DC4Cities

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Episode 3

“ the goal of DC4Cities is to let existing and new data centres become energy adaptive

adapt manage the workload wrt. renewable energy availability

be adapted reply to a regulation of a smart city energy authority

Ajuntament de Barcelona

Hewlett Packard Enterprise

CSUC

gasNatural fenosa

ENEA

10 partners, 30 months

IN OMNIBUS VERITAS
UNIVERSITÄT MANNHEIM

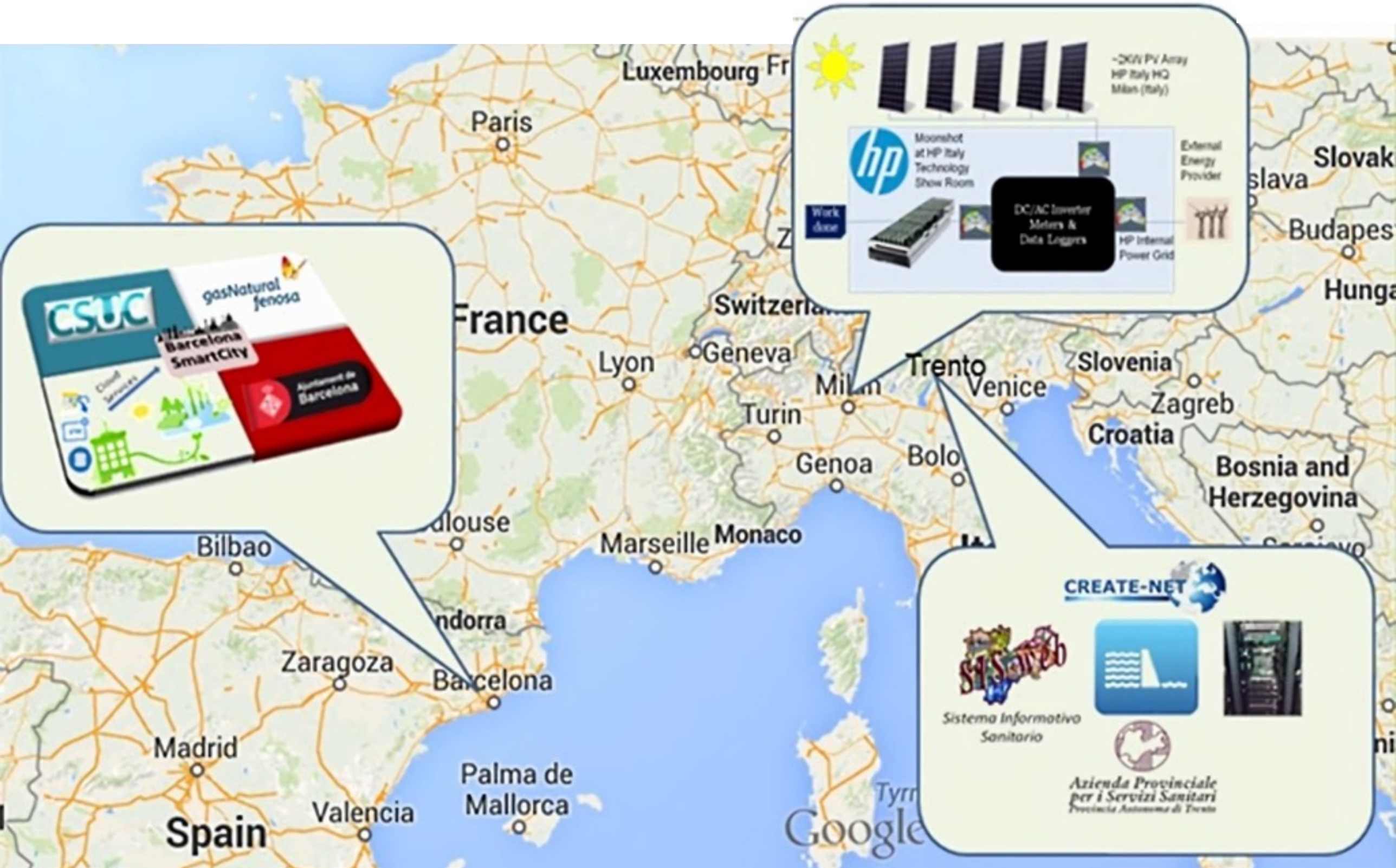
CREATE-NET

informatiques mathématiques Inria

Freemind
Stay in Control

UNIVERSITÄT PASSAU

3 trial sites, 2 periods



TL;DR

metrics
energy modeling
adaptation mechanisms

Beyond PUE & CUE

abstract

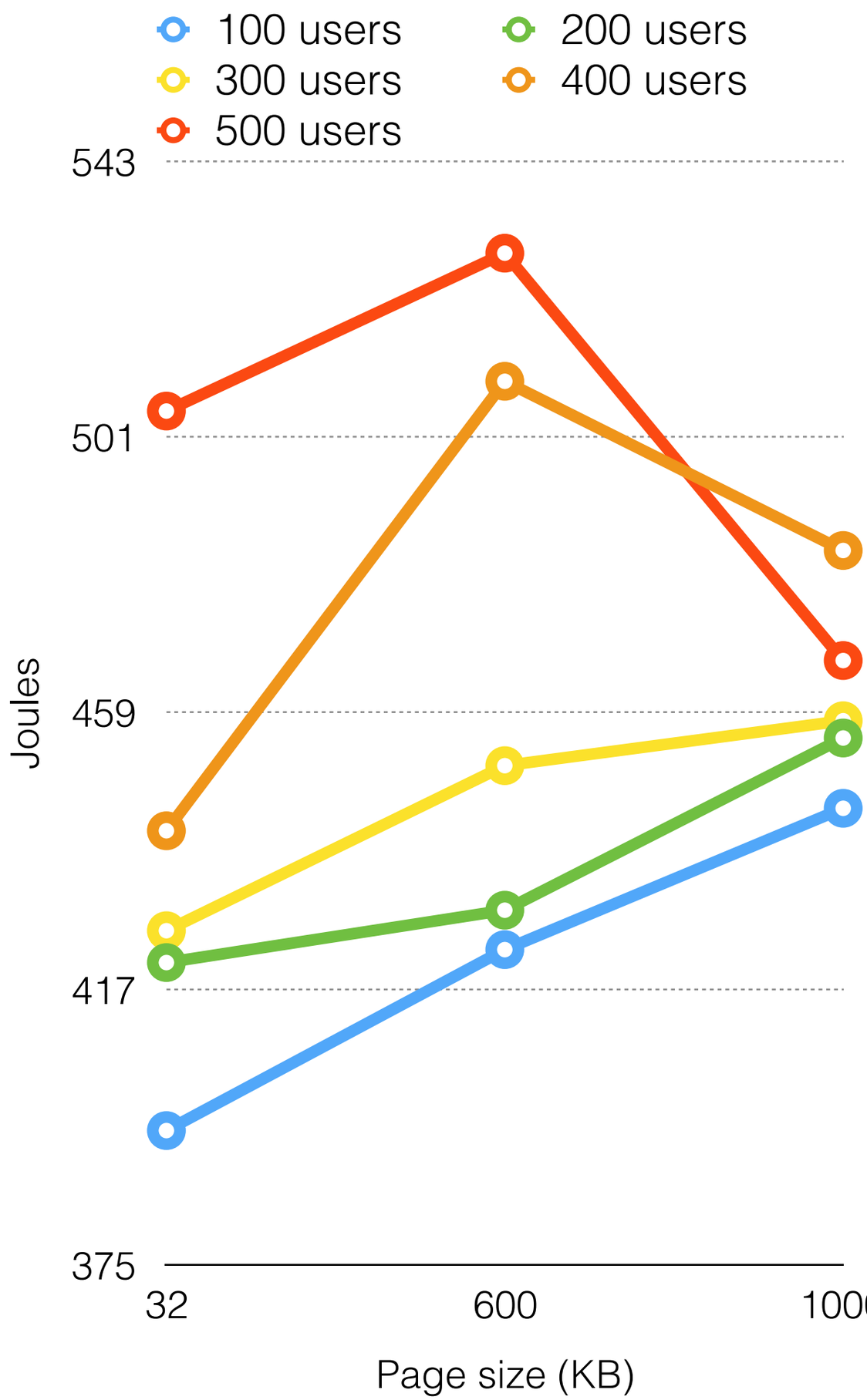
not business oriented

Measuring the work done

Watt per *whatever* request

Measuring adaptivity

work shifting capabilities



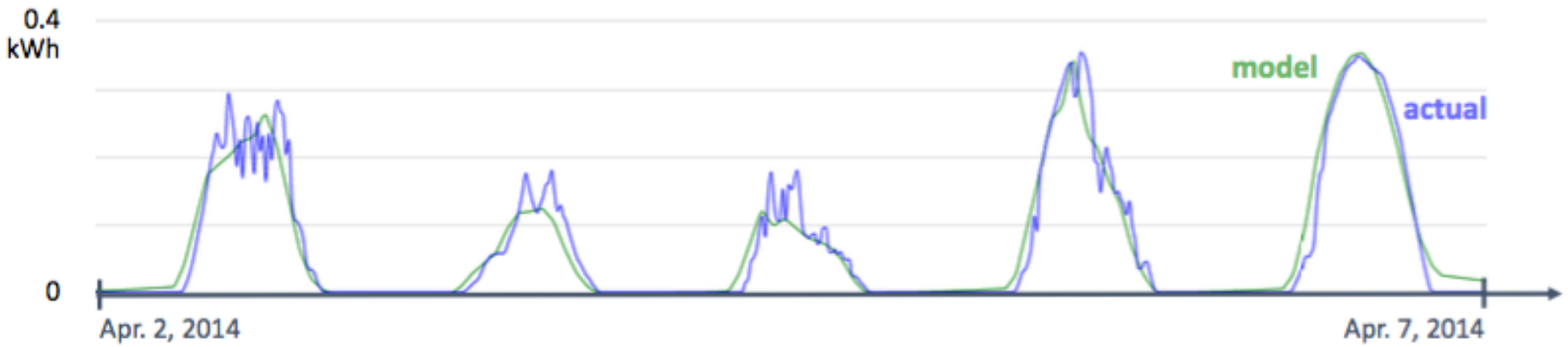
manual modeling
expertise, validation, robustness issues

