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SOFC System and the Economical Feasibility

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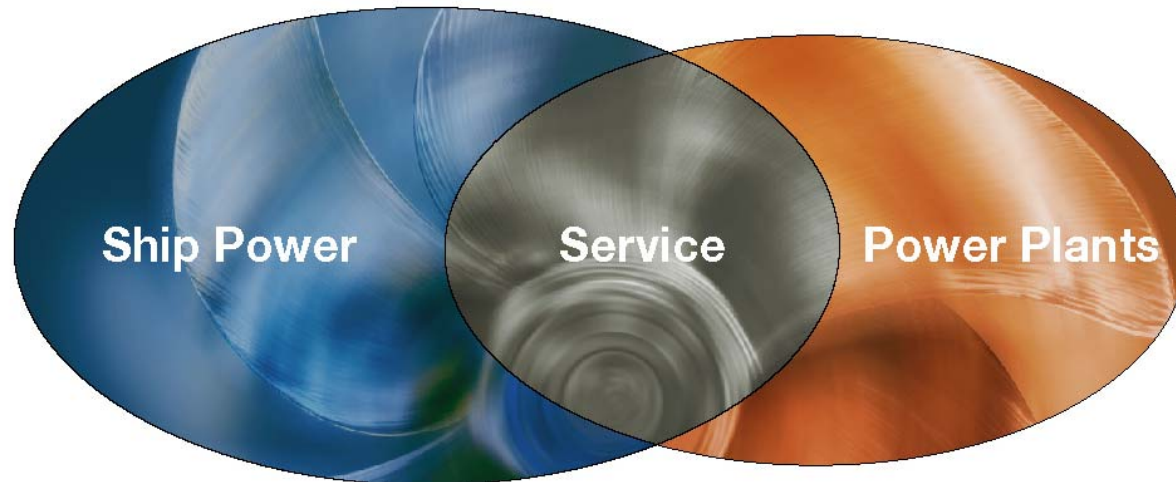
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SOFC Feasibility Analysis

- *Brief introduction to Wärtsilä Corporation*
- *Wärtsilä's role in SOFC industry*
- *SOFC feasibility analysis*
- *Sensitivity analysis, Conventional office case*
- *Conclusions*

Wärtsilä operates in two markets

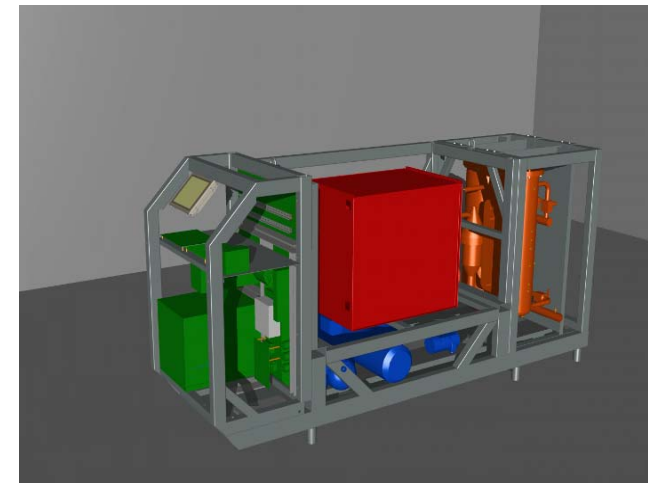
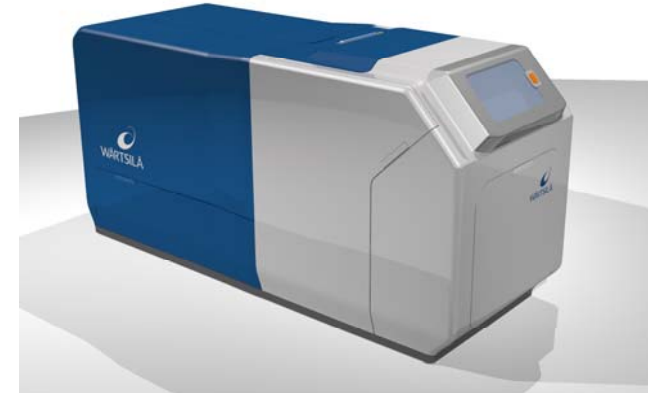


Wärtsilä is The Ship Power Supplier for builders, owners and operators of vessels and offshore installations. We are the company with a global service network to take complete care of customers' ship machinery at every lifecycle stage.

Wärtsilä is a leading provider of power plants, operation and lifetime care services in decentralized power generation.

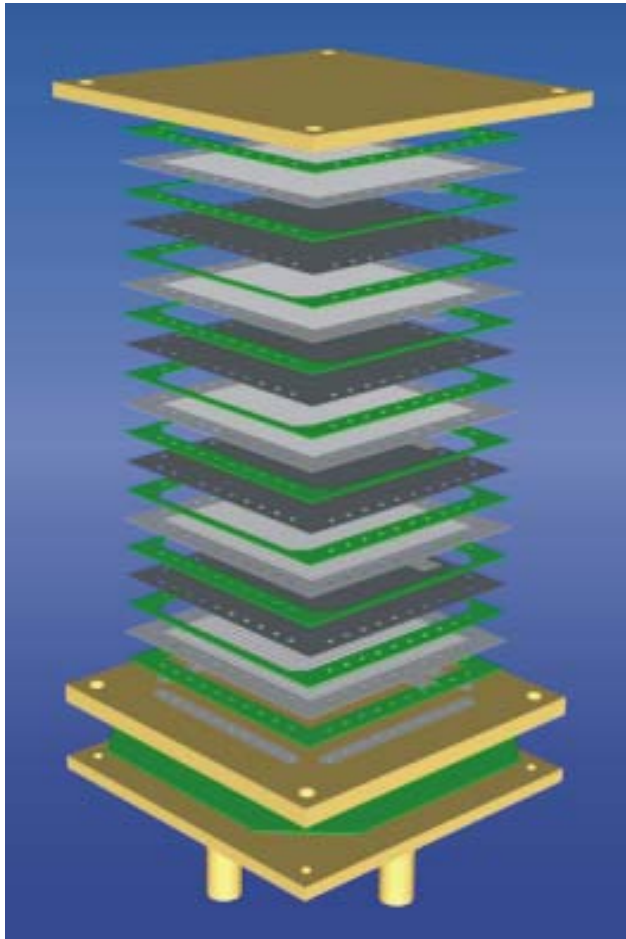
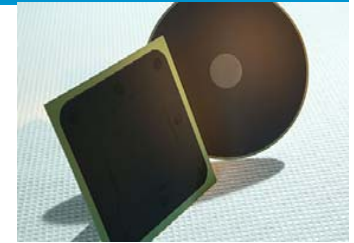
Wärtsilä Fuel Cell Program

- In the year 2000 Wärtsilä started a R&D program to develop and commercialize SOFC based CHP units for distributed power generation and marine APU markets.
- The R&D work in Wärtsilä is focused on design and engineering of fuel cell systems. System integration and application know-how are key areas where Wärtsilä expertise is utilized.
- Wärtsilä will develop a 20 kW α -prototype during 2005 and plans to demonstrate first commercial demonstration units in 50 kW power class within 2007.
- Larger commercial products in 50 - 250 kW power class are planned to follow by 2010.



