



Small Gas Turbine Project

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VGT / COGEN / ECN / TUD

Small Gas Turbine Project

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Small Gas Turbine Project

Industrial participants

- Clyde Petroleum/NOGEPA
 - Eneco
 - Essent
 - ExxonMobil
 - FP Turbomachinery
 - Gasunie
 - Geveke
 - Mesco
 - Nedalo
 - Schelde Heron
 - Stork Turbo Services
 - Thales
 - Urenco Aerospace
 - For more information: contact VGT
- M. Waaijenberg
 - W. Brooks
 - G. Hoek
 - B. Hermsen
 - C. Faddegon
 - K. Hoving
 - C.J. Groen
 - T. Achterberg
 - J. Maree
 - N. Koolen
 - C. de Bruine
 - G. Seppenwoolde
 - F. Friedeman

Why the interest?

Small Gas Turbine Project

- Small gt-sector is relatively young
- Below 3 MW only gas engines (or aircraft propulsion, stand by)
- Late 80's situation changed:
 - more stringent emission regulations
 - research on hybrid propulsion
 - turbo charger manufacturing technology
 - high speed generator
 - use of reliable recuperators
- Now micro-turbines available (up to 100 kW) with high efficiency and low price
- Technology will expand in higher power classes

Project outline

Small Gas Turbine Project

- International status
 - Technology
 - Market survey
 - Company & institute visits (24)
- Applications (focus on Dutch/West European market)
 - economic feasibility
 - market potential
- Government policy issues
- Industrial opportunities
- Demonstration projects

COMPANIES VISITED:

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- USA:
 - MIT
 - NREC
 - Elliot
 - Capstone
 - Honeywell
 - Private consultants
- Europe:
 - Turbec (ABB-Volvo)
 - Turbomeca
 - Bowman
 - Schelde Heron
 - OPRA
- Japan:
 - Tokyo Gas
 - Japan Cogeneration Ctr
 - MyEnergy
 - NEDO
 - JARI
 - Niigata Engineering
 - Ishikawajima HI
 - Mitsubishi HI
 - Toyota Turbine & Syst.
 - Daihatsu Diesel
 - Kawasaki HI
 - Ebara Corporation
 - Honda

