Guidelines for Eco-friendly Data Centres

Lessons learnt in three European Research Projects on Data Centres Energy Savings

Lessons learnt in three European Research Projects on Data Centres Energy Savings

Virtual Machine Dynamic Consolidation and Turn off Servers

Green Service Level Agreements

Adapt to Renewable Energy Availability

Parasol

HP Labs NetZero

FIT 4 GREEN

All4green

DC4Cities

Jan 2010 - Jun 2012

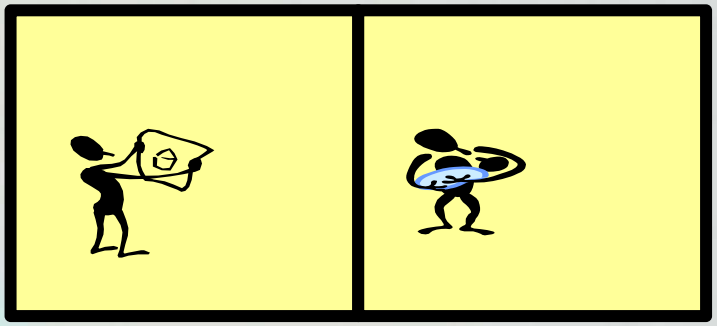
Nov 2011 - Apr 2014

Sep 2013 - Feb 2016

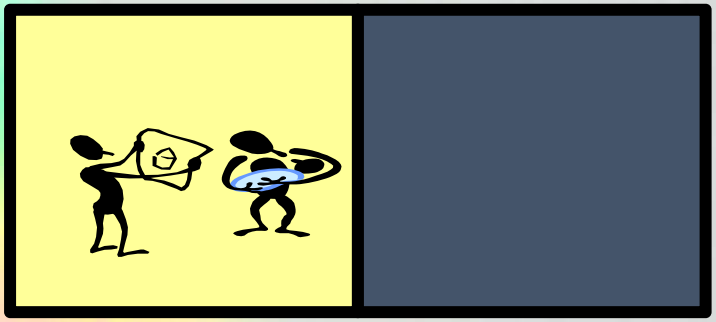
Home Lights vs. Computers and DCs

How could you save energy at home?

- By shifting activities that do not interfere with each other to the same room and switch off unused electrical consumers in the other rooms



- By moving activities to rooms with more energy efficient light bulbs or other more efficient electrical devices that suffice the needs



Energy Saving in Data Centres: FIT4Green Project Overview

FIT4Green - Federated IT for sustainable environmental impact

FP7 Call 4, Objective ICT-2009.6.3.c: ICT for Energy Efficiency - ICT services and software tools enhanced with energy features.

ABSTRACT

FIT4Green aims at contributing to ICT energy reducing efforts by creating an energy-aware layer of plug-ins for data centre management and automation systems. The plug-ins enhance existing ICT solutions deployment strategies by moving computation and services around a federation of ICT data centre sites, with the final goal to minimize the overall power consumption figure.

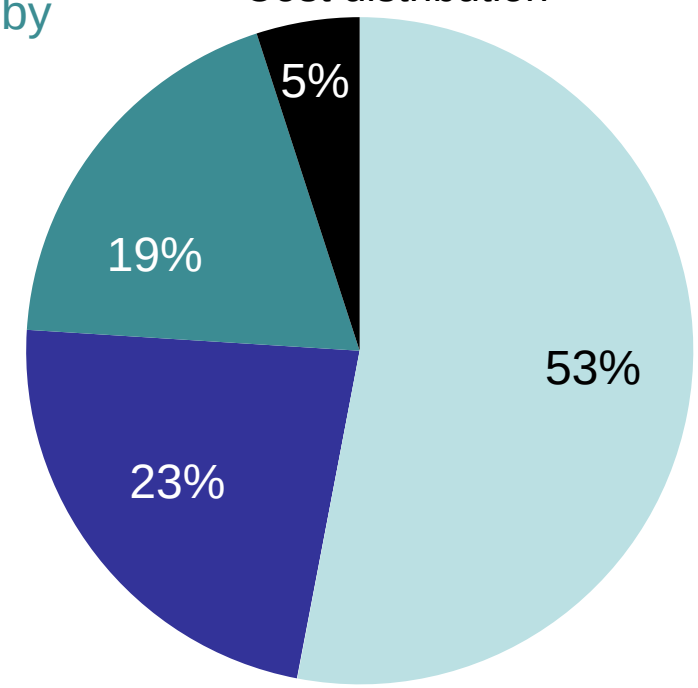
PARTNERS

GFI, hp, eni, almende, VTT, JÜLICH Forschungszentrum, Imperial College London, Universität Passau, Universität Mannheim, CREATE-NET

Influenced by FIT4Green

Src: J.Hamilton, CIDR 2009

Cost distribution



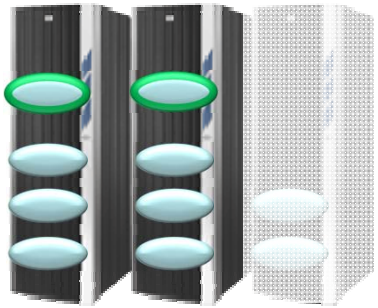
-20%

direct saving in servers and network devices energy consumption

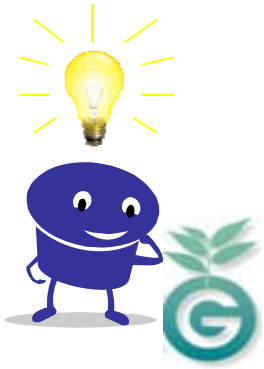
- Servers costs
- Power for Cooling and UPS
- Power for IT
- Other Infrastructure

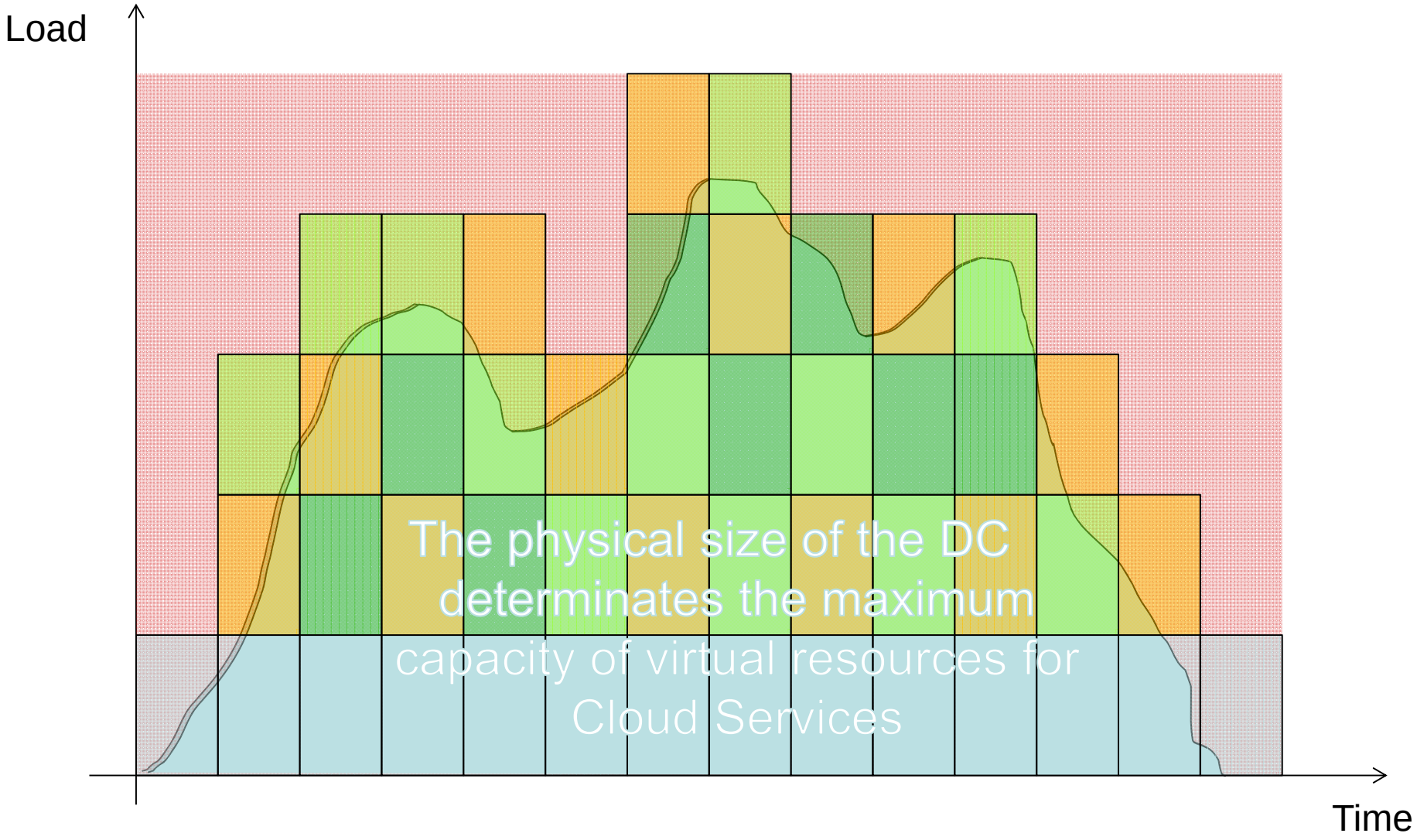
General Strategies applied in a FIT4Green Cloud