modeling power and performance using machine learning

- dominant variable detection
- model generation
- model validation
- output: functions, plots, …

HP-trial PV production

Précision	CVRMSE	MBE	R^2
79,4	26,8	2,5	0,88



$$\hat{y}(t) = -0.49 + \frac{1.49}{1 + e^{-0.0009\ x_1(t) + 0.75}} + \frac{0.09}{1 + e^{-0.6\ x_2(t) + 11.4}}$$

x1: irradiation
x2: outside temperature

CSUC VM power consumption

$$\hat{y}(t) = -343 + \frac{528}{1 + e^{-0.003\ x_1(t) + 1.4}}$$

x1: vCPU usage

adapt

be adapted

Act 1

Energy
Adaptive
Software
Components

attached to an application

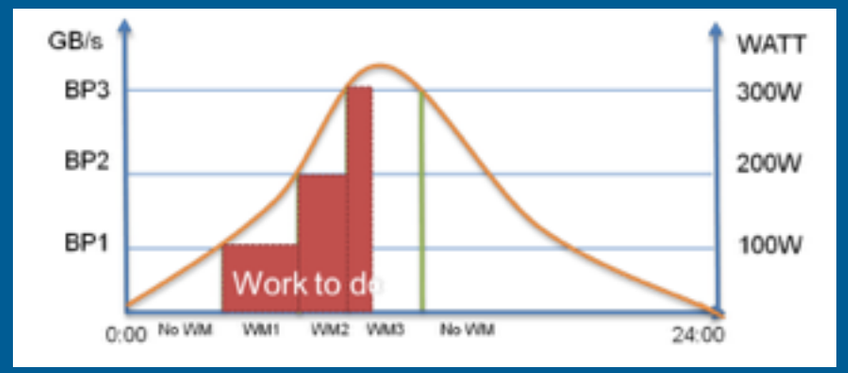
exhibit
- working modes
- actuators

(see UCC'15 paper)

```
- name: pageIndexing
  businessUnit: kPage

workingModes:
  - name: WM0
    actuator: bin/run.sh WM0
    performance: !amount '0 kPage/h'
    power: !amount '6 W'

  - name: WM1
    actuator: bin/run.sh WM1
    performance: !amount '32 kPage/h'
    power: !amount '27 W'

  - name: WM2
    actuator: bin/run.sh WM2
    performance: !amount '60 kPage/h'
    power: !amount '33 W'
```

Each EASC proposes

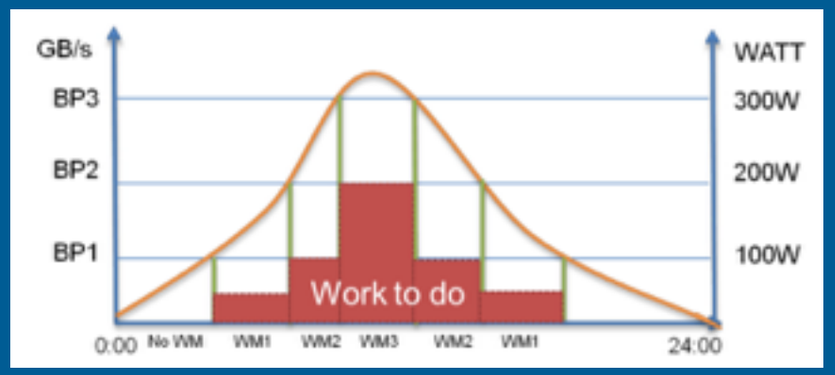
alternative execution plans
matching a power budget



