



ANR Datazero

DATAcenter with Zero Emission and RObust management using renewable energy

October 1st, 2015 — March 31st 2019



as green as possible

Jean-Marc.Pierson@irit.fr



Outline

- Introduction
- Application profiling
- IT Profiling
- Power Sources Profiling
- Electrical schemas
- IT and Power Middleware
- Links
- Conclusion



Datazero question



How to manage the electricity and the service flows in order to deliver services to customers in a robust and efficient manner within datacenters operated with several energy sources?



Project Facts

- Consortium:



- Costs: 3 022 467€ (829 466€ granted)
- Duration: 42 months
- About 30 researchers / engineers

Challenges to address **Power Dynamic Data Center with Long term Green power Storage**

Challenge 1. Make demand and envelope constraints coincide on electrical and IT planes

Challenge 2. Dimensioning the equipment

Challenge 3. Optimal command of the electrical converters

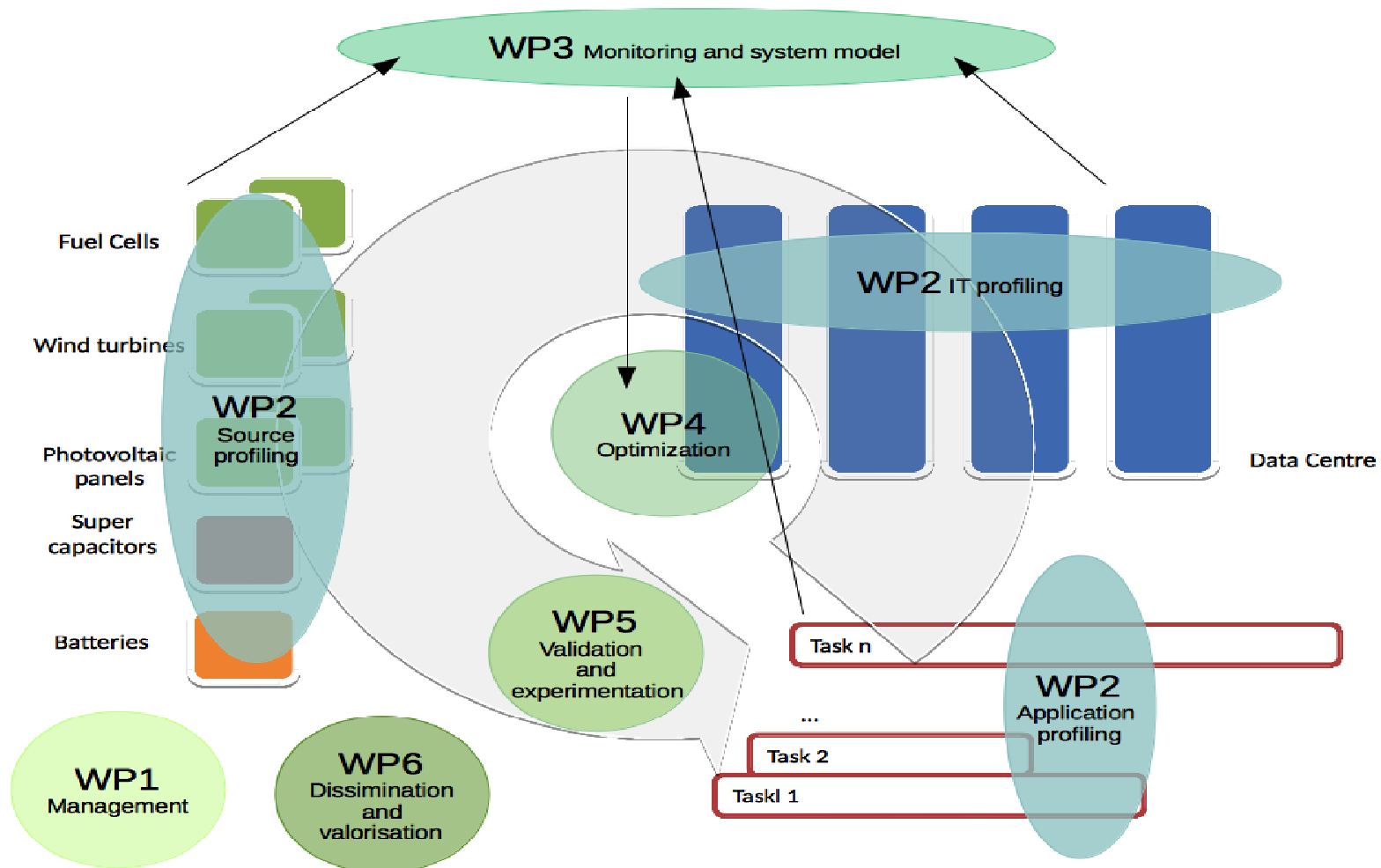
Challenge 4. Scheduling IT load, and IT management

Challenge 5. Thermal management

Challenge 6. Optimization problem complexity

Challenge 7. Develop a simulation toolkit

DATAZero WP and Global picture



Target and Outcome



- Small and middle size datacenters Cloud / Virtualization (1000 m2, 1 MW)
- Rethink datacenter with alternative power
- Simulation toolkit and real platform experiments / validation



DCWorms



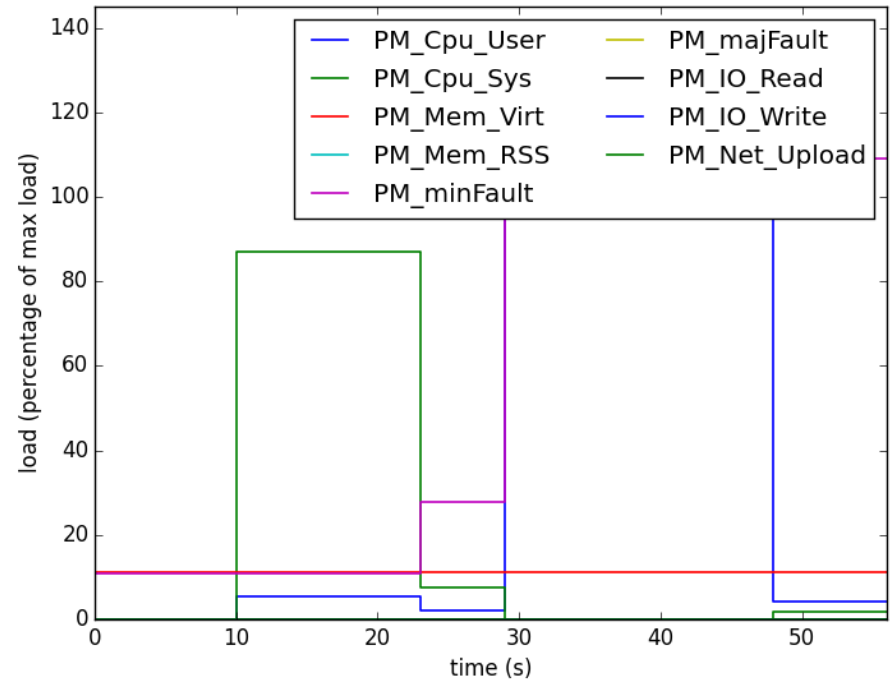
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Application Profiling

An application is modelled by:

- Time of arrival
- Resource consumption profiles over time
- Processor, memory, IO, network
- Policy related informations (scheduling priority, ...)



A workload is in SWF format (for each task: arrival time, profile, requirements)

Application Profiling: an XML description of the profile

```
<resourceConsumptionProfile>
<resourceConsumption>
<referenceHardware>Generic Intel</referenceHardware>
<degradationLevel>none</degradationLevel>
<duration>PT11S</duration>
<behaviour name="userLoad"><value>0.000000</value> </behaviour>
<behaviour name="systemLoad"><value>0.000000</value> </behaviour>
<behaviour name="vSize"><value>11173888.000000</value></
behaviour>
<behaviour name="RSS"><value>242.000000</value> </behaviour>
<behaviour name="minFault"><value>97.000000</value></behaviour>
<behaviour name="majFault"><value>0.000000</value></behaviour>
<behaviour name="ioRead"><value>0.000000</value></behaviour>
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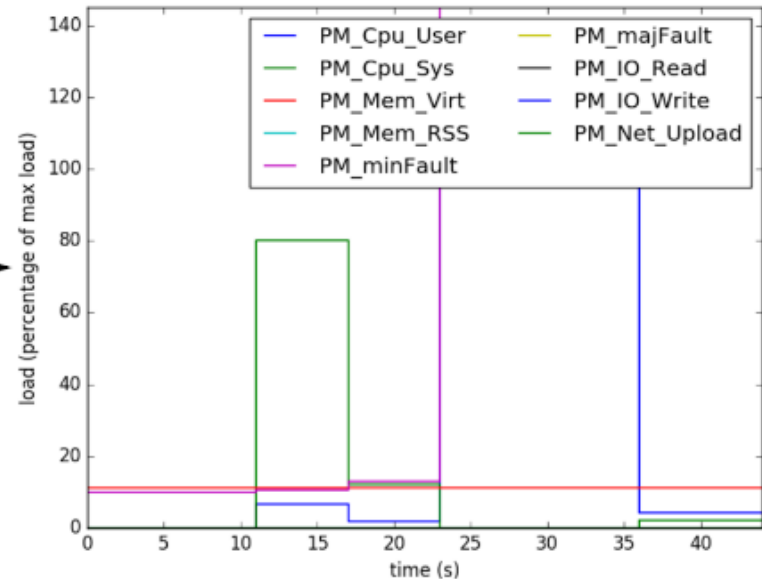
degradation levels represent the different ways of running an application, from normal (none) to any.

From one application to profiles

```
    }  
    close(fd);  
    unlink("/dev/shm/test_file");  
    for(i=0; i<5000; i++) {  
        usleep(1000);  
        a=sqrt((double)i)*sin(a+cos(a))  
        a=sqrt((double)i)*sin(a+cos(a))  
        a=sqrt((double)i)*sin(a+cos(a))  
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    }
```

```
#cpumodel Generic Intel  
#timestamp userLoad systemLoad vSize RS:  
1464856255 0.000000 0.000000 11173888 2.  
1464856256 0.000000 0.000000 11173888 2.  
1464856257 0.000000 0.000000 11173888 2.  
1464856258 0.000000 0.000000 11173888 2.  
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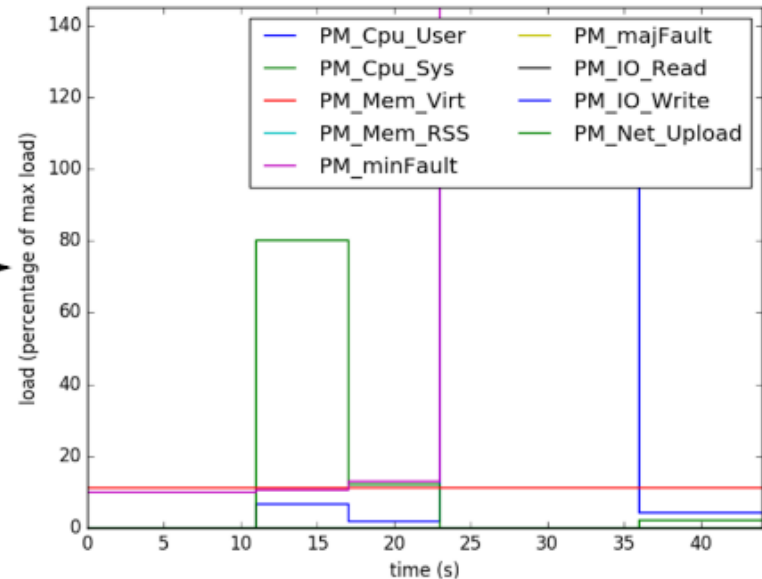


