Martin Zerta (Presenter)

Earth & Space-Based Power Generation Systems – A Comparison Study

L-B-Systemtechnik GmbH
Munich/Germany

Solar Power From Space – SPS'04

Consortium overview

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LBST - CONSORTIUM OVERVIEW

Terrestrial Group

Space Group

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Study Tasks

Cost, risk and reliability comparison of terrestrial and space-based solar power systems for BASE LOAD scenarios for Europe 2030

Cost, risk and reliability comparison of terrestrial and space-based solar power systems for NON-BASE LOAD scenarios for Europe 2030

Identification of synergies for combined terrestrial and space-based solar power scenarios based on base load and non-base load scenarios

Calculation of energy payback times for selected terrestrial and space-based scenarios

Major Assumptions and Definitions

BASE LOAD scenarios: continuos power supply (8,760 hours/yr)
power levels: 0.5 GW, 5 GW, 10 GW, 50 GW, 100 GW, 500 GW

NON-BASE LOAD scenarios: 'peak power' supply
power levels: 0.5 GW, 5 GW, 10 GW, 50 GW, 100 GW, 150 GW

Launch parameterization: launching of solar power satellites is defined as a key parameter. Space concepts are calculated without launch costs. Calculation of the total allowable launch cost targets of space systems to be competitive with terrestrial scenarios. Calculation of required learning curve for SPS launching

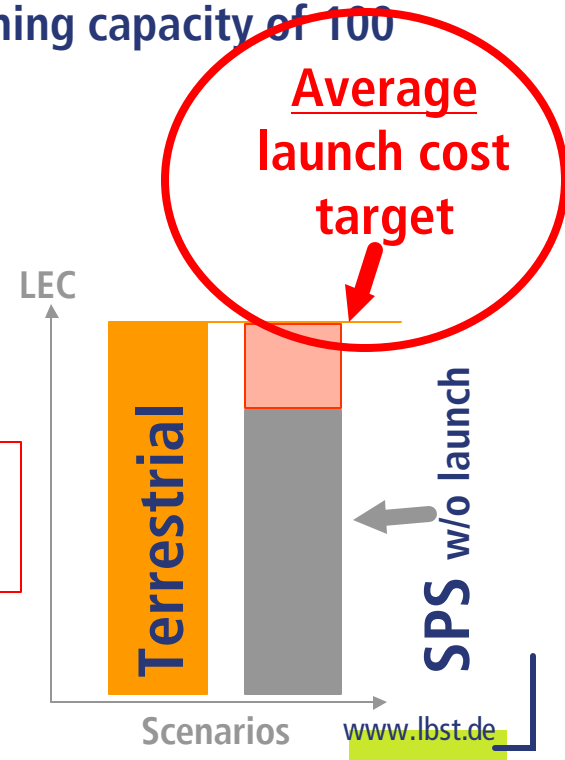
Inputs for learning curve calculation

a) assumptions for launch parameter:

learning effect: cost reduction of 20 % with each doubling of mass transport capacity; today's launch cost = 10,000 EUR/$kg_{payload}$ @ launching capacity of 100 tons per year

b) average launch cost targets:

Costs of terrestrial - costs of SPS systems (without launch) = average launch cost targets



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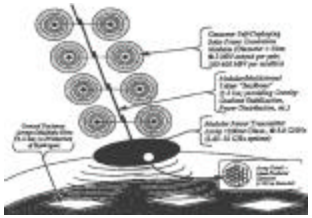
Selected concepts for scenarios

TERRESTRIAL SCENARIOS:


Solar thermal (SOT): BASE LOAD
high full load hours per year

Photovoltaic (PV): NON-BASE LOAD
on house roofs, facades,... in Europe

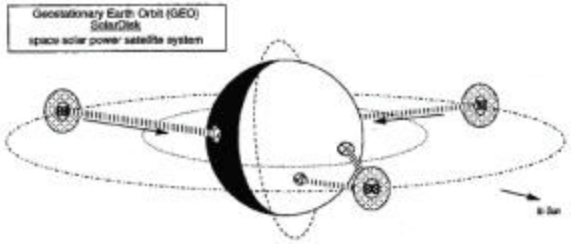

SPACE SCENARIOS:



Reference:
NASA Fresh Look Study, 1997

Sun Tower in MEO:
for smallest scenarios only (0.5 GW)

Solar Disk in GEO
for all larger scenarios (5 to 500 GW)



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Selected concepts for scenarios