Wärtsilä Fuel Cell Program

SOFC stack at Topsøe Fuel Cell A/S



- Planar Cell Design
- Anode-supported
- Metallic Interconnect
- Operates at 750 °C
- Low degradation
- Currently tested at pilot test facilities over 10 000 h
- Extensive fuel processing experience



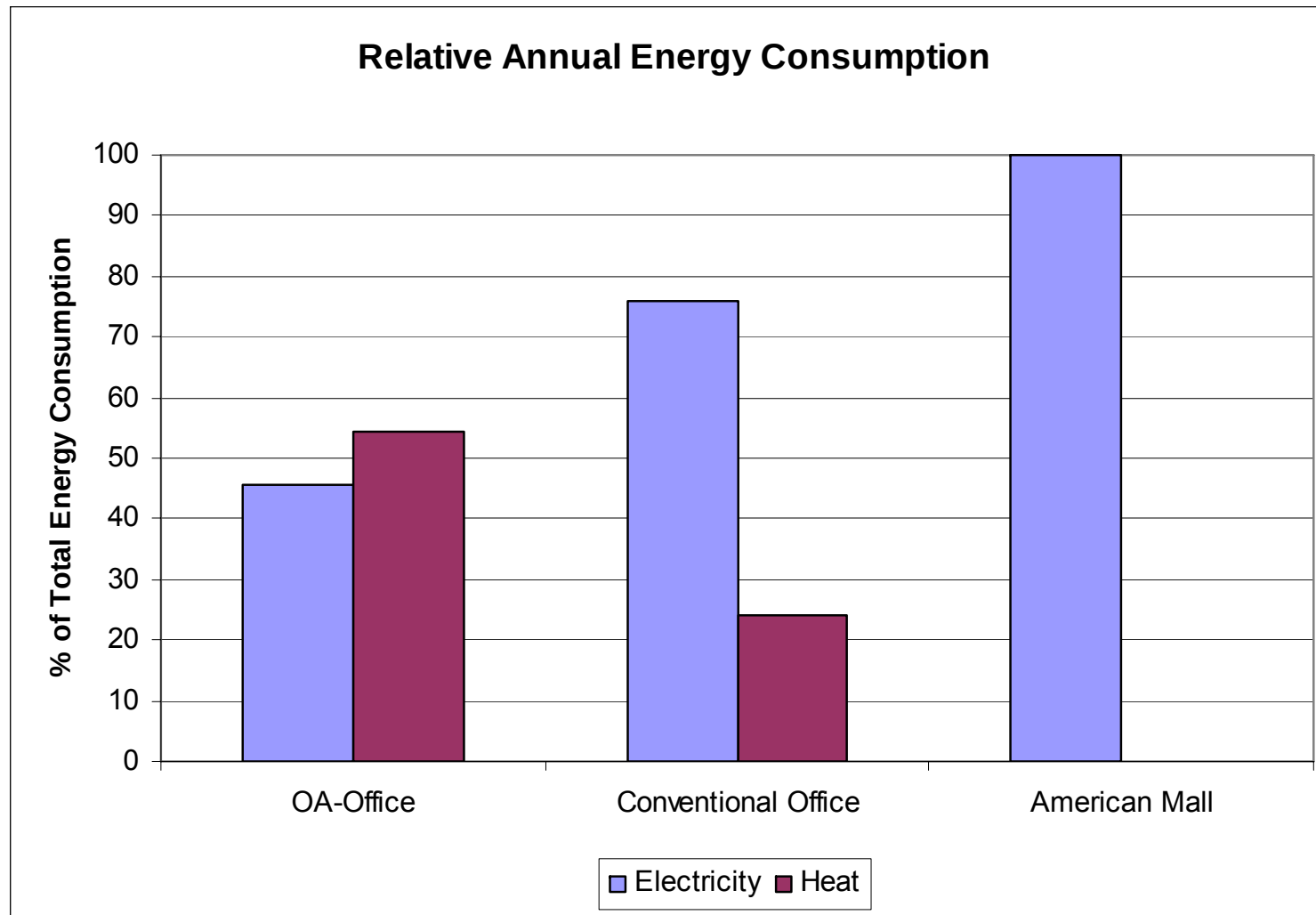
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SOFC Feasibility Analysis