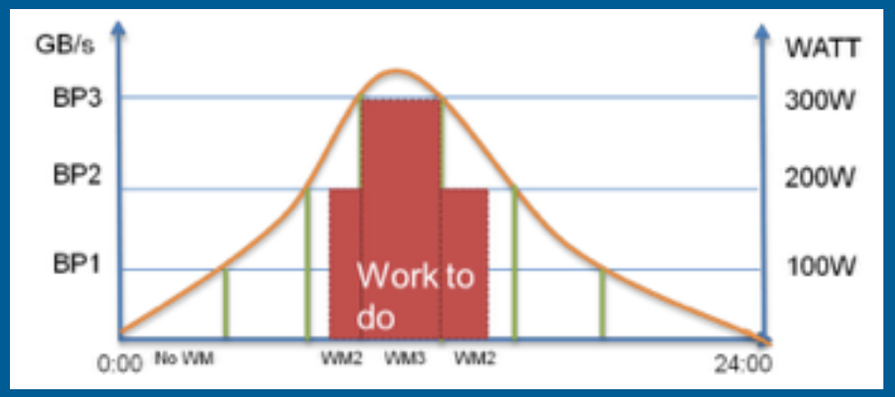
greedy

One consolidator chooses

one plan for each EASC
maximising ren%



proportional



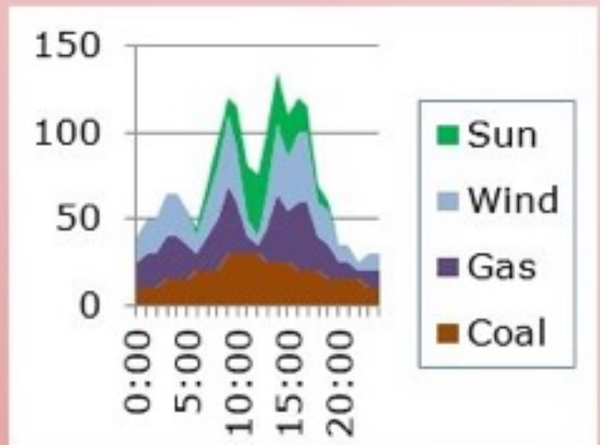
aggressive

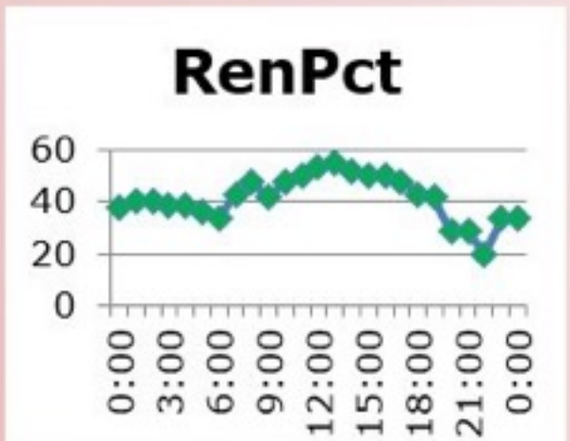
CHOCO

Grid/Smart Grid

Renewable Energy Providers

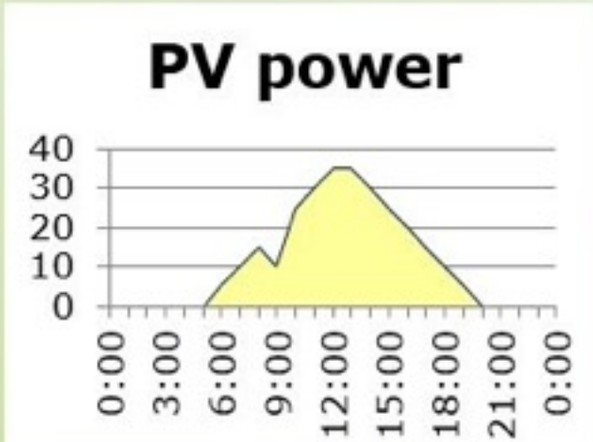
Smart City Control





Energy Availability Forecast

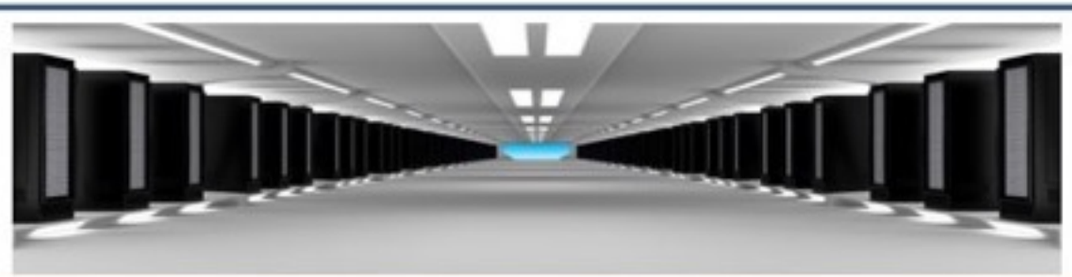
Weather Forecast



Power/Energy Goals

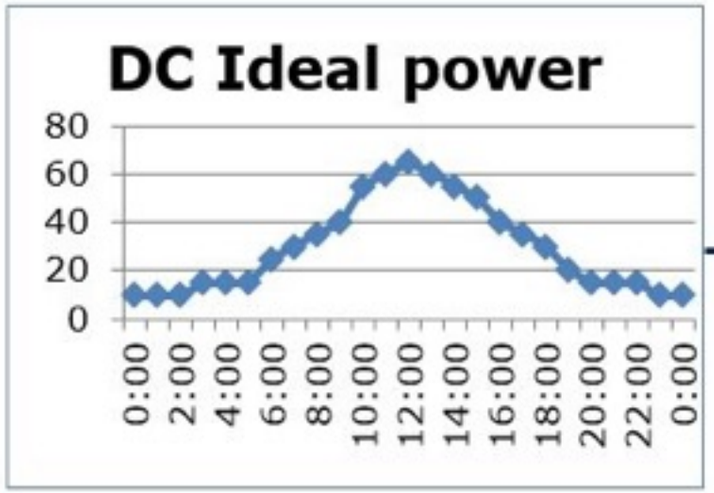
80% Ren

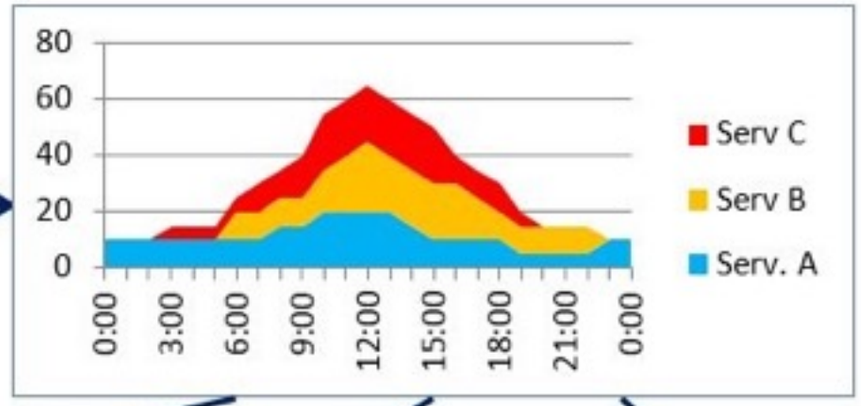
Renewable Energy Adaptive Interface



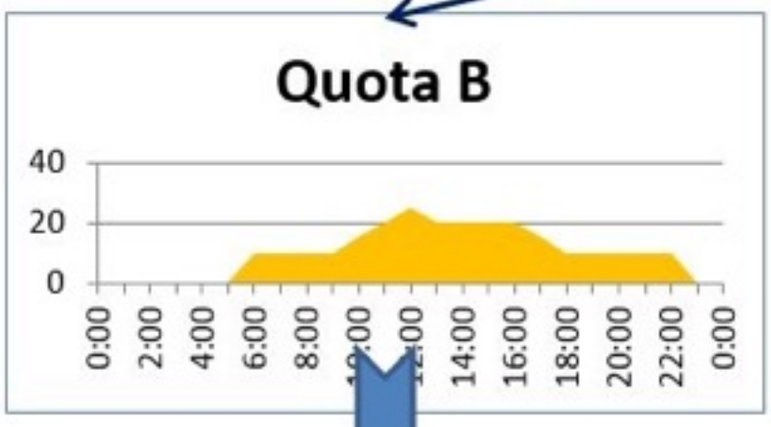
Data Centre Energy Controller

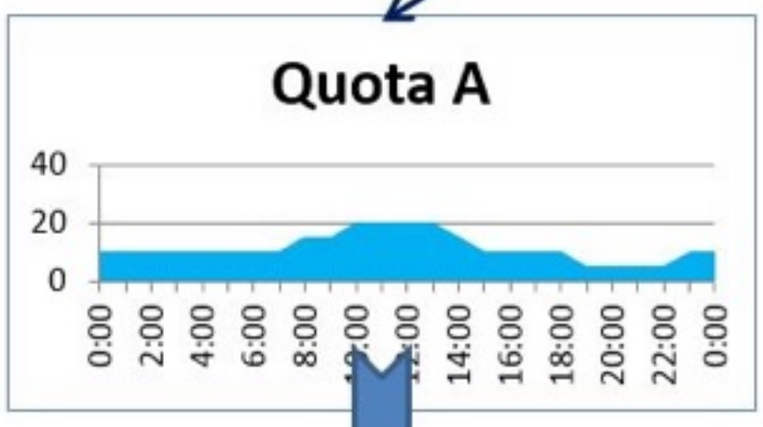
Data Centre Energy Controller

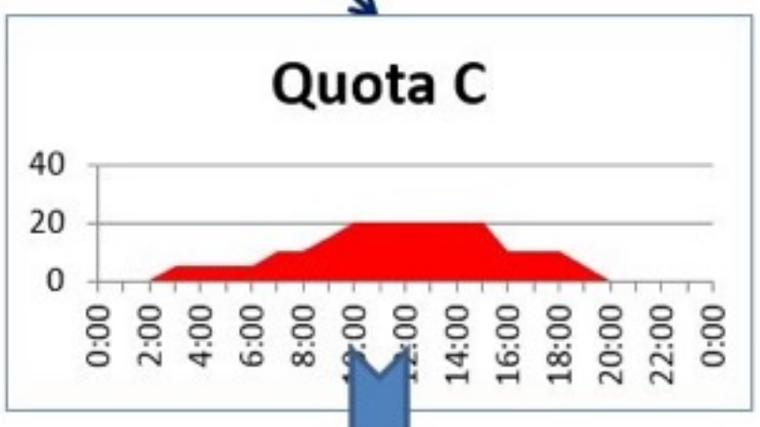




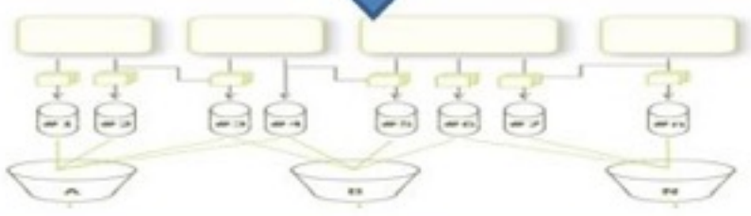
Service Quota Split Policies



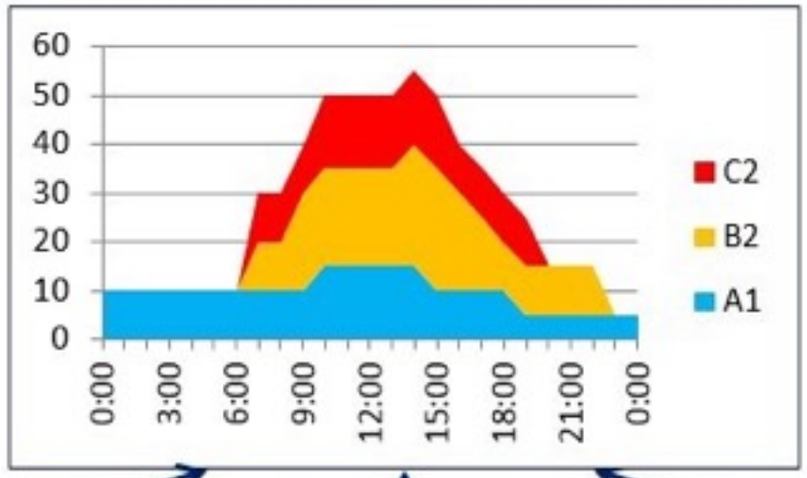


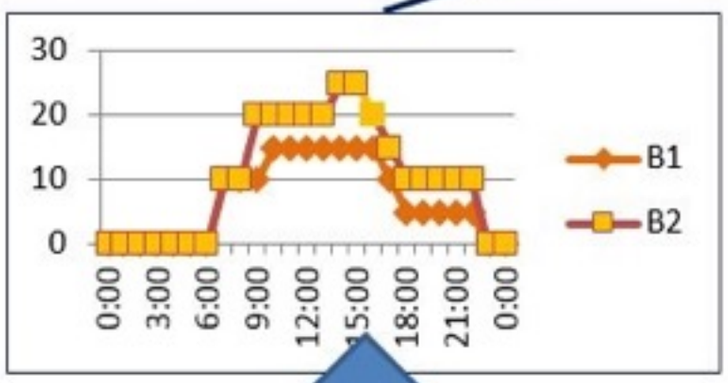


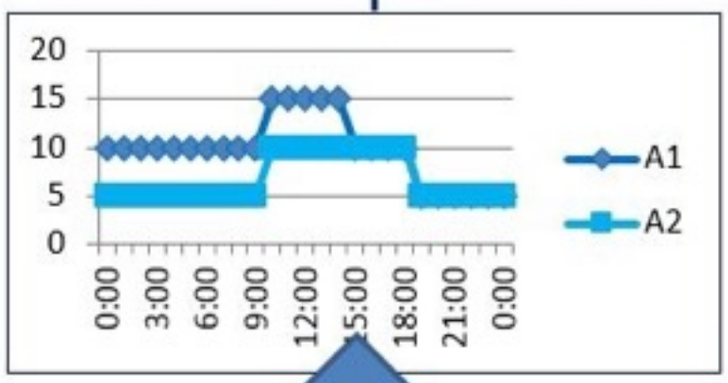
Energy Adaptive Data C ntre Operation Interface