- VMs are consolidated and unused servers are turned off

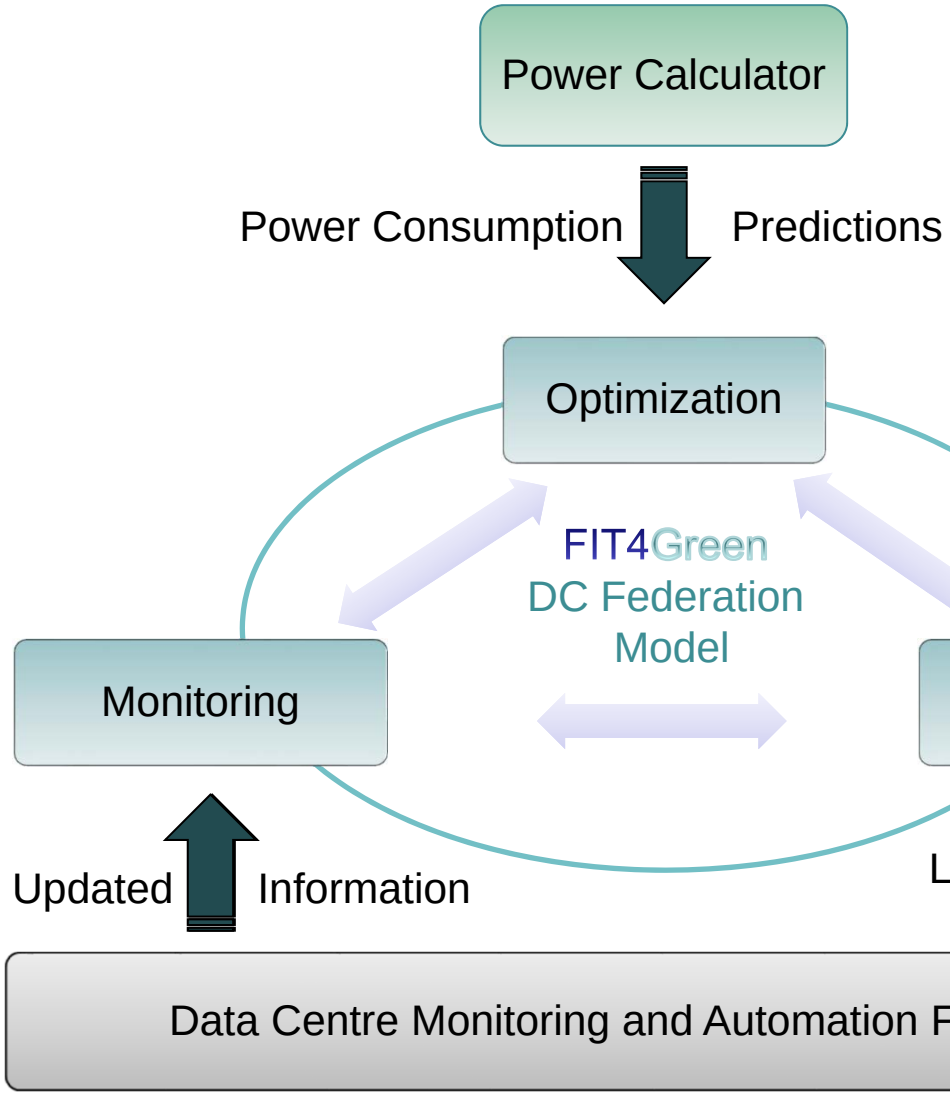


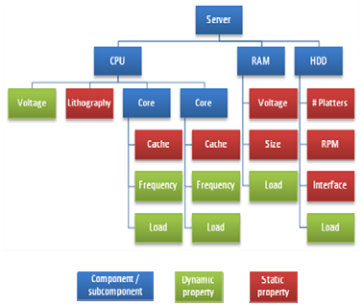
- VMs are allocated to "more efficient" servers/data centres: incremental "cost" considered.




Load
The physical size of the DC determinates the maximum capacity of virtual resources for Cloud Services
Time

FIT4Green "High Level View"





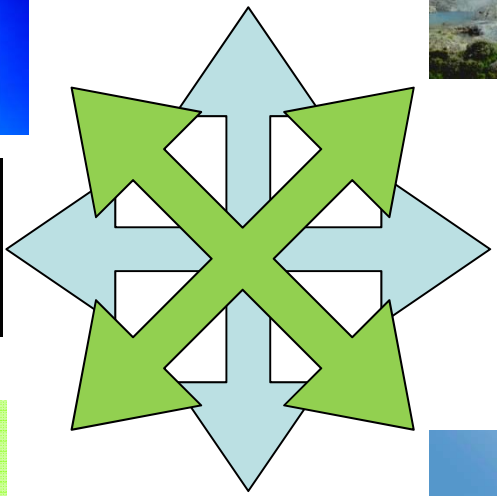
FIT4Green Federation-Enabled Optimizations

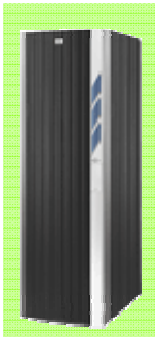
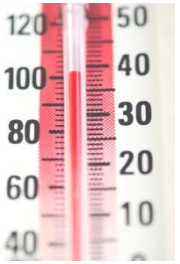
“Federation” policies seek to:

- ✓ Relocate VMs to capitalize on geographical characteristics like:
  - ✓ Season &Temperature differences
  - ✓ Time-zone differences – ‘Follow the Sun’
  - ✓ Energy source differences
- ✓ Relocate VMs to capitalize on data centres characteristics like:
  - ✓ Equipment & Infrastructure differences
  - ✓ PUE & CUE differences
  - ✓ Cogeneration options








All strategies are ranked through their Energy KPIs.

FIT4Green 2nd trial tests numeric results

Numeric results	Single site tests	Federated site tests
Traditional/Cloud DC ENI (Italy)	Around 30%	From 28% to 50%
Supercomputing DC Jülich FZ (Germany)	From 4% to 28%	From 30% to 51%
Cloud computing DC HP (Italy)	From 10% to 24%	From 17% to 21%

[Results may vary depending on the test environment]

Refrigerators vs. Computers and DCs

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UK world sport football opinion culture business lifestyle fashion environment tech travel all

home › environment › energy pollution climate change wildlife

Energy efficiency

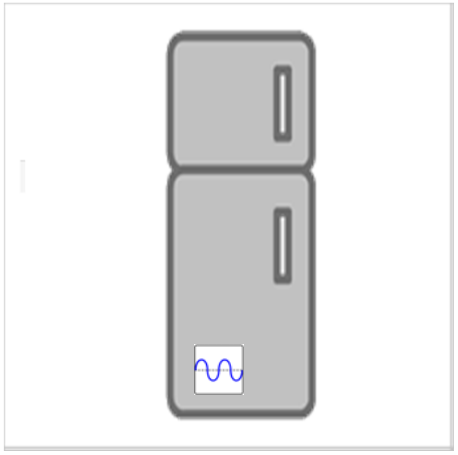
UK set to trial 'smart fridges'

Widespread use of dynamic demand fridges could save 2m tonnes of CO2 a year, according to a report out today

Jo Adetunji
Tuesday 2 December 2008 10.30 GMT

Save for later Shares 0

This article is 7 years old



Three thousand "intelligent" refrigerators, which will adapt their power use to the ebb and flow of demands on the national electricity grid, are to be given away in a trial by the UK government next year.

[...]

He added: "An algorithm device sits in th[illegible] monitors grid frequency and if the grid frequency goes up or dow[illegible]t adjusts energy [illegible]e within safe parameters.

[...]

RLtec estimates that large numbers of appliances running with dynamic demand technology would create a "virtual power station" that could displace coal-fired generators. For example, fitting all the fridges in the UK with dynamic demand technology would allow the decommissioning o[illegible] a 750-megawatt [illegible]ack-up" power station

ALL4GREEN: ACTIVE COLLABORATION IN DATA CENTRE ECOSYSTEM TO REDUCE ENERGY CONSUMPTION AND GHG EMISSIONS

All4Green: what and who

All4Green - Active collaboration in data centre ecosystem to reduce energy consumption and GHG emissions

FP7 Call 7, Objective ICT-2011.6.2: ICT systems for energy efficiency

Tools to optimize energy performance for planning, systems development and operation

Abstract

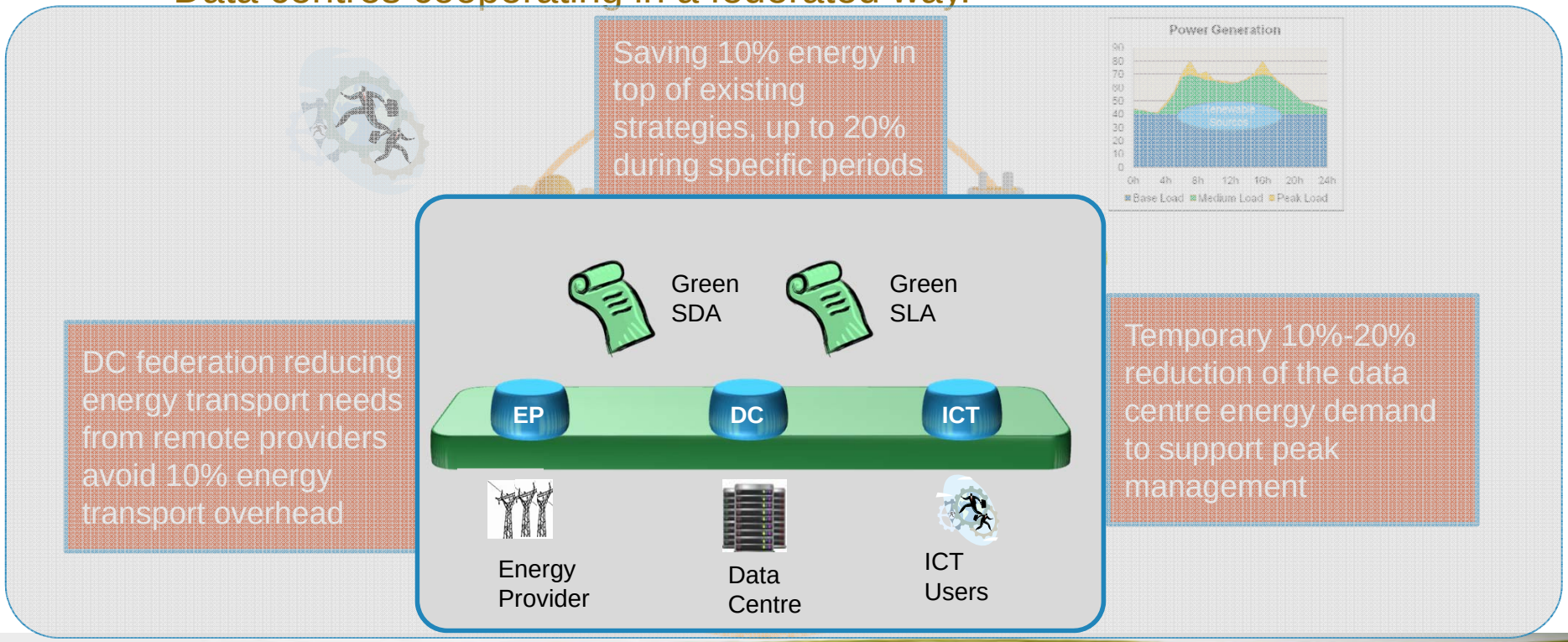
http://www.all4green-project.eu

All4Green aims at contributing to ICT energy reducing efforts by creating an energy-aware ecosystem where the active collaboration between Energy Providers, Data Centres and their customers allows to save energy and emissions. Energy savings generated in the Data Centre through the new relation with ICT users are magnified at the source of the electricity transformation process and become economically sustainable, and therefore not limited to customers with a strong ecological conscience

Partners

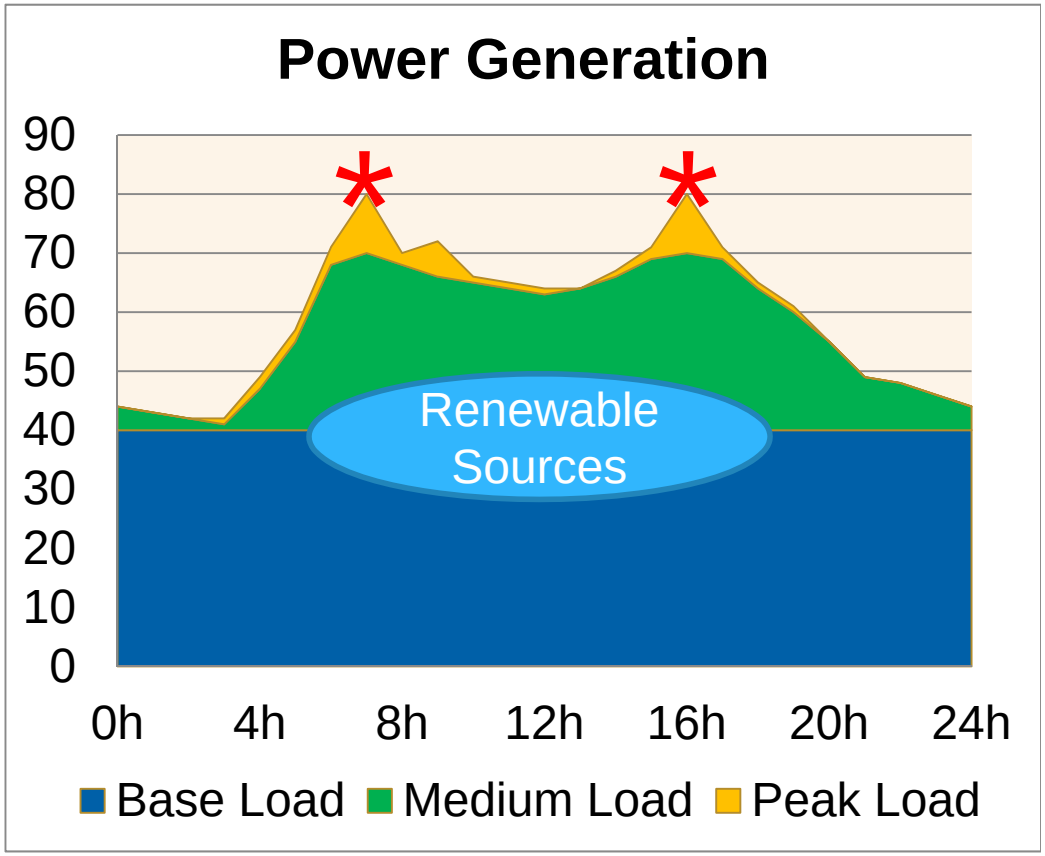
Project and Goals

- ***All4Green*: Full ecosystem in which DCs operate**
- **Collaboration between all entities of this ecosystem with the common goal of saving energy**
  - ICT users deploying services in the data centre,
  - Electrical power providers,
  - Data centres cooperating in a federated way.