Applications

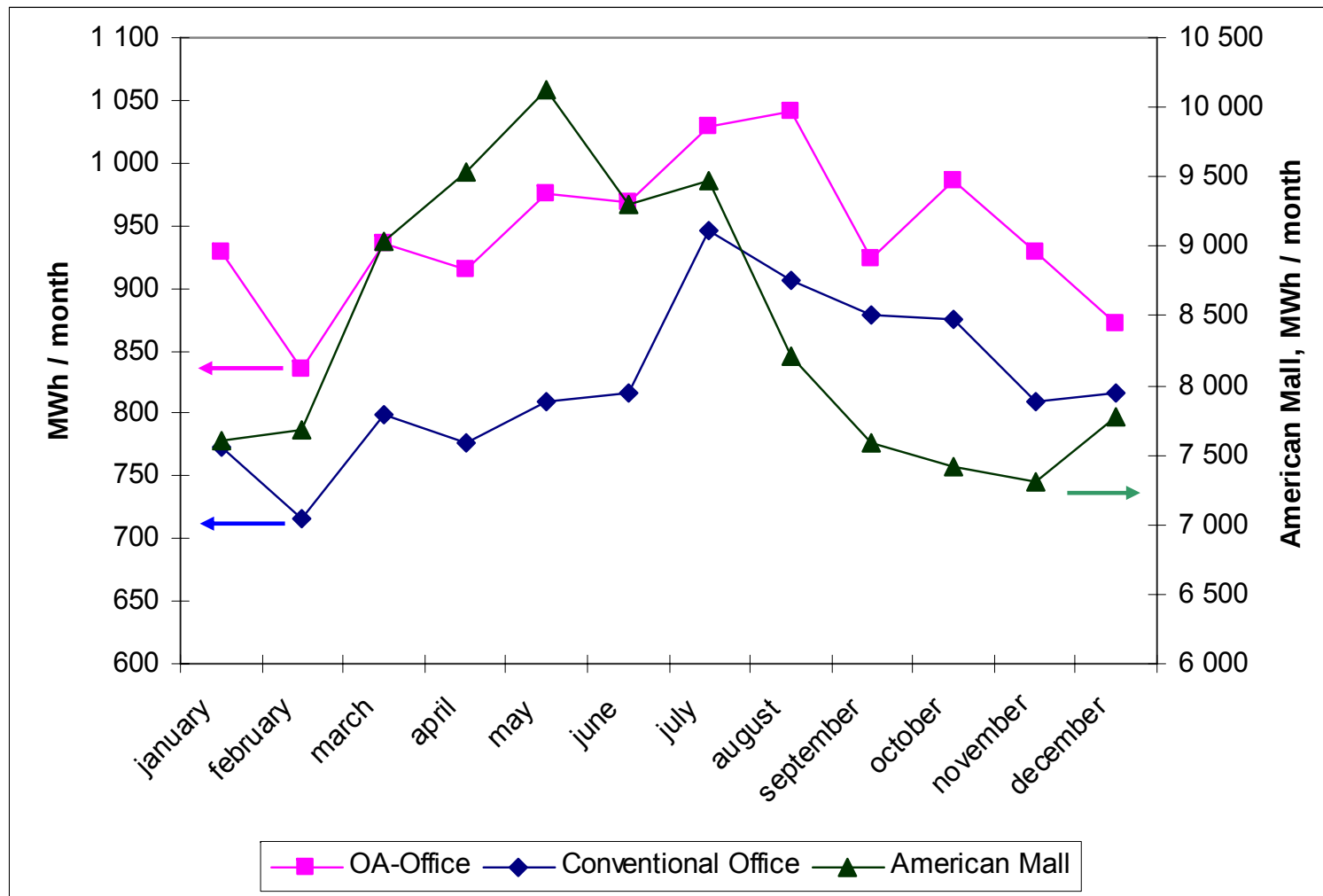
Energy consumption profiles



SOFC Feasibility Analysis

Applications

Seasonal variation of the electricity consumption



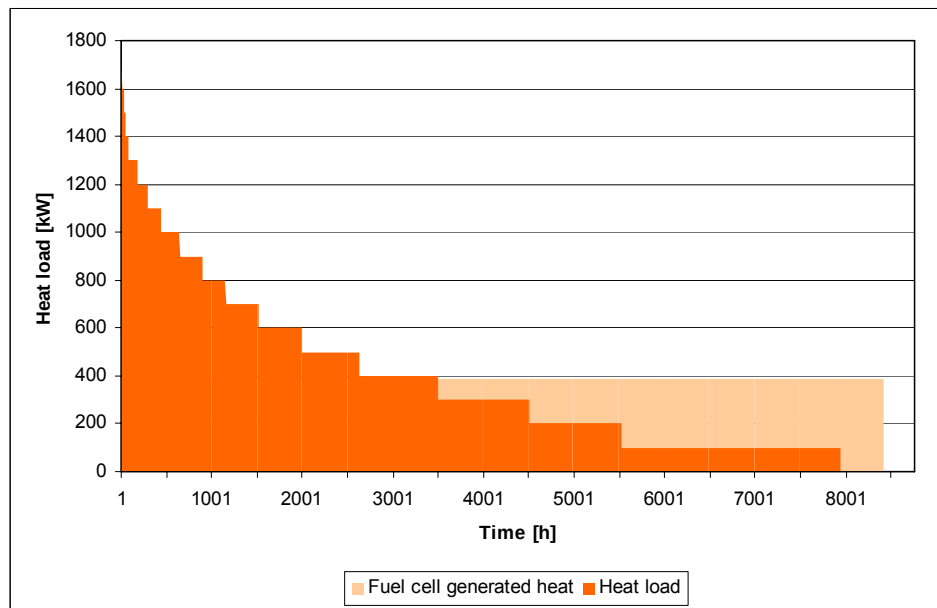
SOFC Feasibility Analysis

Applications

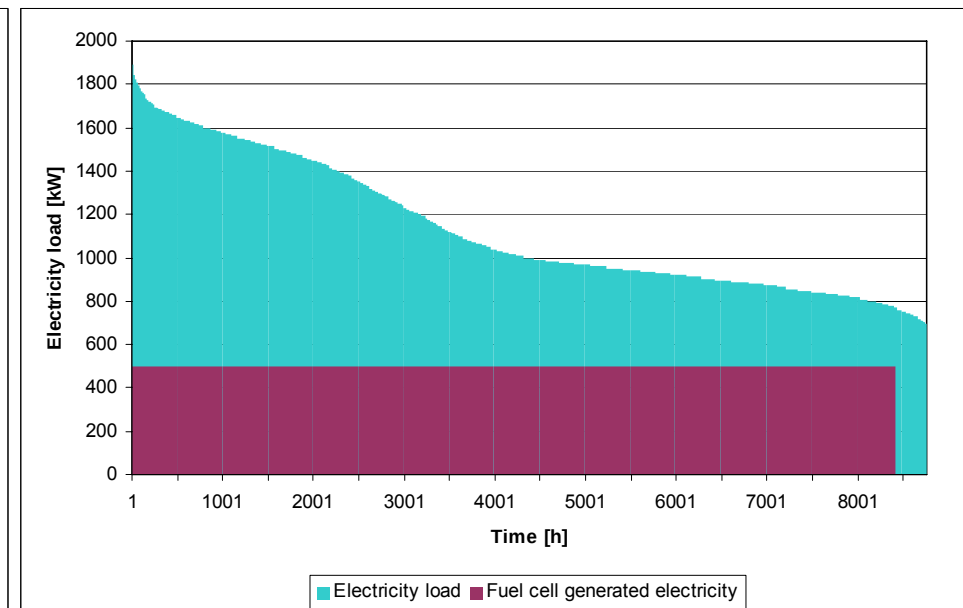
Energy consumption profiles for Conventional Office