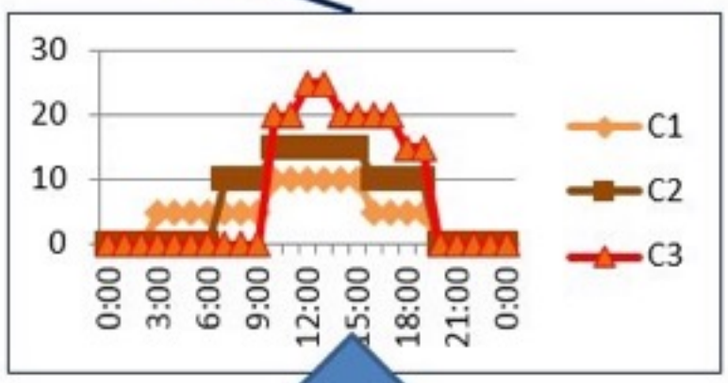


Data Centre Energy Controller









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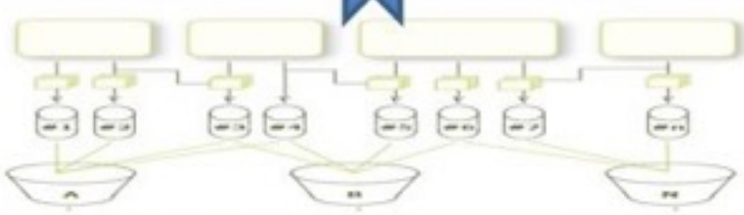

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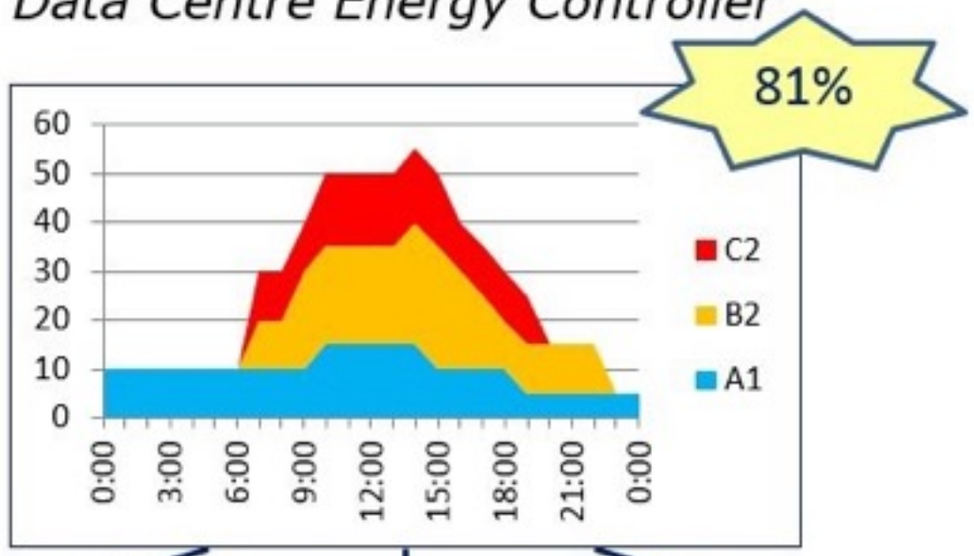
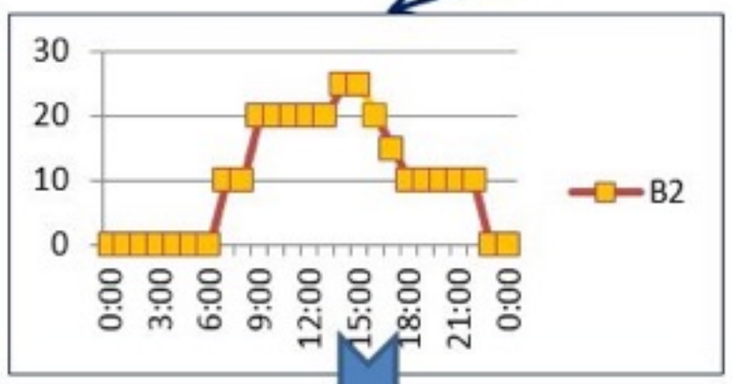
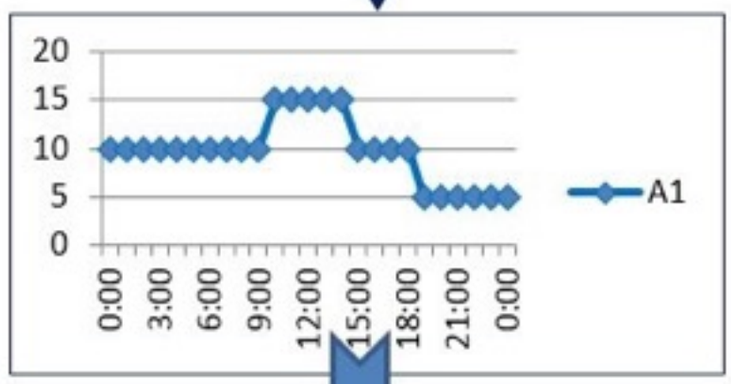
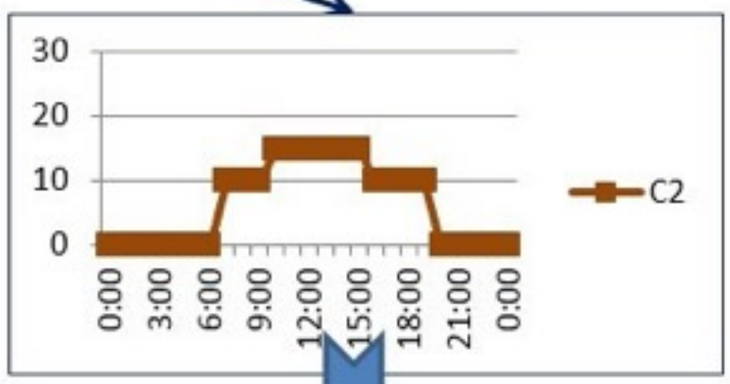
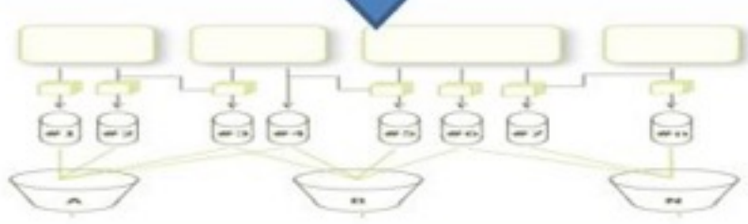