Additional required electricity storage

a) Hydrogen (H_2) storage

+ high modularity and flexibility
- higher energy losses

b) Pumped hydro storage

+ higher efficiency
- geographical limitations

Results

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Levelized energy costs for terrestrial base load scenarios

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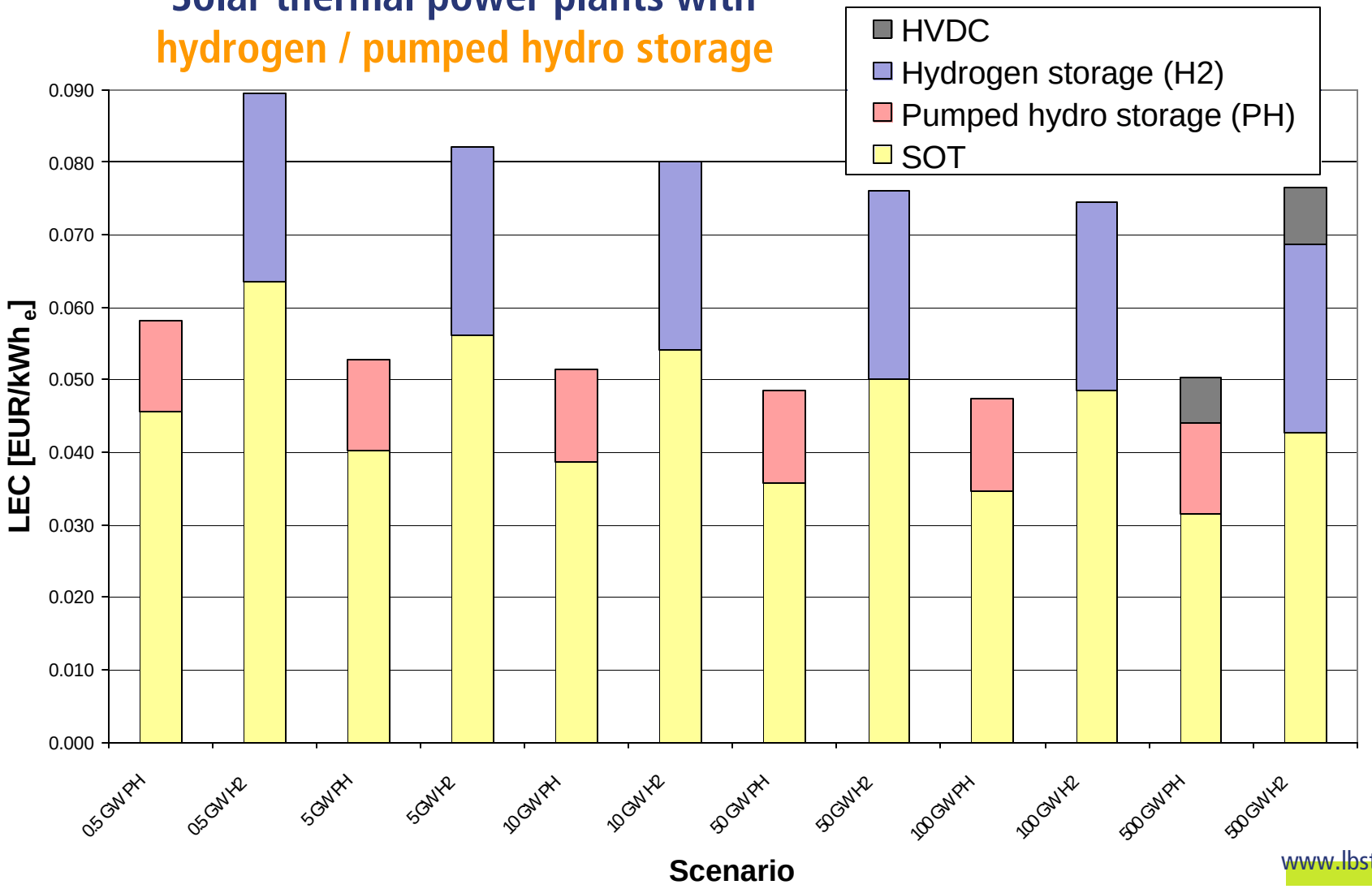
Solar thermal power plants with hydrogen / pumped hydro storage



