



## **10<sup>th</sup> eConcertation meeting Brussels, 6 March 2013**

# The costs of the HTC/HPC e-Infrastructures

Fotis Karagiannis, Sandra Cohen,  
Independent/Athens University of Economics and Business-Research Center  
e-FISCAL project director

[www.efiscal.eu](http://www.efiscal.eu)



*"Talking about e-Science"*

**10th e-Infrastructure Concertation Meeting 6-7 March 2013**

6-7 March 2013



# 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!

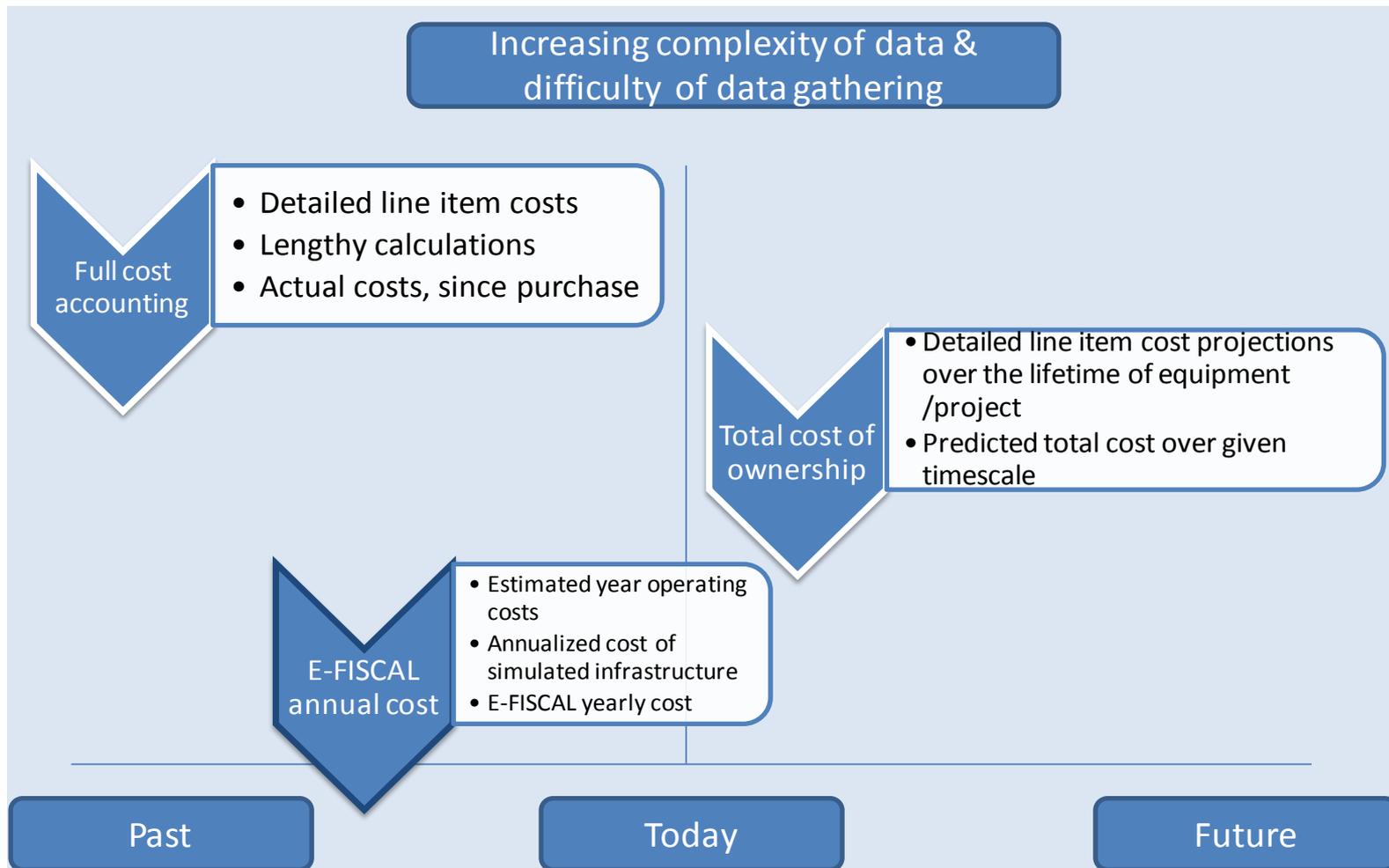


# e-FISCAL outputs

- **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)