Heat load

Part of the heat is wasted



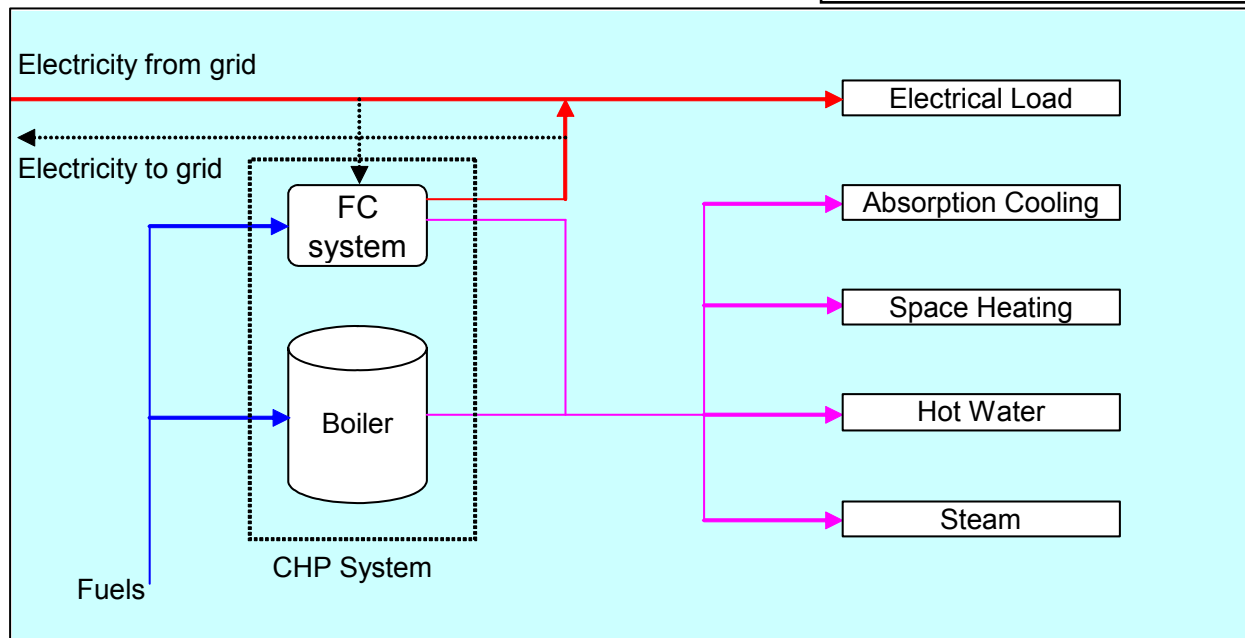
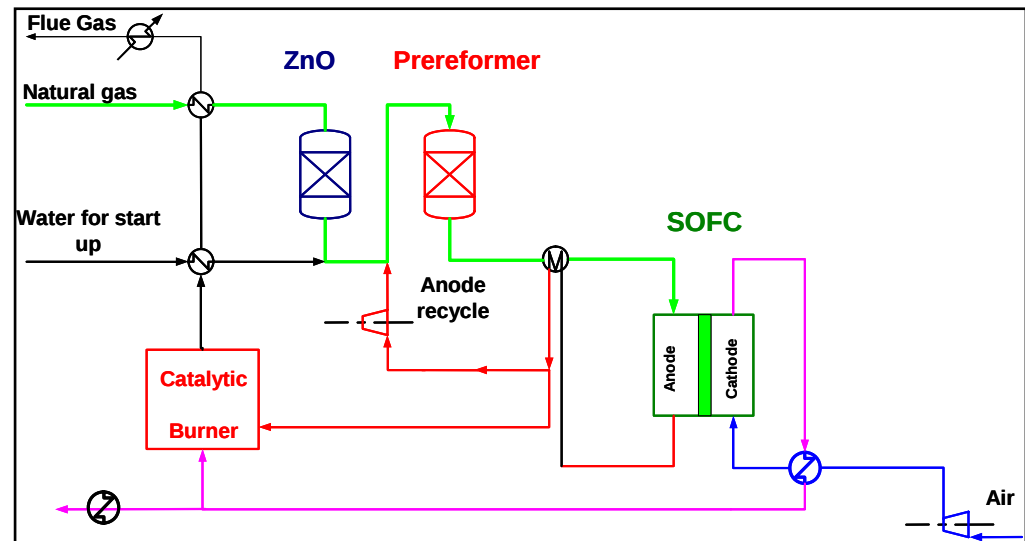
Electricity load