Micro Gas Turbines



Small Gas Turbine Project

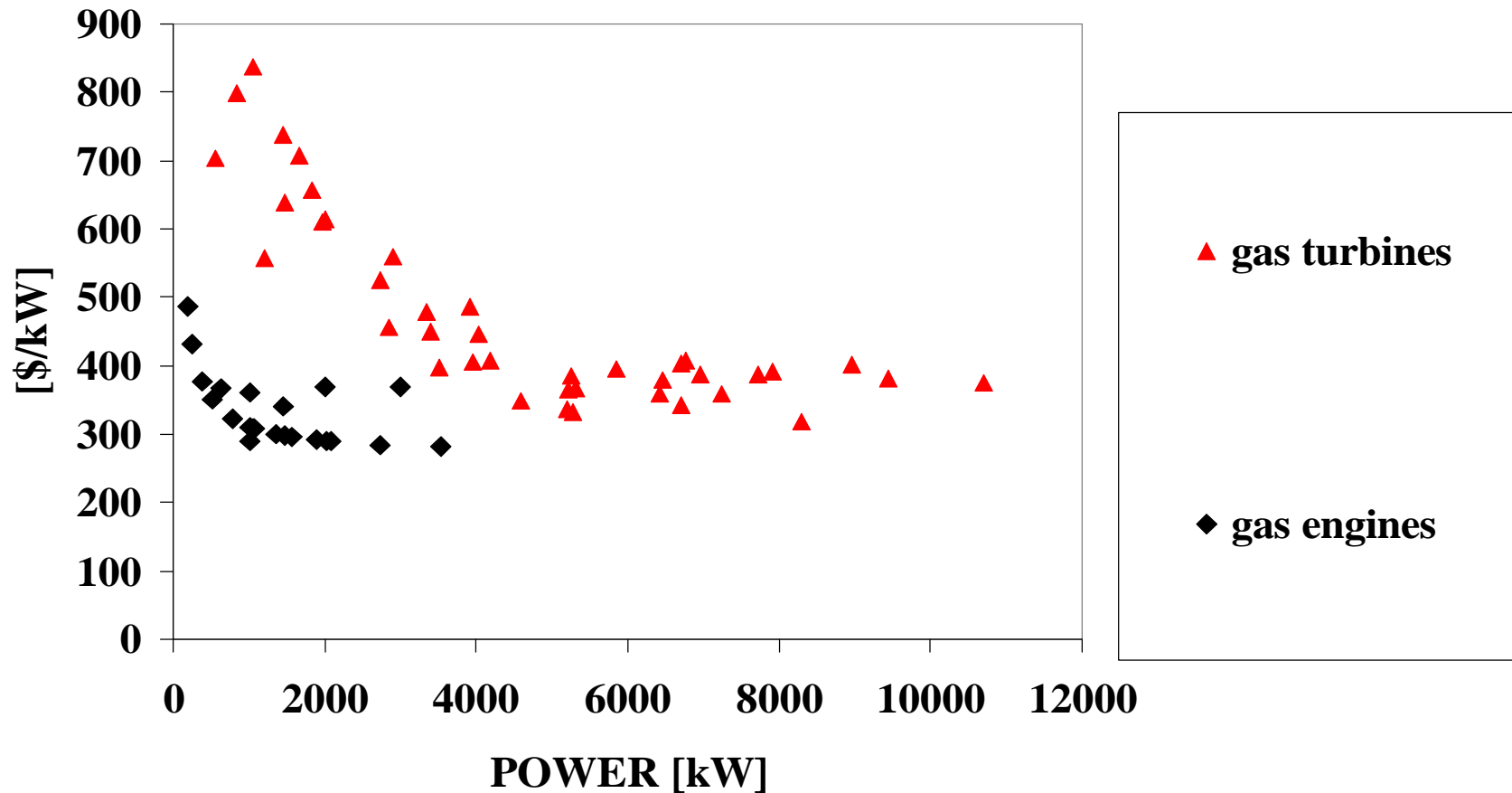
Model	Power [kW]	Efficiency [%]
Capstone	28	28
Elliott	35 – 80	14 – 30
Parallon	75	28
IR Power Works	70	33
Turbec	100	30

Genset Package

Specific Investment Level [US\$/kWe]