Levelized energy costs for space-based base load scenarios

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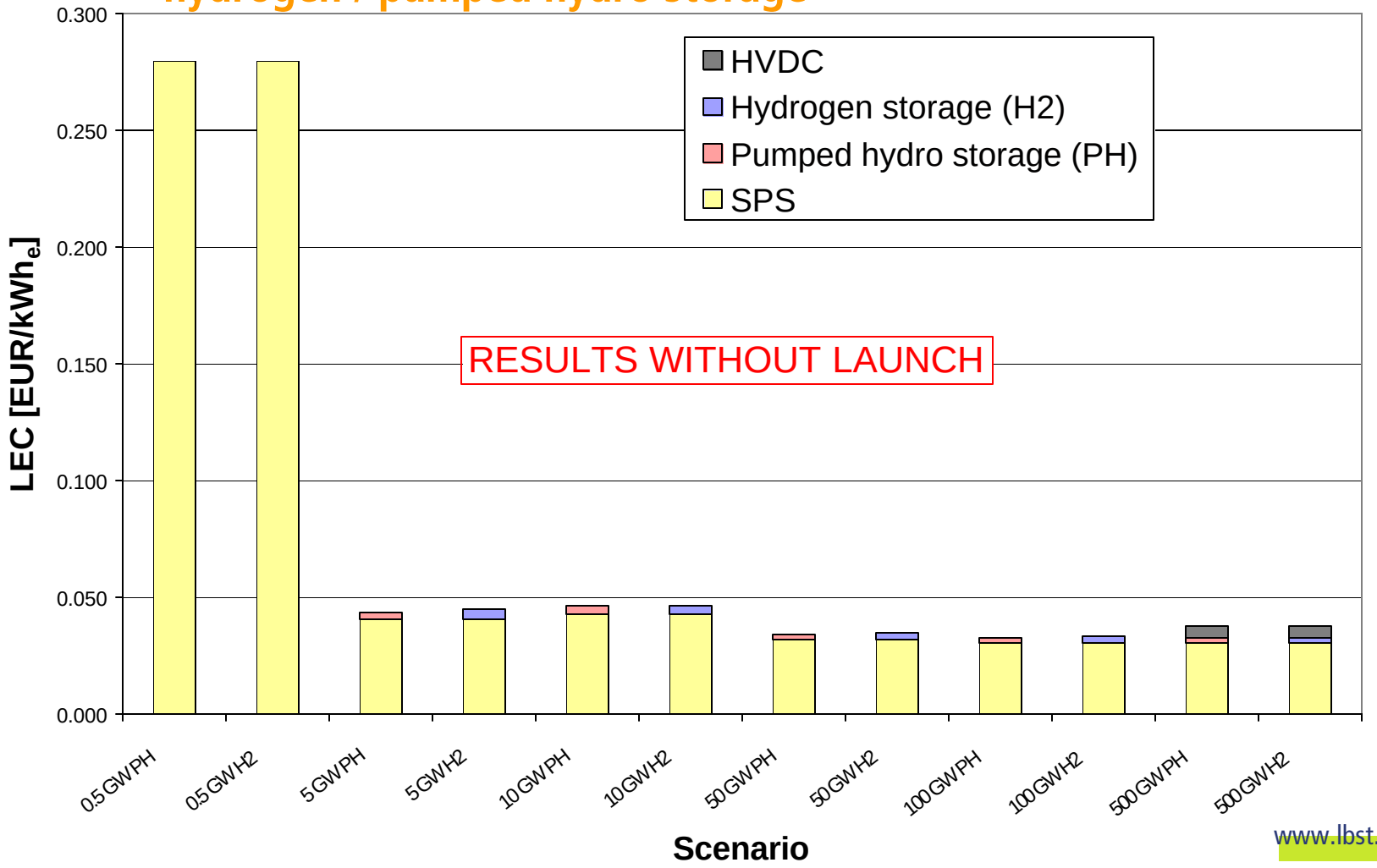
Solar power satellite scenarios with hydrogen / pumped hydro storage



