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The costs of the HTC/HPC e-Infrastructures

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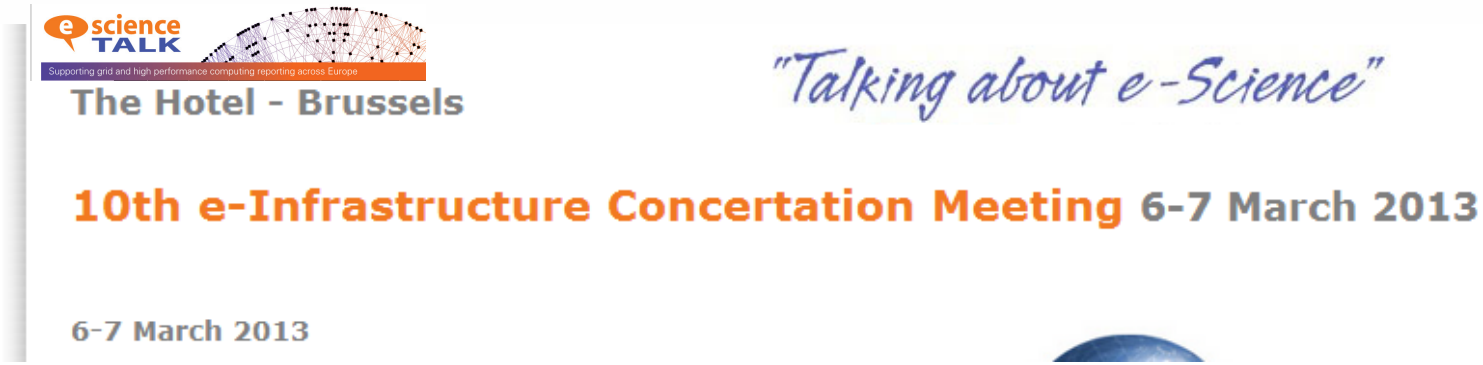

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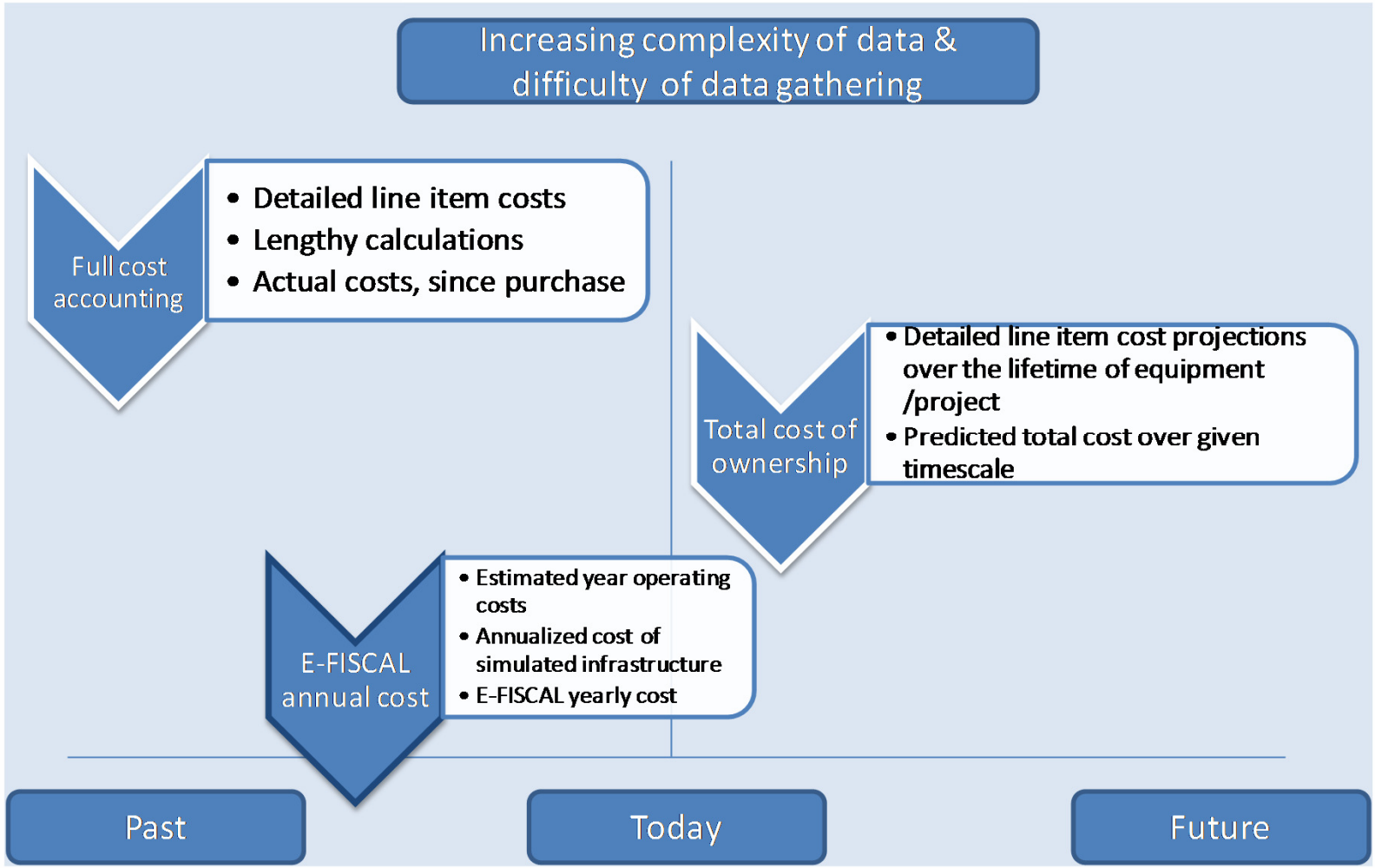
Not trivial….