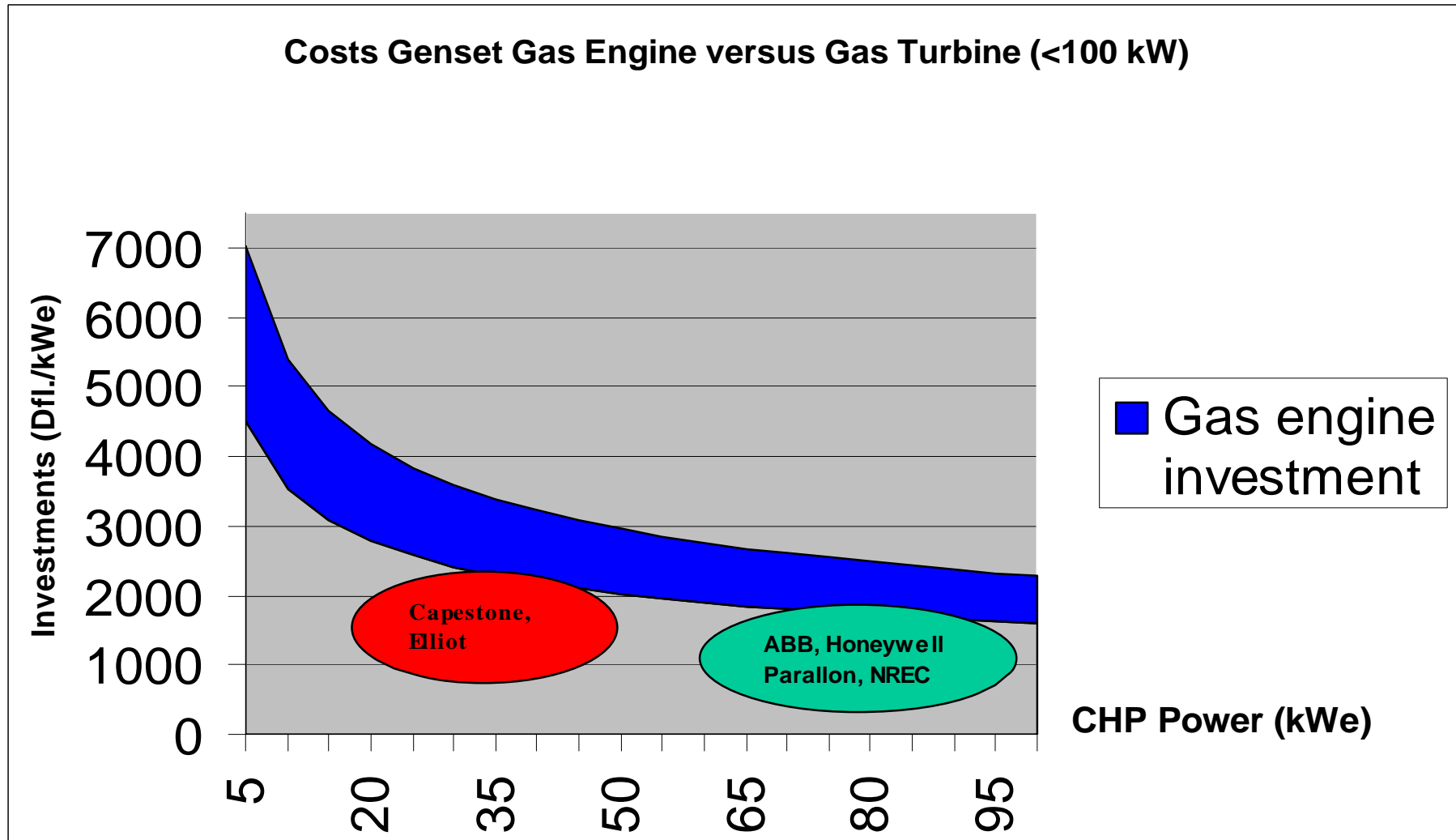
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