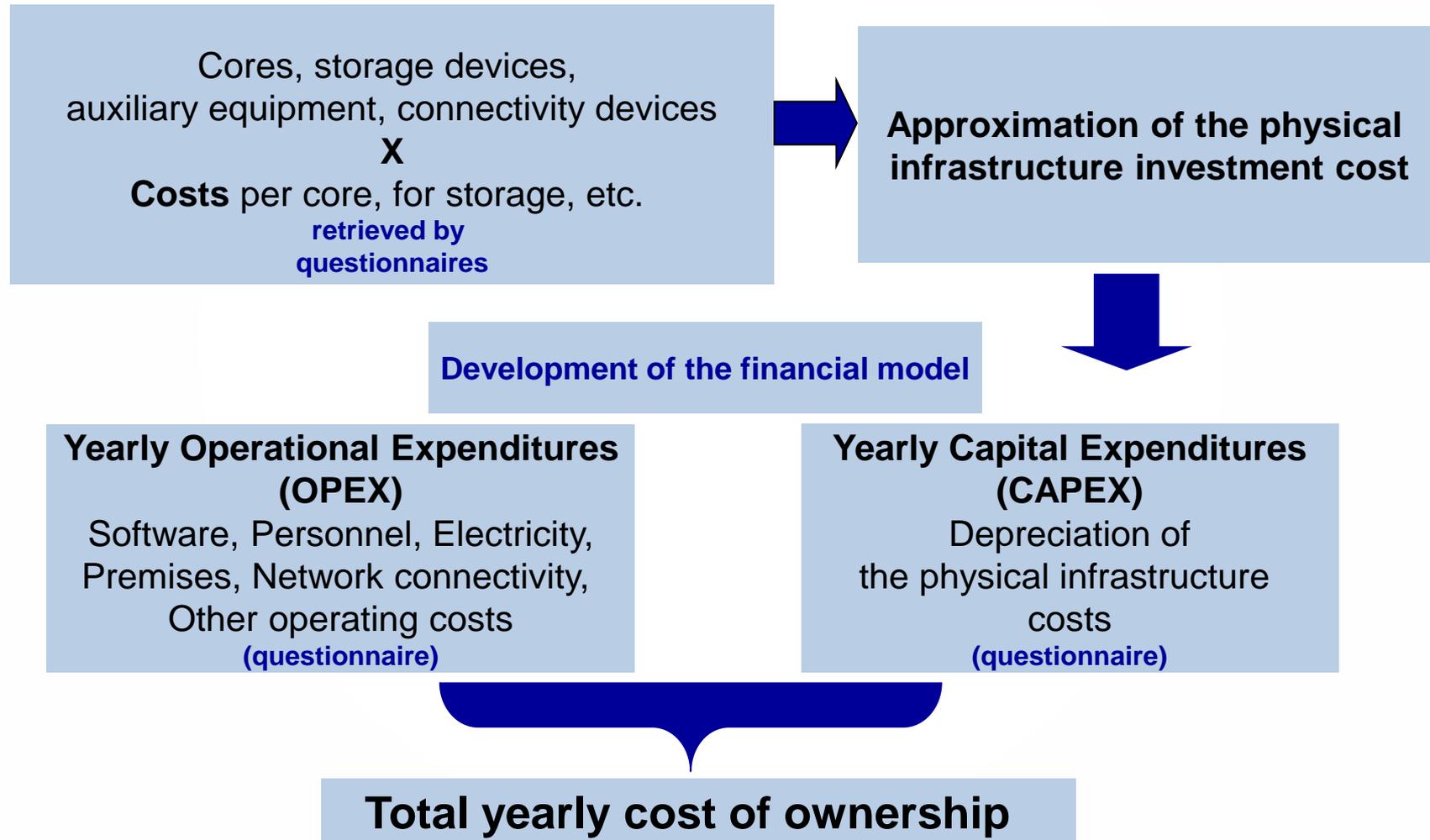


# Basis of costing exercise





# Methodology





# 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: ~175-295M€



# 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

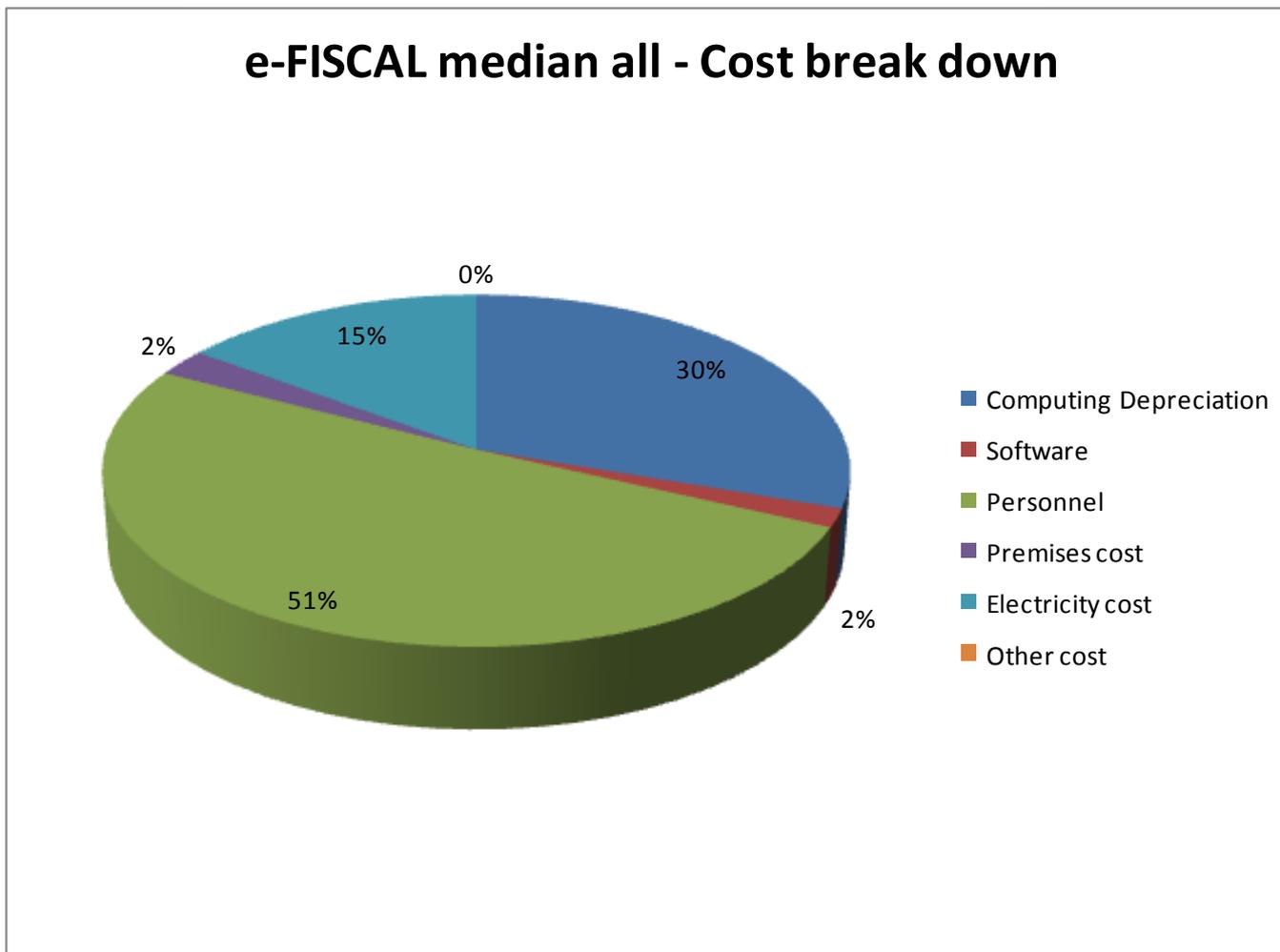
Amounts in €	e-FISCAL average all	e-FISCAL median all
Total yearly cost/core	416	208
Utilisation rate	65%	75%
Cost per core hour	0,073	0,0317
CAPEX as % of total costs	26%	30%
OPEX as % of total costs	74%	70%
FTEs/1,000 cores	4,61	2,16