Background Information

- **Base load power plant**:
  - Cheap generation of energy
  - Responsiveness to changes in load is low
- **Medium load power plant:**
  - Medium cost for energy generation
  - Responsiveness to changes in load is moderate
- **Peaking power plant:**
  - Generation of energy is **very** expensive
  - Highly responsive to changes in load



The contribution of renewable energies is not constant (but somehow predictable) and might be difficult to control.

All4Green Philosophy: 3S

SHARE

SHAPE

SAVE

SHARE

SHAPE

SAVE

Traditional vs. Green SLAs

Traditional SLAs

- **Fixed** Guarantee terms; e.g.
  - Performance = X
  - Redundancy = Y
  - Backup frequency = Z
- **No Green**/Energy KPI
- DC/Customer **Separation**

Green SLAs

- **Flexible** Guarantee terms: time/ calendar/ context dependencies; e.g.
  - **Perf @Day**=X1 **@Night**=X2
  - **Redund @week**=Y1 **@w-end**=Y2
  - **Backup @REG**=Z1 **@ES**=Z2
- **Green**/Energy KPIs, e.g.
  - **Emissions@** < 200gCO2/MWh
  - **Energy@** < 120 Wh/server
- DC/Customer **Collaboration**
  - **@ES**: request PAUSE VM

GreenSDA & GreenSLA

Regulated by:
GreenSDA

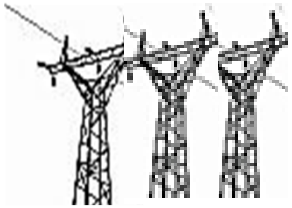
{ Flexibility
GreenKPIs
Collaboration }

Regulated by:
GreenSLA

Reduce Energy Consumption

Pause Virtual Machines

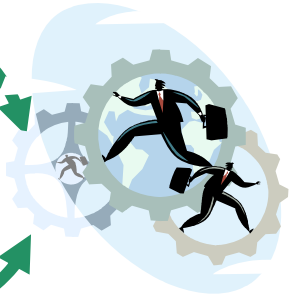
deficit



surplus

Collaboration
Negotiation
Compensation

Collaboration
Negotiation
Compensation



EP

Consume Extra Green Energy

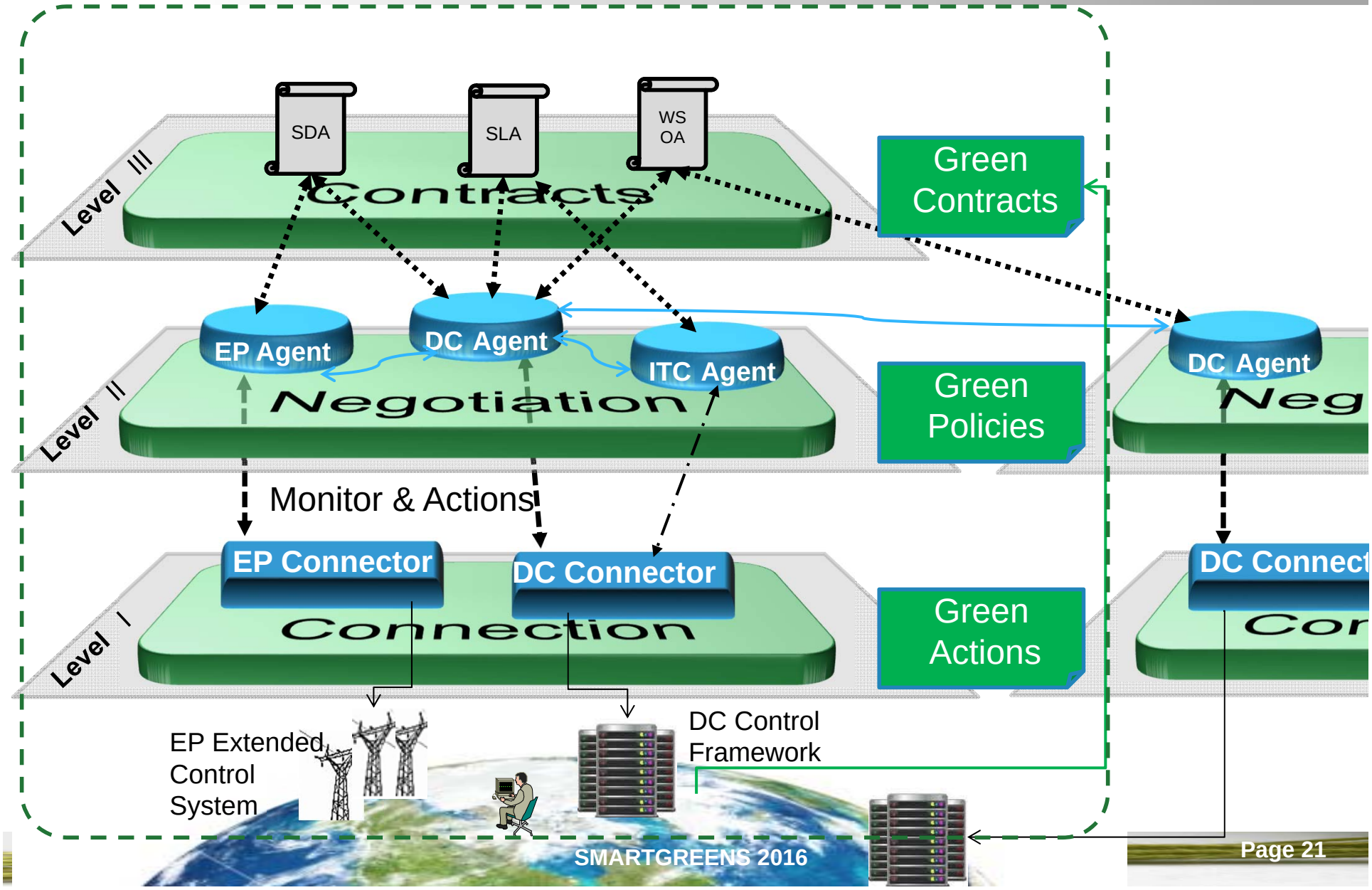
DC

Start Delayed jobs

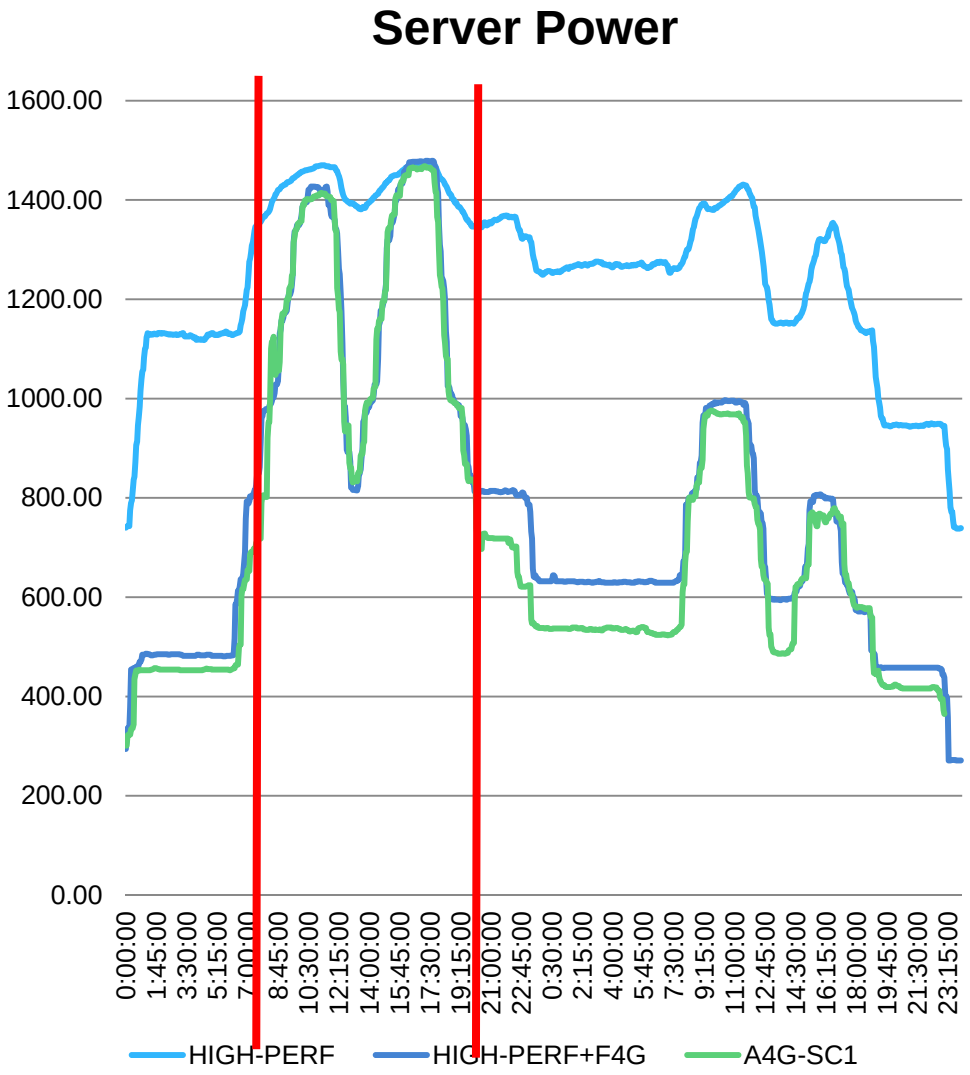
ITC

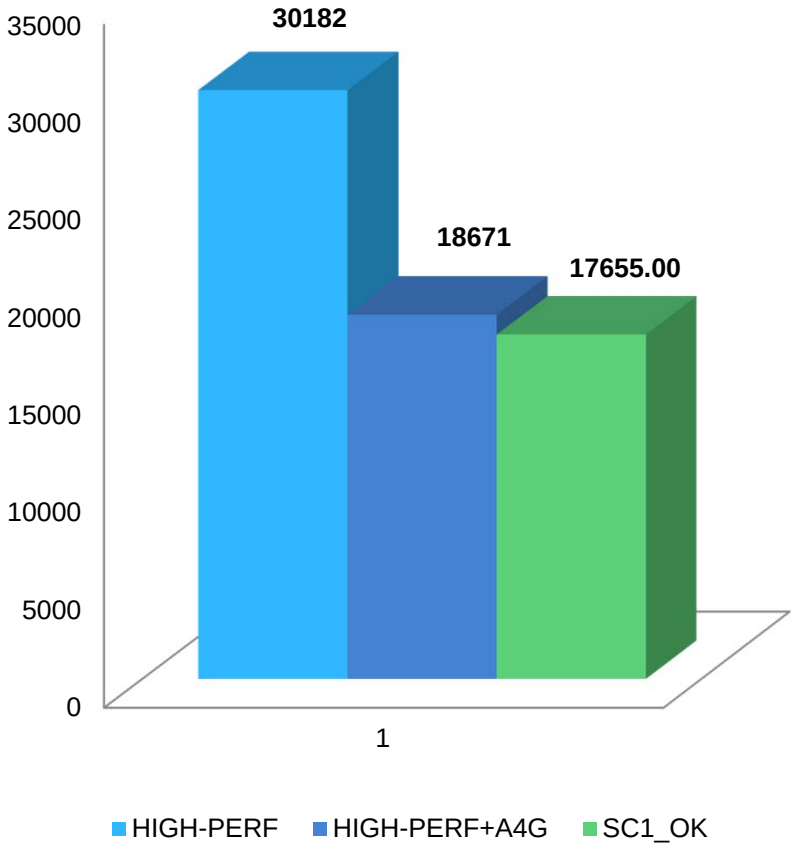
The compensation is related to cooperative attitude and the "real value" of the received "*help*"