- Hundreds of funding **sources**!
- **Comparing** e-Infra **costs with** Cloud **prices**!
  - Comparing 2011 costs with 2012-2013 prices
  - Prices not always cost-based
  - Multiple cloud instances: on-demand, reserved, etc.
- **Confidentiality**/Anonymity of data
- e-Infrastructure providers **sensitivity** on costs
- Note: Moving to cloud a different exercise!
  - Focusing on avoidable costs and time value of money
  - In such case take into account the qualitative value of e-Infrastructures
    - Cost is different from value!

e-FISCAL outputs

- **Pioneer** costing federated computing e-Infrastructures
  - in a highly **distributed-heterogeneous** environment!
  - **Hybrid** methodology - Cost structures
    - Questionnaire: 28 high quality answers from 16 countries
- Estimation of several **metrics**
  - Cost per core hour, CAPEX/OPEX ratio, depreciation rates, cost distribution, electricity/PUE, …
- **Comparisons** with Clouds – Amazon EC2
  - **Benchmarking** efforts (HPC/HTC vs. Amazon EC2)
- http://www.efiscal.eu/**state-of-the-art** (50 articles)

Basis of costing exercise



Methodology

Cores, storage devices,
auxiliary equipment, connectivity devices
X
Costs per core, for storage, etc.
retrieved by questionnaires

→ **Approximation of the physical infrastructure investment cost**

Development of the financial model

Yearly Operational Expenditures (OPEX)
Software, Personnel, Electricity,
Premises, Network connectivity,
Other operating costs
(questionnaire)

Yearly Capital Expenditures (CAPEX)
Depreciation of
the physical infrastructure
costs
(questionnaire)

Total yearly cost of ownership

Countries contributing

We would like to thank all contributors!