- **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

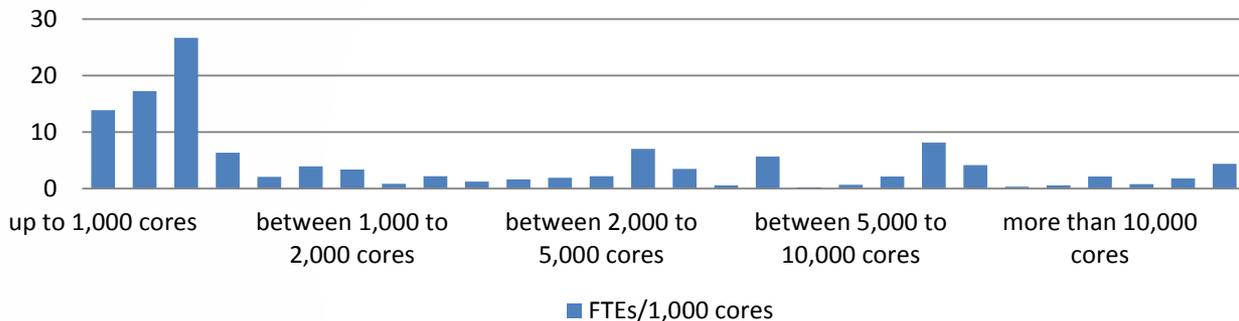
HTCs		
Amounts in €	e-FISCAL HTC average	e-FISCAL HTC median
Total yearly cost/core	411	229
Utilisation rate	59%	74%
Cost per core hour	0,0795	0,0353
CAPEX as % of total costs	21%	26%
OPEX as % of total costs	79%	74%



# Case by case analysis

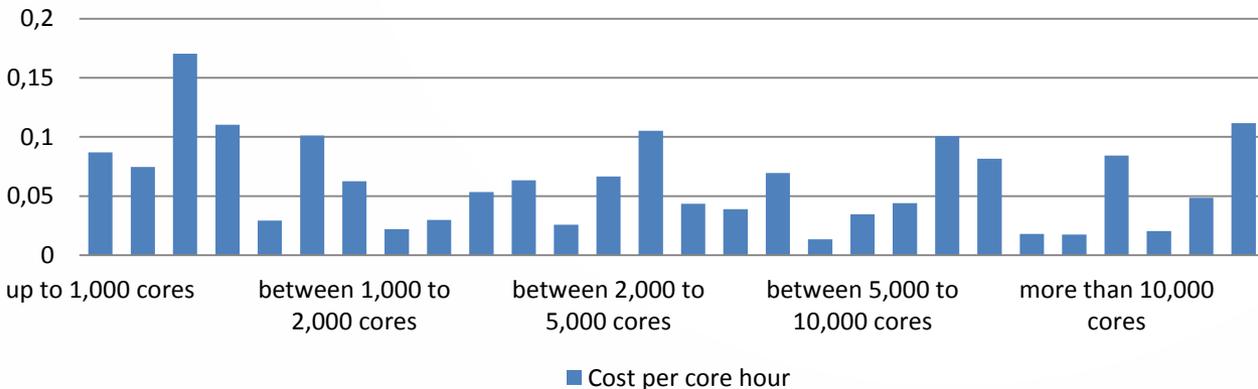
- **Cost per core hour: Median all: 0.058, HPC Median: 0.039, HTC Median: 0.066**

**FTEs/1,000 cores**



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

**Cost per core hour (€/core hour)**

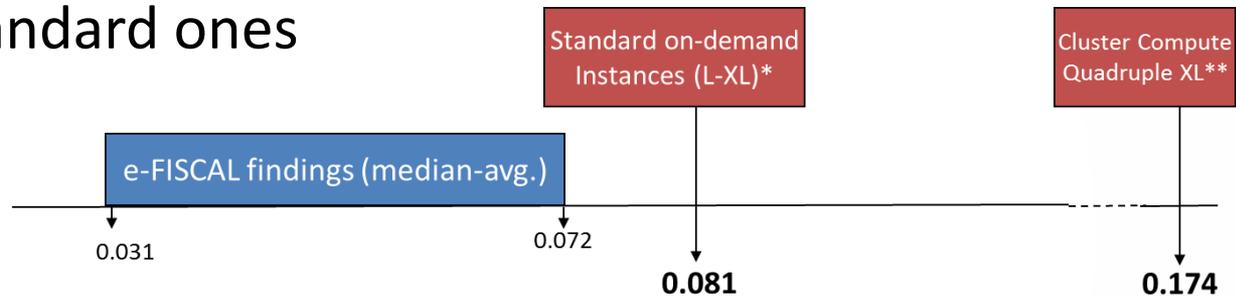


Cost per core hour is higher in small sites with < 1,000 cores  
 Cost per core hour are around € 0.09 for sites with < 1,000 cores and € 0.05 for sites with > 1,000 cores.