All4Green Multi-level Architecture

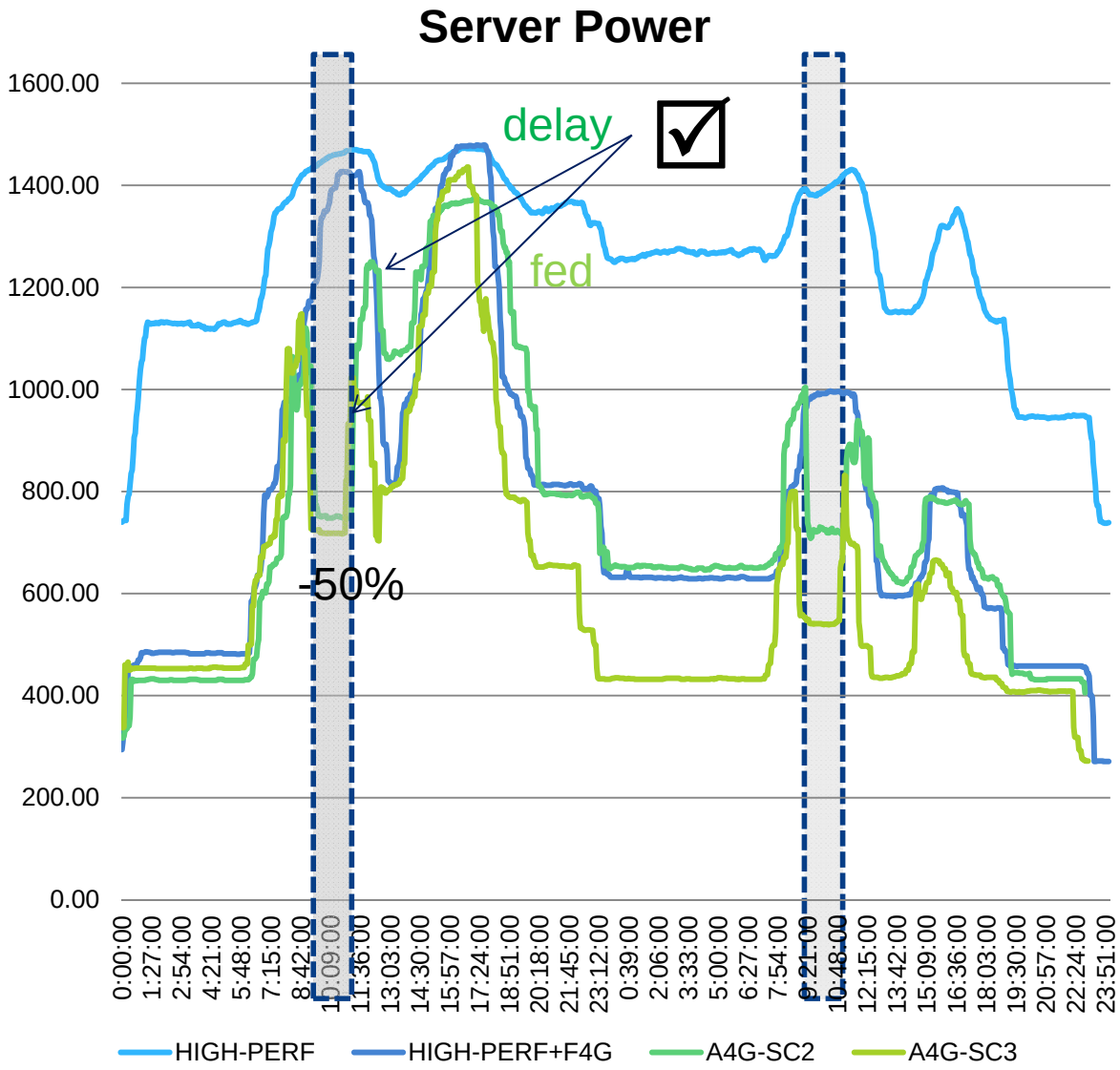


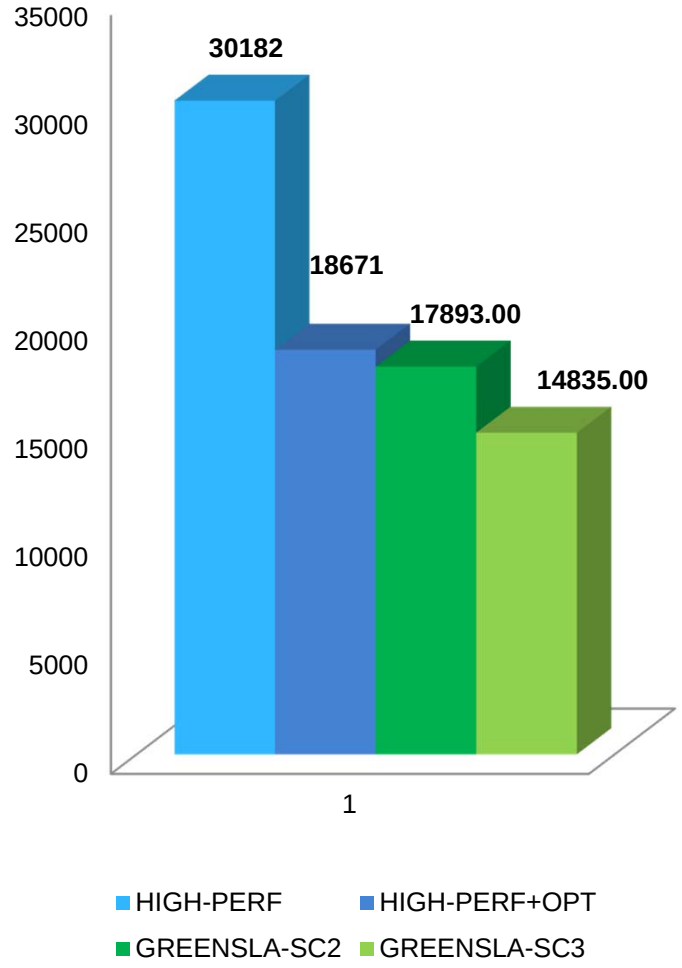
Green SLAs Effects





“Adaptation” Requests Effects





Cars vs. Computers and DCs

SPEED
Km/h
Miles/h

POWER
HPs

AERODYNAMICS
C_d
C_x

FUEL
CONSUMPTION
Km/Litre
Miles/Gallon

EMISSIONS
gCO2/Km
gCO2/Mile

Hybrid
Power

EV
batteries
recharge

1970 1980 1990 2000 2010 2020

CPU SPEED
Mips
MHz

DC LOGISTICS
PUE, CUE, WUE

ENERGY/EMISSIONS
CONSUMPTION
DC work/Wh
gCO2/**DC work**

DC4Cities: an innovative approach for efficient and environmentally sustainable Data Centre for Smart Cities

DC4Cities Project and Partners

DC4Cities:
an environmentally sustainable data centre for Smart Cities

FP7-SMARTCITIES-2013 (ICT Call) Objective ICT-2013.6.2
Data Centres in an energy-efficient and environmentally friendly Internet

Certain Services require DCs to be close to users

Smart Cities require Services, hosted by DCs

Smart Cities need Eco-friendly DCs

Europe needs new metrics for DC energy efficiency

UNIVERSITY OF MANNHEIM
Freemind Stay in Control
Hewlett Packard Enterprise
Ajuntament de Barcelona Institut Municipal d'Informàtica
UNIVERSITÄT PASSAU
CREATE-NET
CSUC
gasNatural fenosa
ENEA
informatiques mathématiques Inria

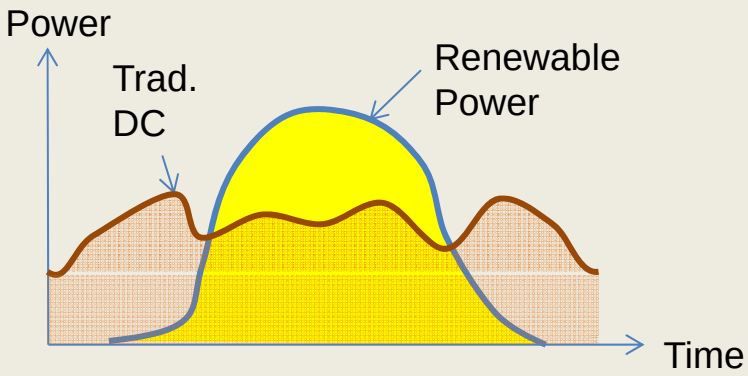
DC4Cities Concept

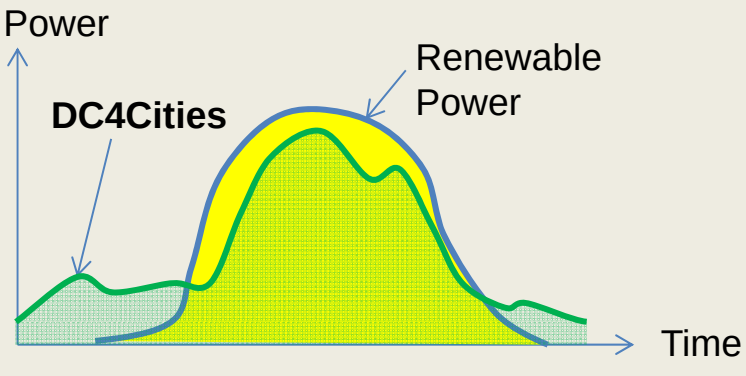
DC4Cities: let DCs become energy adaptive

Eco-friendly DC energy policies needs to be capable of

adapting the power consumption to the availability of renewable energy

being adapted to the requests received by the Smart City Energy Management authority