Energy Adaptive Data C ntre Operation Interface



Lessons learned

The good

it worked at M10
quite scalable

The bad

software && hardware dependent
flexibility at the client side

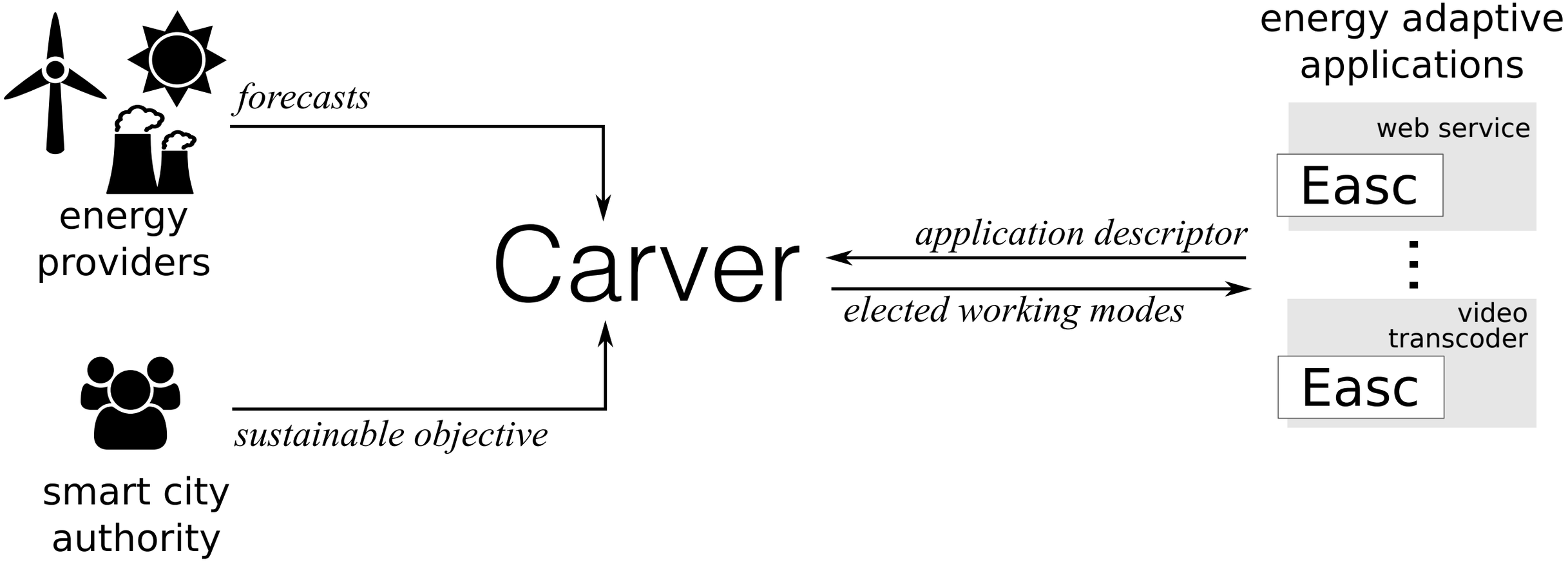
The ugly

some magic assumptions
very limited flexibility

Act 2

~ The takeover ~

shape EASCs for sustainable profitability



pick WMs such as

min(penalty(SLO) + penalty(SMA) + price(E))

Energy
Adaptive
Software
Components

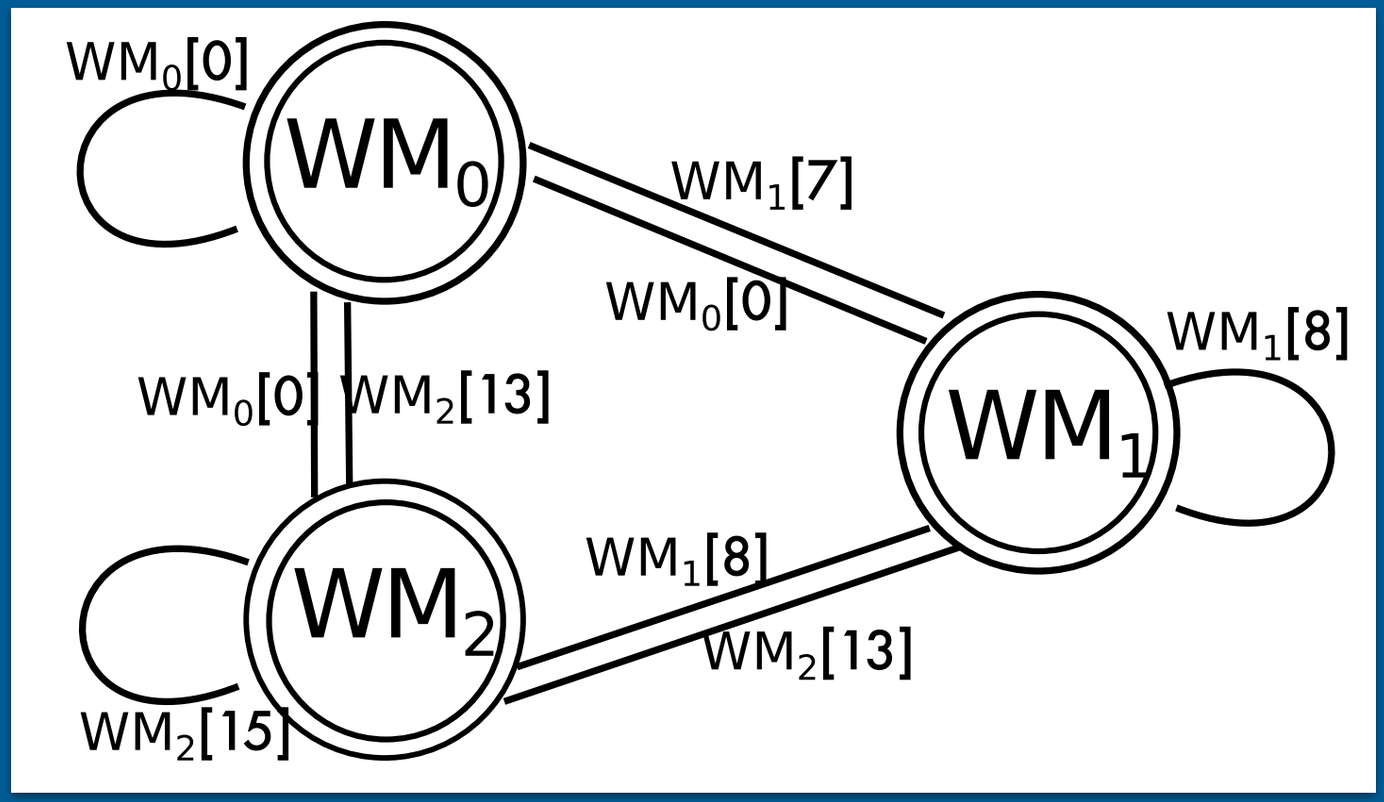
attached to an application

exhibit

- working modes
- SLO (cumulative or instant)
- transition costs
- actuators

```
- name: pageIndexing
  businessUnit: kPage
  SLO:
    - timeFrom: 00:00:00
      timeTo: 24:00:00
      cumulativeObjective: !amount '200 kPage'
      basePrice: !amount '100 EUR'
      priceModifiers:
      - threshold: !amount '200 kPage'
        penalty: !amount '0 EUR/kPage'
      - threshold: !amount '100 kPage'
        penalty: !amount '-1 EUR/kPage'
      - threshold: !amount '0 kPage'
        penalty: !amount '-100 EUR'
  workingModes:
    - name: WM0
      actuator: bin/run.sh WM0
      performance: !amount '0 kPage/h'
      power: !amount '6 W'
      transitions:
        - target: WM1
          performanceCost: !amount '1 kPage'
        - target: WM2
          performanceCost: !amount '2 kPage'
- name: WM1
  actuator: bin/run.sh WM1
  performance: !amount '32 kPage/h'
  power: !amount '27 W'
  transitions:
    - target: WM2
      performanceCost: !amount '2 kPage'
- name: WM2
  actuator: bin/run.sh WM2
  performance: !amount '60 kPage/h'
  power: !amount '33 W'
```

