


from http://www.terna.it/SistemaElettrico/TransparencyReport/Generation/Forecastandactualgeneration.aspx

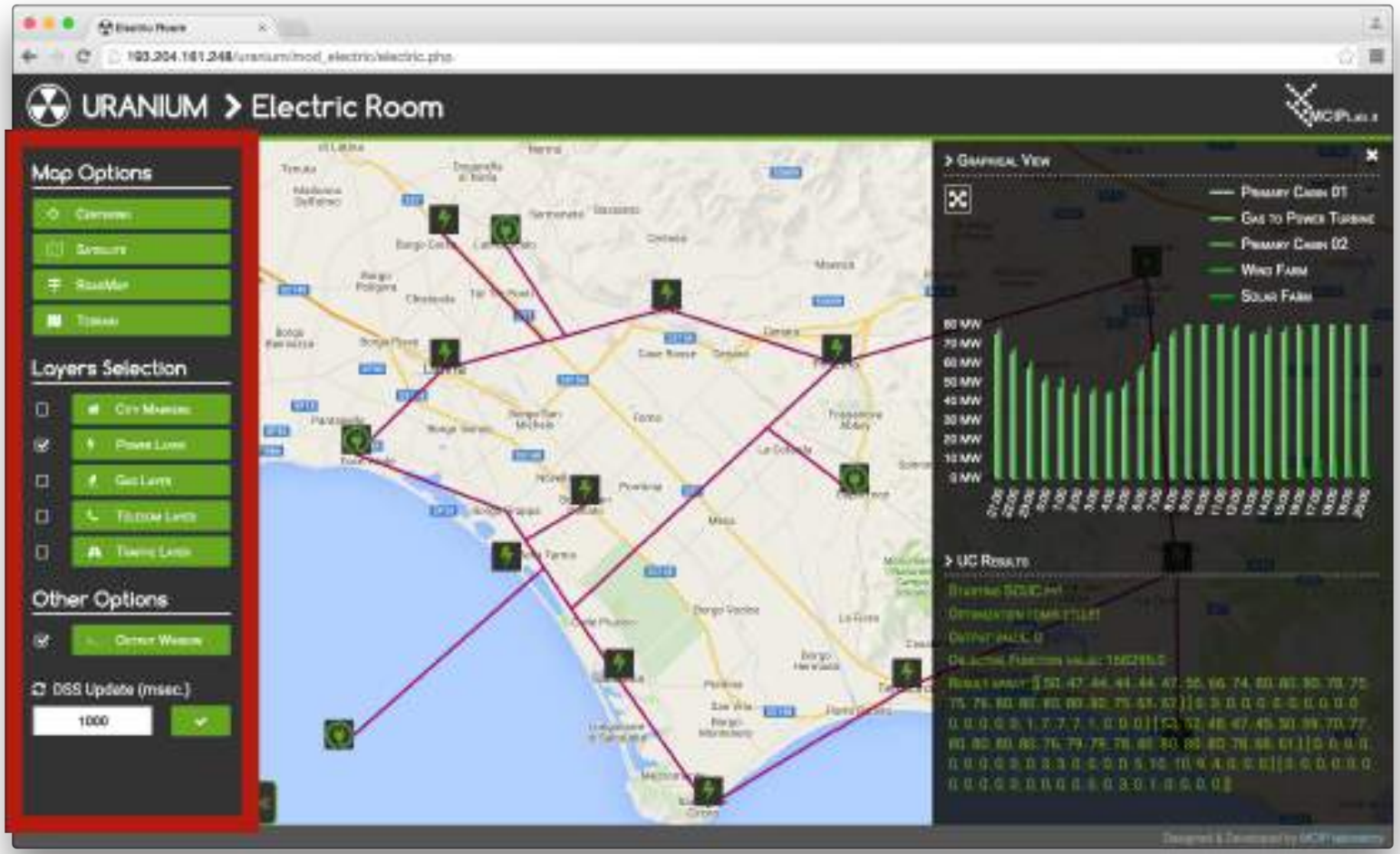
The Console


URANIUM > Electric Room
Map Options
Layers Selection
Other Options
DSS Update (msec.)
1000
> Graphical View
Primary Cabin 01
Gas to Power Turbine
Primary Cabin 02
Wind Farm
Solar Farm
> UC Results