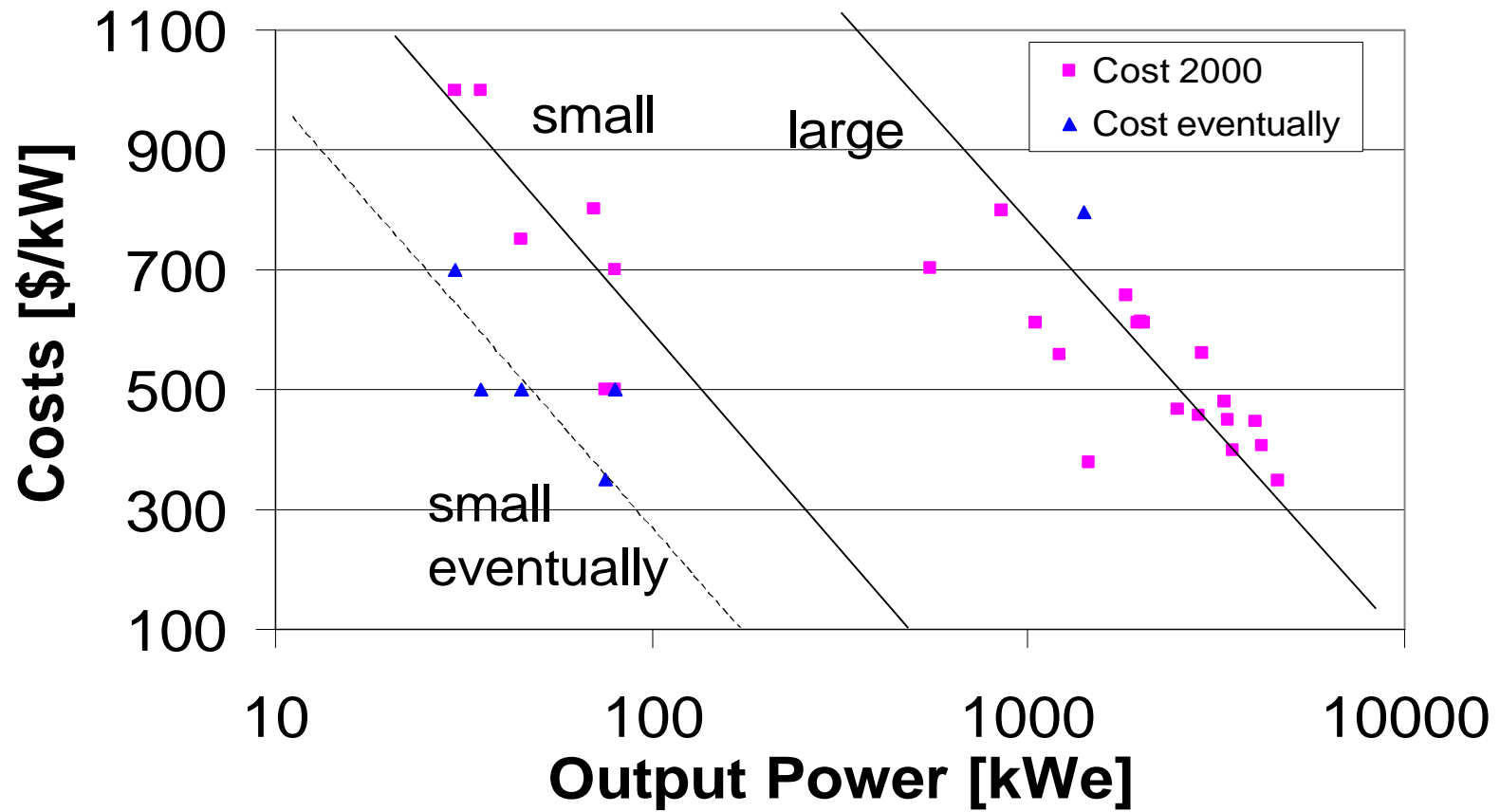
Investment level micro-turbine vs gas engine



