

## Smart Grid : Vague Concept

- No official definition (ex: Wikipedia)
- Almost one different definition per expert
- Several names
  - Smarter Grid, Intelligent Grid, Next-Generation Grid, Electric Grid of the Future, Grid 2.0, Smartgrids
  - In French: generally not translated or “réseau du futur”, “réseau intelligent”
- Unknown origin (Conference in Brussels in 2004?)
- Some even recommend not to define it

## Smart Grid : Definition

The vision of the grid of the future,  
optimally efficient, economic, reliable,  
secure, safe, flexible and sustainable



It is an utopia of a perfect grid  
able to serve all the needs of the  
society

## Smart Grid : Technical Definition

The vision of a highly automated and interconnected network where power, information and knowledge<sup>①</sup> flow bi-directionally<sup>②</sup> through intelligent systems to transparently serve all stakeholders and users<sup>③</sup>, enabling high performances in planning, operation and maintenance with optimal<sup>④</sup> efficiency and reliability, at lowest cost and in a reliable, secure and safe manner without harming the environment

## Lessons Learned: Technical Challenges

- How to select the winner technologies?
  - Suppliers lobbying
  - Select the “right” technologies on the long term
  - Scalable systems
  - Good practices and standards
- Technical challenges
  - Huge quantity of data (acquisition, transfer, storage)
    - Costs
    - Security
    - Sharing (standards)
  - Continuously operating an ever evolving system
  - Lack of qualified engineers
  - Interference of non-engineer decision-makers

## Lessons Learned: Challenges

- Proven profitability
  - Complex studies
  - Fair and impartial
- Who pays for what?
  - R&D investment by the private sector
  - Fair share of costs and earnings
  - Risk management
- Goodwill
  - Power systems stakeholders
  - Consumers
- Coordinate action of all players : “Smart Grid Task Force”

## Content

- Large-scale Battery Storage Systems
  - Applications of large-scale storage systems
  - Comparison between storage technologies
  - World biggest battery storage systems (BSS)
  - Real examples
  - Barriers to implementation
  - Levelized costs

## Applications of Large-Scale Storage Systems






Distribution – Big BESS ( $\geq 1$ MW)	Grid – Mega BESS ( $\geq 20$ MW)
Local Load Leveling	System Load Leveling
Island and micro grids	Dispatch of intermittent energy sources
Reliability improvement	Frequency regulation & reserves
Power quality	Voltage regulation
Distribution system upgrade deferral	HV and generation investment deferral
Power factor correction	HV Long line stabilisation
Black Start, Carbon emission reduction, etc.	

## Comparative Analysis – Centralized Storage

Depending on the Grid Requirements, Different Storage Chemistries are Suitable

Total Renewable Energy Storage Market: Comparative Analysis of Storage Technologies (Europe), 2009

	Energy Density	Temperature/ Safety	Operating Cost	Efficiency	Lifecycle	Capital Cost	Development Stage	Total
Pumped Hydro							Most widely used form of storage	21
Flow Batteries							Commercialised but only very few projects implemented in Europe	15
Lithium-ion							Research stage	16
CAES							Commercialised. 2 plants in operation globally – Germany and US	19
Thermal Storage							Molten salt widely used for CSP plants	20
Lead Acid							Widely used	14
Sodium Sulfur							165 MW installed capacity in Japan. No projects as yet in Europe	22
Sodium Nickel Chloride							Been in existence for over 20 years. MES-DEA only company in Europe manufacturing these batteries	17

 Very High Attractiveness = 5
  High Attractiveness = 4
  Moderate Attractiveness = 3
  Low Attractiveness = 2
  Very Low Attractiveness = 1

Source: Frost & Sullivan

## World biggest BSS

	Alaska	Japan	UAE	UK
Suppliers leader	ABB	NGK	NGK	EDF-NGK
Batteries	Ni-Cd	NaS	NaS	NaS
Total capacity	40 MW	~300 MW	350 MW	150 MW
Capacity in one location	40 MW	0.5 to 34 MW	4 to 40 MW (60 MW)	?
Storage capacity	7 min	6 to 7.2 h	6 h	6 h
Main use	Outages mitigation	Load levelling + Wind farm	Load levelling	Ancillary services