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    </behaviour>  
  </resourceConsumption>  
</resourceConsumptionProfile>
```



Several runs with different parameters —> several profiles

Using profiles in IT simulator

XML profiles used in IT Simulator:

- directly

or

- the IT simulator adapts the profile depending on the exact state of the IT hardware infrastructure. (e.g. using a lower frequency extends the running time of the application)

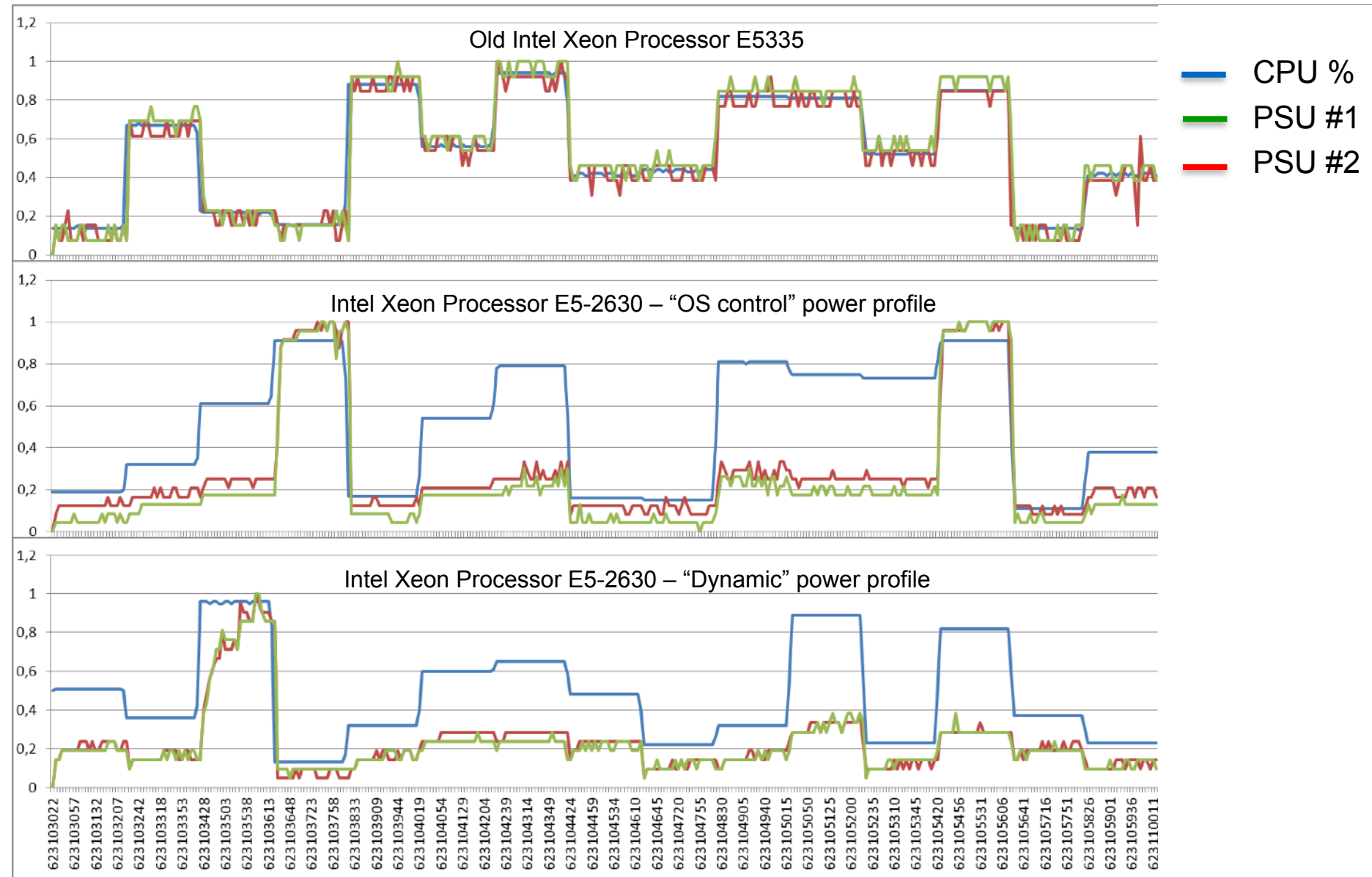
or

- the IT simulator uses several profiles (several XML) for each application in order to represent the different levels of downgrading of the quality of service

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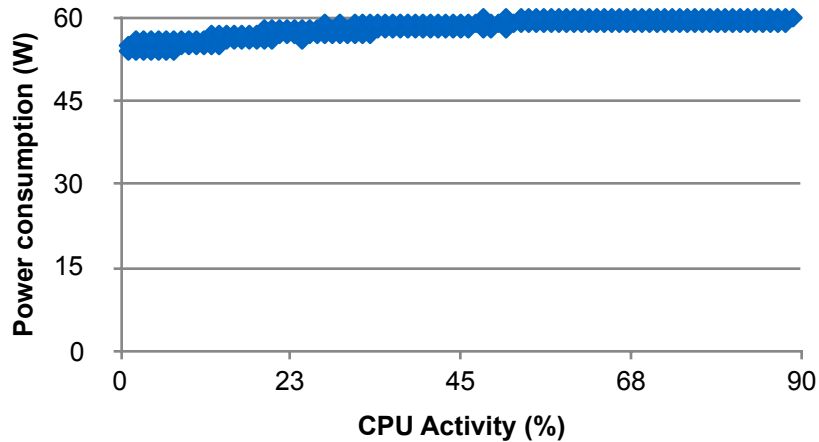
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IT profiling