28 respondents from 16 countries

Belgium (5), Bulgaria, Cyprus, Finland, Germany, Greece (4), Hungary, Ireland, Italy, Latvia, Norway, Poland, Romania, Spain (6), Turkey, UK

e-FISCAL main findings

- In-house HPC/HTC e-Infrastructures are cost-effective
  - With high utilisation rates & depreciation rates (as reported)
  - However per application cost analysis is also needed
  - ~ **€ 0,03 per core hour** (median) - ~ **€ 0,07 per core hour** (average)
- Personnel ~50% of total costs; CAPEX/OPEX=30/70%
  - Average salary ~50K, PUE~1,5
- Larger sites have in general less FTEs/1000 cores
- Small-scale benchmarking efforts between in-house e-Infras and Amazon instances:
  - Average ~43% performance degradation of the latter for HPC, ~27% for HTC
- Total annual cost of EU computing e-Infras: ~175-295*M€*

3-way analysis

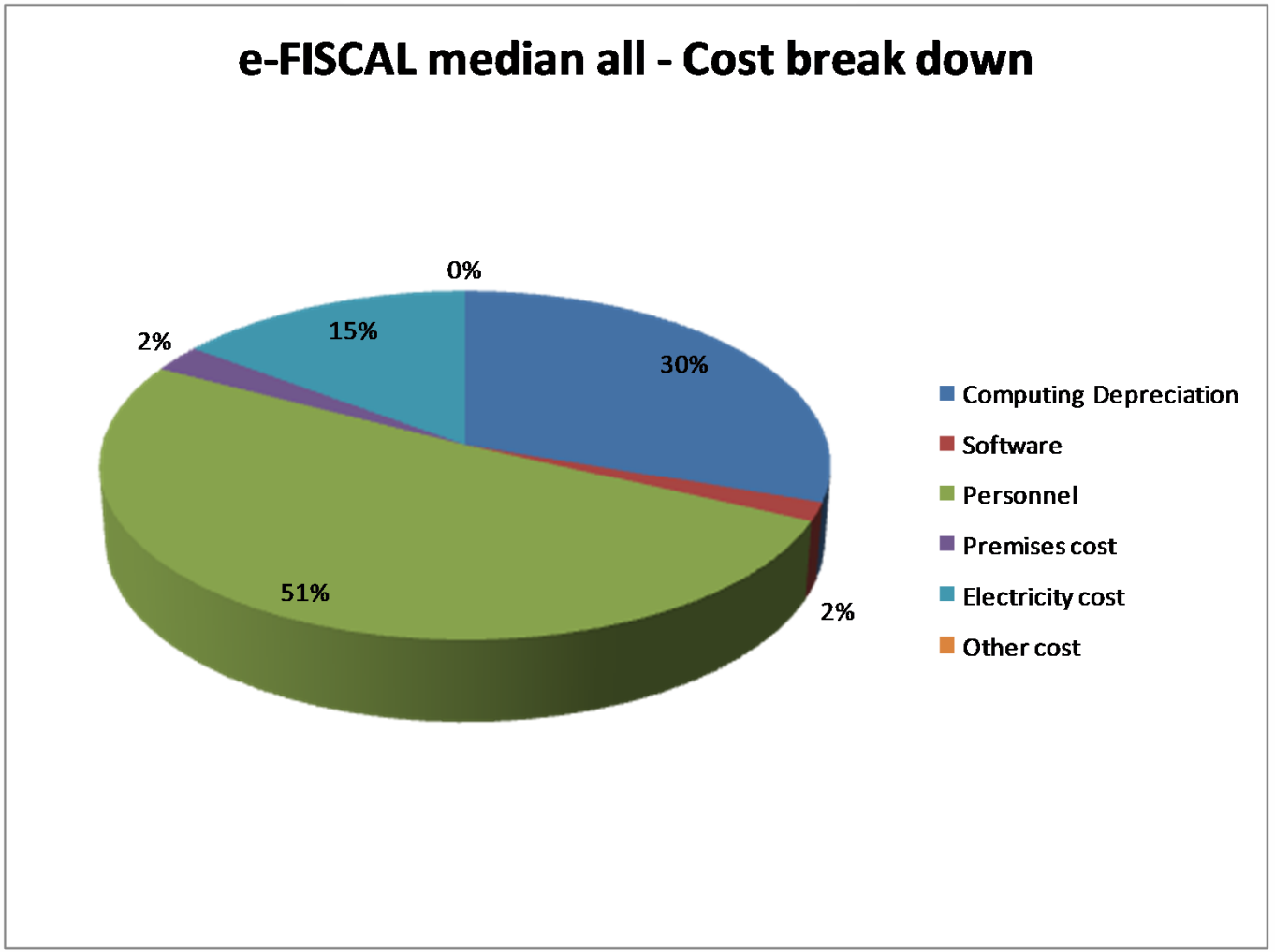
- Calculation of cost per core and cost per core hour under three alternatives
  - **Basic Case**
    - Use of average and median values of total sample
  - **Basic Case split into HPC and HTC**
    - Categorization based on centres self-declaration
  - **Case by case analysis**
    - Use of input per site
    - Replacement of missing values of inputs with averages from total sample