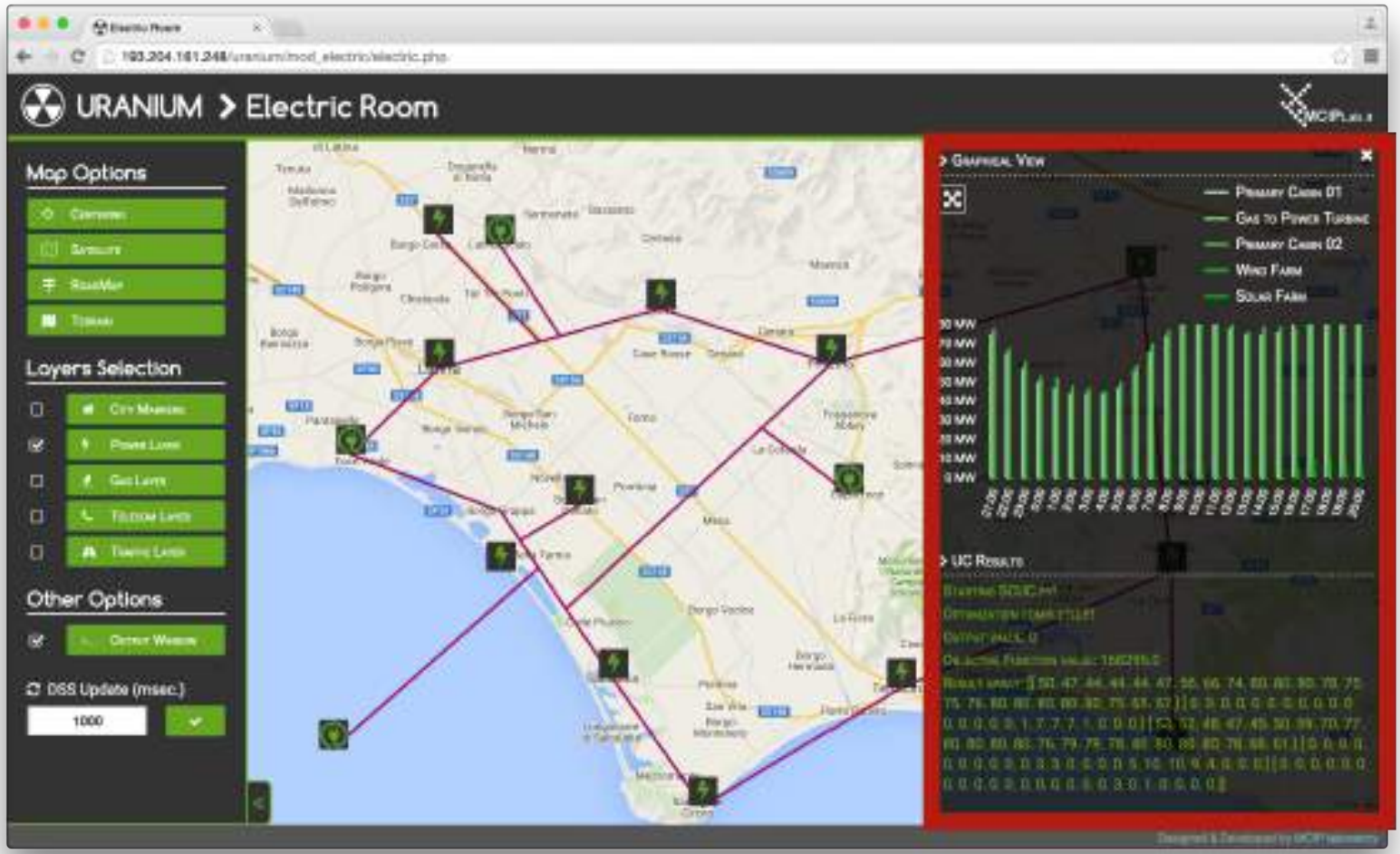
The Console



The Console



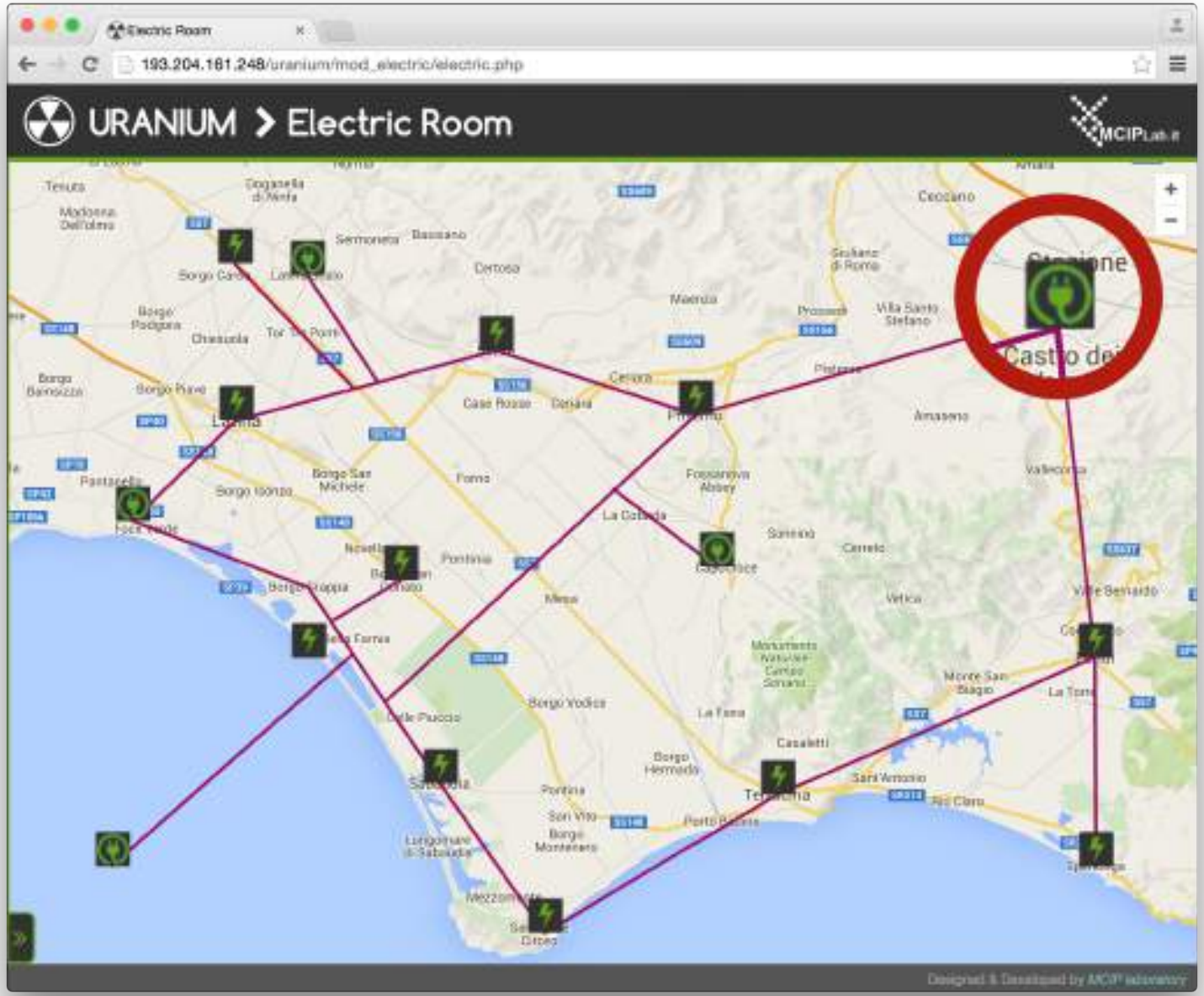
The Console


URANIUM > Electric Room
Map Options
Layers Selection
Other Options
DSS Update (msec.)
1000
> Graphical View
> UC Results