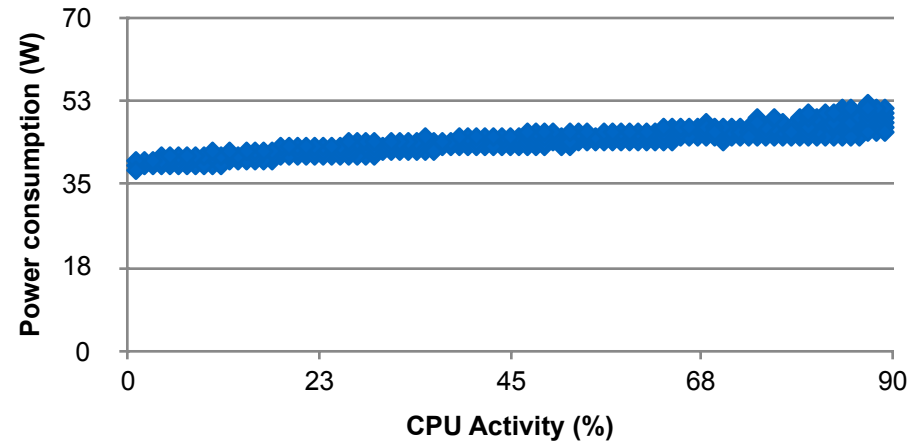


VM - IT profiling

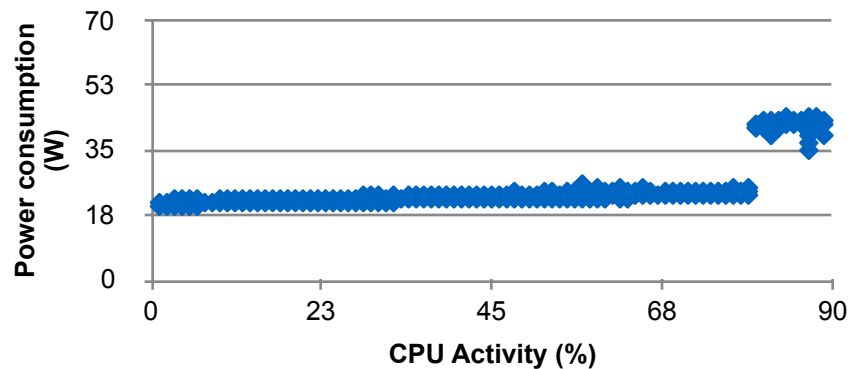
HP Static low power



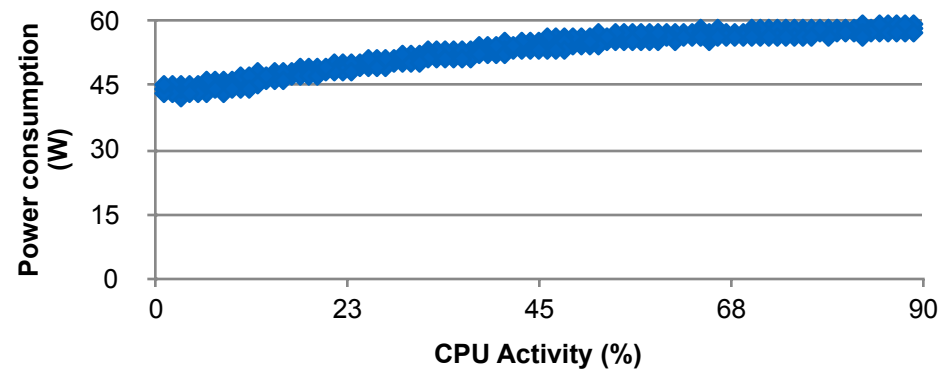
HP Dynamic power saving



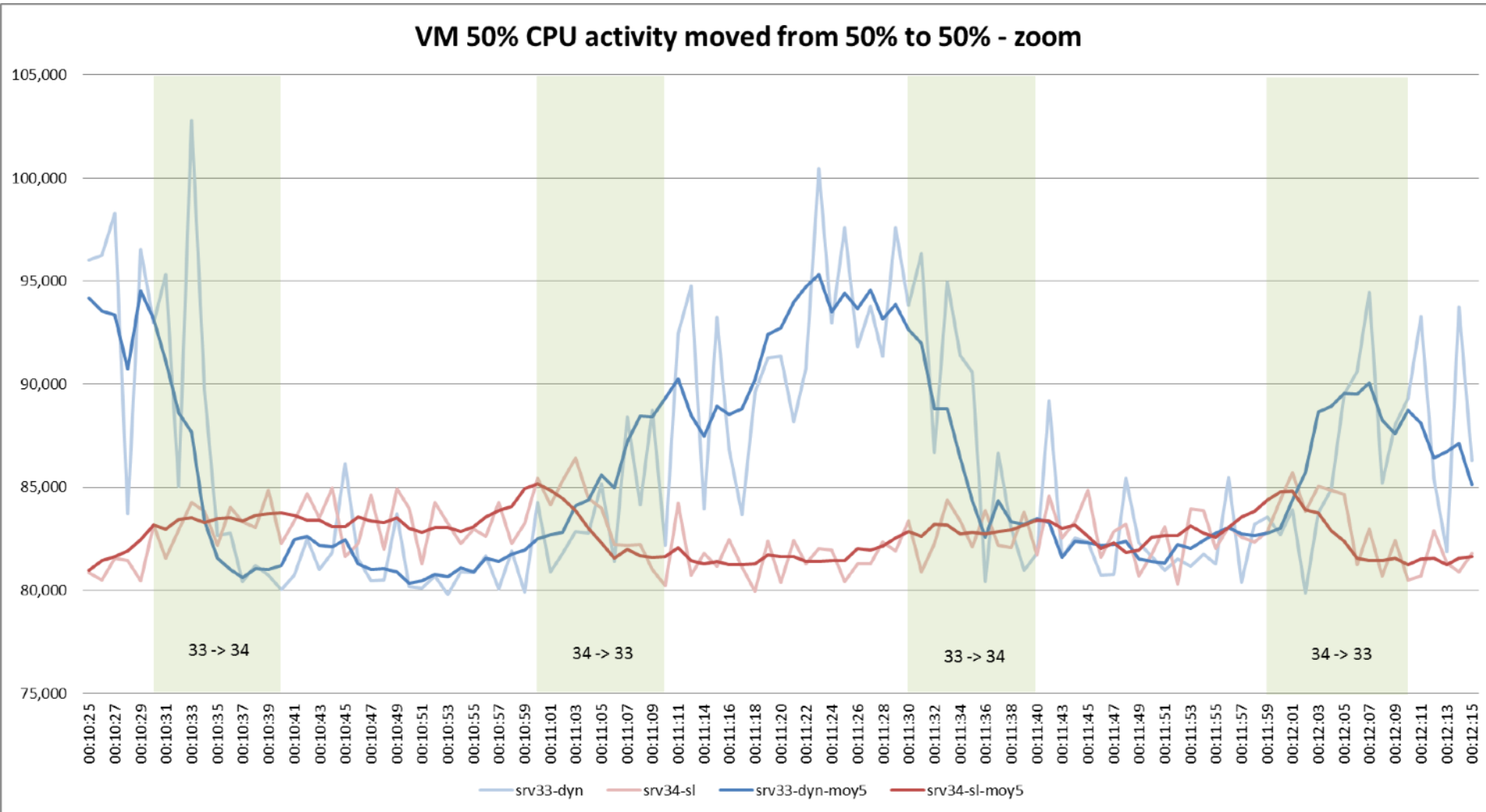
HP OS control – MS Hyper-V



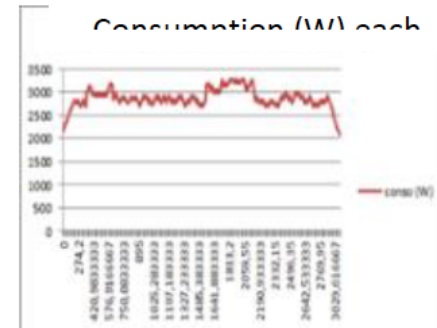
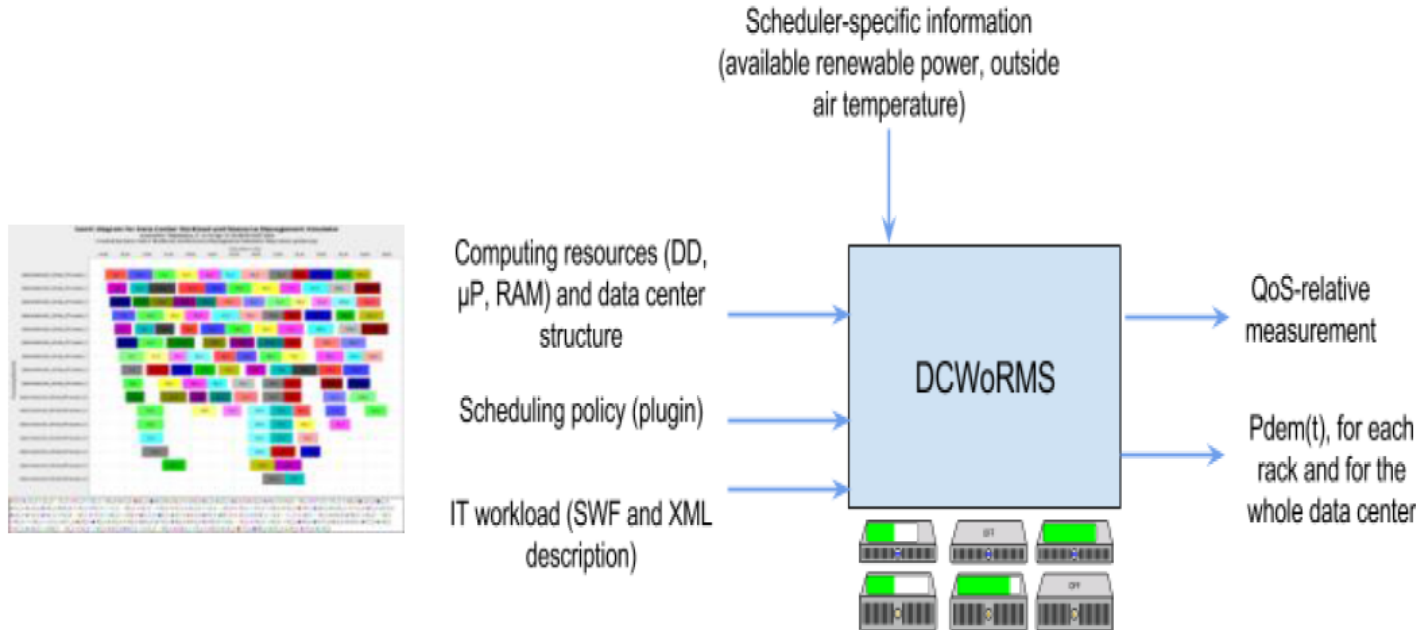
HP OS Control – Vmware ESXi



VM Migration



IT Simulation



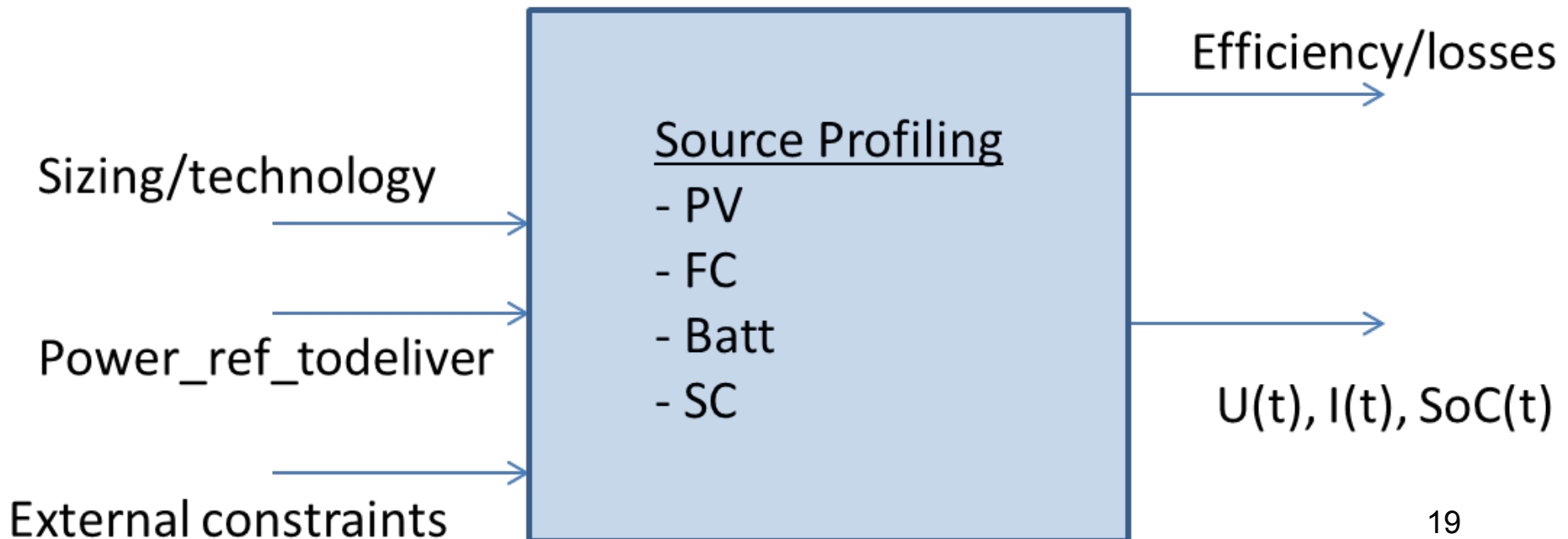
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Power source profiling

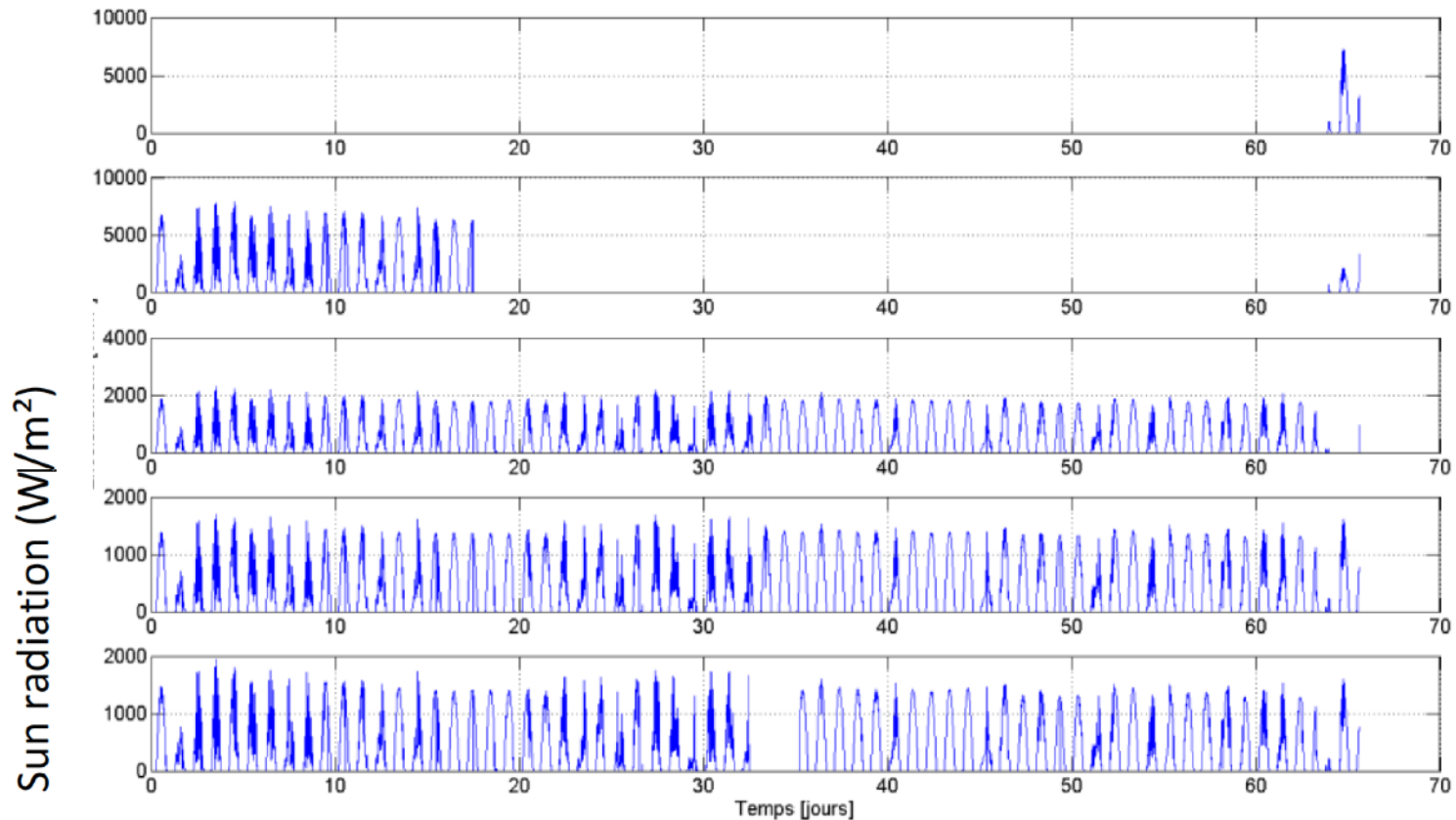
First step : using data measurements (Data Carac), making polynomial approximation to extract a model and its parameters, scalable on different sizing

Second step, depending on the sizing and reference power to deliver, furnishes discrete equations giving at each discrete step time t , what are the current $I(t)$, voltage $V(t)$, state of charge $SoC(t)$ and efficiency/losses of each source.