Basic case

Amounts in €	e-FISCAL average all	e-FISCAL median all
Total yearly cost/core	416	208
Utilisation rate	65%	75%
Cost per core hour	0,073	0,0317
CAPEX as % of total costs	26%	30%
OPEX as % of total costs	74%	70%
FTEs/1,000 cores	4,61	2,16

- **Also:**
  - Core useful lives: **5** years (literature usually cites 3 years)
  - Interconnect equipment : **10%** of hw costs
  - Software costs: between **2% - 4%** of hw costs
  - Personnel cost per FTE in € in 2011**:** **49k - 54k**
  - Power Usage Effectiveness: approx. **1.50**

Costs breakdown
(2011-median)



Basic case split to HPC/HTC

- HPC sites are larger on average
- Multi-core
- Good practices in energy / Green IT reported

HPCs

Amounts in €	e-FISCAL HPC average	e-FISCAL HPC median
Total yearly cost/core	301	182
Utilisation rate	66%	75%
Cost per core hour	0,052	0,0277
CAPEX as % of total costs	28%	32%
OPEX as % of total costs	72%	68%

- Modest size HPC centres similar to state-of-the-art HTC ones

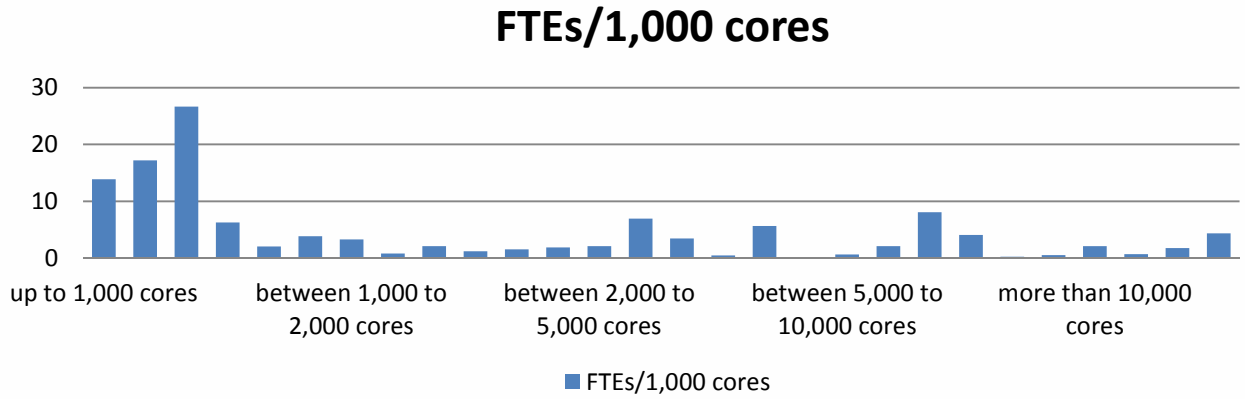
- Small HTC sites (<1000 cores) are the ones who drive averages higher