EASC
weighted automata
with counters

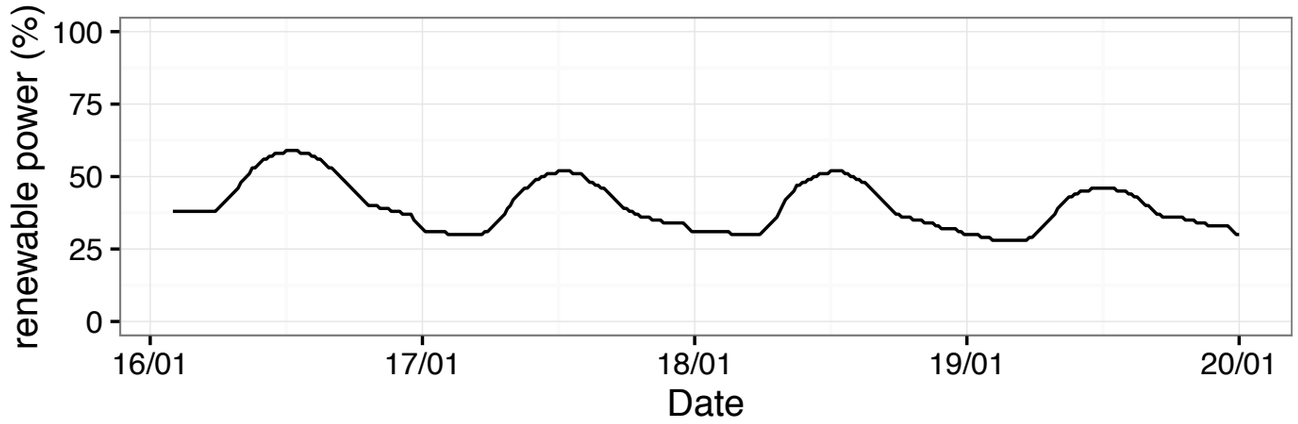


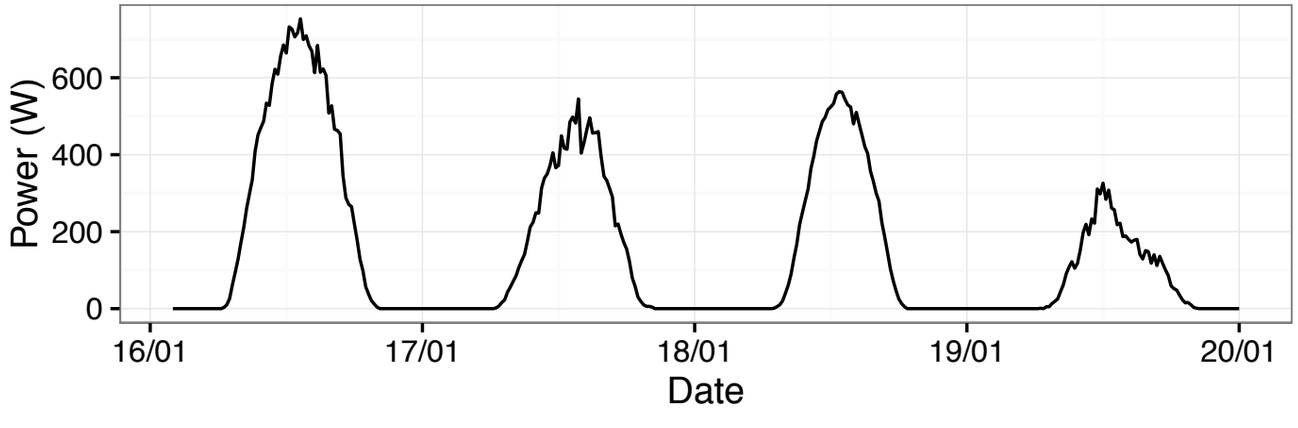
\+ penalty functions for the Smart City Authority
the SLA

CHOCO

Hewlett Packard Enterprise

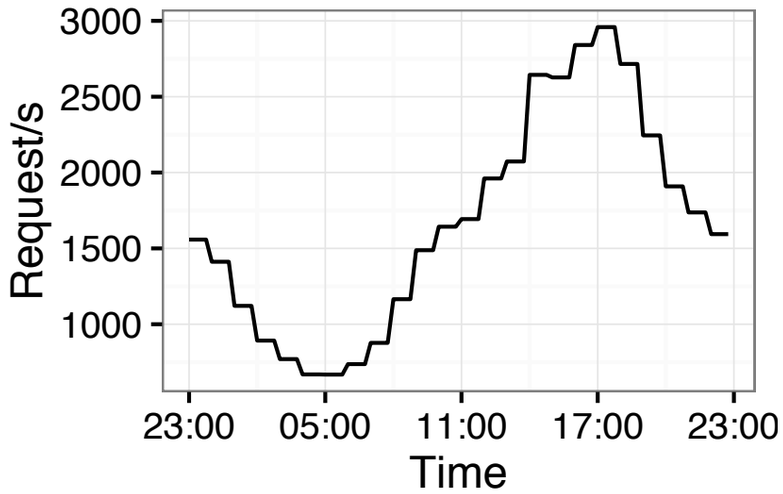
grid renewable part



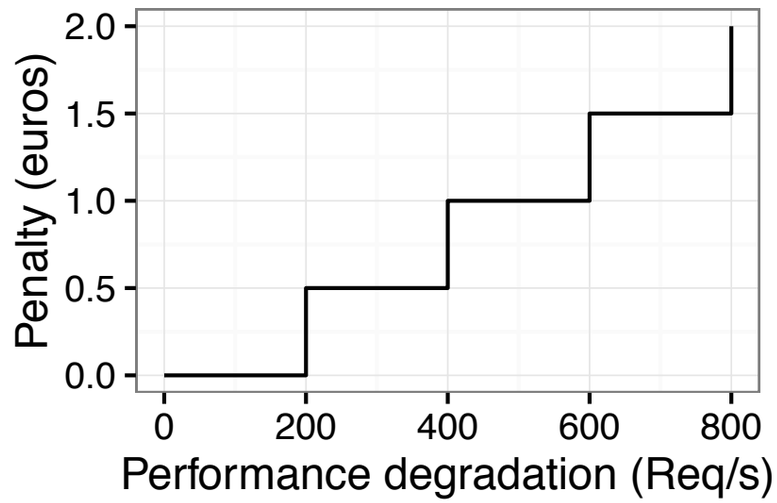


Hewlett Packard
Enterprise

6 to 20 moonshot cartridges



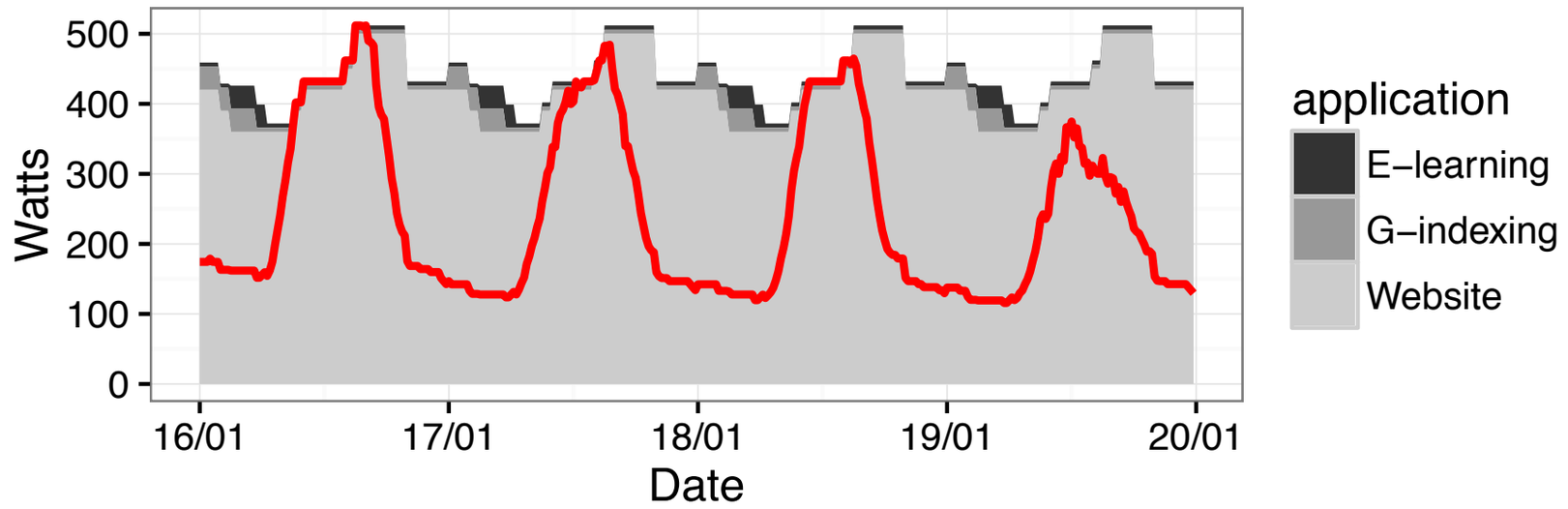
SLO



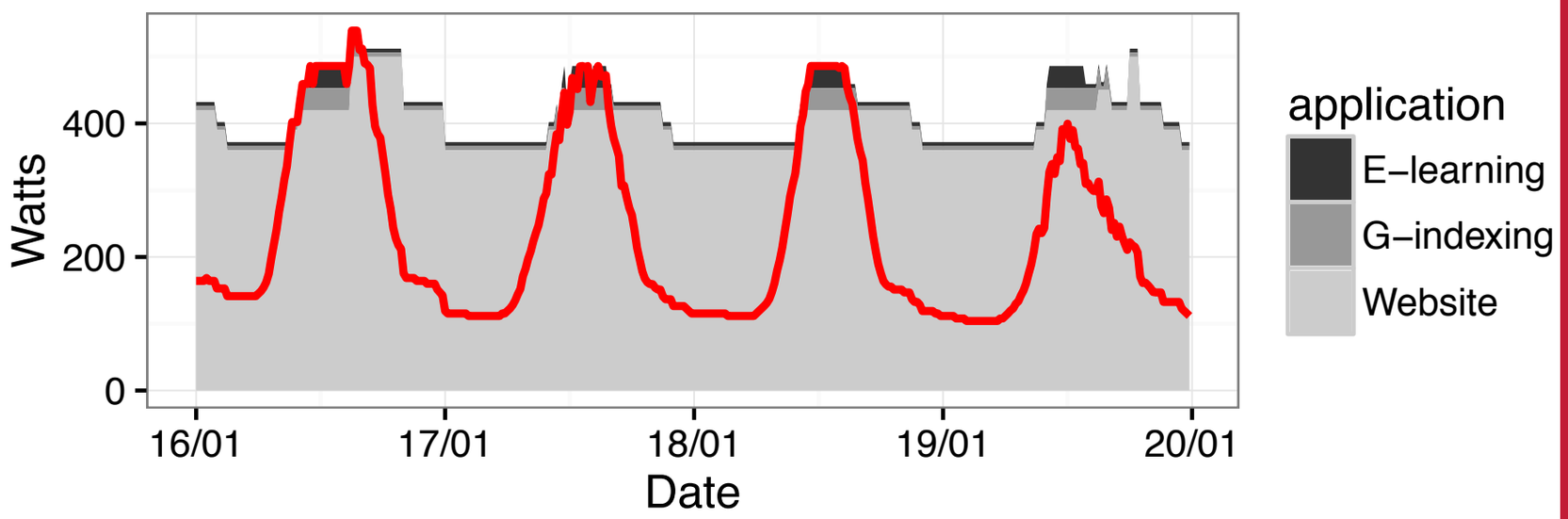
penalty model

Application	Performance	Power (W)
Website	1050 – 3250 Req/s	360 – 550
G-indexing	0 – 565 kPages/h	6 – 33
E-indexing	0 – 60 kPages/h	6 – 33