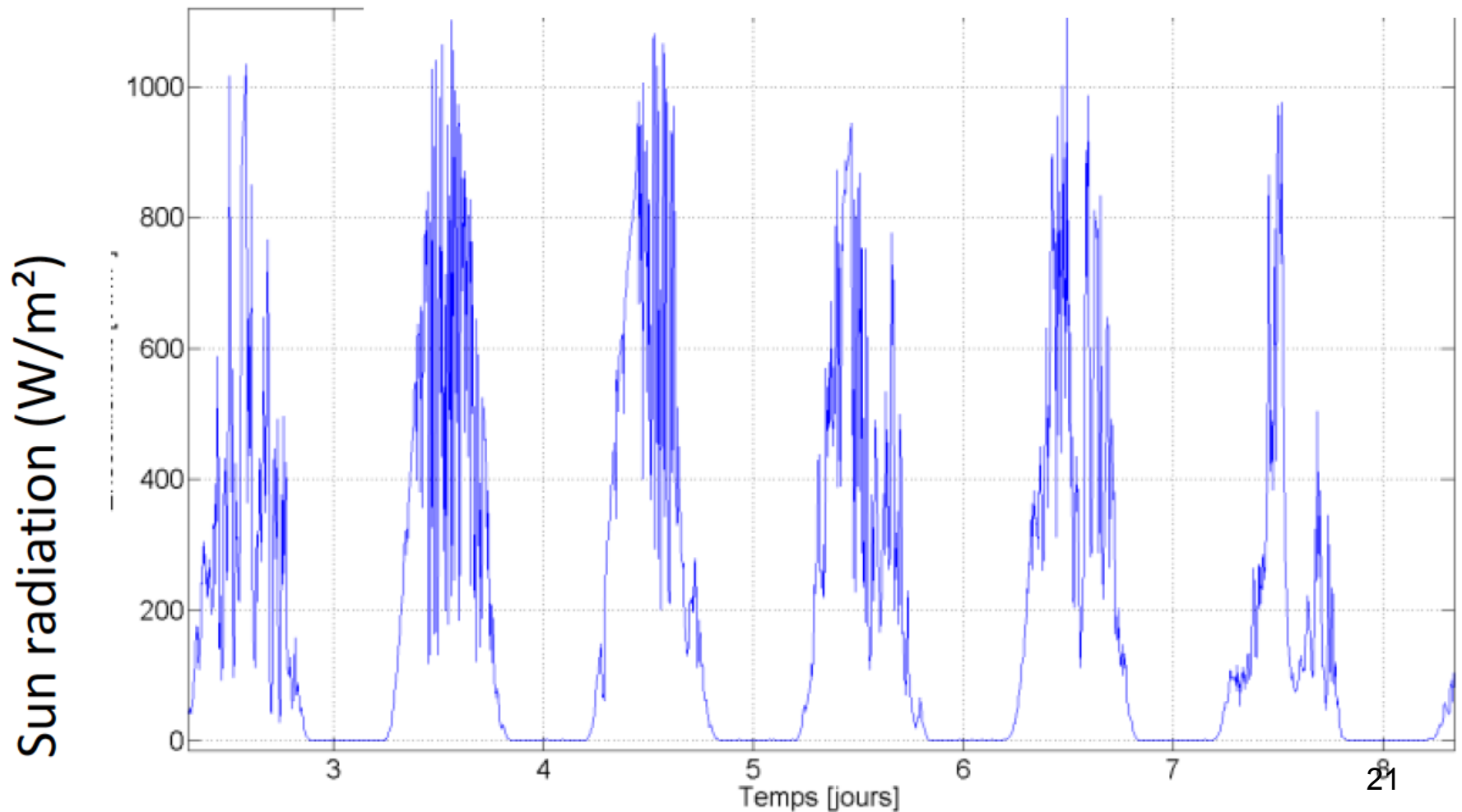
Towards modelling PV

Sun radiation [may 18th 2015 – july 24th 2015] on different panel

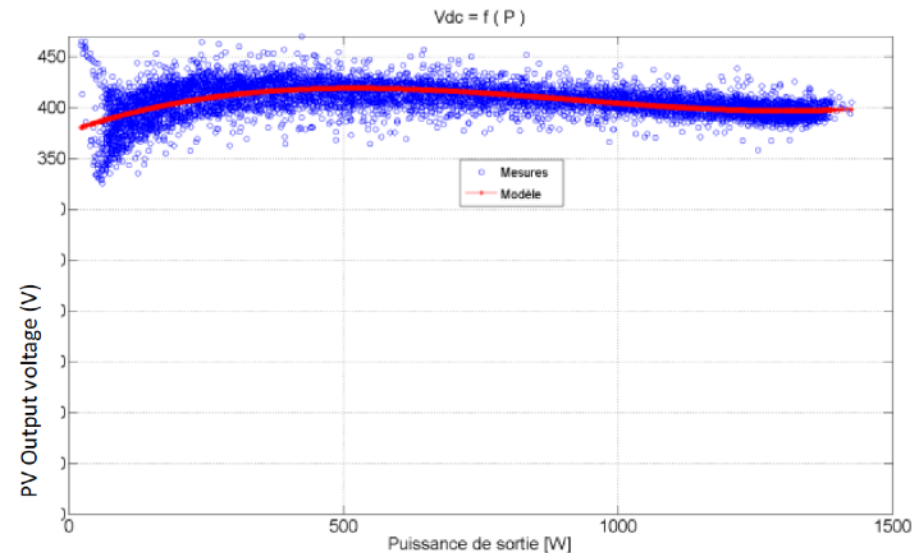
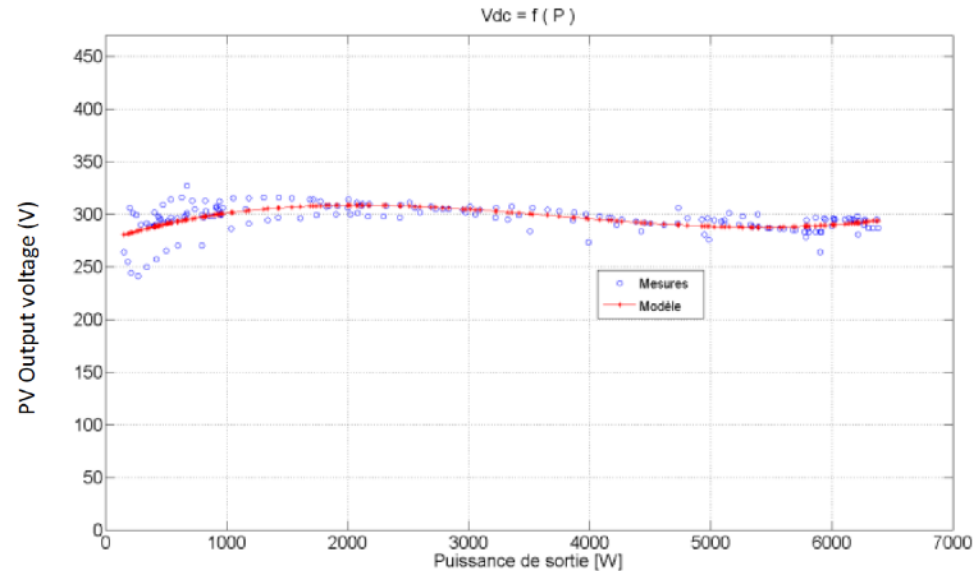


Towards modelling PV

Sun radiation 1panel 1 week



Photovoltaic modelling



different coefficients of third order polynom (ax^3+bx^2+cx+d)
for each PV technology (5 PV technologies tested)

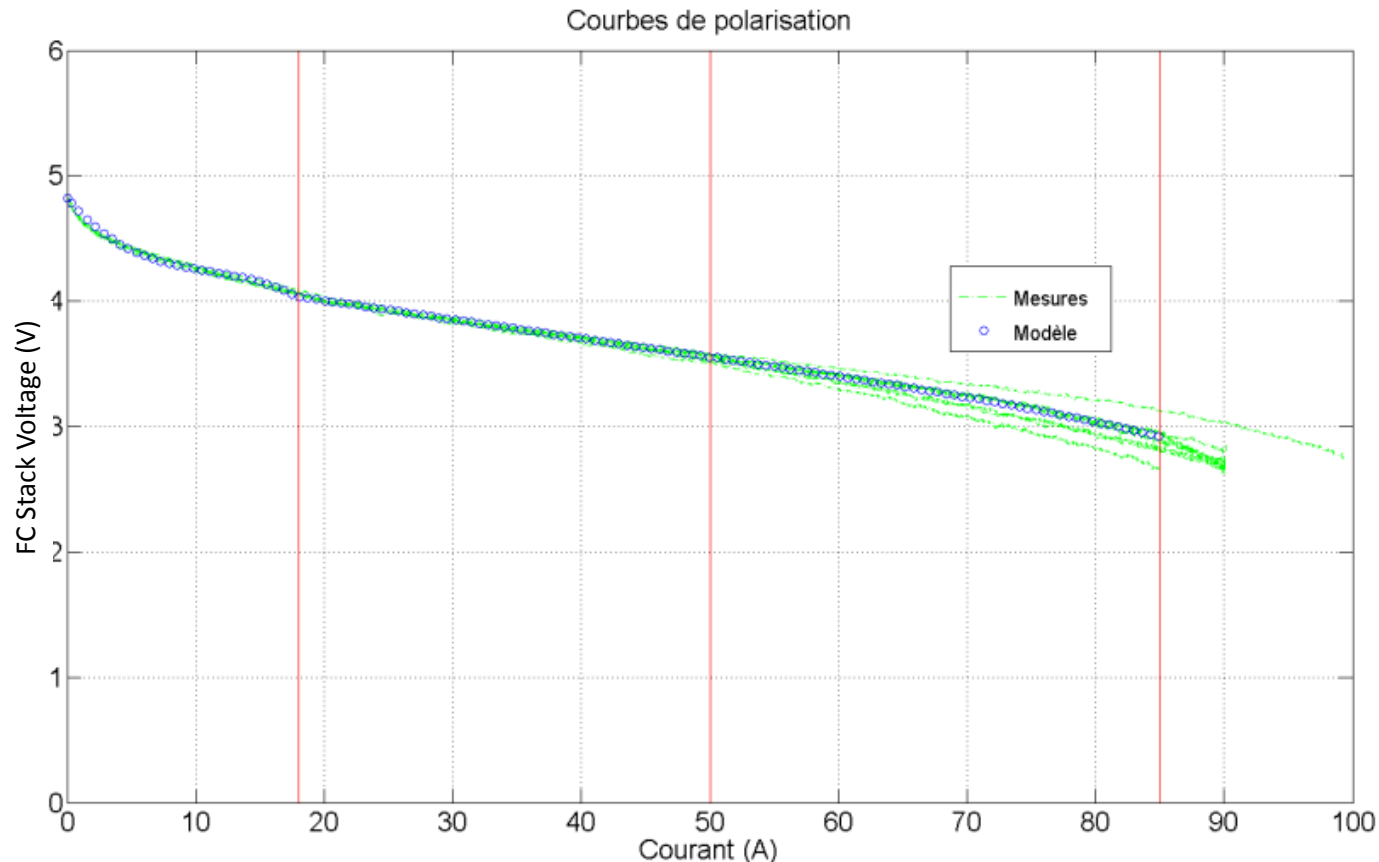
Fuel Cells modelling

A set of 3 third order polynoms (ax^3+bx^2+cx+d) corresponding to 3 specific behaviours.

1 –Activation zone P1 (0A-18A) :

2 – Ohmic zone P2 (18A-50A) :

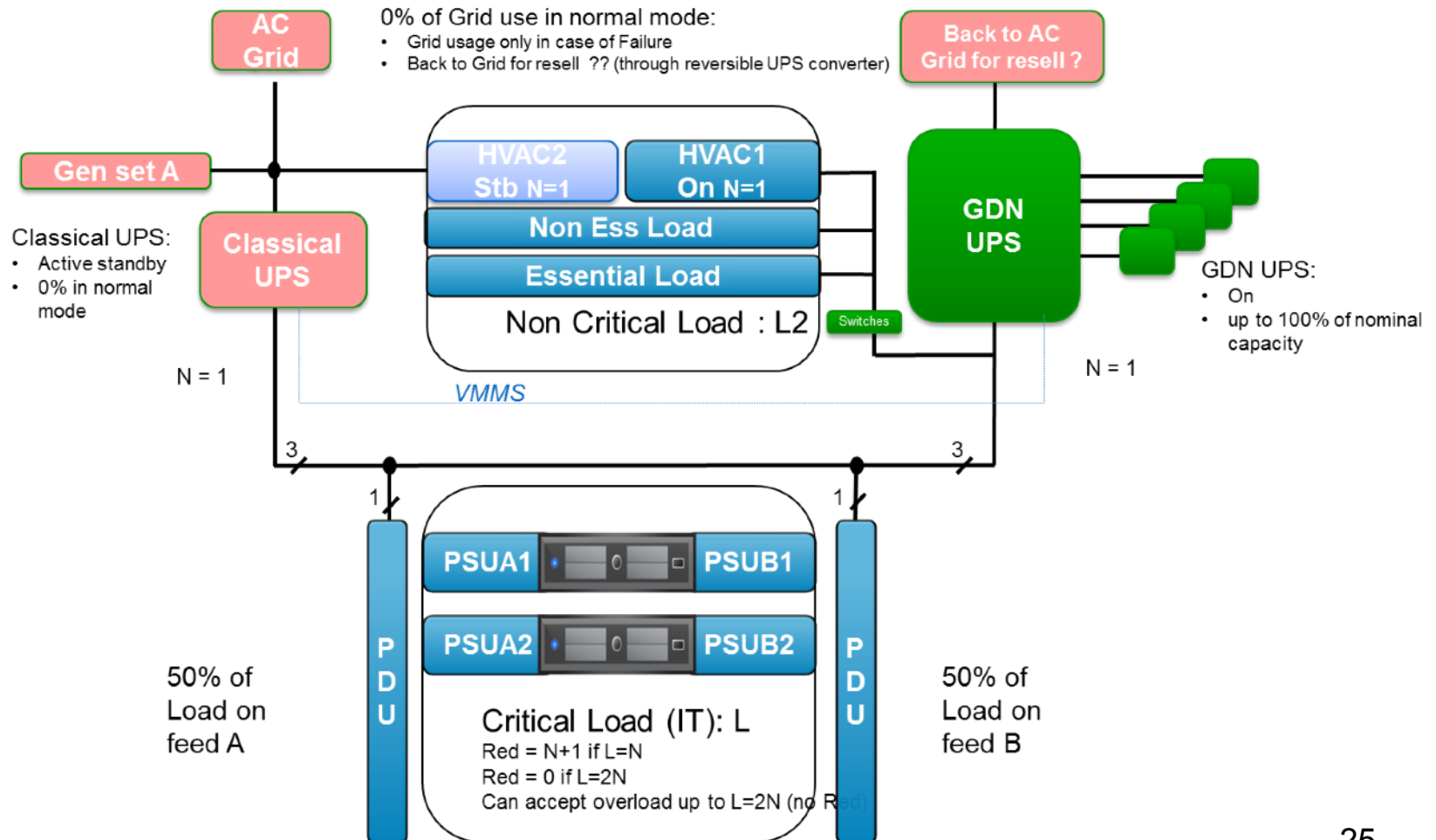
3 – Diffusion Zone P3 (50A -85A)



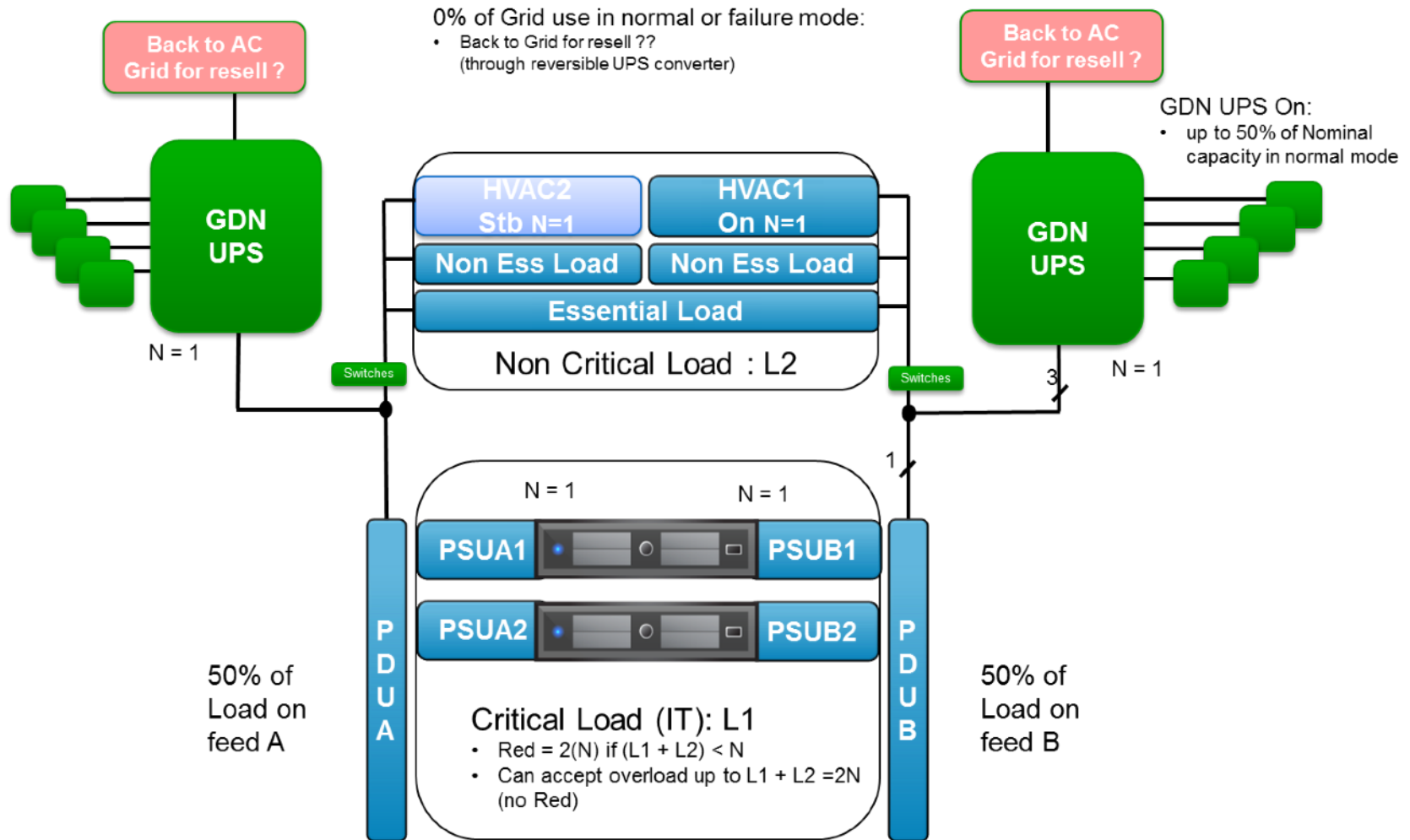