HTCs

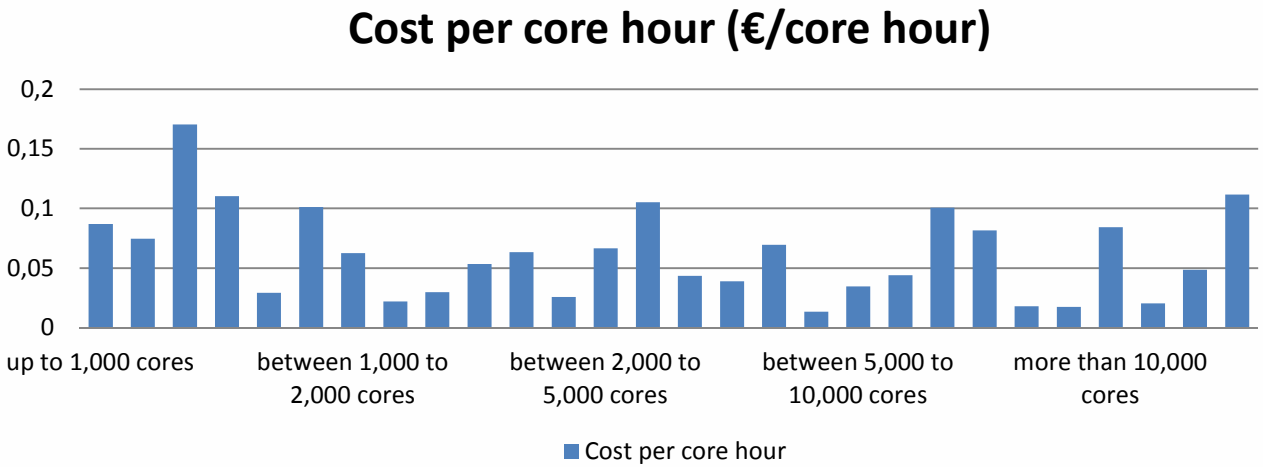
Amounts in €	e-FISCAL HTC average	e-FISCAL HTC median
Total yearly cost/core	411	229
Utilisation rate	59%	74%
Cost per core hour	0,0795	0,0353
CAPEX as % of total costs	21%	26%
OPEX as % of total costs	79%	74%

Case by case analysis

- **Cost per core hour: Median all: 0.058, HPC Median: 0.039, HTC Median: 0.066**



The larger the site the lower the number of FTEs/1,000 cores. Statistically significant relationship

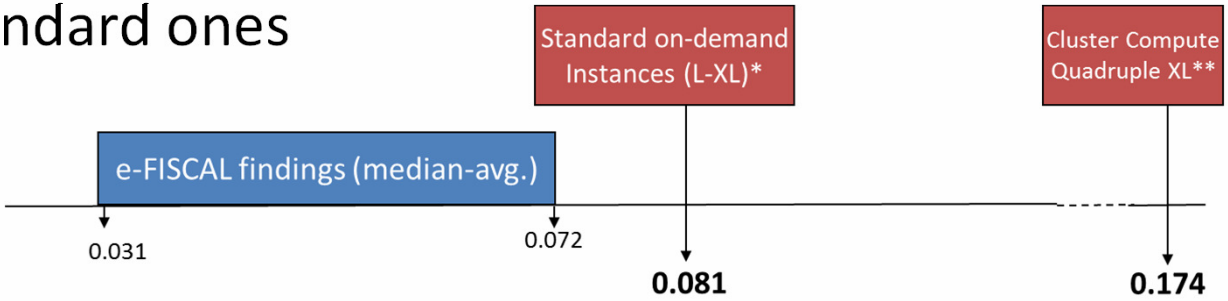


Cost per core hour is higher in small sites with < 1,000 cores
Cost per core hour are around € 0.09 for sites with < 1,000 cores and € 0.05 for sites with > 1,000 cores.