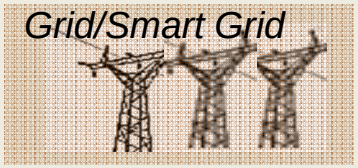
50% DC **not using** Renewable Power

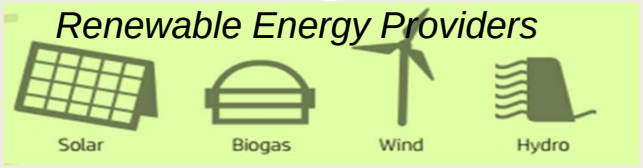
50% DC **using** Renewable Power

20% DC **not using** Renewable Power

80% DC **using** Renewable Power

DC4Cities Overview

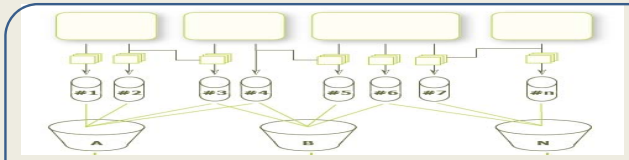




Renewable Energy Adaptive Interface

Data Centre Energy Controller

Energy Adaptive Data Centre Operation Interface



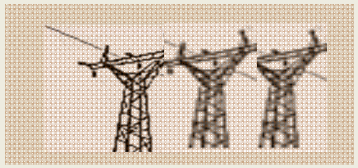
User and Admin Task Scheduling

Infrastructure Mgmt

Energy Adaptive SW

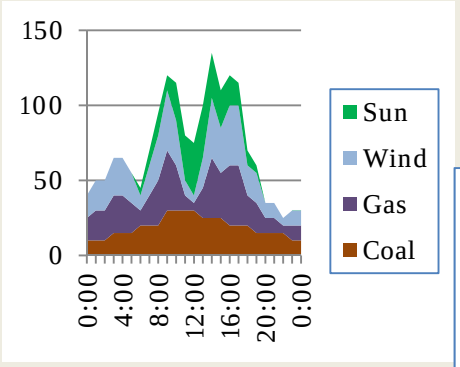
DC4Cities Overview (North)

Grid/Smart Grid



Renewable Energy Providers

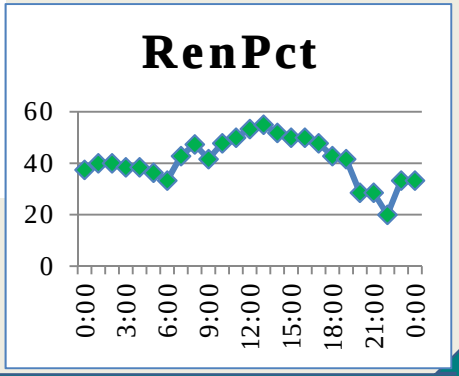
Smart City Control

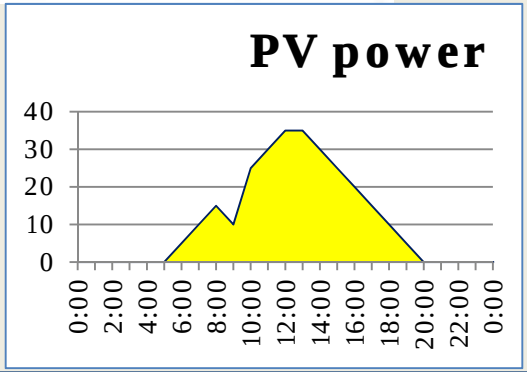


Energy Availability Forecast

Weather Forecast

Power/ Energy Goals



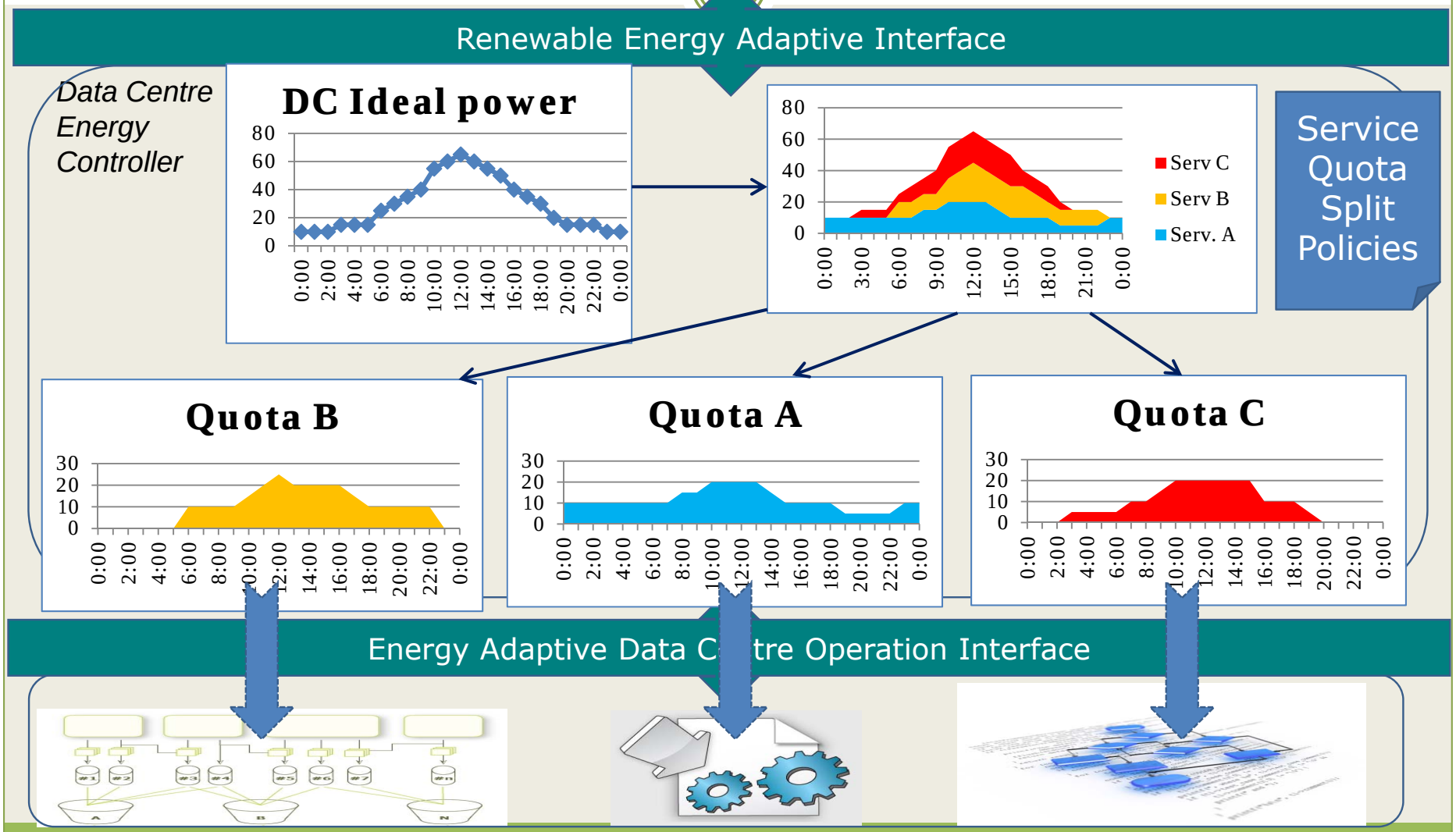


80 % Ren

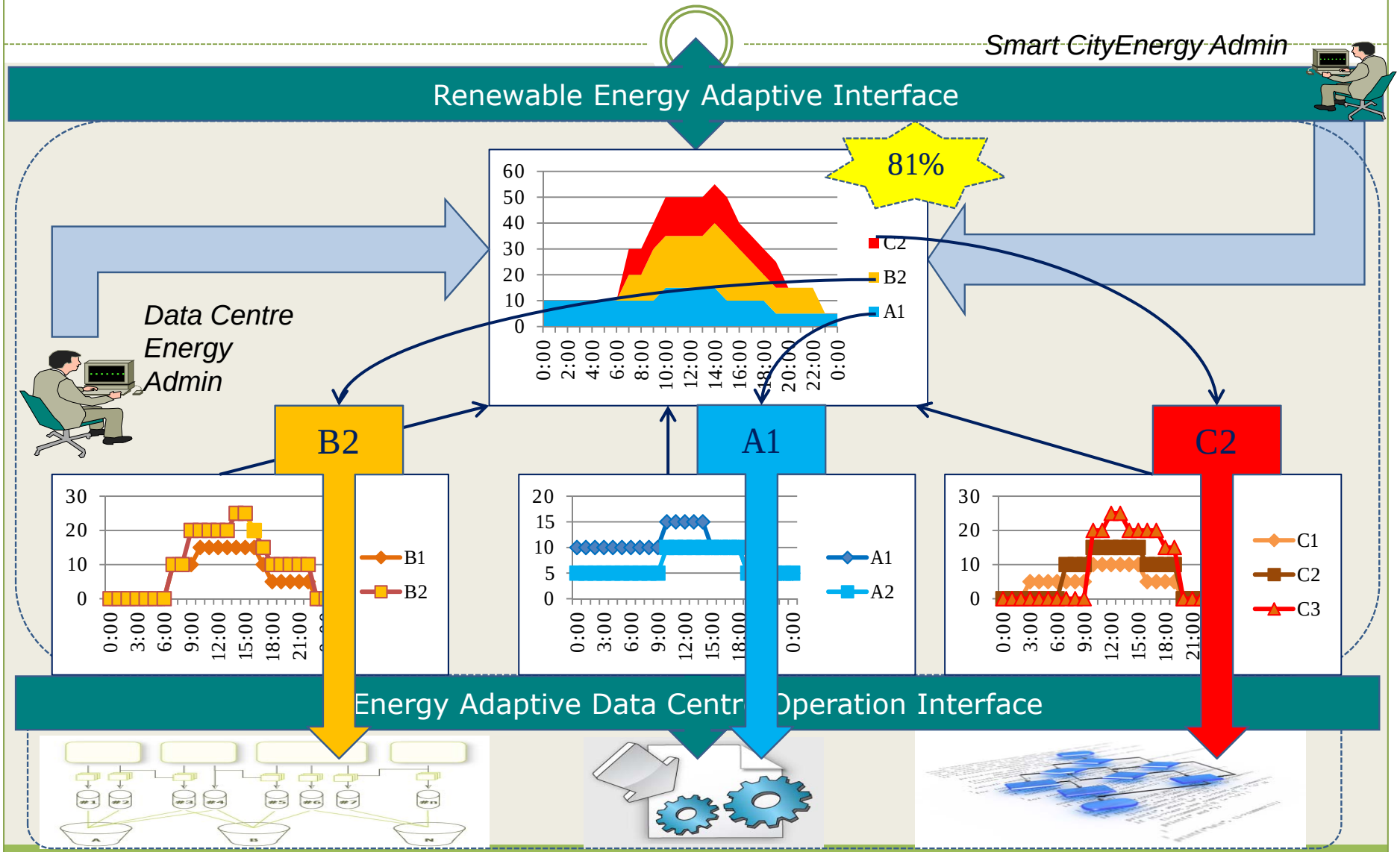
Renewable Energy Adaptive Interface

Data Centre Energy Controller

DC4Cities Overview (Control)



DC4Cities Overview(Control/S)