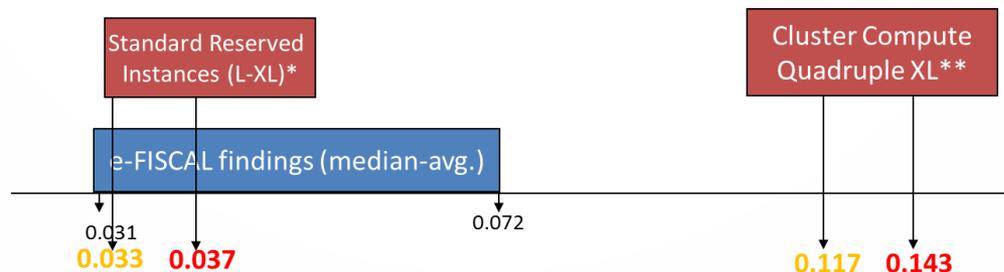
# Comparison with Amazon

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



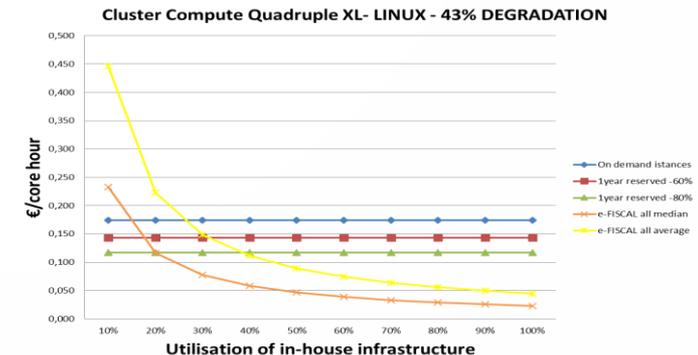
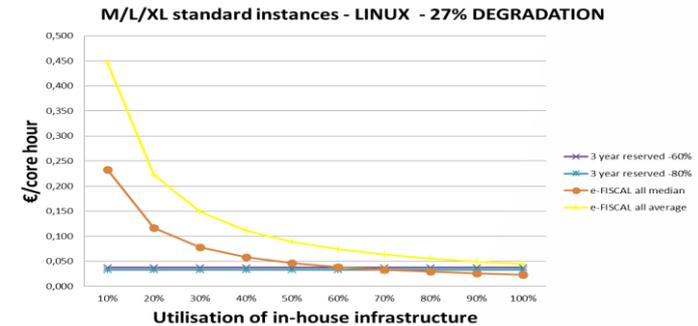
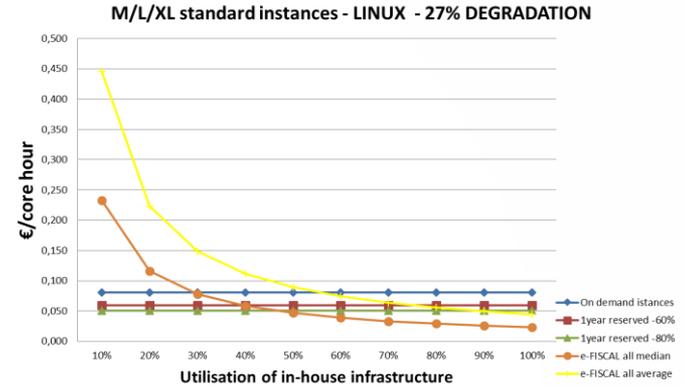


# In-house utilisation vs. EC2...

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”



**e-Fiscal Project**  
For more information visit <http://www.efiscal.eu>

## Financial Study for Sustainable Computing e-Infrastructures

QUESTIONNAIRE   RESULTS & ANALYSIS   COMPARATIVE GRAPHS

*\*All Average and Median values refer to 2011*

- Number of processing cores:  cores
- Disk Storage in TB:  TB
- Tape Storage in TB:  TB
- Months of logical CPU wall clock time  
 Define utilization rate of your computing infrastructure  
 Months of logical CPU wall clock time:  months
- Acquisition cost per logical CPU in € either as average value or as range:  €  
 or  
 From:  € To:  €
- Acquisition cost per TB in disk storage in € either as average value or as range:  €  
 or  
 From:  € To:  €

Show Help

**e-Fiscal Project**  
For more information visit <http://www.efiscal.eu>

The e-FISCAL project is co-funded by the European Commission Seventh Framework Programme under contract number RI-283448.