SOFC Feasibility Analysis

System description

NG fuelled SOFC in Commercial application



SOFC Feasibility Analysis

Assumptions

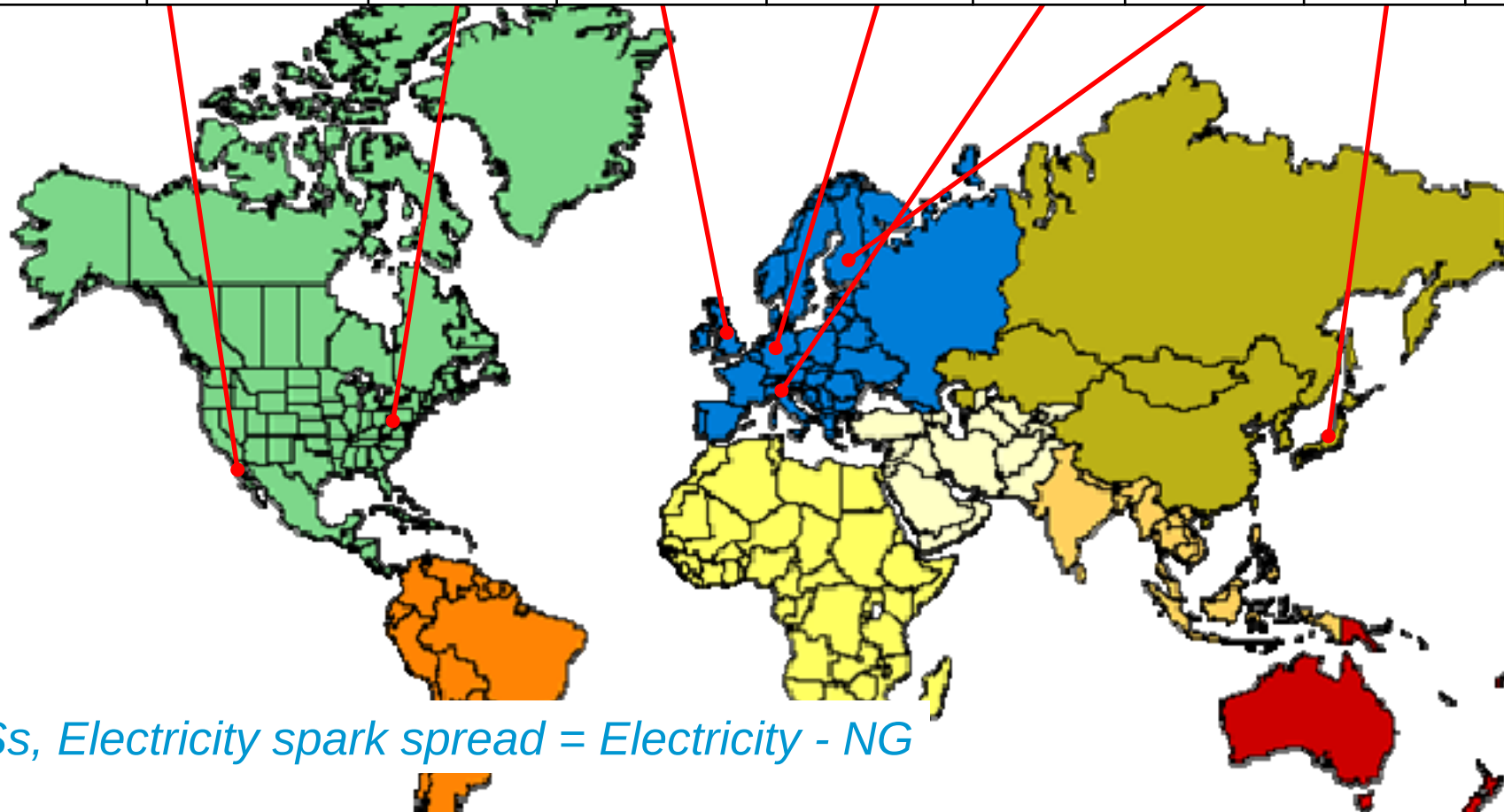
Main assumptions used in the study

Item	Value	Unit
Project life time	15	years
Project's discount rate	6	%
Depreciation period for fixed assets	3	years
Boiler system purchase price	50	€/kW
Fuel cell generated energy		
Electricity / Thermal	500 / 390	kWe /th
Fuel cell load	100	%
Annual fuel cell operation time	351	Days
Annual power generation	4 212	MWhe
Boiler system's total efficiency	70	%
Fuel cell's maintenance cost	20	€/MWh
Boiler system's maintenance cost	10	€/MWh
Fuel cell's electricity efficiency in baseline case	45	%
Fuel cell's total efficiency in baseline case	80	%

SOFC Feasibility Analysis

Market conditions

€cent /kWh	California	New Jersey	UK	Germany	Italy	Finland	Japan	EU15
Electricity	6,75	7,74	4,78	7,4	7,48	6,92	6,65	6,82
NG	2,22	2,18	1,76	2,71	3,51	1,37	2,78	3,17
Ess	4,53	5,56	3,02	4,69	3,97	5,55	3,87	3,65