Optimizer "global" view

DC4Cities OPTIMIZER Target:
Maximize DC Profit

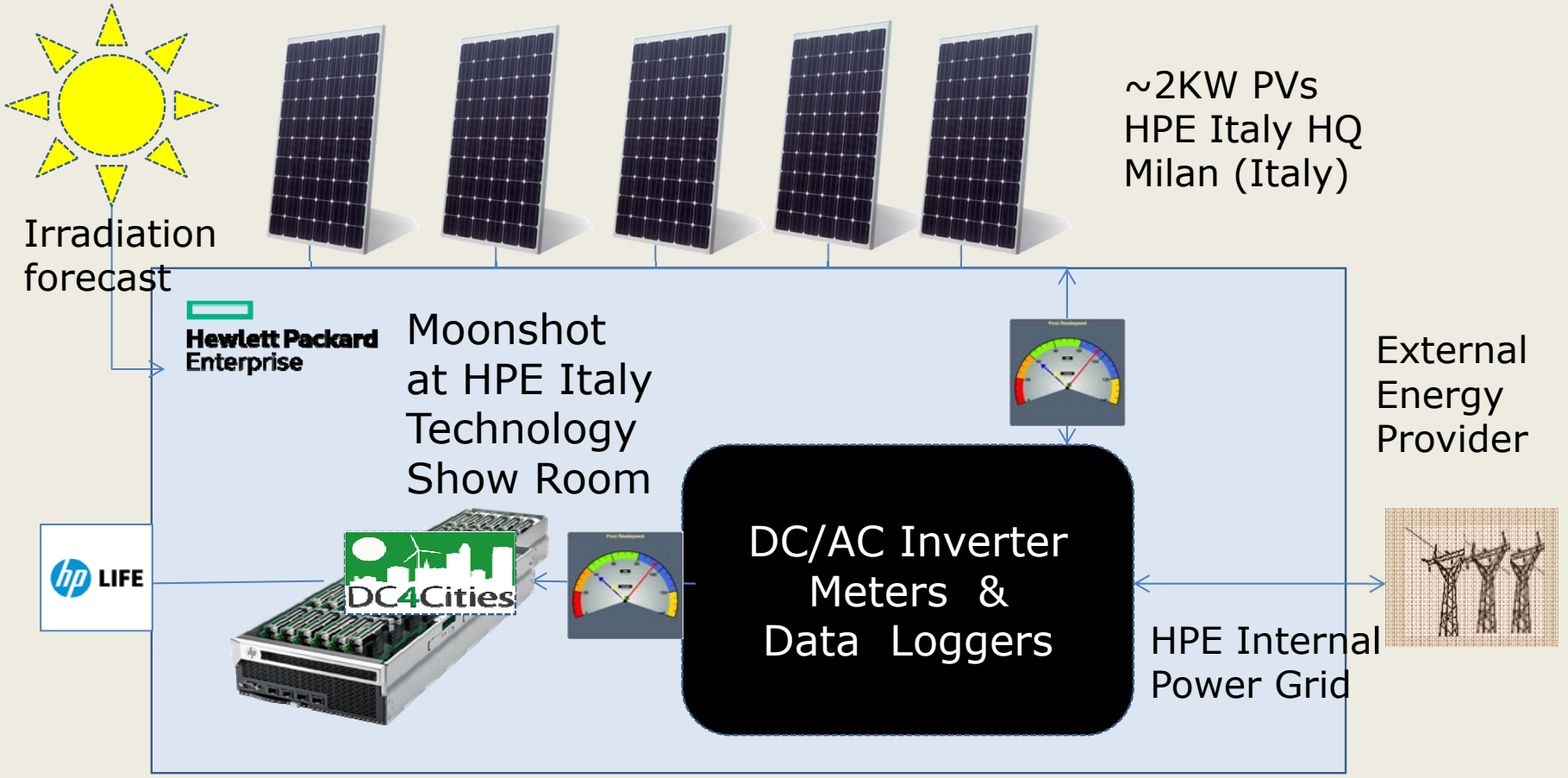
DC Profit =
+ Services selling prices
- Services SLA penalties
- Smart City Energy penalties
- Energy costs

"The current driver for green technology is to save money through optimizing energy use, rather than a desire to be seen to be green." **[Computer Weekly, February 25th, 2013]**

DC4Cities RenPercent Goal

HPE "Solar Lab"

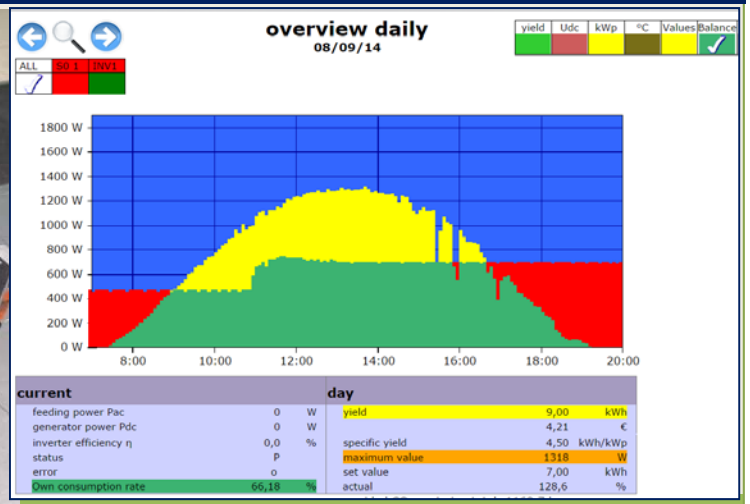
Experiment = limited scope (Rack - not DC & No Real Smart City) but Real PVs



HPE "Solar Lab"

avoided CO_2-emission total: 1554 kg (March 18th 2014 – March 17th 2015)

HPE Moonshot



HPE Moonshot

- HPE Moonshot modern server architecture with low power consumption
  - Radically new system design with 1,000's of servers per rack—significantly lowering complexity and TCO
  - Application-tuned configurations delivering best-of-breed performance per watt

ILO with power meter for chassis, network switches and for each one of the cartridges (up to 45)

www.hp.com full web site
From
- **46 Legacy servers**
- **115k Watts**

To
- **6 Moonshot systems**
- **6k watts**

300M
hits per day

100%
www.hp.com

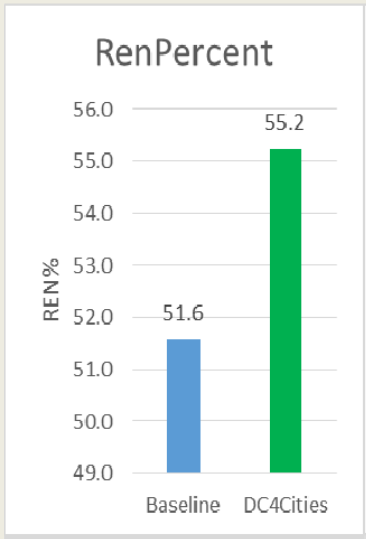
100%
ftp.hp.com

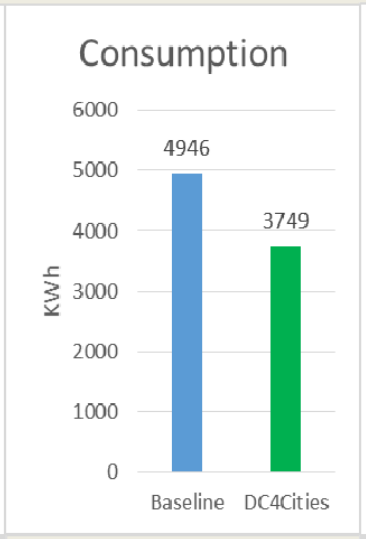
89%
Less space

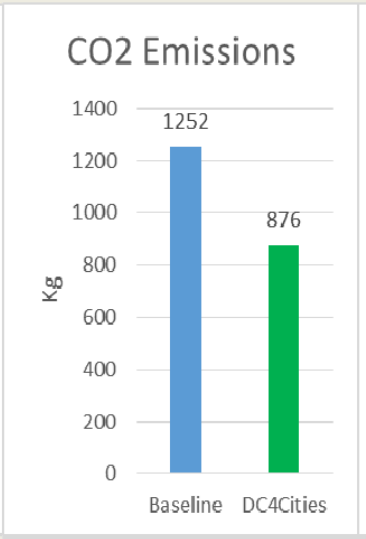
94%
Less power

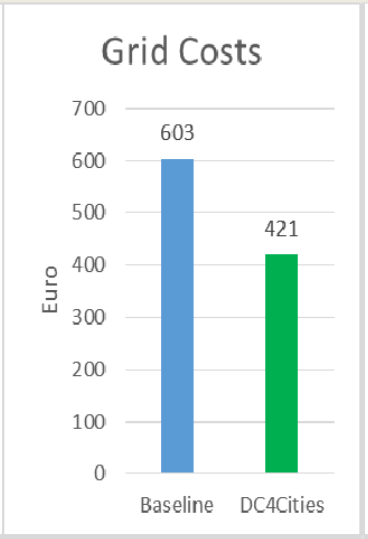
(1)