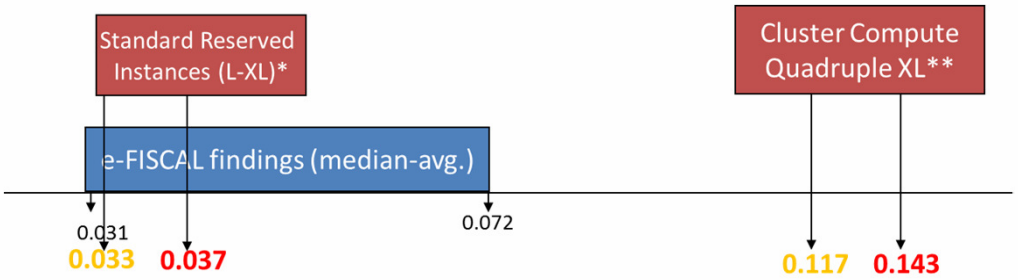
Comparison with Amazon

PERFORMANCE DEGRADATION INCLUDED

- EC2 “on-demand” instances always more expensive
  - Even standard ones



- “Reserved” instances much more competitive
  - However EC2 “cluster compute” (HPC in the cloud) > 1,5-2 times more expensive

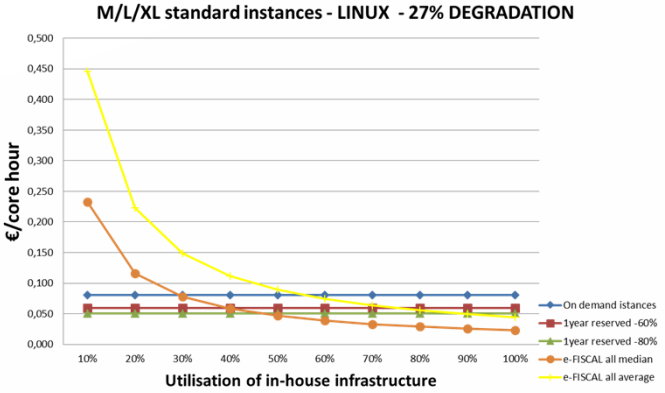


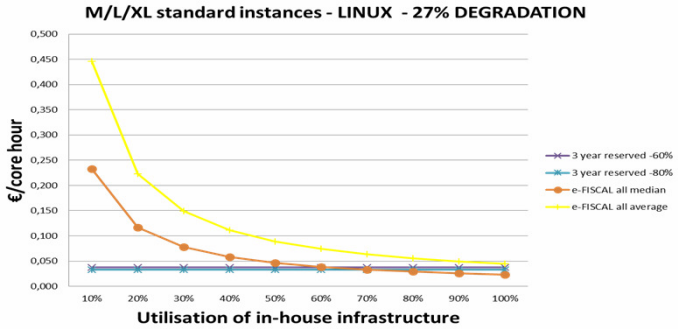
In-house utilisation vs. EC2…

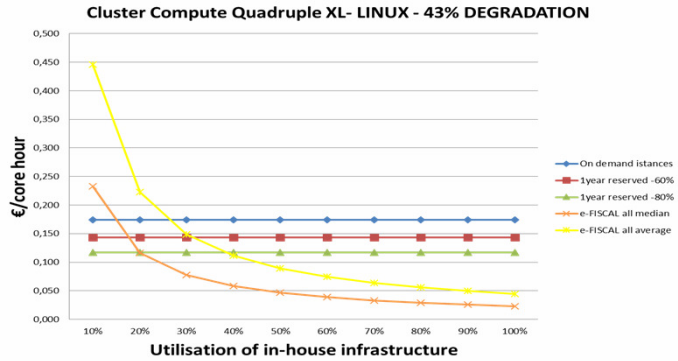
PERFORMANCE DEGRADATION INCLUDED

Depends on specific instances:

- **“Standard” instances**
  - **>30-55% compared to “on-demand” instances**
  - **>40-90% compared to “1 year reserved ones”**
  - **>65%-always cheaper compared to “3 year reserved”**
- **“Cluster Compute” instances**
  - **>15-27% compared to “on demand”**
  - **>18-40% compared to “1 year reserved”**







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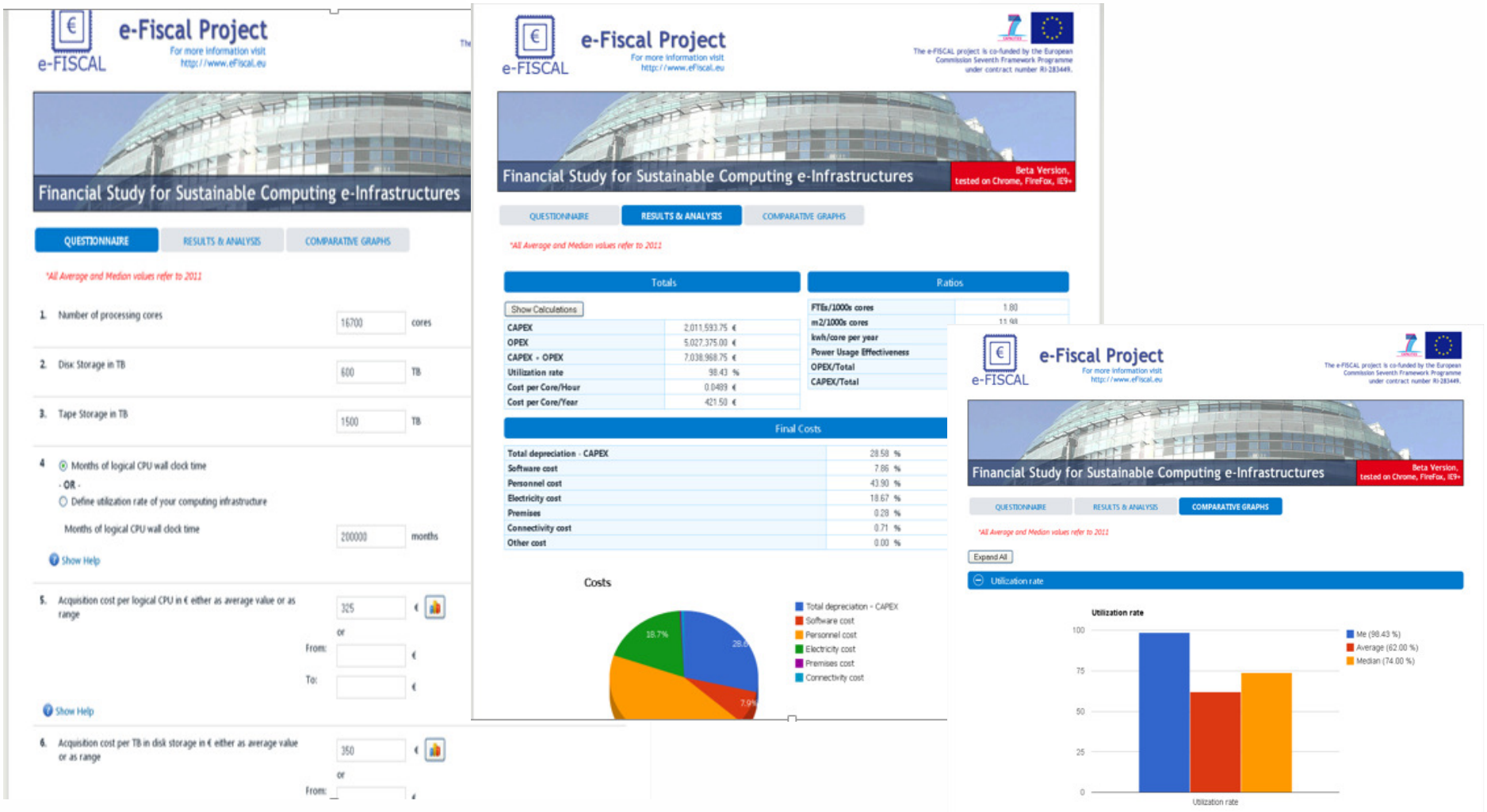
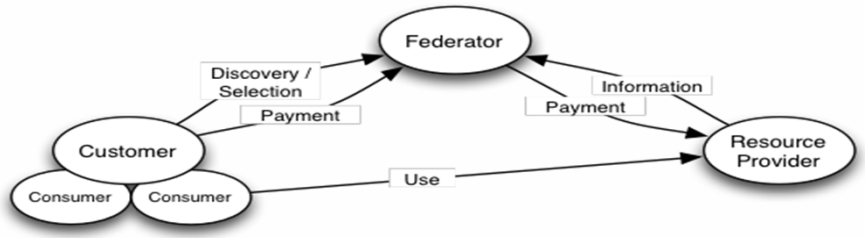