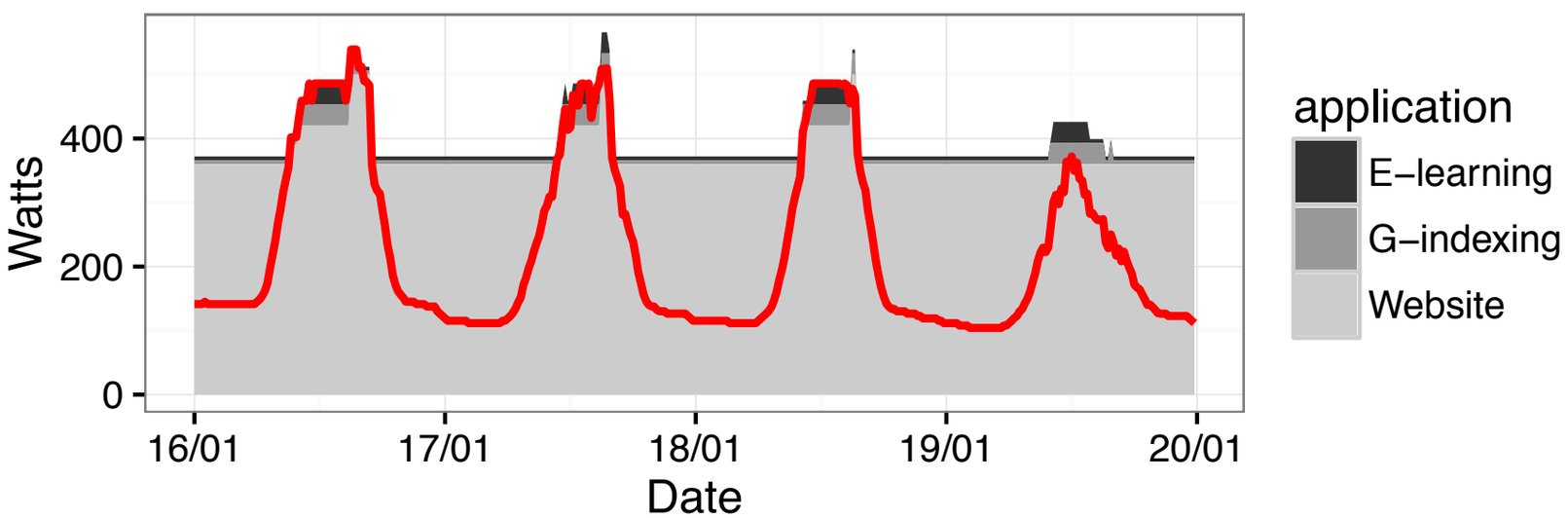
baseline
(satisfy perf)



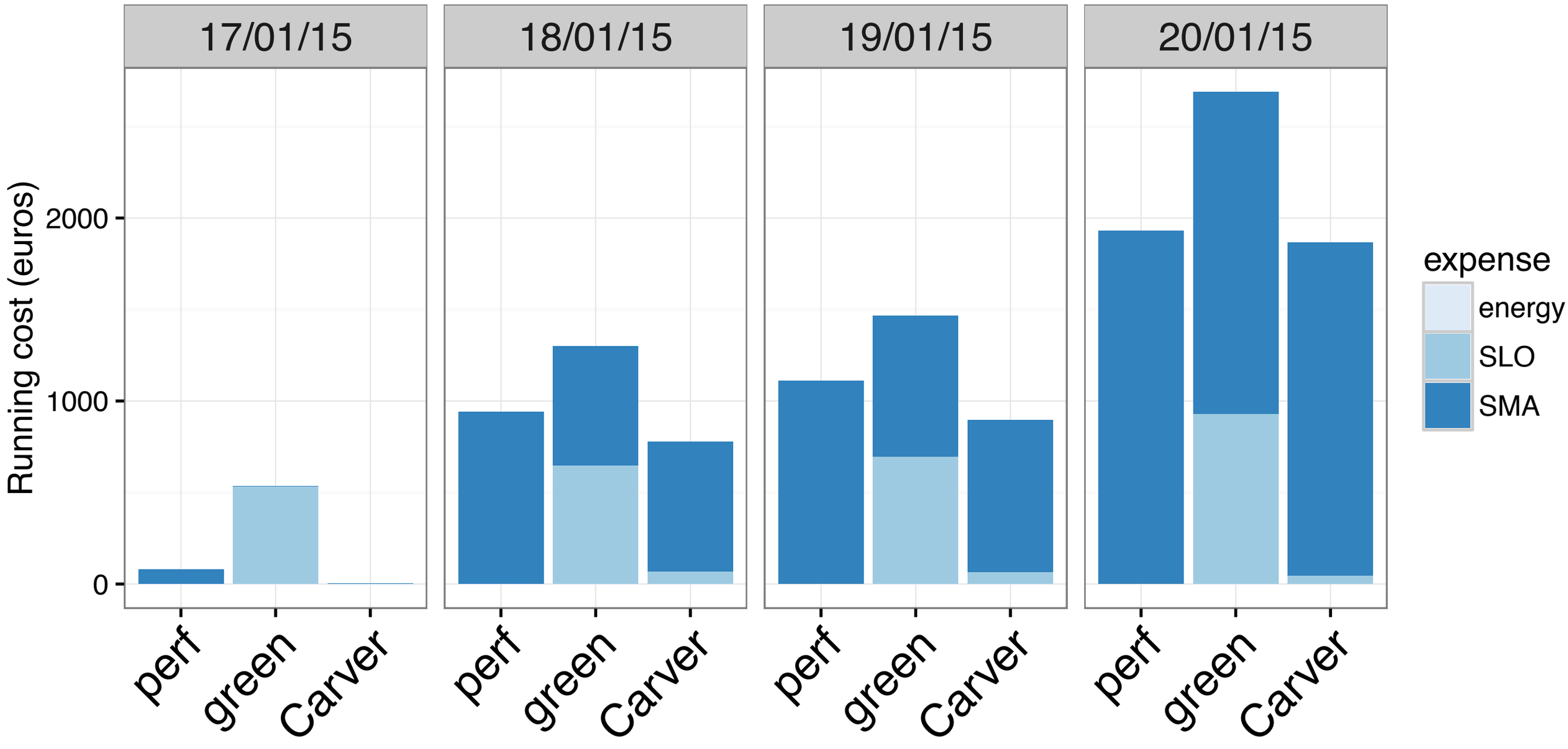
carver



“green”
(max renewable)