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Classical Electrical Schema: Up to N+1 (Green+Grid)



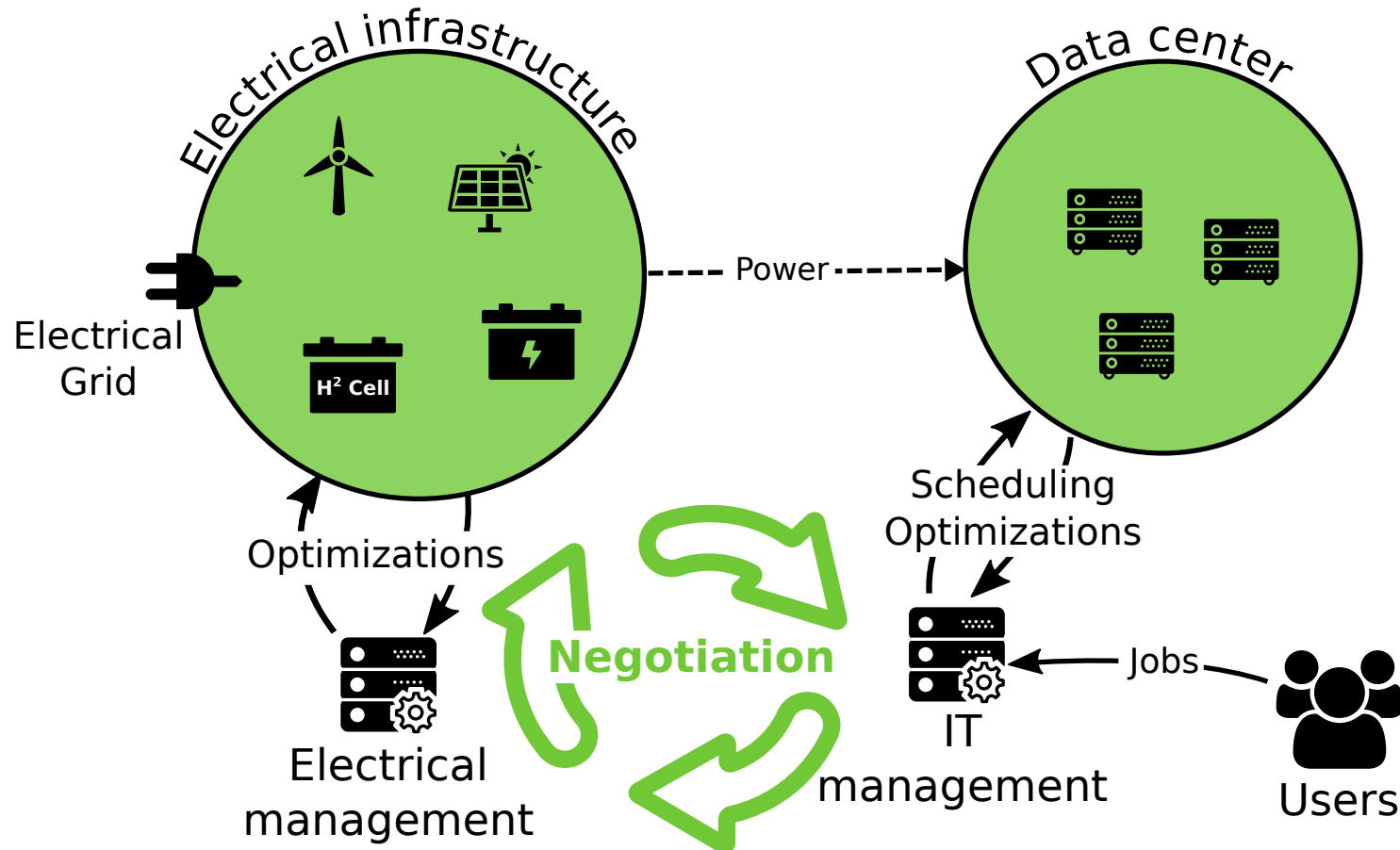
Novel electrical Schema: Up to 2N Green



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IT, GE and Negotiation Modules



Negotiation Module

1st approach based on attraction concept:

Representing the interest of a system for a proposal

- interest for the electrical part to produce 2000W from 11am to 1pm?
- interest for the IT part to execute a task at 11am?

Abstracted to a float number in $[-1, 1]$

- 1 : absolute reject (a very high penalty)

+1 : a very high attraction

0 : neutral

intermediate values available

Attraction values depend on the possibilities 29

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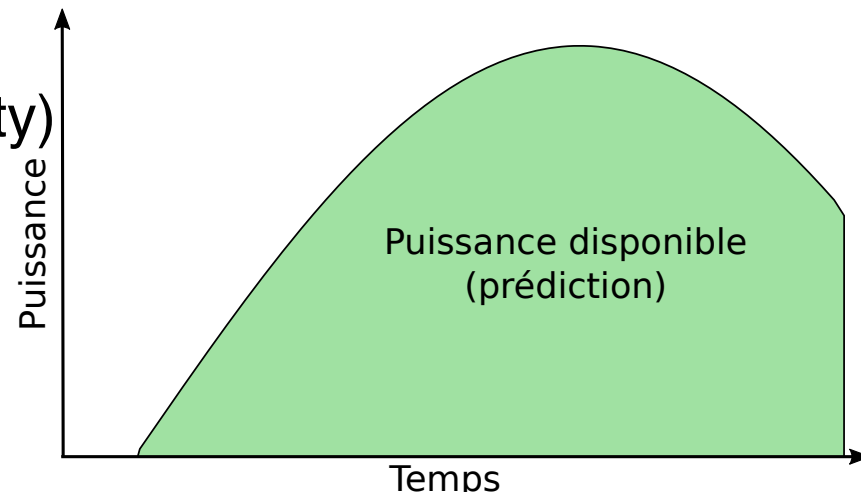