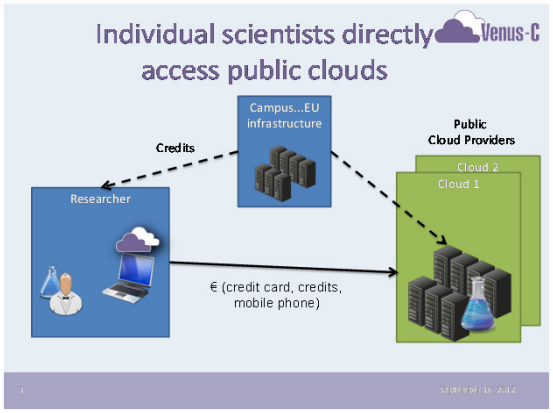
e-FISCAL sustainability

- Tools will remain available on the website
- State of the art repository also
- LinkedIn group on ICT cost assessment linkd.in/VqEth0 continues discussions
- Cost collection/estimation to continue in part through the EGI compendium (go.egi.eu/EGI-Compendium-2011)
- Consortium members can provide consultancy

Business models

- High utilization key to maintain economic efficiency
- A broker role is essential to facilitate demand meeting the right suppliers
- Need to evolve funding streams and new pricing models





Way forward is…open!

- Probably a mix of several e-infrastructure service components; each component has its merits!
  - In-house HPC and HTC, Hybrid clouds: In-house HTC cloud + commercial HTC/HPC clouds
  - Service-Oriented e-Infrastructure to provide e-Science as a Service….

Conclusions

- e-Infrastructures have been a major European success story
  - but **cost awareness hasn't been its strong point**
- The challenge proved to be non-trivial from the accounting perspective -> **required new methodology and domain experts**
  - accounting, e-Infrastructure service provision and policy areas
  - Approach can be considered for a broad range of activities
- Went into uncharted territory, **spearheading role** and prepared the ground for future activities
- Appreciation of cost aspects: **Nothing is free**!
- Understanding of e-Infrastructure **cost ranges**
- Development of a **community** interest on costs
- **Cost ≠ value** and strategy may influence decision-making more

Recommendations

- To e-Infrastructure providers and HPC/HTC centre managers
  - **Keep track of cost structures** and costs through a systematic way to assist in planning and determining their centres' sustainability.
- Research communities and end users
  - Costs are not the main issue: Collect and **document experiences on in-house vs. commercial clouds**
- e-Infrastructure policy makers and funding agencies
  - Recognise the **cost parameter as an important one** in the sustainability of computing e-Infrastructures

Thanks!

- www.efiscal.eu
  - e-mail us at info @ efiscal.eu

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- **Total funded effort in PMs:** 33.75
- **Web site:** www.efiscal.eu

Consortium

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