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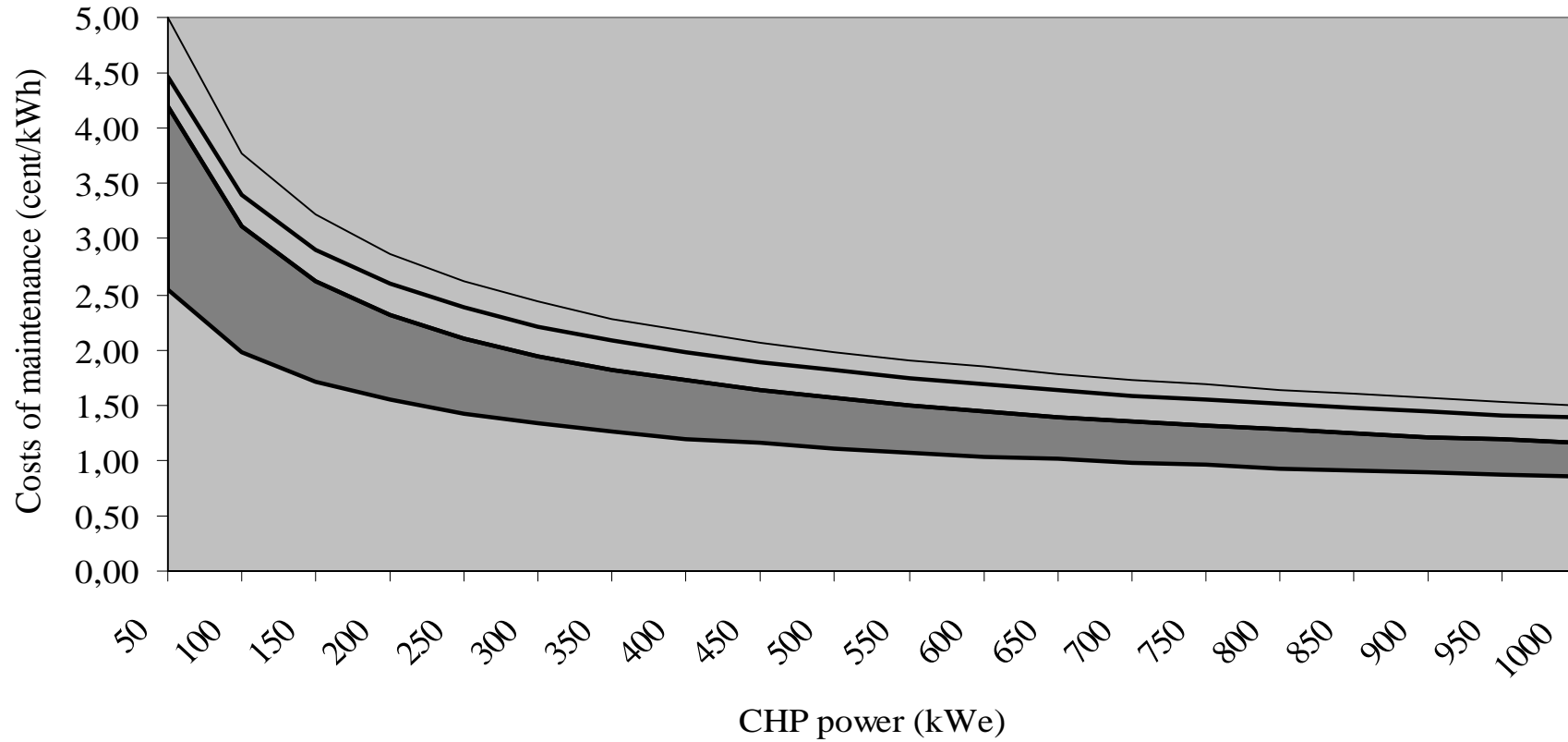
Costs vs. Output Power