Average launch cost targets

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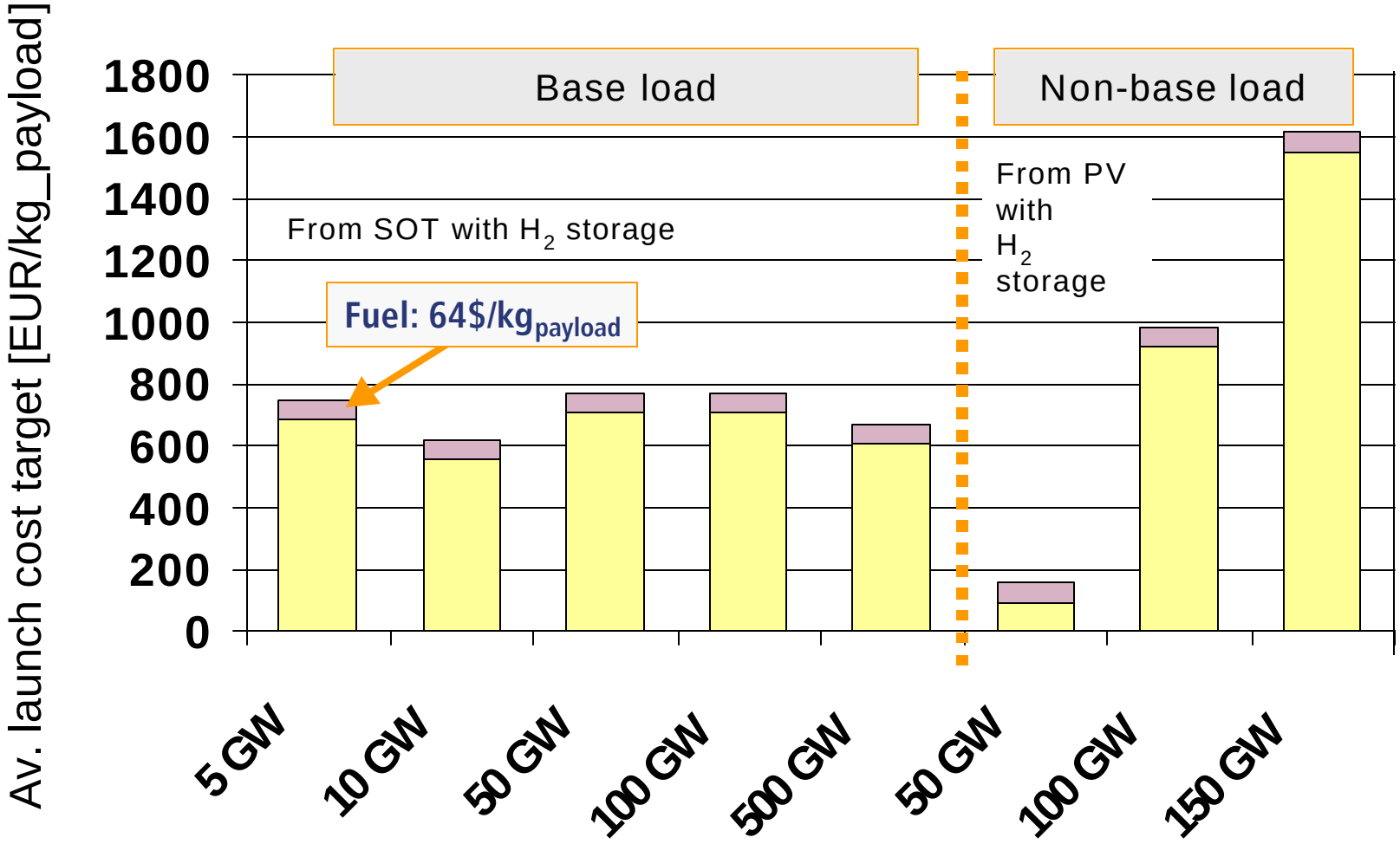
Average launch cost target for SPS including hydrogen storage