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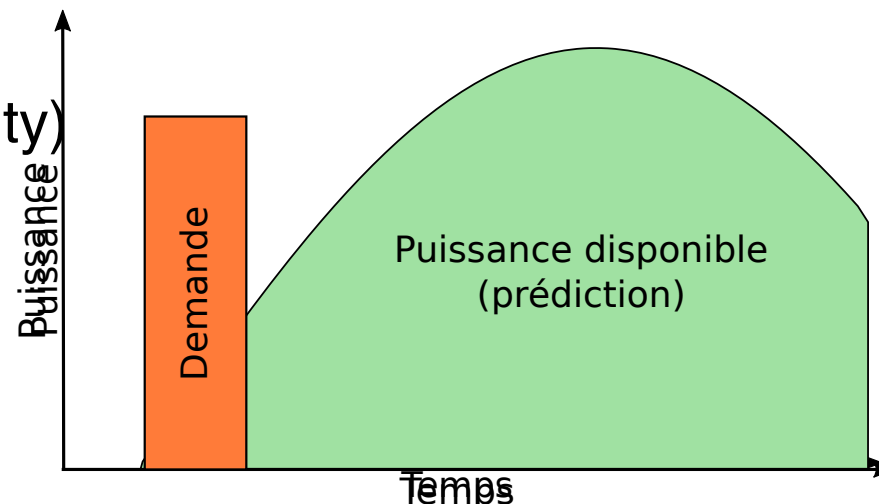
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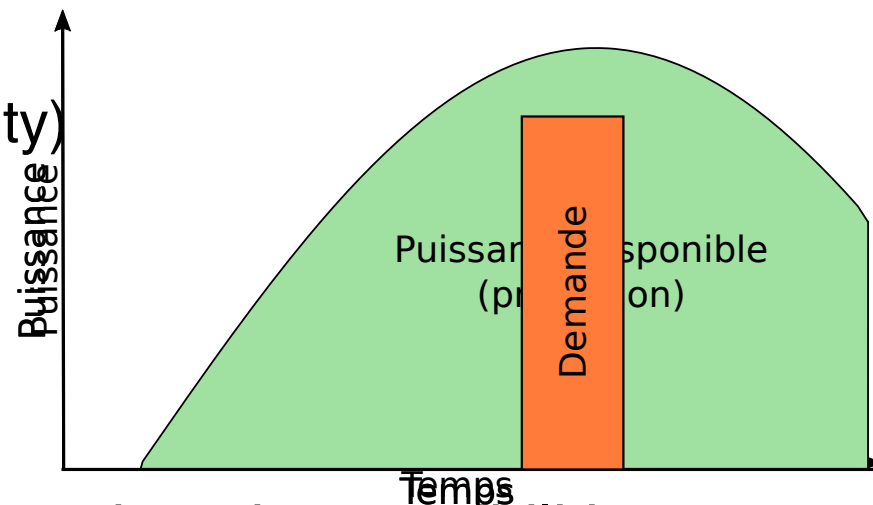
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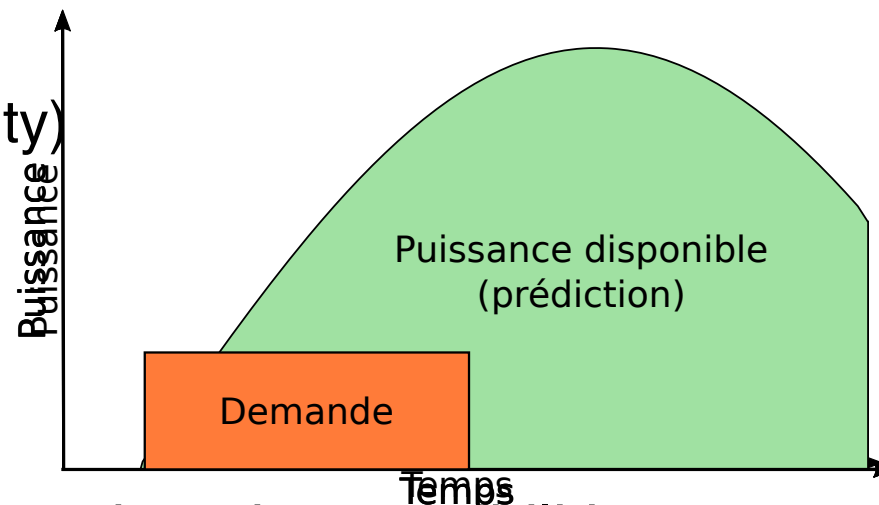
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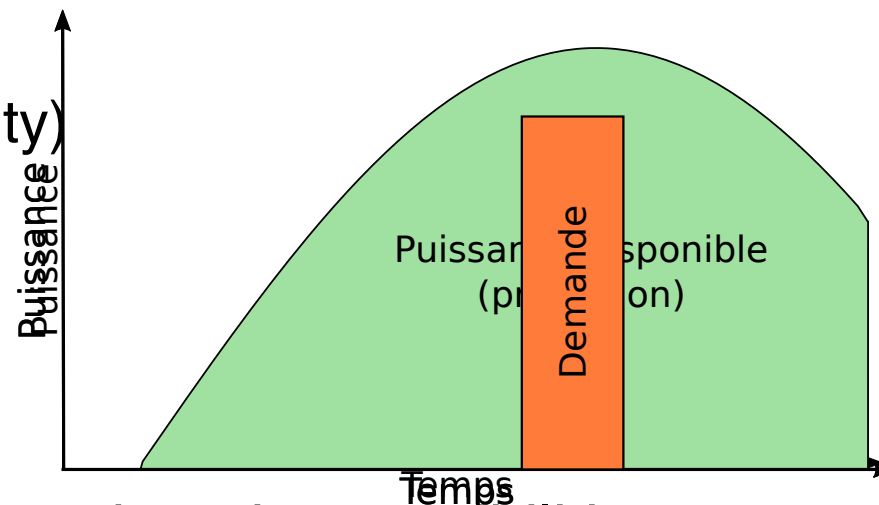
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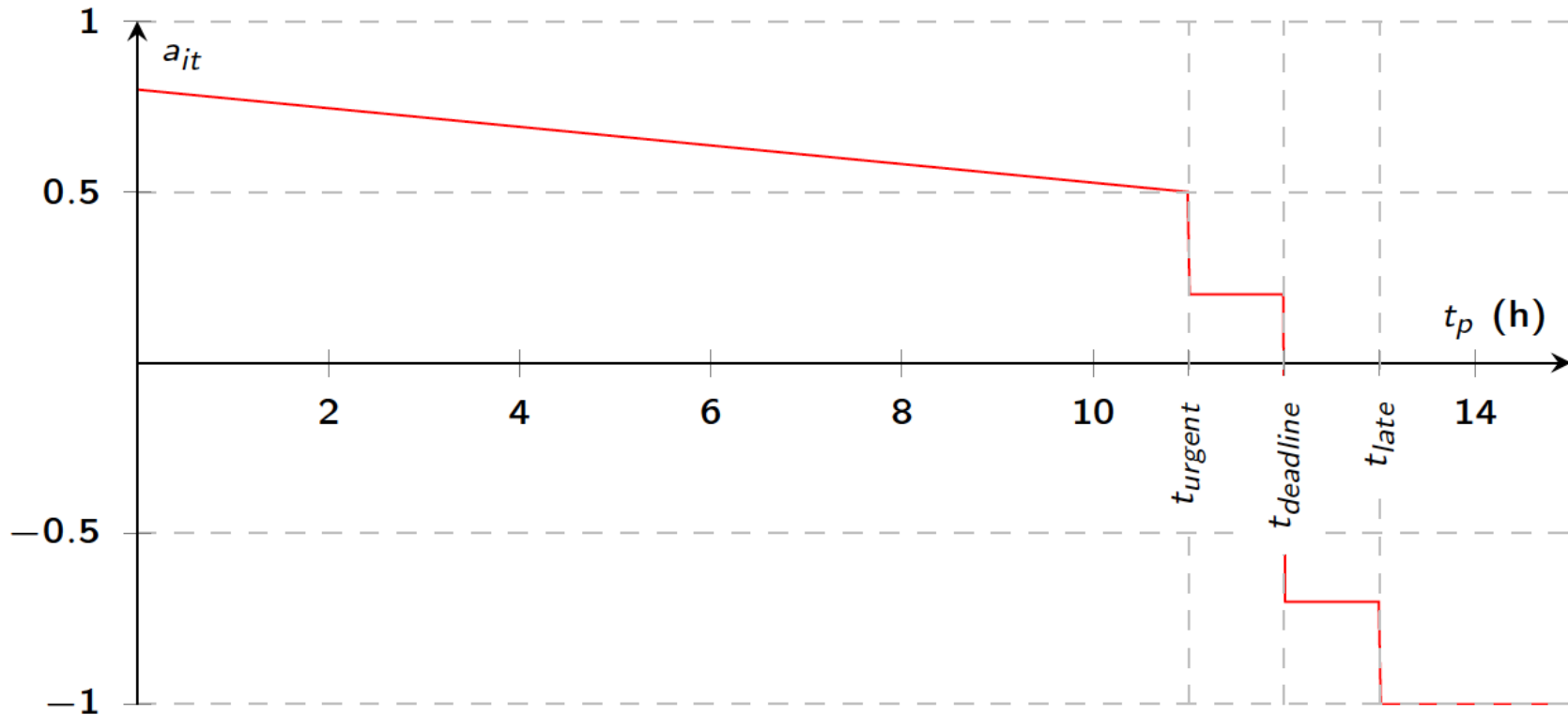
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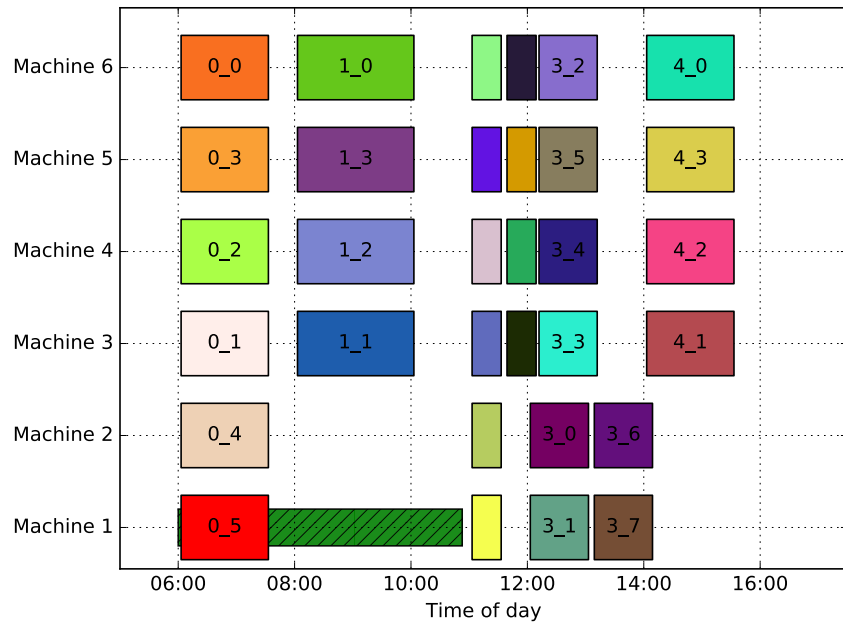
Attraction values depend on the possibilities 29

Negotiation: IT attraction

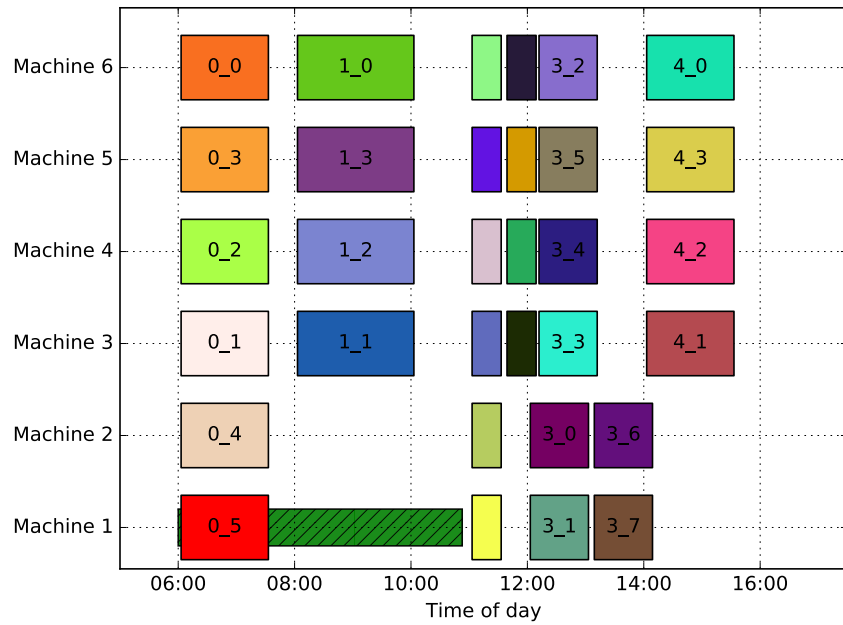


Flexibility is given with the deadline

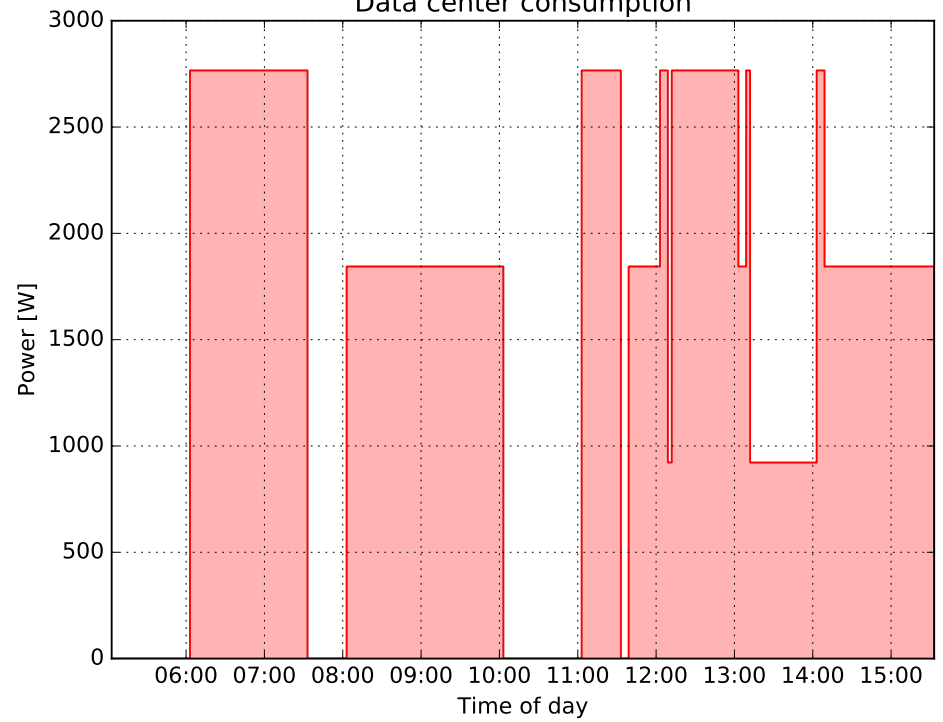
Task executed on each machine



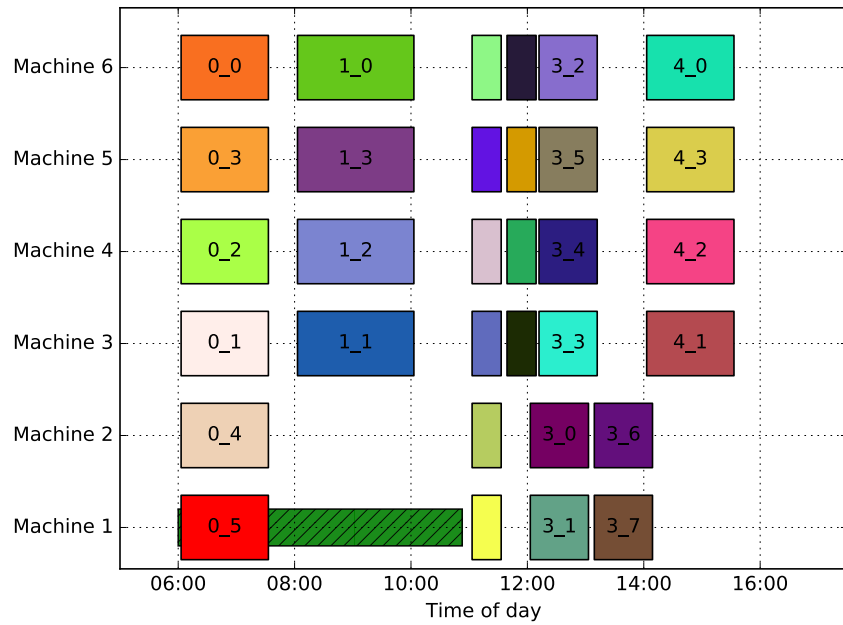