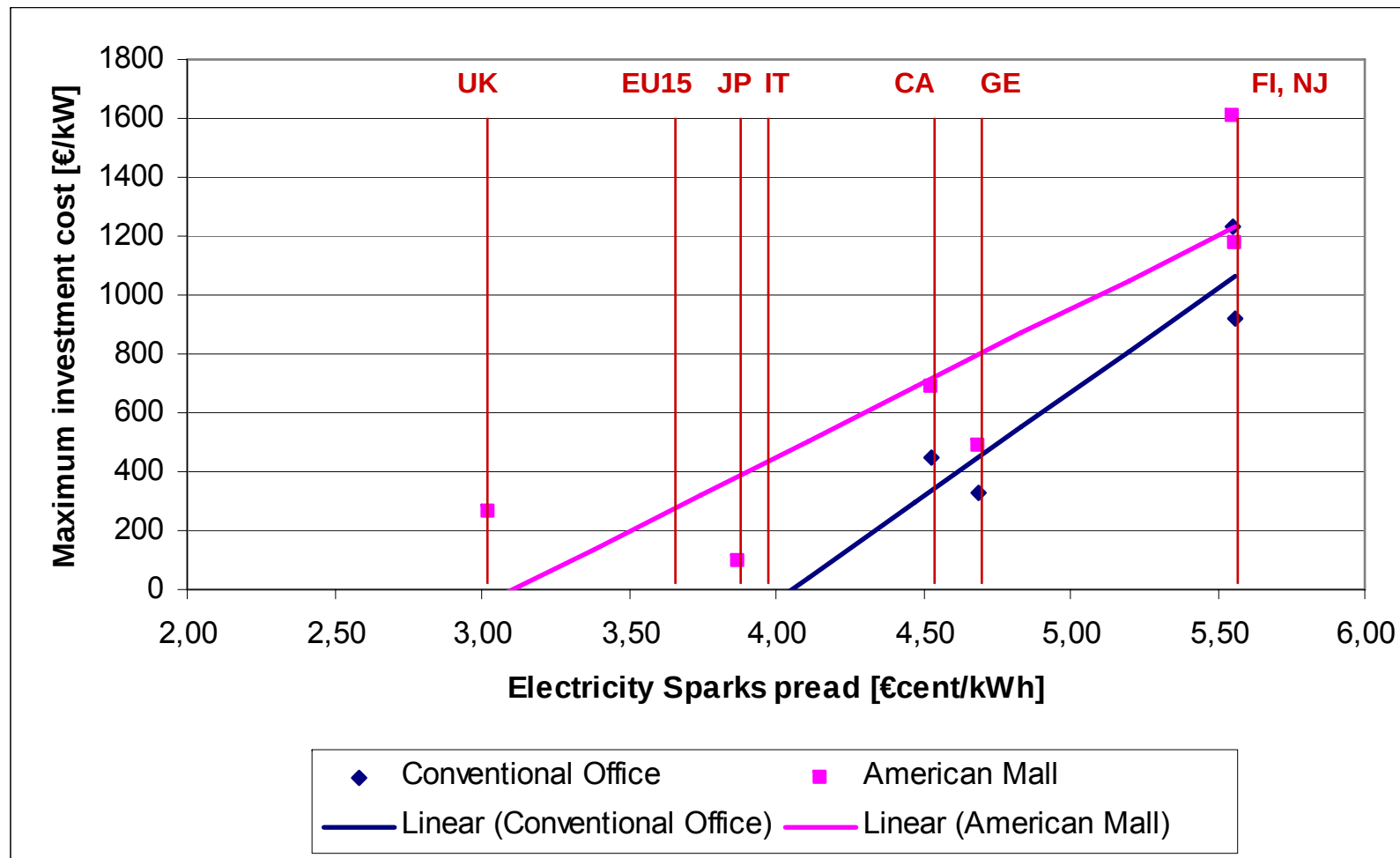


ESs, Electricity spark spread = Electricity - NG

SOFC Feasibility Analysis

Maximum investment cost for the FC unit, Heat not valued

Heat Spark spread HSs = 0 €cent/kWh

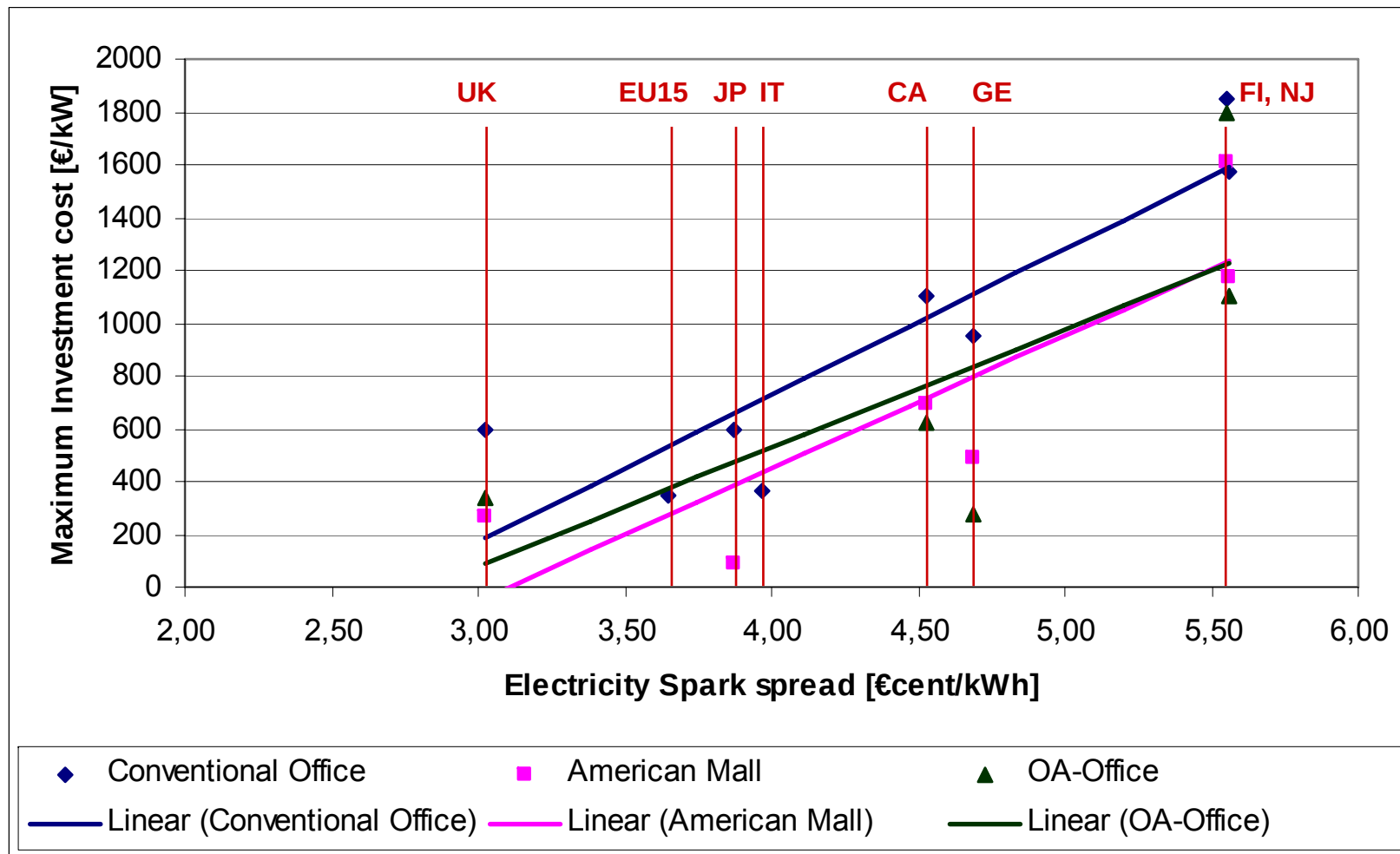


OA - office application remains unprofitable
HSs, Heat spark spread = Heat - NG

SOFC Feasibility Analysis

Maximum investment cost for the FC unit, Baseline Case

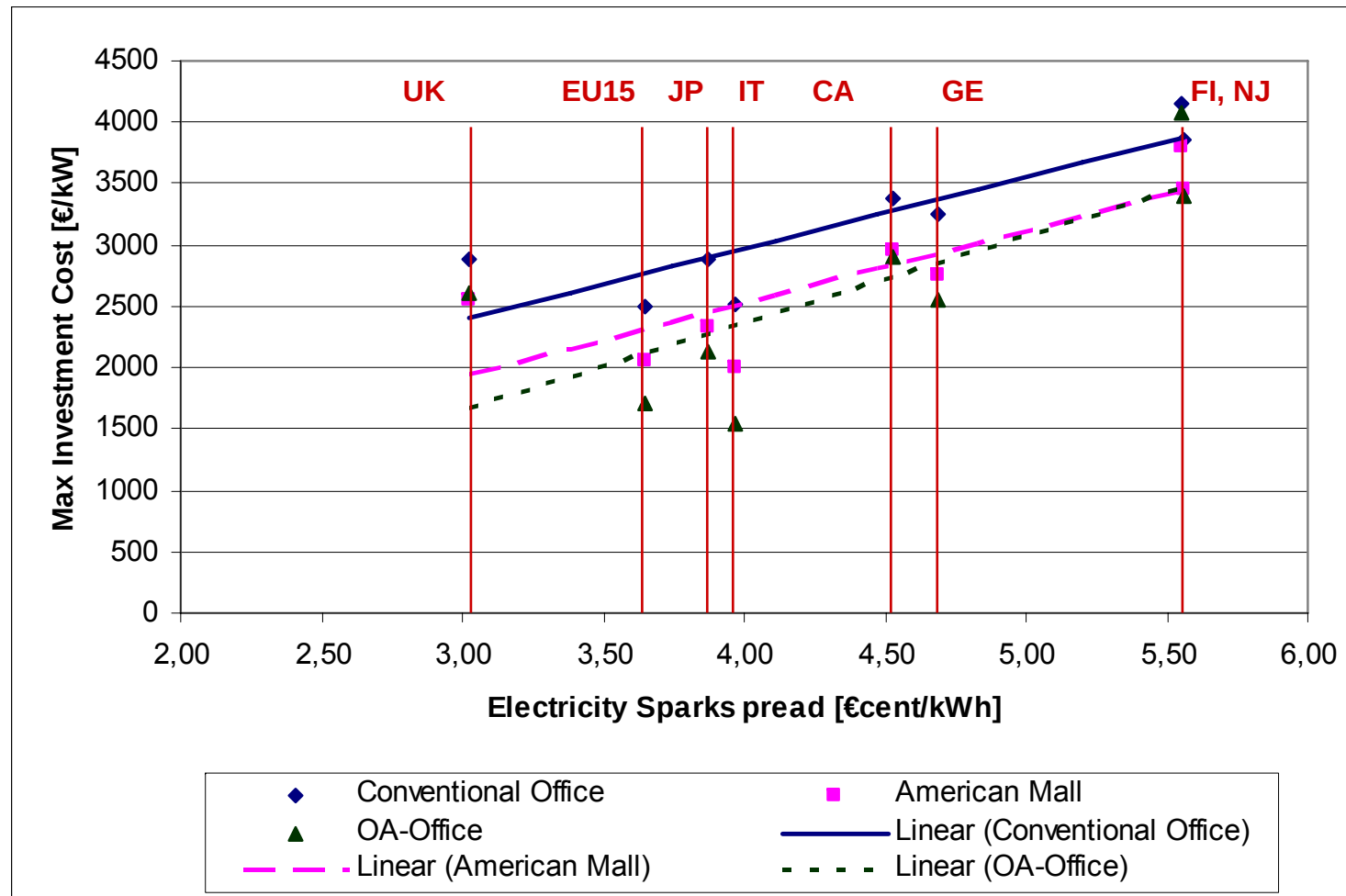
Heat Spark spread $HSs = 2.0 \text{ €cent/kWh}$