Resulting running costs

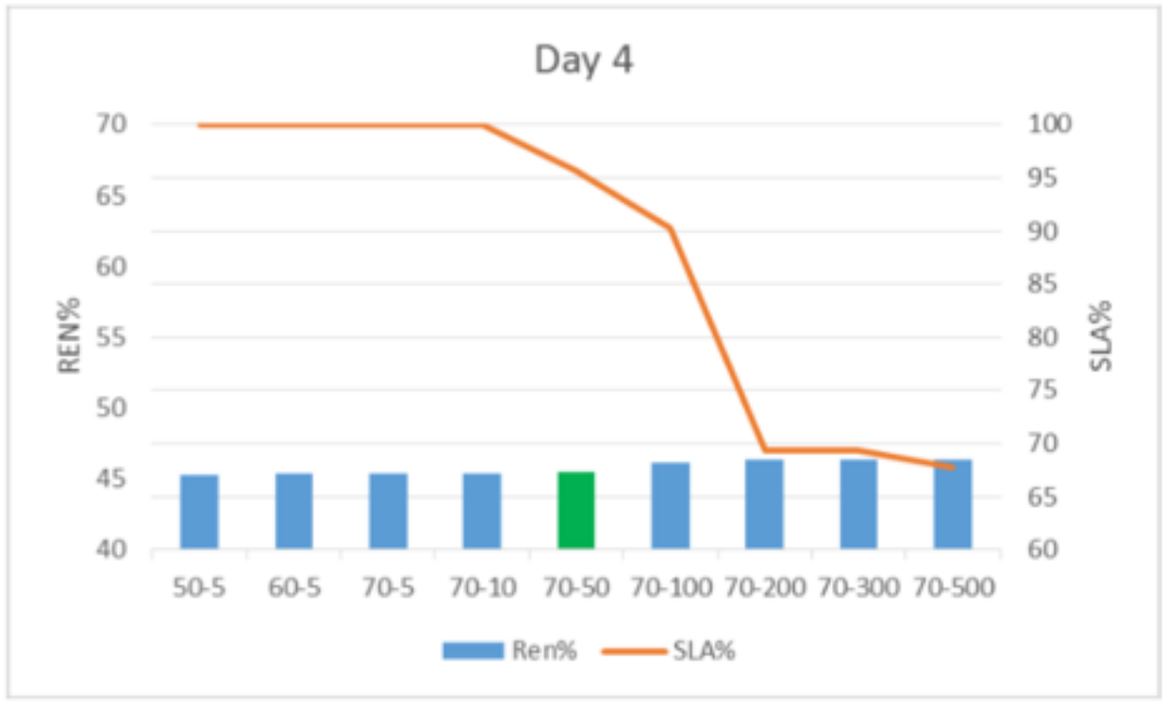


Side tools using simulation

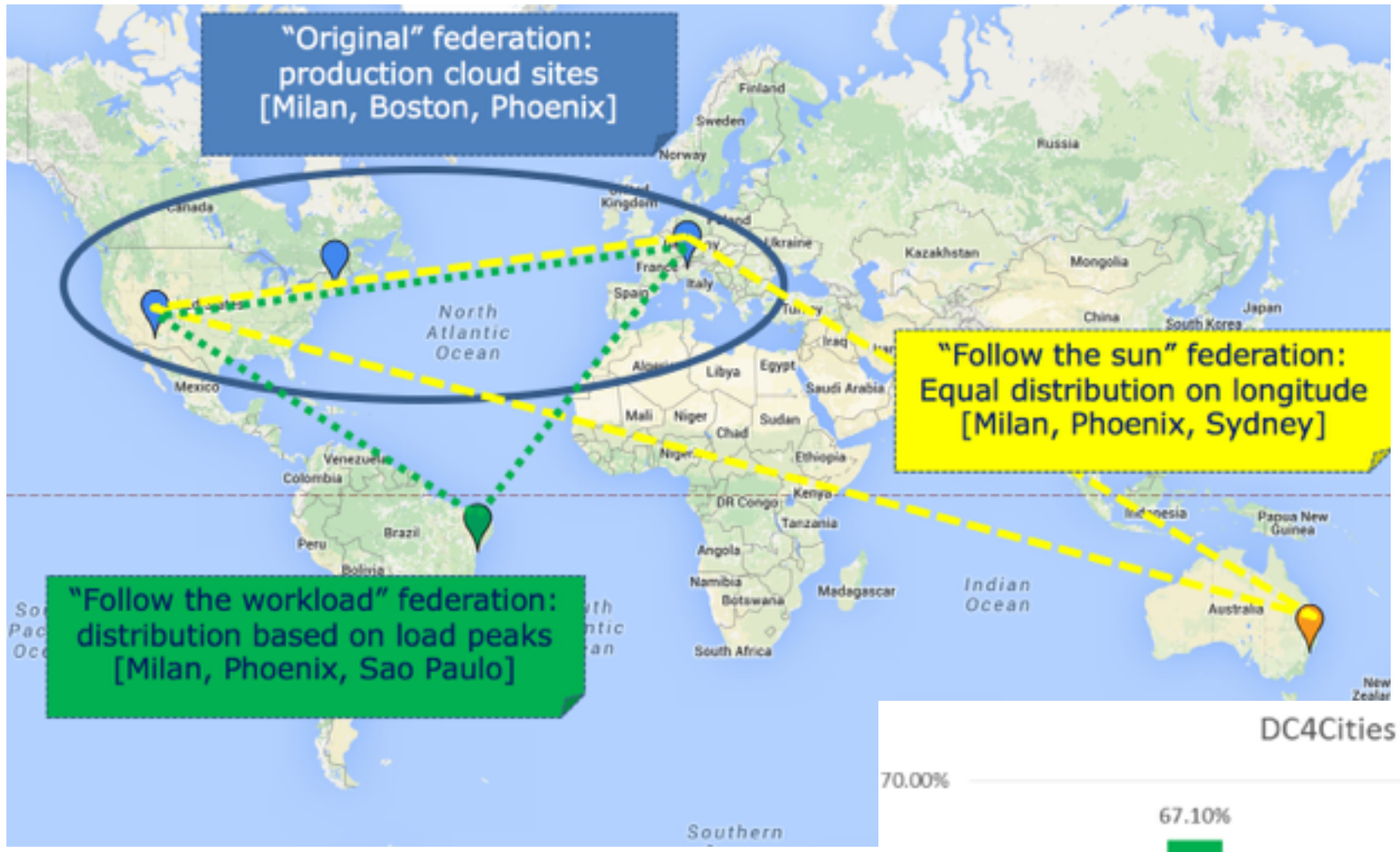
sensitivity analysis

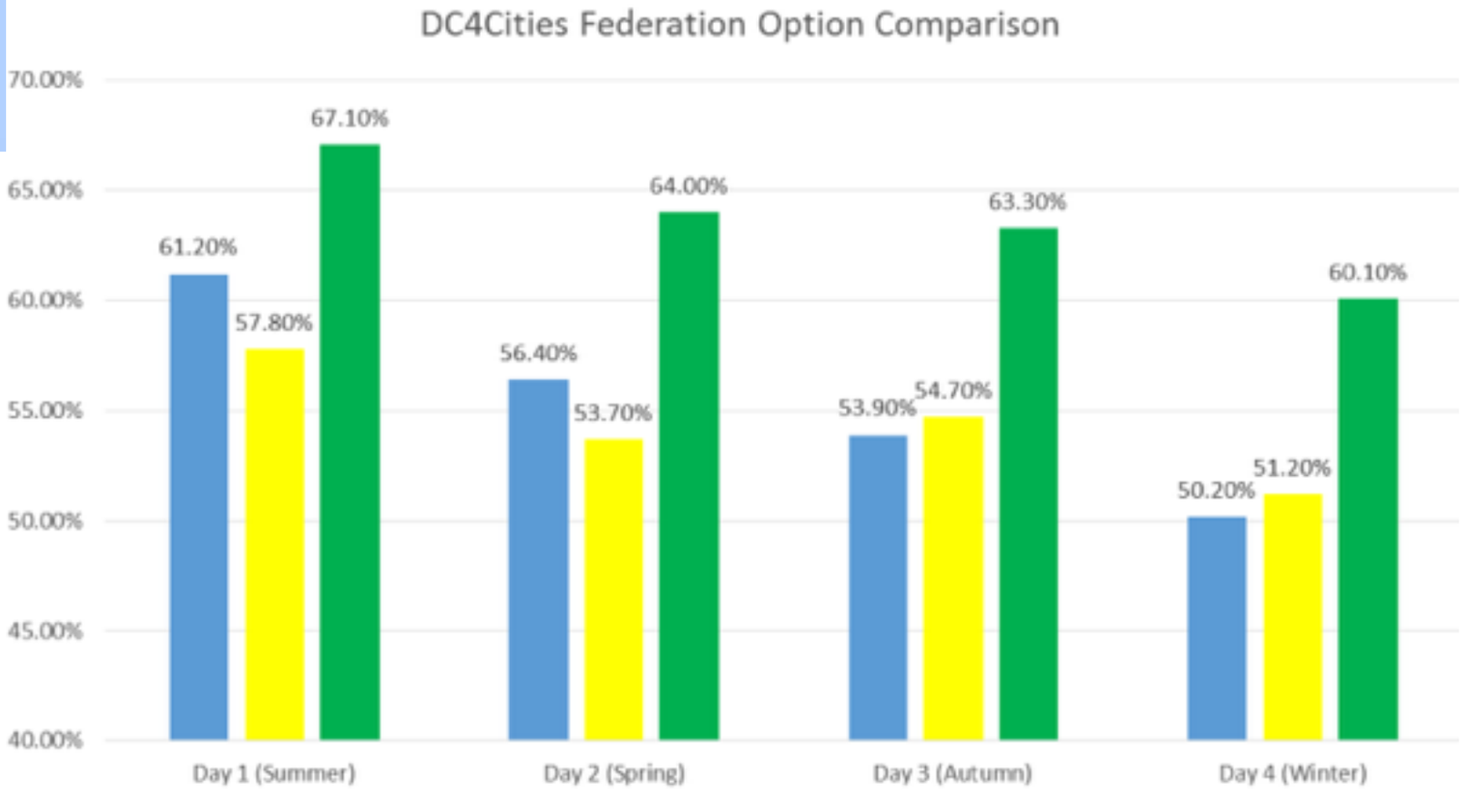
smart city authority penalties

SLOs



seeking for installation sites





Lesson learned

adaptation requires flexibility at every level
    from hardware to SLOs

workload affinity is a thing

mixing economy and sustainability makes sense (to me)
    good pricing value as a consecutive challenge
    does the energy cost really drive everyone ?

http://www.dc4cities.eu