The Console
Nominal Conditions

Mechanical Fault at Primary Cabin 02

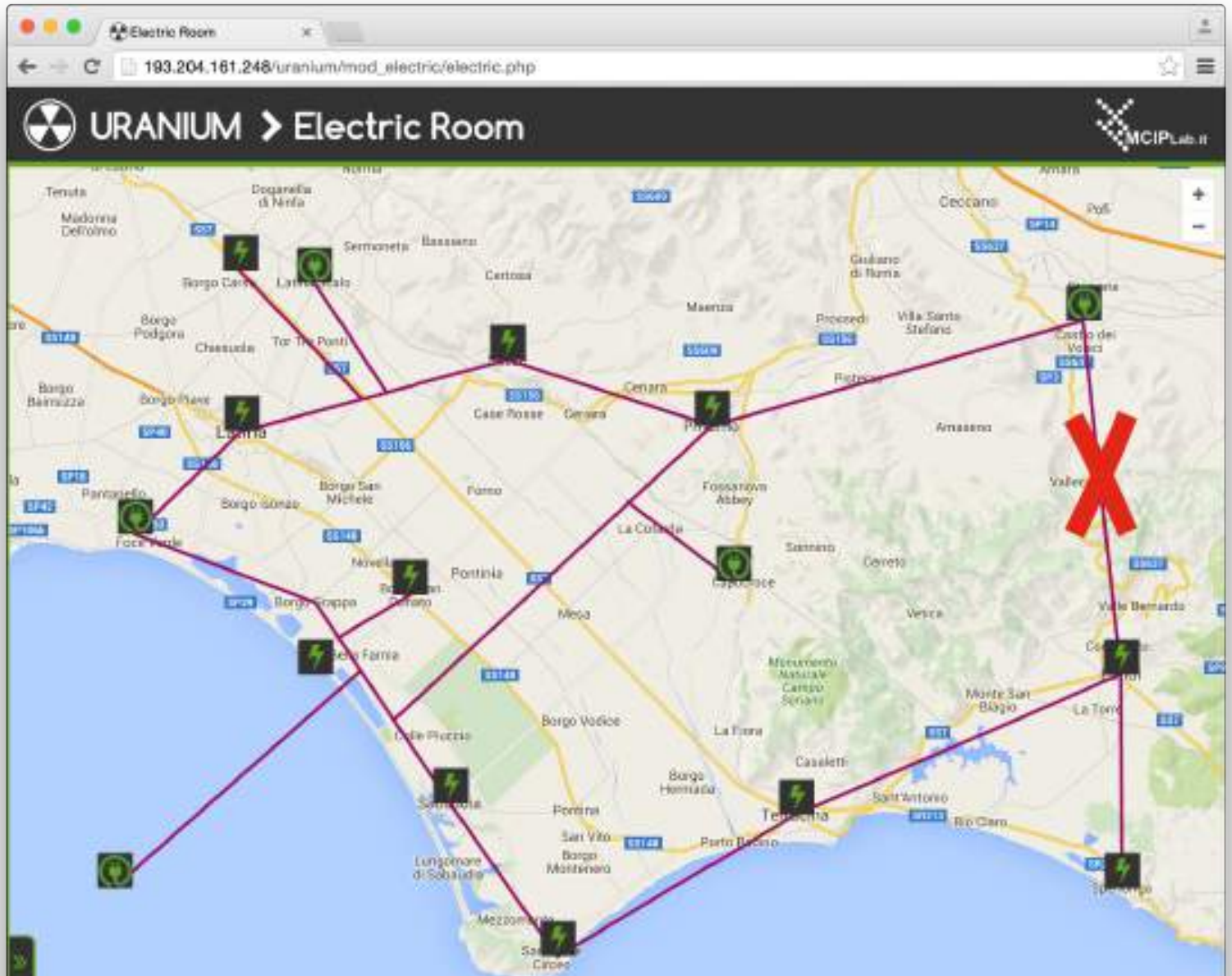
Which is Primary Cabin 02?



Mechanical Fault at Primary Cabin 02

Subsequent Mechanical Fault at Wire

near primary cabin 02



Subsequent Mechanical Fault at Wire
near primary cabin 02

Conclusions

Unit Commitment problem is a key process of the Energy Management System. The traditional algorithm can be modified for including the results of CISIApro, due to propagation algorithms of malfunctioning.

Further developments will include the detailed models of other renewable resource generators and electric vehicles.

Feedback
Contact Information

In case you have comments, suggestions or have found a bug, please do not hesitate to contact me. You can find my contact details below.

Eng. Chiara Foglietta
chiara.foglietta@uniroma3.it

ROMA TRE
UNIVERSITÀ DEGLI STUDI

Thanks to all MCIP lab students, researchers and professors
but especially to:
Simone Imbrogno,
Cosimo Palazzo,
Riccardo Santini,
Dario Masucci
Giulia Franchi and
Prof. Stefano Panzieri

ROMA TRE
UNIVERSITÀ DEGLI STUDI