Average launch cost targets

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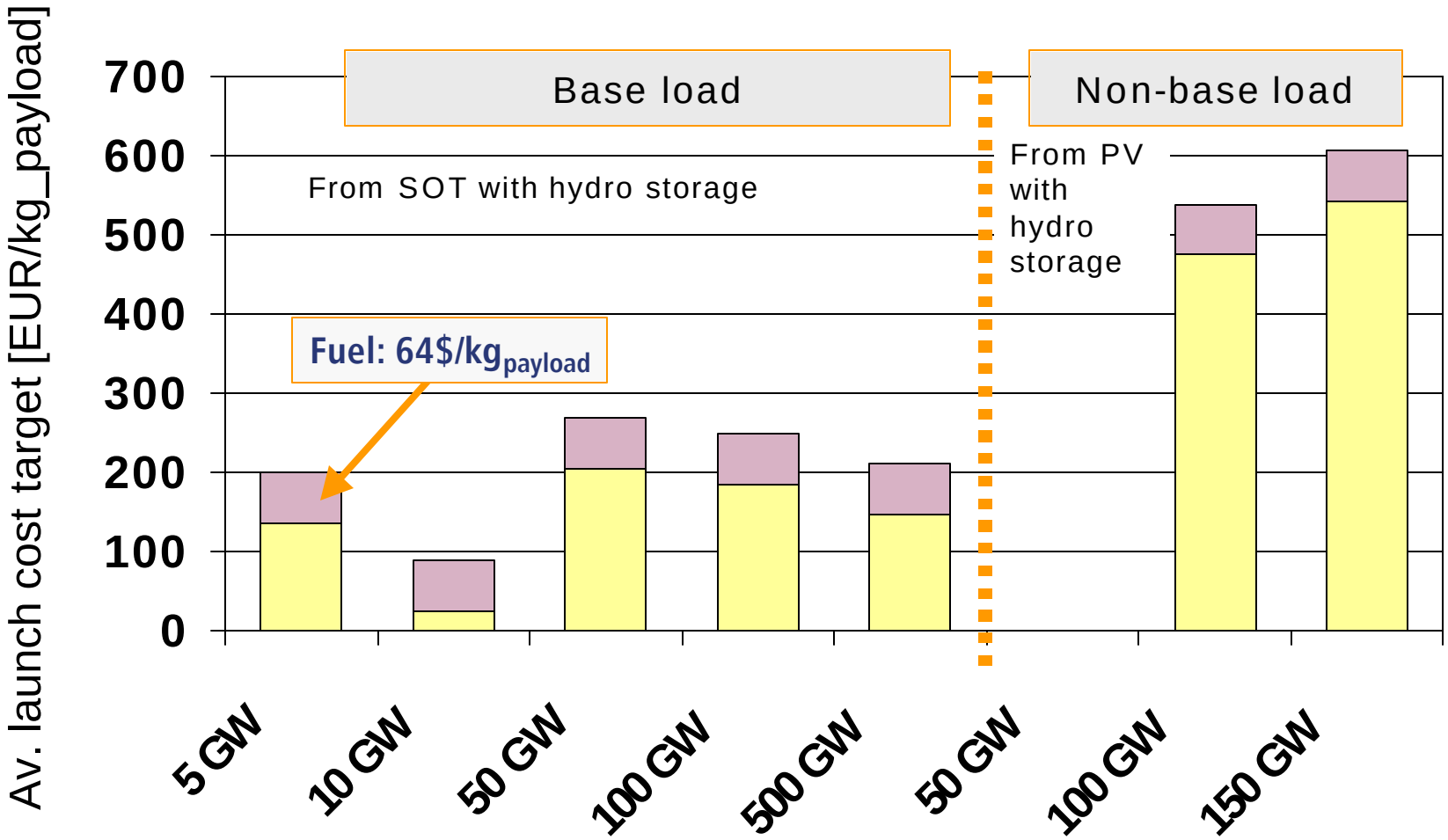
Average launch cost target for SPS including pumped hydro storage



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Conclusion BASE LOAD and NON BASE LOAD scenarios:

- major cost driver for terrestrial systems: STORAGE
- major cost issue for space systems: LAUNCHING
- Installations in Europe reduce significantly costs due to reduction of power transmission via HVDC

Competiveness of SPS scenarions:

	BASE LOAD SCENARIOS	NON-BASE LOAD SCENARIOS
Terrestrial scenario with pumped hydro	NOT COMPETIVE	$\geq$ 100 GW with final launch costs: 323-366 EUR/kg$_{payload}$
Terrestrial scenario with hydrogen storage	$\geq$ 50 GW with final launch costs: 411-480 EUR/kg$_{payload}$	$\geq$ 100 GW with final launch costs: 625-1,060 EUR/kg$_{payload}$

Discussion of possible synergies effects of combined scenarios: terrestrial + space

for base/non-base load

- **Substitution of terrestrial storage by SPS*:**
  no synergies identified
- **Co-siting of rectenna with terrestrial plants*:**
  no synergies identified
- **Common PV technology basis*:**
  synergies expected

* under the scenario definitions given

Synergies effects of combined scenarios: terrestrial + space

„Further potential synergies“

- Hydrogen fuel option
- Network synergies:
  flexible SPS operation
- Other renewables:
  reduction of terrestrial storage requirements

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Energy payback time
base load scenarios

Energy payback times of solar power systems are far below their operational lifetimes

Space-based systems:	**0.4 - 0.5 years** (~2.0 years for 0.5 GW scenario)
Terrestrial systems:	**~0.7 years** (0.4 - 0.5 years without storage)

Dominating energy effort:

- Space: transportation fuel
- Terrestrial: storage systems

* according to DIN

Risk discussion

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Major discussion points:

- Power transmission via microwaves
- Launch
- Use of large land areas
- Atmospheric pollutions
- Geo-political implications
- Public acceptance

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Thank you!