## Financial Study for Sustainable Computing e-Infrastructures

QUESTIONNAIRE   RESULTS & ANALYSIS   COMPARATIVE GRAPHS

*\*All Average and Median values refer to 2011*

Totals		Ratios	
<input type="button" value="Show Calculations"/>			
CAPEX	2,011,593.75 €	FTIs/1000s cores	1.80
OPEX	5,027,375.00 €	m2/1000s cores	11.98
CAPEX - OPEX	7,038,968.75 €	lwh/core per year	
Utilization rate	98.43 %	Power Usage Effectiveness	
Cost per Core/Hour	0.0493 €	OPEX/Total	
Cost per Core/Year	421.50 €	CAPEX/Total	

Final Costs	
Total depreciation - CAPEX	29.59 %
Software cost	7.86 %
Personnel cost	43.90 %
Electricity cost	18.67 %
Premises	0.28 %
Connectivity cost	0.71 %
Other cost	0.00 %

**Costs**

**Utilization rate**

**e-Fiscal Project**  
For more information visit <http://www.efiscal.eu>

The e-FISCAL project is co-funded by the European Commission Seventh Framework Programme under contract number RI-283448.

## Financial Study for Sustainable Computing e-Infrastructures

QUESTIONNAIRE   RESULTS & ANALYSIS   COMPARATIVE GRAPHS

*\*All Average and Median values refer to 2011*

Utilization rate

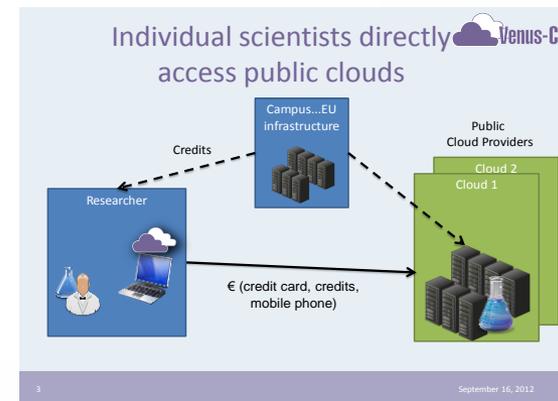
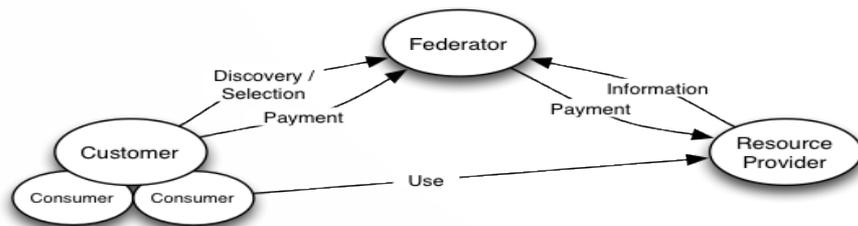


# e-FISCAL sustainability

- Tools will remain available on the website
- State of the art repository also
- LinkedIn group on ICT cost assessment [linkd.in/VqEth0](https://www.linkedin.com/company/linkd.in/VqEth0) continues discussions
- Cost collection/estimation to continue in part through the EGI compendium ([go.egi.eu/EGI-Compendium-2011](http://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](http://www.efiscal.eu)

■ e-mail us at [info @ efiscal.eu](mailto:info@efiscal.eu)

- **Project acronym:** e-FISCAL
- **Contract n° :** RI-283449
- **Project type:** CSA-SA
- **Start date:** 01/08/2011
- **Duration:** 18 months (end 31/1/2013)
- **Total budget:** 392.523 €
- **Funding from the EC:** 349 999 €
- **Total funded effort in PMs:** 33.75
- **Web site:** [www.efiscal.eu](http://www.efiscal.eu)





# Consortium



ATHENS UNIVERSITY OF ECONOMICS AND BUSINESS

ΟΙΚΟΝΟΜΙΚΟ ΠΑΝΕΠΙΣΤΗΜΙΟ ΑΘΗΝΩΝ 

AUEB-RC



**European Grid Infrastructure**

Towards a sustainable grid infrastructure

EGI.eu



**NUI Galway**  
**OÉ Gaillimh**

NUIG\*  
(ICHEC)



**EMERGENCE TECH LTD.**

ETL

\* National University of Ireland, Galway / Irish Centre for High End Computing (ICHEC)