SOFC Feasibility Analysis

Maximum investment cost for the FC unit, Heat valued + Subsidy

HSs = 2.0 and subsidy 5.11 €cent/kWh for generated electricity



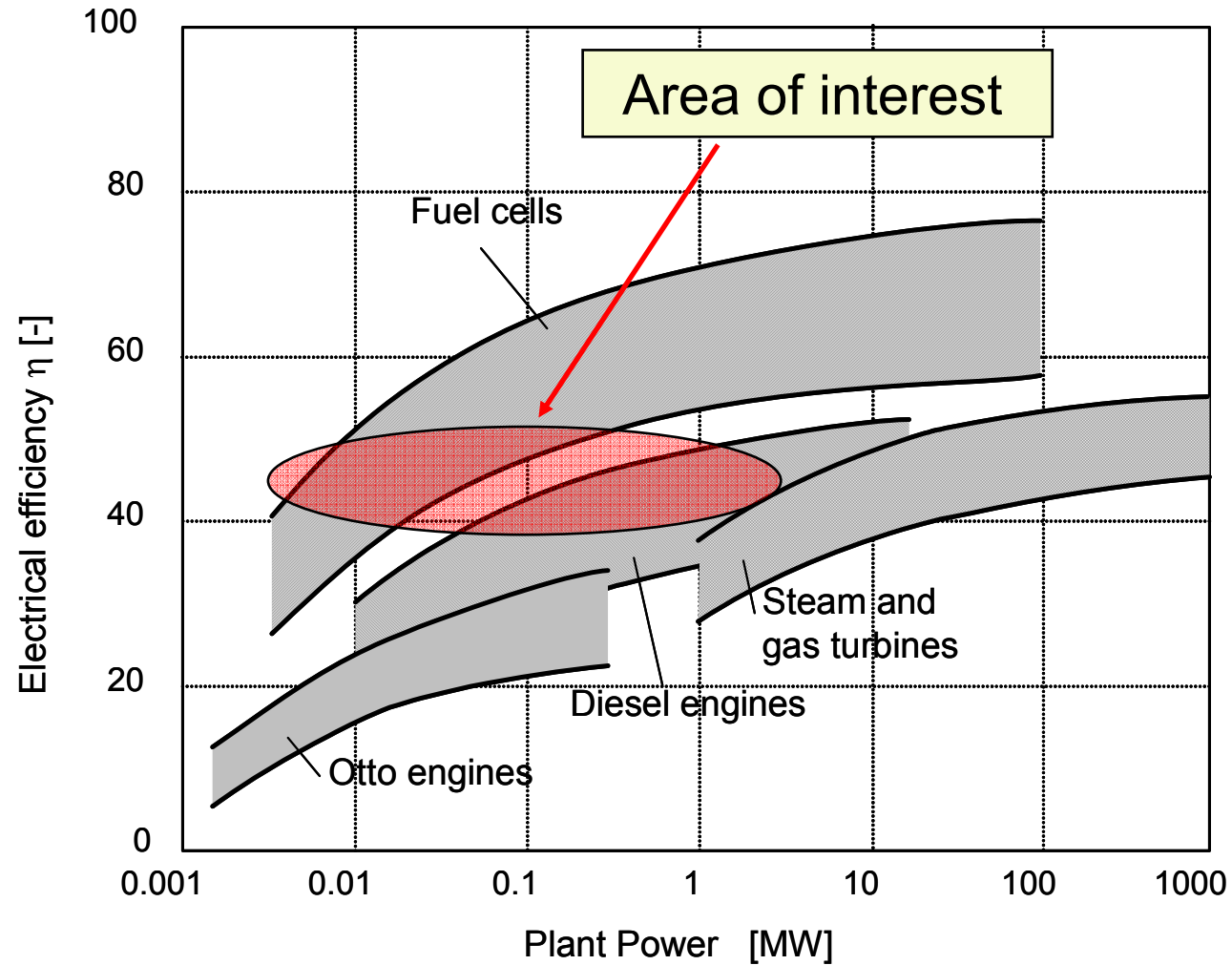
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SOFC Feasibility Analysis