# E-Energy 2010

Real Smart Grid Applications Workshop  
Large-scale Battery Storage Systems

## New Scale



**66 Wh/l  
31 Wh/kg**

**Crude oil  
10300 Wh/l  
12000 Wh/kg**

**20 kW Lead Batteries**



**143 Wh/l  
106 Wh/kg**

**50 kW NAS Batteries**

## Example – NaS

- United Arab Emirates
- 4 MW – 6h



## Example – Power Conversion Systems (PCS)

- 2 x 2 MVA



## Example – Island Grid with BSS

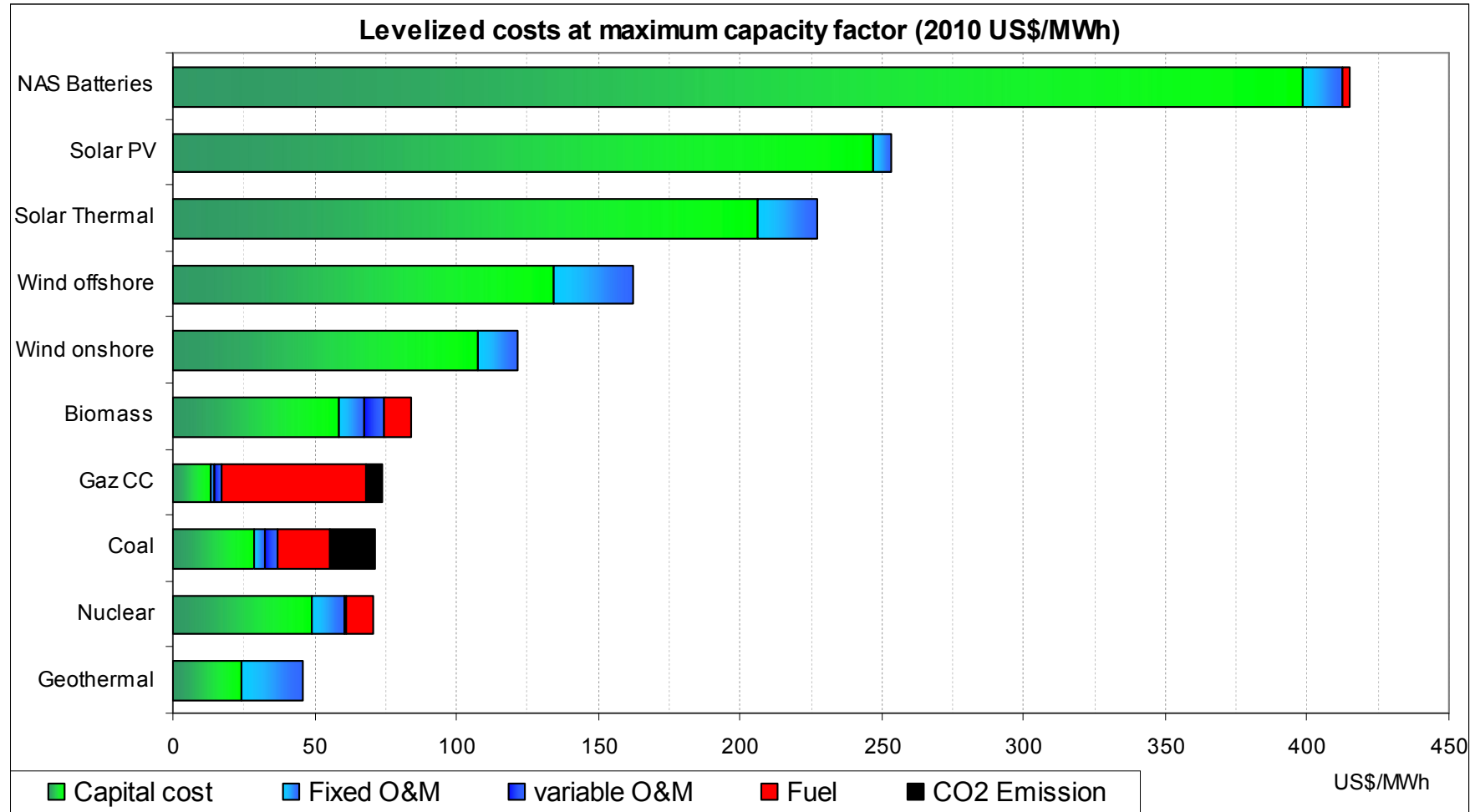
- Younicos test bay (Berlin)
  - Wind, solar, load and network simulator
  - 1 MW NAS battery
- Case study : Graciosa Island, Azores
  - 4600 inhabitants
  - Peak load : 3 MW
- Objective : Optimal control for
  - Stable operation with 100% of renewable energy
  - Maximum 10 to 30% of energy backup with biofuel