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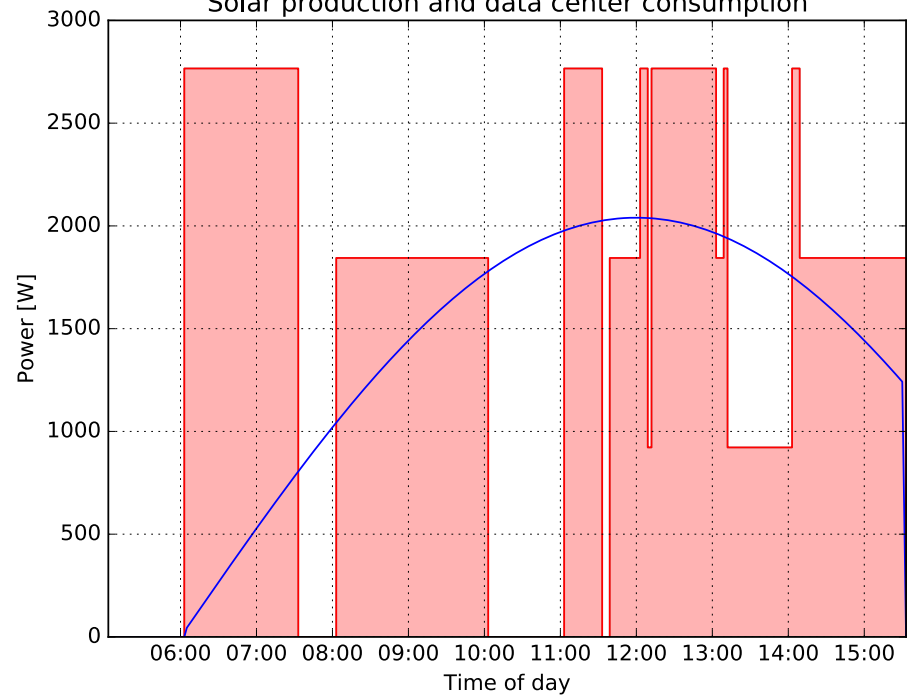
Data center consumption



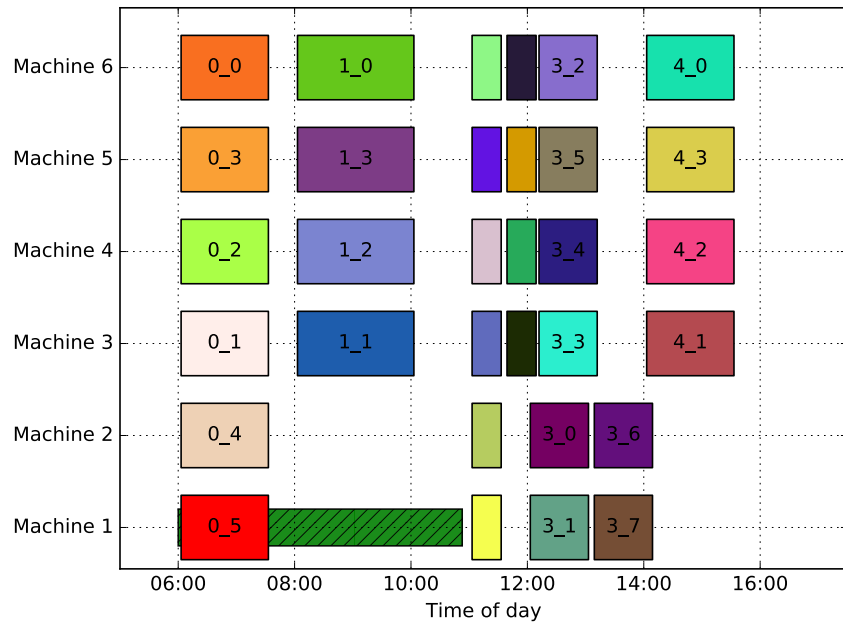
Task executed on each machine



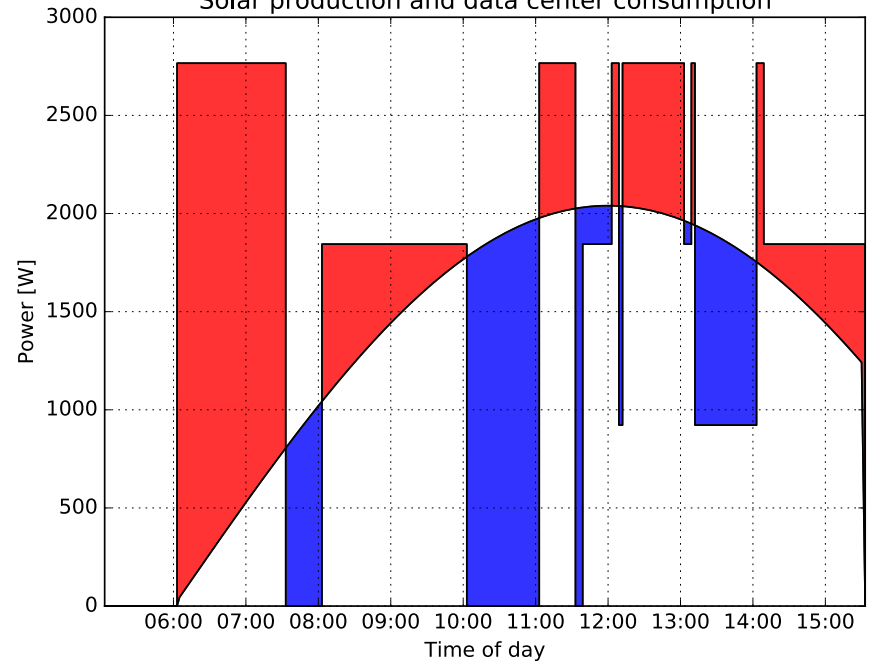
Solar production and data center consumption



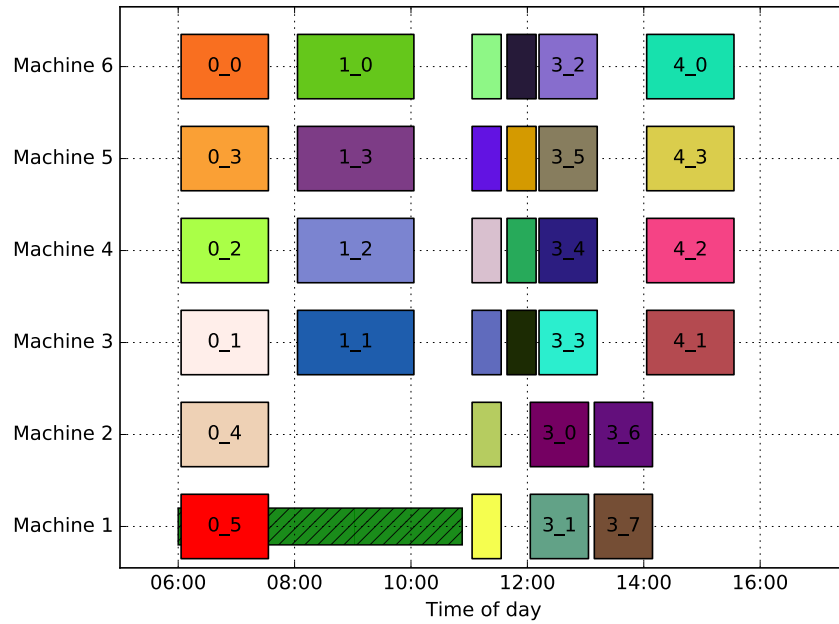
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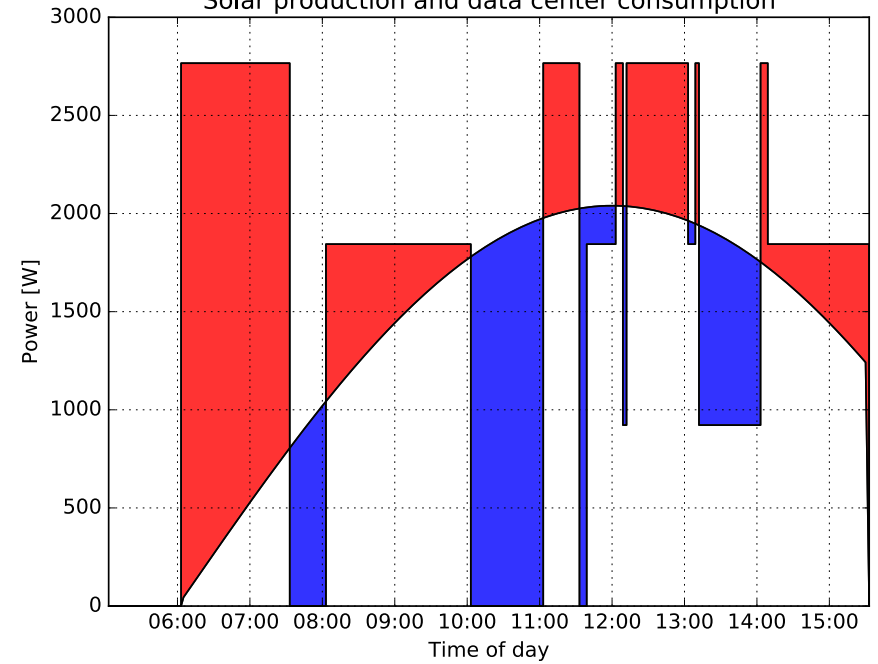
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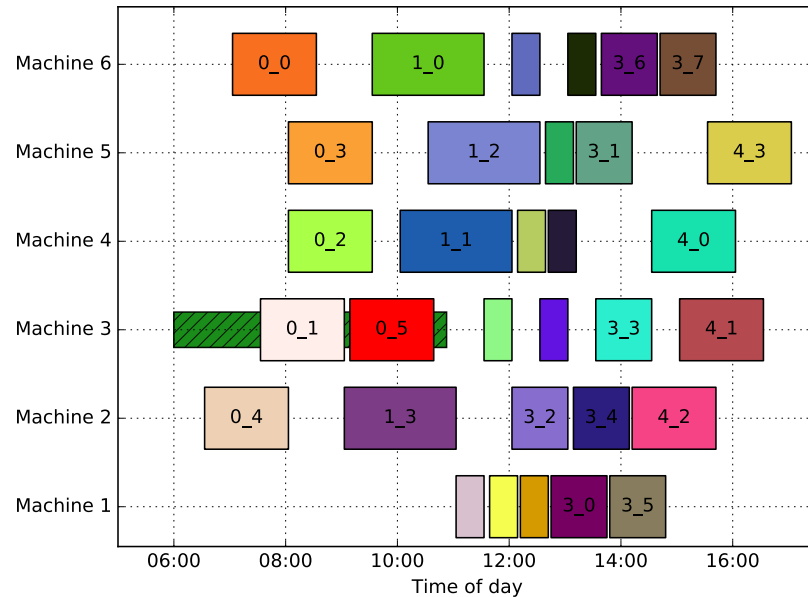
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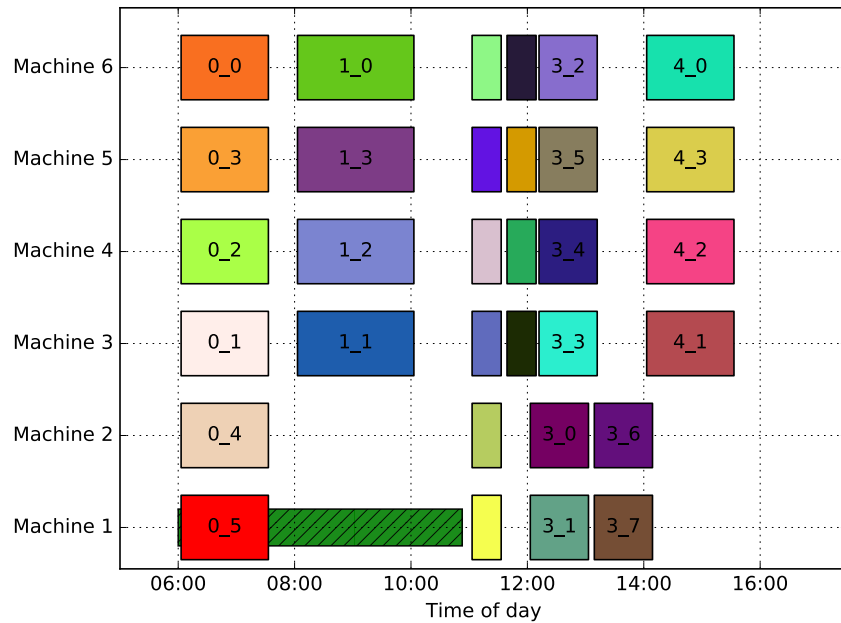
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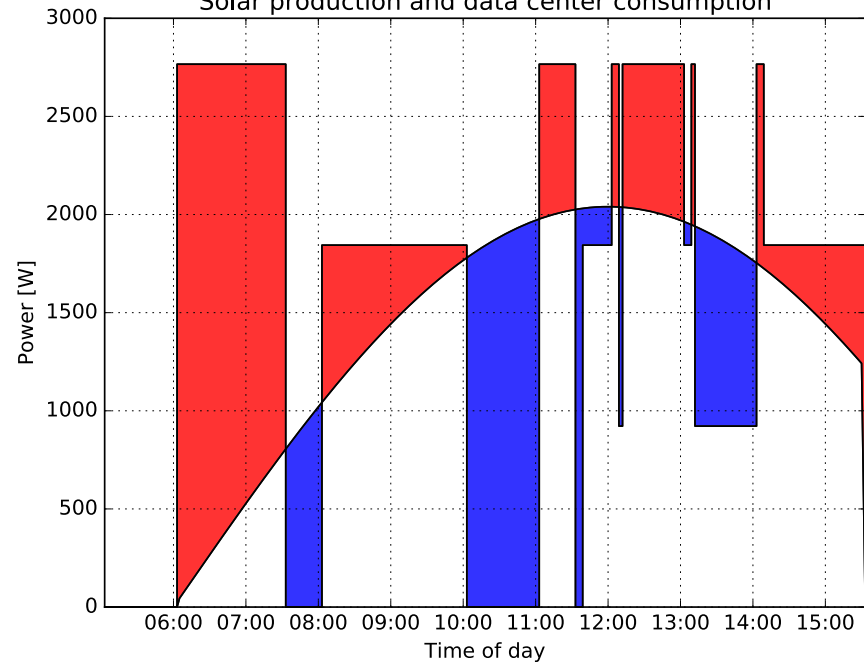
Task executed on each machine



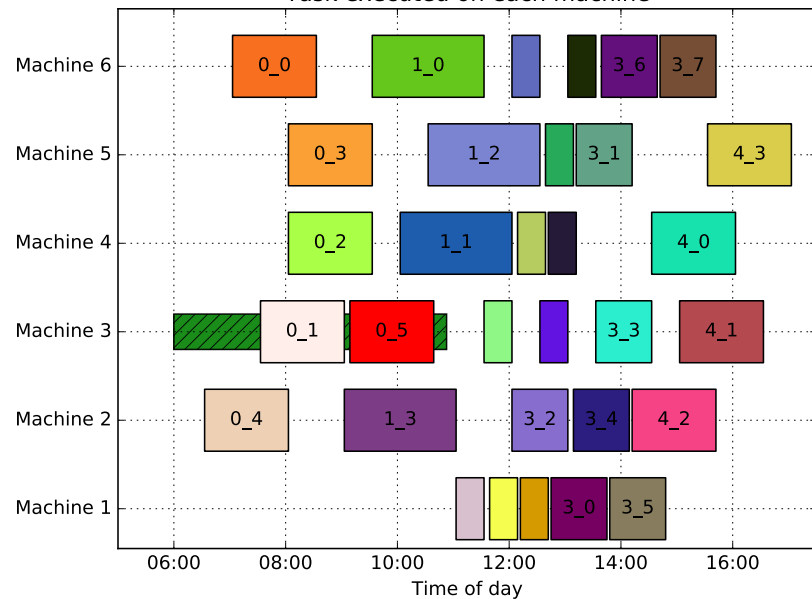
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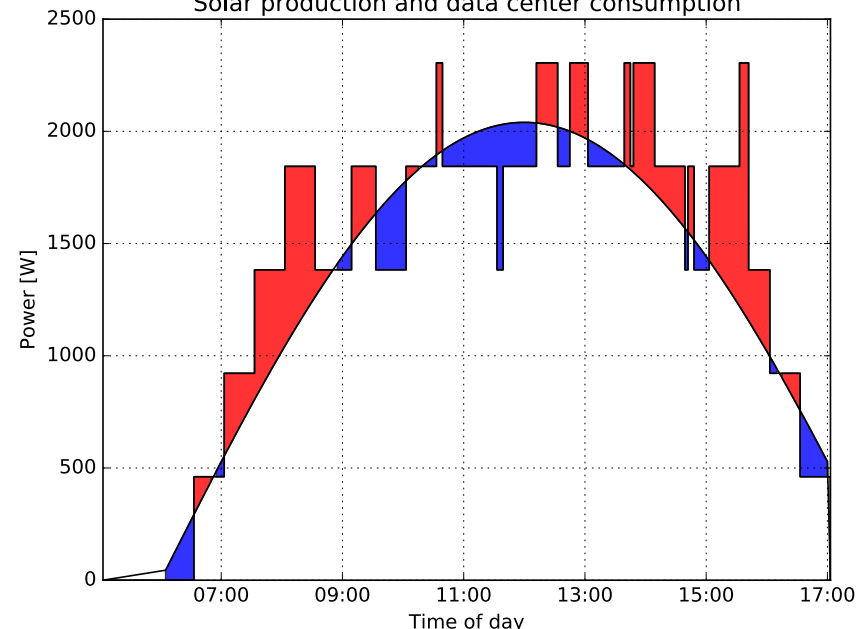