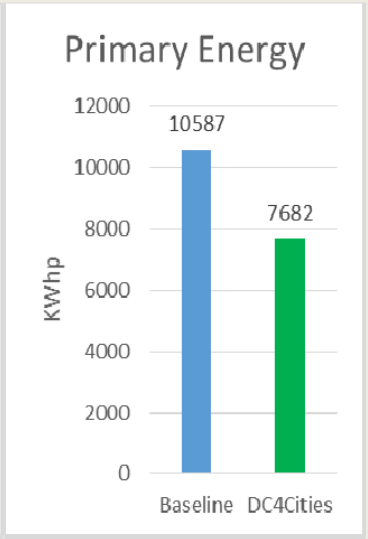
Yearly Extrapolation







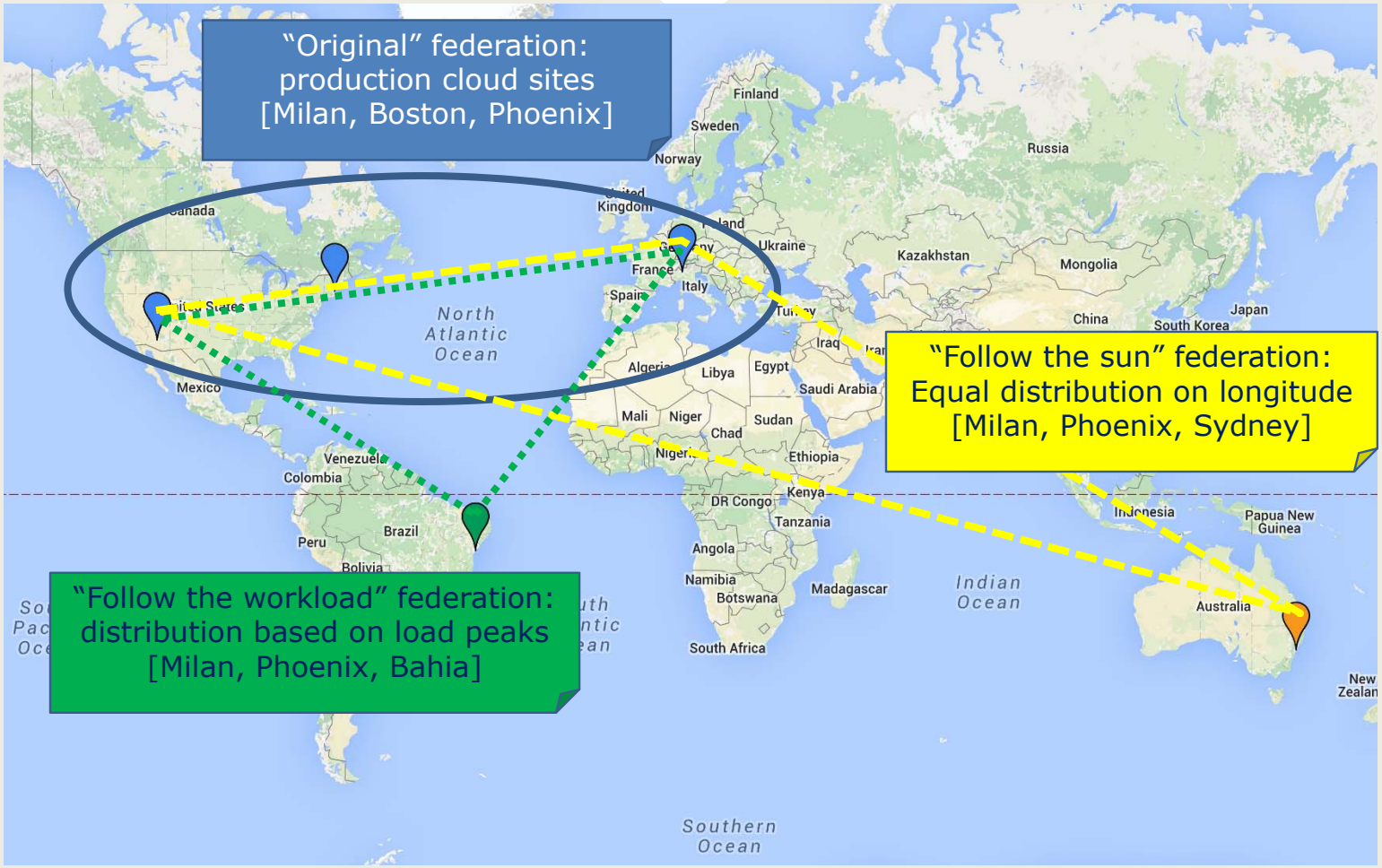




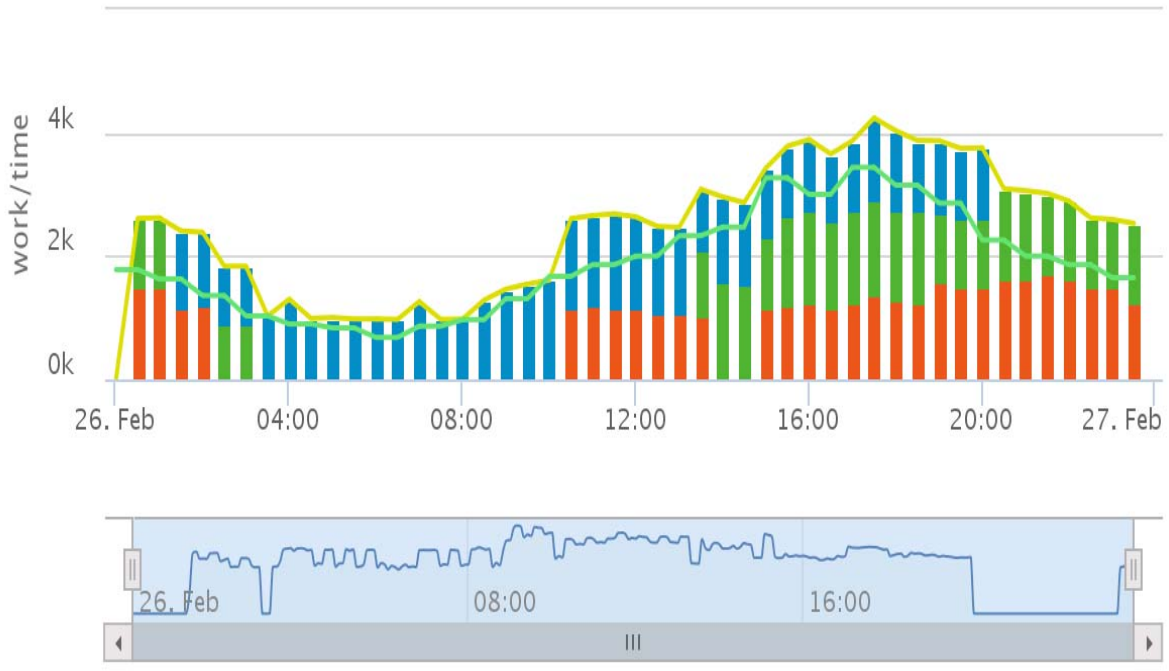
Δ 3.66 p%	Δ 1197 KWh	Δ 376 Kg	Δ 182 Euro	Δ 2096 KWhp
+7.1%	**-24.2%**	**-30.0%**	**-30.2%**	**-27.4%**

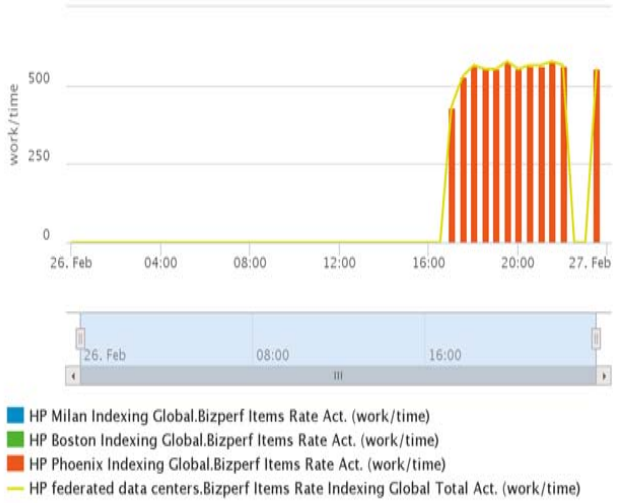
Savings ONLY due to DC4Cities optimizations for the infrastructure of trial application (HP LIFE)