Sensitivity Analysis, Efficiency

Fuel cell system efficiency

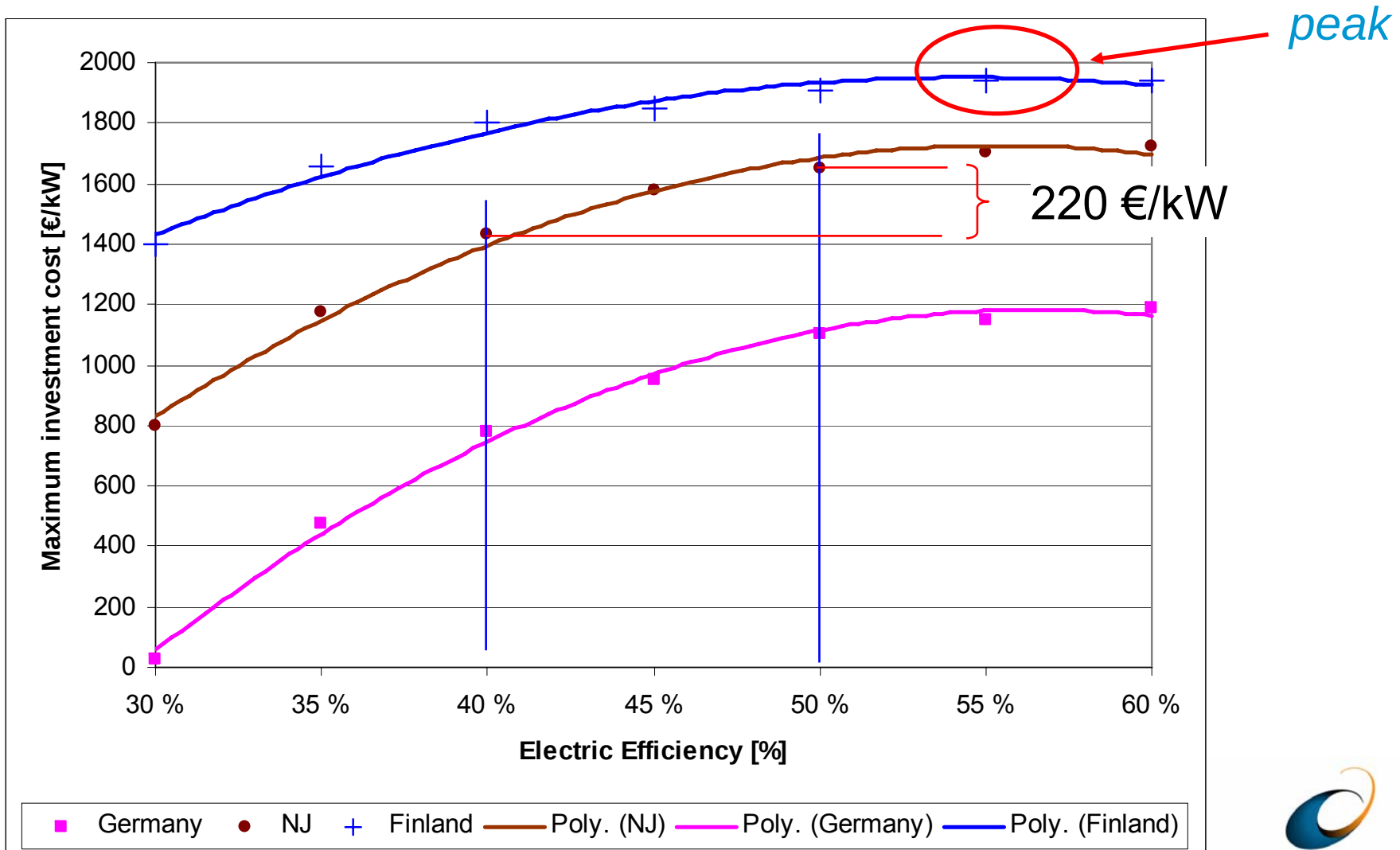


Source : W. Vielstich, *Handbook of Fuel cells – Fundamentals Technology and Applications*, Volume 1, Chapter 4, p. 29. Wiley (2004), ISBN: 0-471-49926-9
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SOFC Feasibility Analysis

Sensitivity Analysis, Efficiency

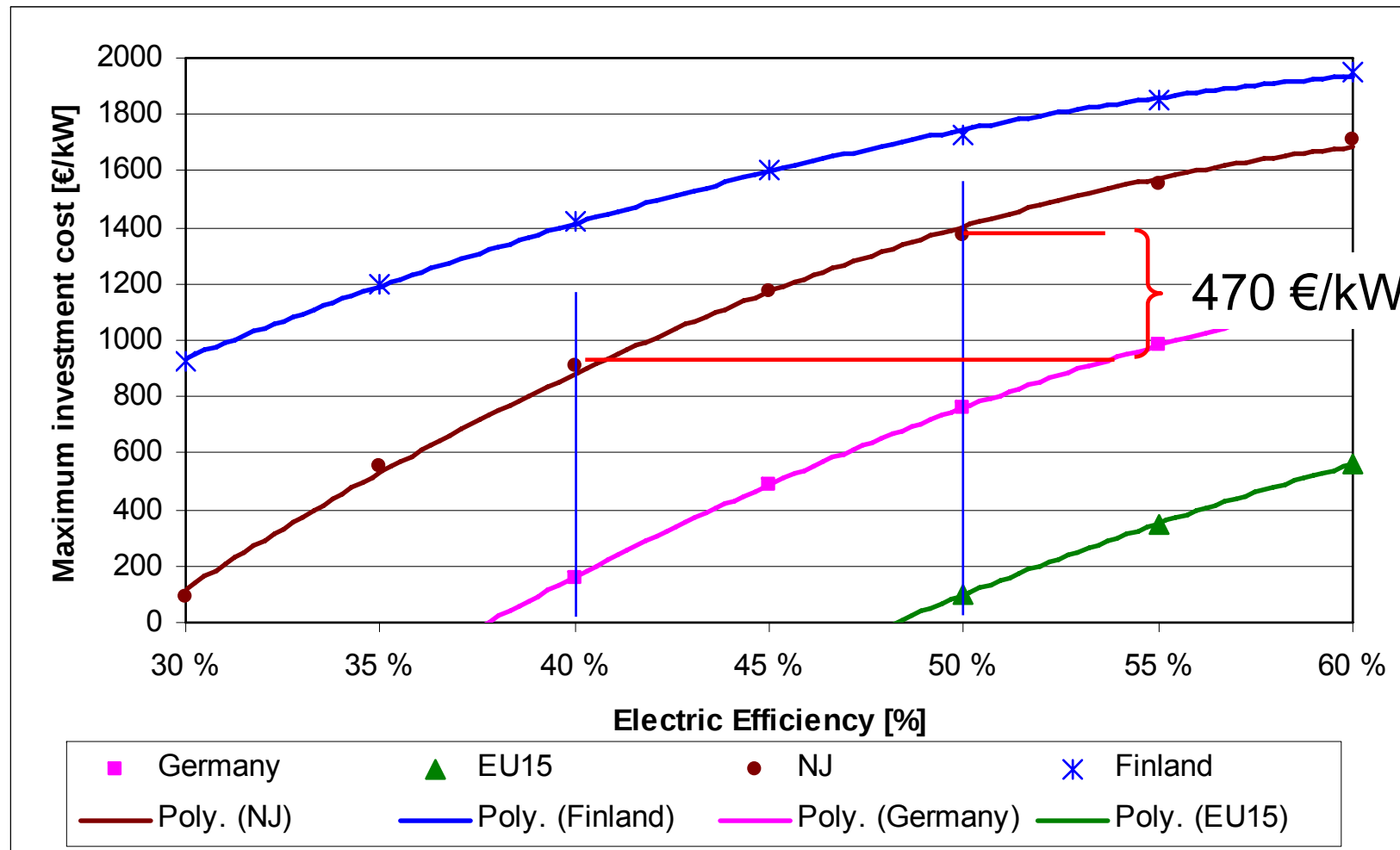
Conventional office application, baseline case



SOFC Feasibility Analysis

Sensitivity Analysis, Efficiency

Mall – application, no heat load



SOFC Feasibility Analysis

Sensitivity Analysis, Maintenance cost and Payback time

Conventional office application, baseline case

Allowed investment cost (€/kW)	UK	EU15	JP	IT	CA	GE	FI	NJ
Electricity spark spread (€cent/kWh)	3,02	3,65	3,87	3,97	4,53	4,69	5,55	5,56
Maintenance cost (€/MWh)	From 20-5 => Average increase = 680 €/kW							
20	600	350	600	362	1100	950	1850	1575
10	1060	790	1025	800	1550	1460	2325	2030
5	1275	1020	1265	1010	1775	1680	2550	2250

Payback time (years)	From 15 - 5 => Average Decrease = 600 €/kW							
15	600	350	600	362	1100	950	1850	1575
10	430	230	420	240	800	705	1400	1160
5	185	70	180	75	400	350	730	600

- A comprehensive tool for the feasibility analysis of various fuel cell applications has been developed.
- Feasibility of the fuel cell systems depends highly on the local energy markets and consumption profile of the application.
- CHP operation is essential for economical feasibility.
- Electrical efficiency up to 55 % increases the allowed investment cost in the analyzed CHP application.
- Short - medium term feasibility is critical.
- Considerable cost reduction combined with subsidies and incentives are needed for commercial market acceptance in short - medium term.

SOFC Feasibility Analysis

Thank You for your attention

By Wärtsilä Fuel Cell Group

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