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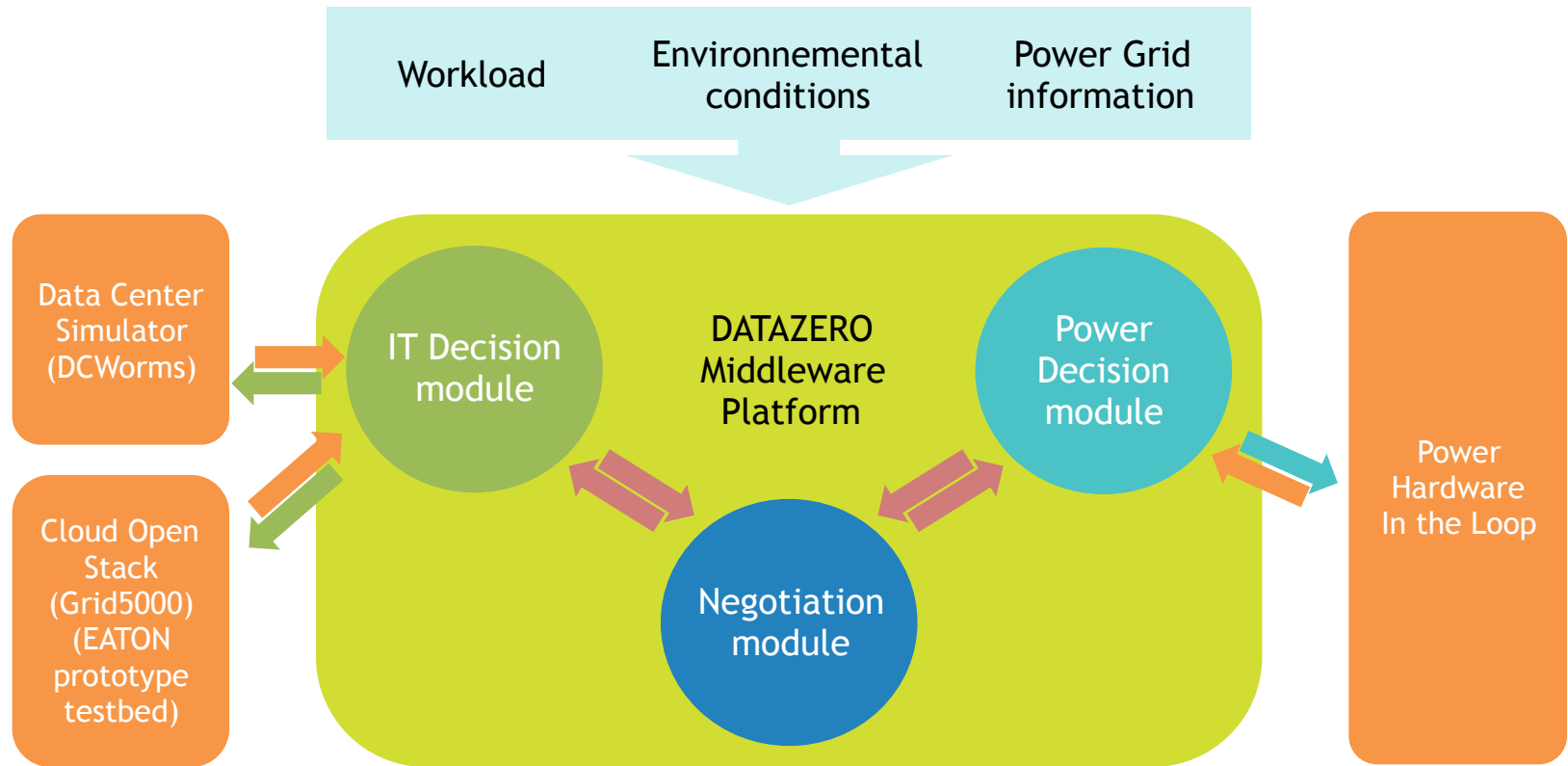
Task executed on each machine



Solar production and data center consumption



Middleware, Simulation, Real Hardware



Need for a middleware for the communications. Problem of synchronisation between simulators, and between simulators and real hardware

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Links with other projects

- Projects where partners are/were involved in IT and GE (e.g. **GreenDataNet**, RenewIT, CoolEmAll...)
- ISO IEC JTC1/39 on “EE in and for IT”
- Open to other collaborations (for models for instance, for experiments...)

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Conclusion



- An ongoing work
- Still about 3 years to go
- About 25 researchers involved
- Keep in touch!

Jean-Marc.Pierson@irit.fr