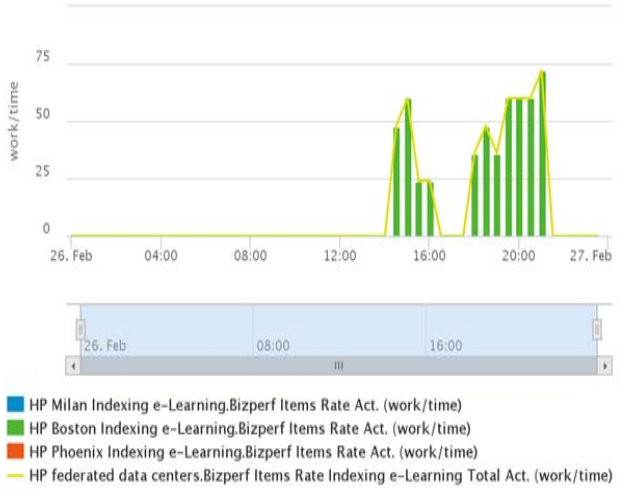
Federation Options



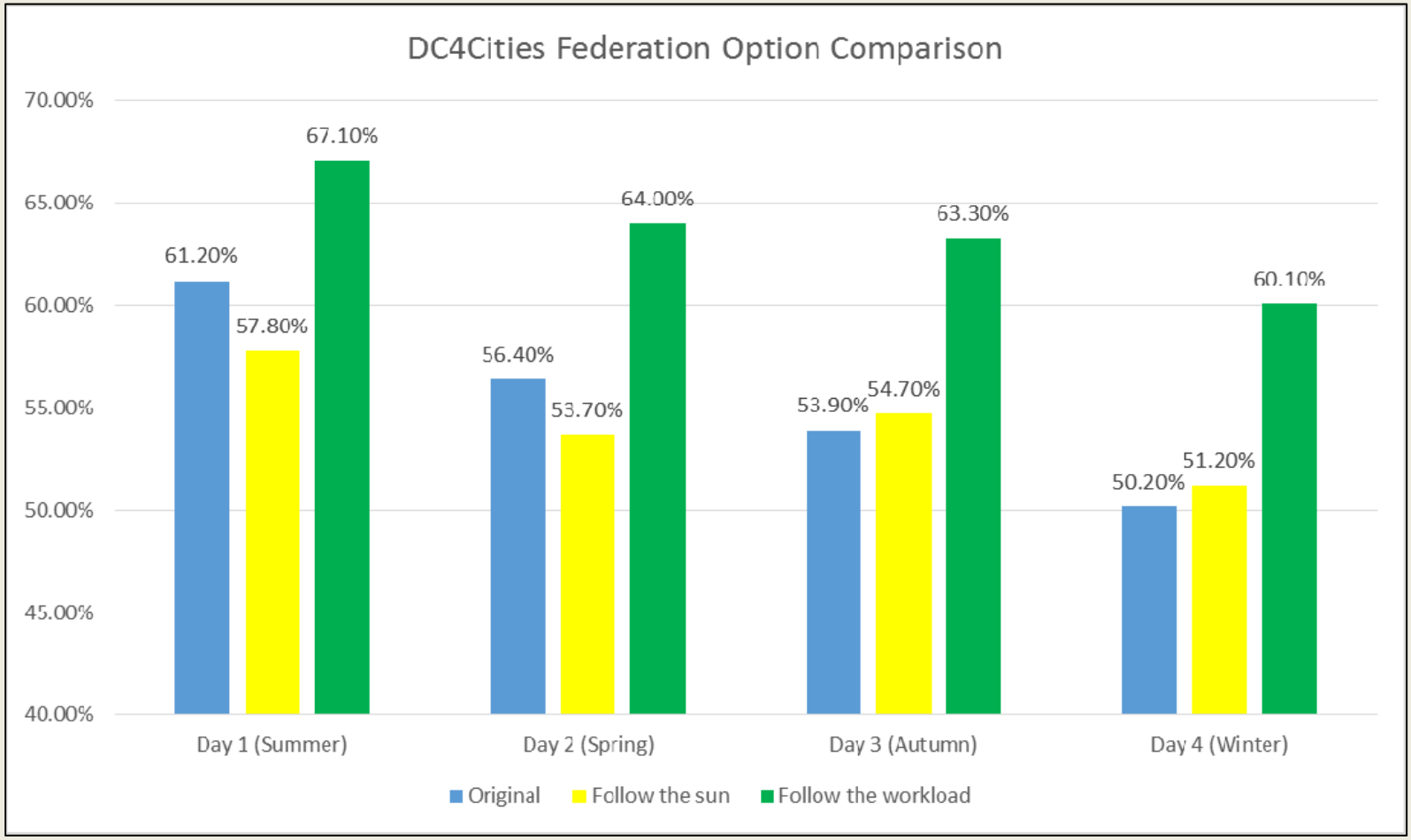
Federated Sites: workload distribution



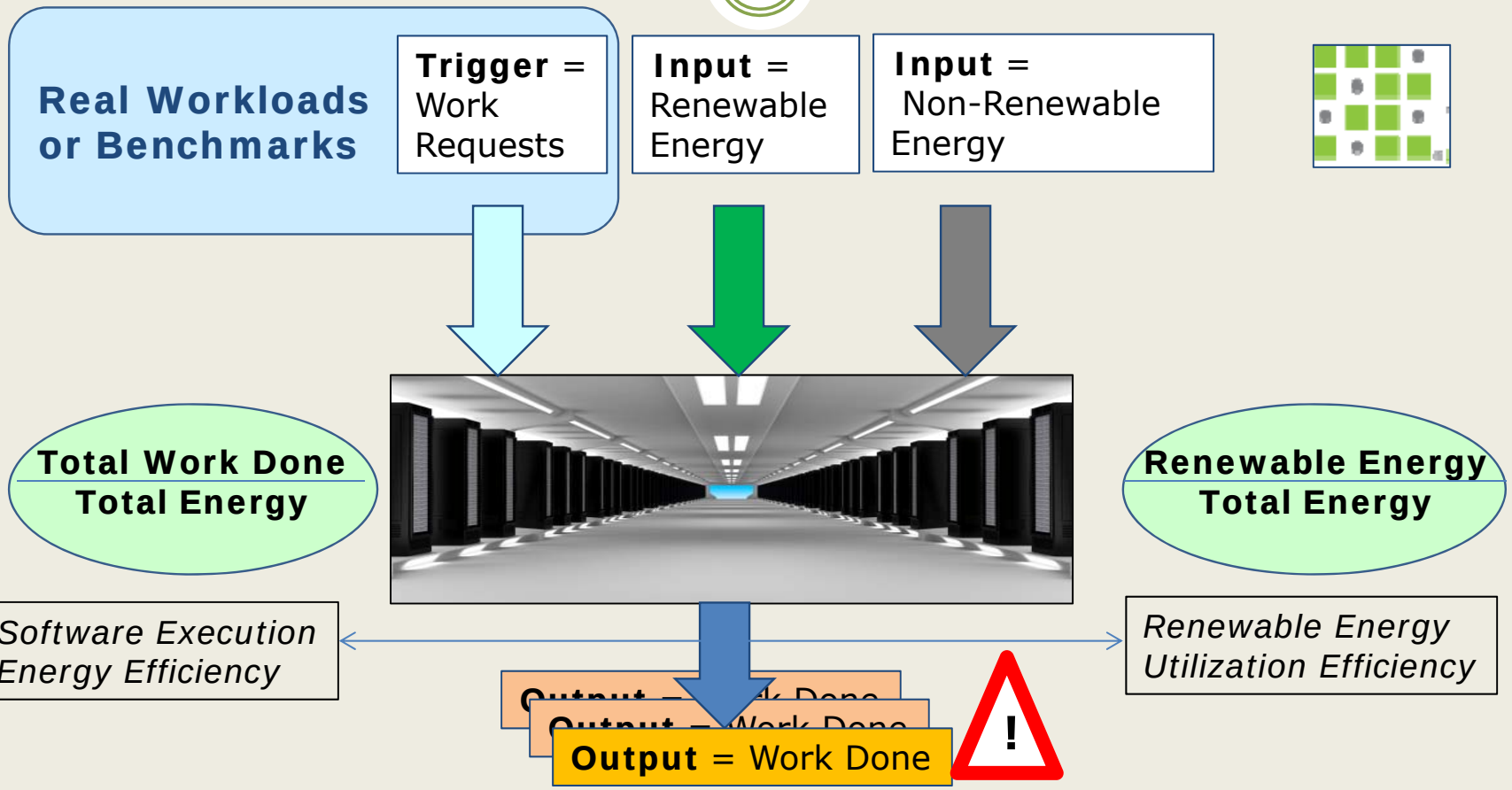




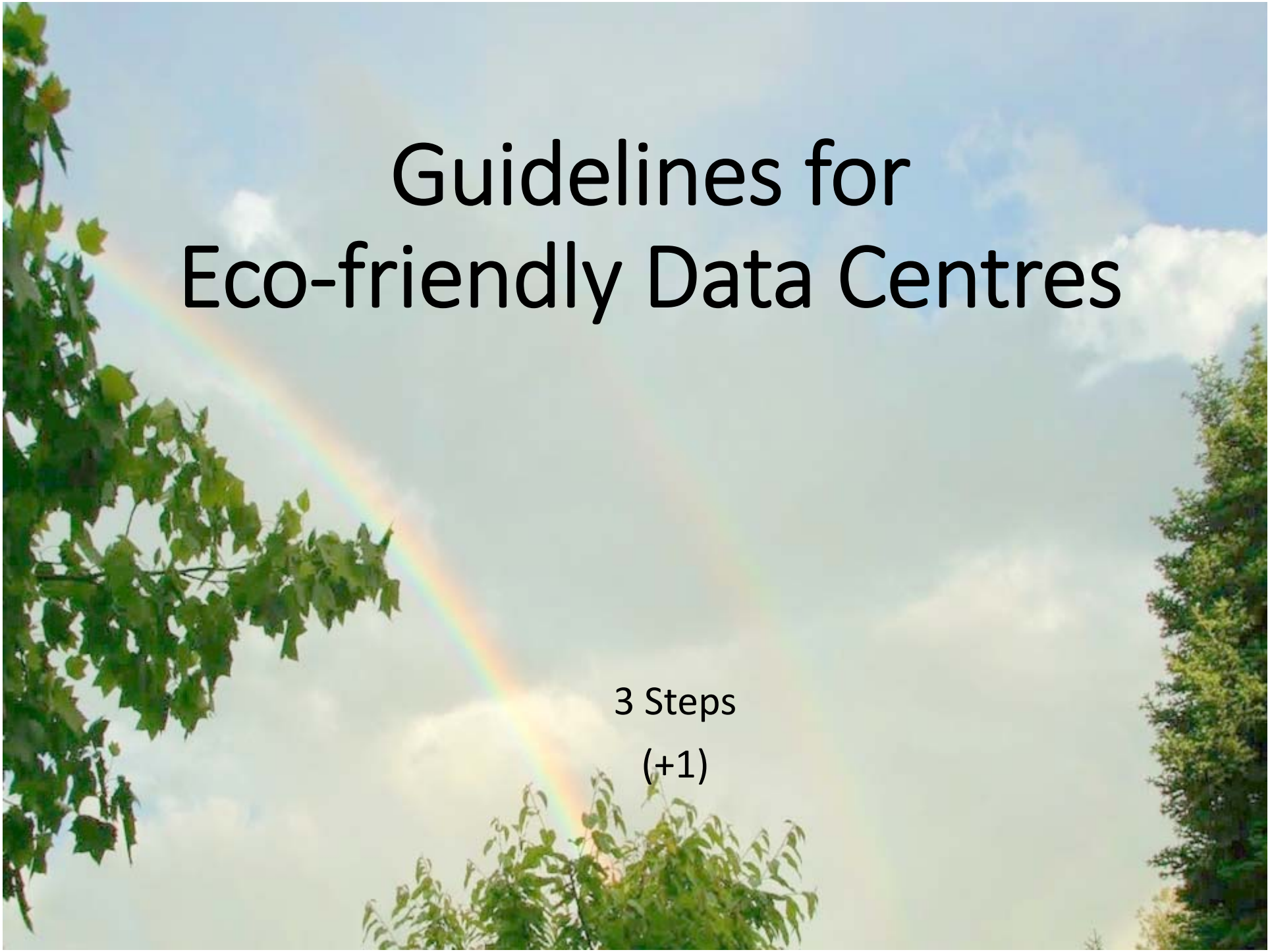
Federation Options Simulation Results



Proposal for New Metrics



In addition to Collaboration inside EU Project Cluster for common standardization proposal to CEN-CENELEC-ETSI Coordination Group on Green Data Centres



Guidelines for Eco-friendly Data Centres

3 Steps

(+1)

Quotes from analysts on Datacenter Energy Efficiency

"The current driver for green technology is to save money through optimizing energy use, rather than a desire to be seen to be green."

ComputerWeekly **February 25th, 2013**

"Green datacenter market will grow nearly 28% every year for the next four years, up to 45.4 bn $ in 2016 "

PikeResearch **2013**

Quotes from Data Center owners

"Sustainability is no longer a choice – it determines future business performance"

Deutsche Post DHL **Christian Erhart, May 2015**

"Corporate responsibility has always been and will continue to be a core part of our business strategy ,..... is not just a "nice to have" – it's an expectation"

NOVARTIS **Joe Jimenez, CEO, April 2015**

" Sustainability needs to be integrated into all parts of the business … there have to be clear sustainability goals ….and they need to have the same priority as other goals"

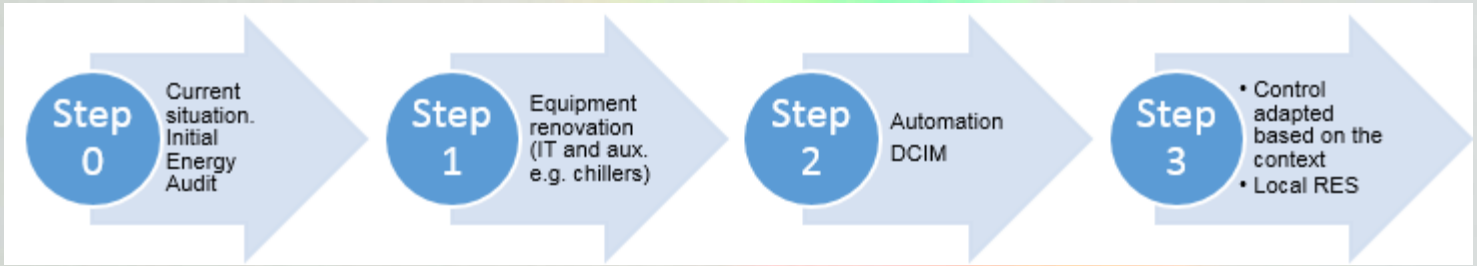
H&M **Karl-Johan Persson, CEO, March 2015**

"Being energy efficient is at the core of our mission as a company. But it's also part of the agenda for many fortune 500 companies …… We believe it will matter to Data Centre customers. "

Google **F.Sterin, Director of Global Infrastructure, Nov. 2014**

Steps towards an Eco-friendly Data Centre

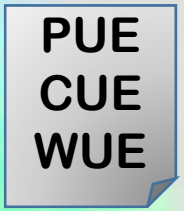
- **Step 0 - Metrics:** Energy Audit, Measures, KPIs
- **Step 1 - Efficiency:** Equipment (IT and facility)
- **Step 2 - Control:** IT Automation and DCIM
- **Step 3 - Adaptability:** context and local RES

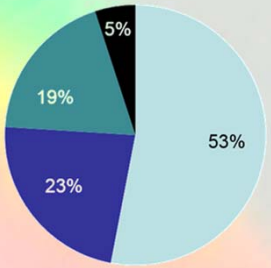


DC4Cities FIT4GREEN All4green DC4Cities

Step 0: Metrics and measures

- Learn about DC energy metrics and equipment certifications
- Perform energy assessment/audits
- Install energy meters
- Analyze energy split inside DC
- Analyze energy related costs
- Who pays energy bills?





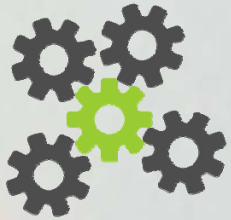
Step 1: Equipment Energy Efficiency

- Record energy measures as selectively as possible
- Learn about Efficiency for:
  - DC facility equipment (e.g. AC, UPS)
  - IT equipment (i.e. servers, storage, network)
- Plan equipment renovation considering energy savings from more efficient equipment
  - *Learn also about "Embodied Energy" (complex topic)*
- Consider metrics like

"DC income" / "cost of power"

Step 2: Control and Optimize

- DCIM for the facility
- Monitoring and Automation Tools for IT
- Consider dynamic IT consolidation
  - *Hot Topic: VM power*
- Consider Flexible SLAs
- Optimize operations
  - System Administration
  - DC SW deployment
- Keep energy KPIs under control



Step 3: Adaptability in DC Control

- Consider “special” energy contracts from providers
- Consider “smart” integration of local Renewable sources
- Apply DC energy control policies to both facility and IT
- Use metrics related to Renewable utilization:
  - RenPercent
  - Primary Energy
  - CO2 emissions

and DC “work done”

Adapt DC behavior to external context balancing environment and business


Thanks for your attention
Any question?
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