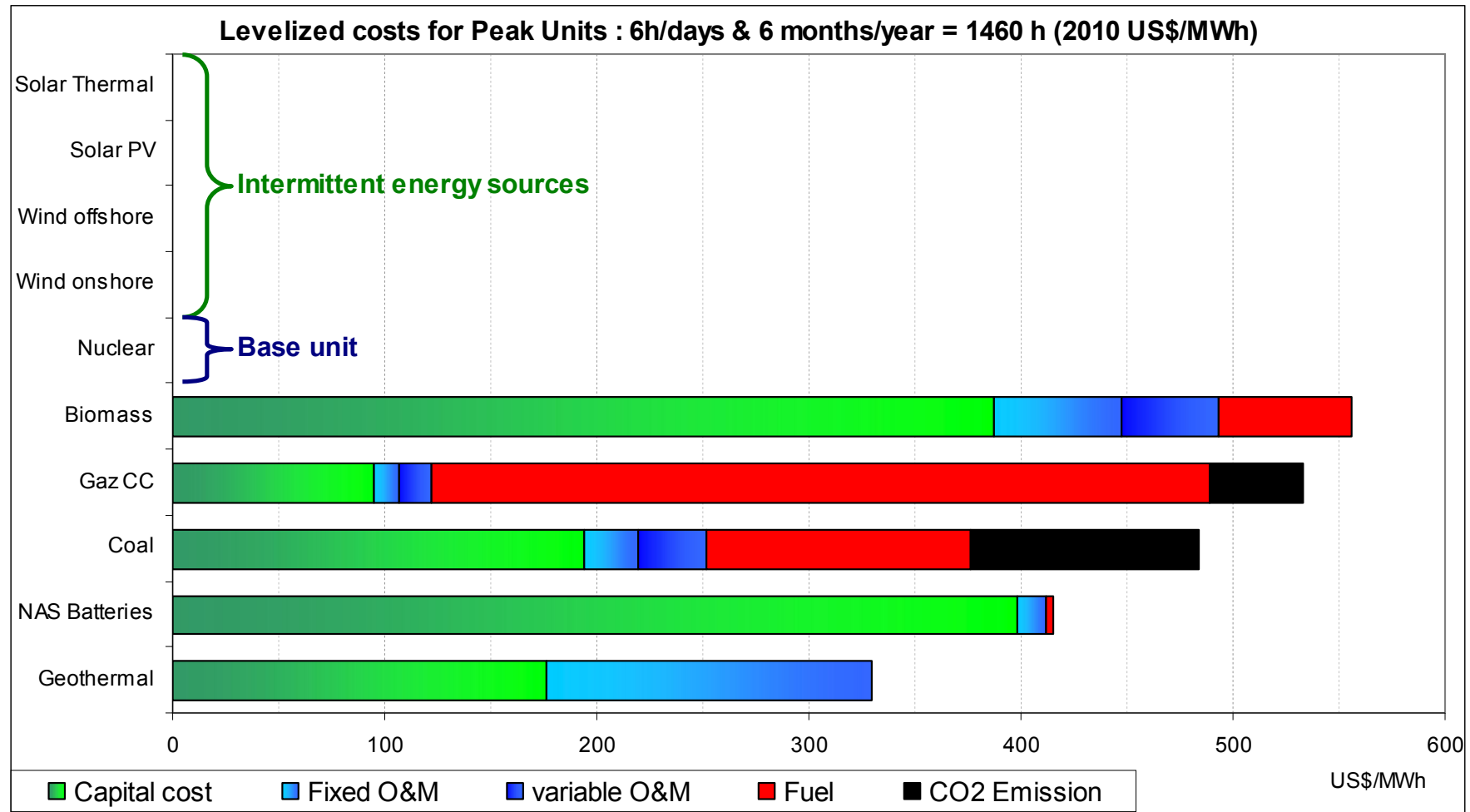
## Barriers to implementation

- Only one supplier able to deliver mature large-scale (both capacity and energy) battery storage systems in less than one year
- Capital investment cost
  - ~3500 US\$/kW turn-key all inclusive
    - BSS
    - PCS
    - Communication and control systems
    - Connection to the network (substation and transformers)
  - 2500 US\$/kW within 5 to 10 years ?

## Levelized Costs – At max. capacity factor



## Levelized Costs – Peak units



## Conclusion

The technology is ready

The need is there

They have now to meet