Maintenance Costs Gas Engines



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Maintenance gas engine
 NOx reduction with uremsystem
 Fluegas purification for CO2 fertilisation

Comparison for small scale CHP

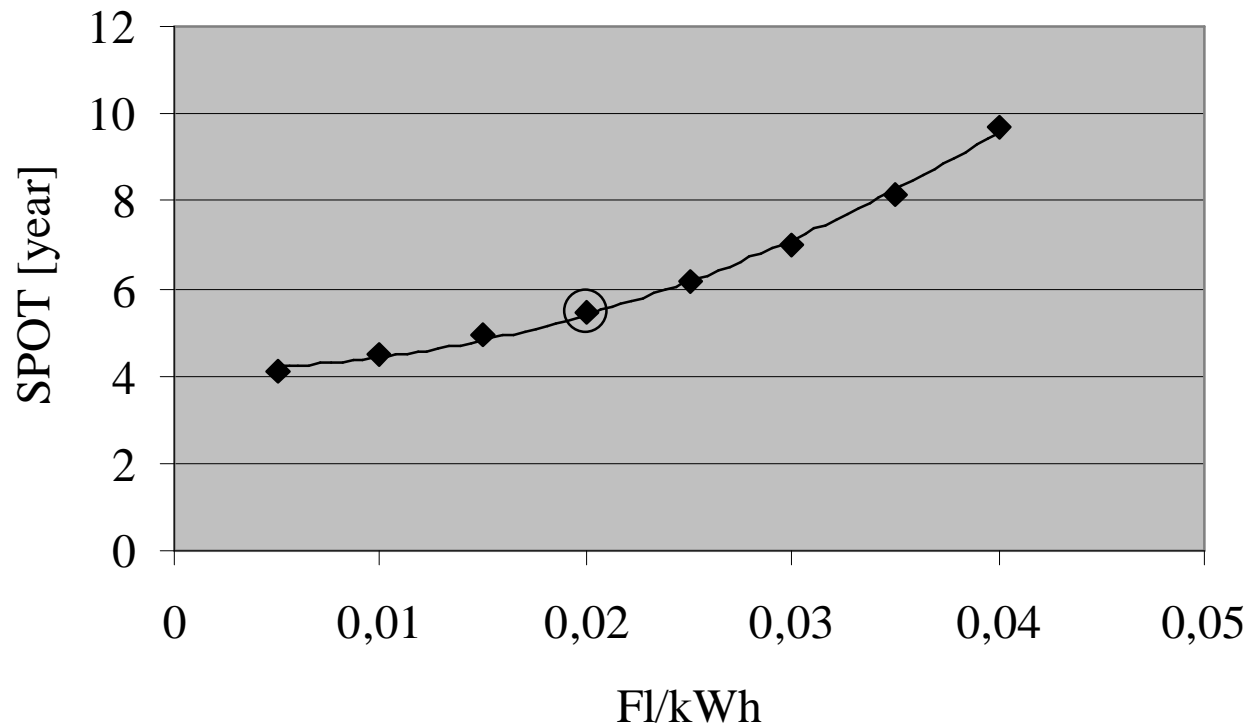


Small Gas Turbine Project

Co-generation 4000 hours/year	Base Case	Example 5 0-200 kW Based on 70 kW		
		Gas Engine	Micro-Turbine now	Micro-Turbine future
Investment [Dfl./kW]	1000	1800	2000	1250
Electric Efficiency [%]	30	33	28	28
Total Efficiency [%]	80	85	75	75
Maintenance Costs [ct./kWh] (Incl. major overhaul)	2	5	1,25	1,25
Reference Price of Electricity (Dfl./kWh)	0,15	0,15	0,15	0,15
Price of natural gas (Dfl./ m ³)	0,50	0,50	0,5	0,50
SPOT	5,5	16,5	12,4	7,7

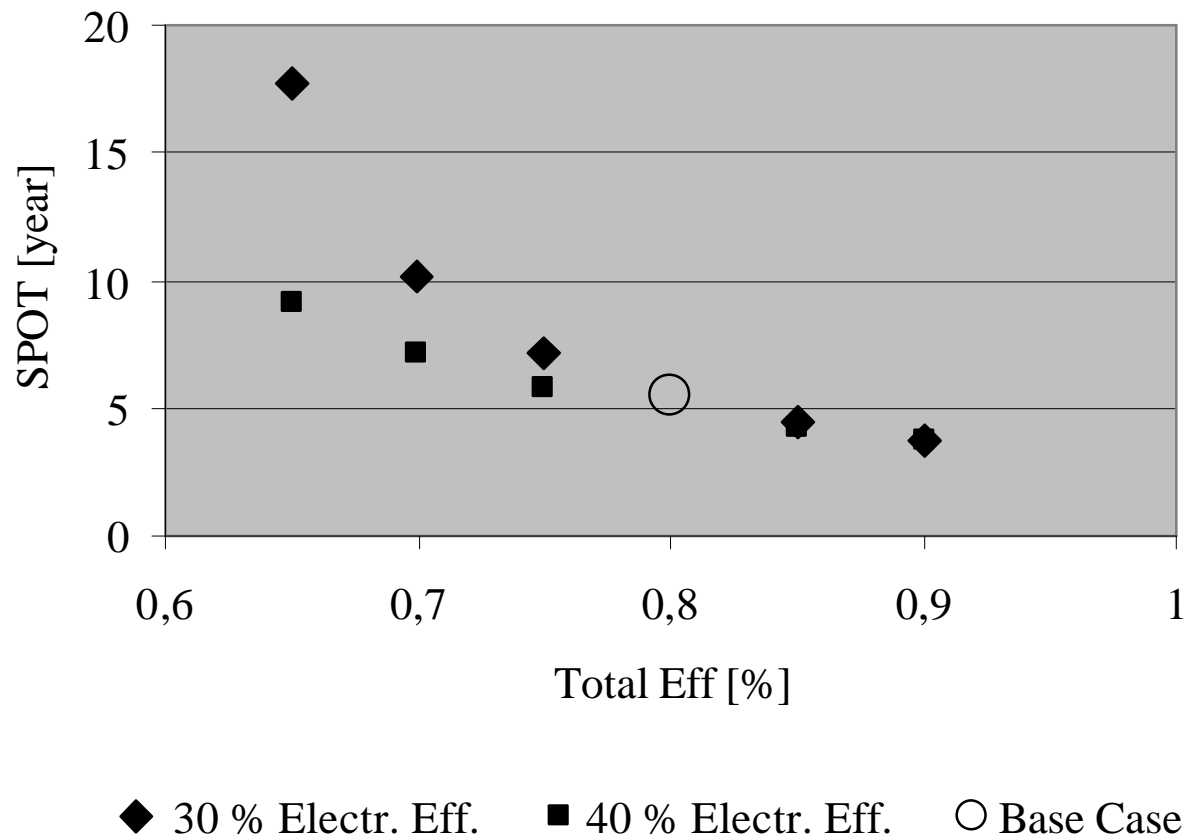
Maintenance Costs

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Utilisation of Heat

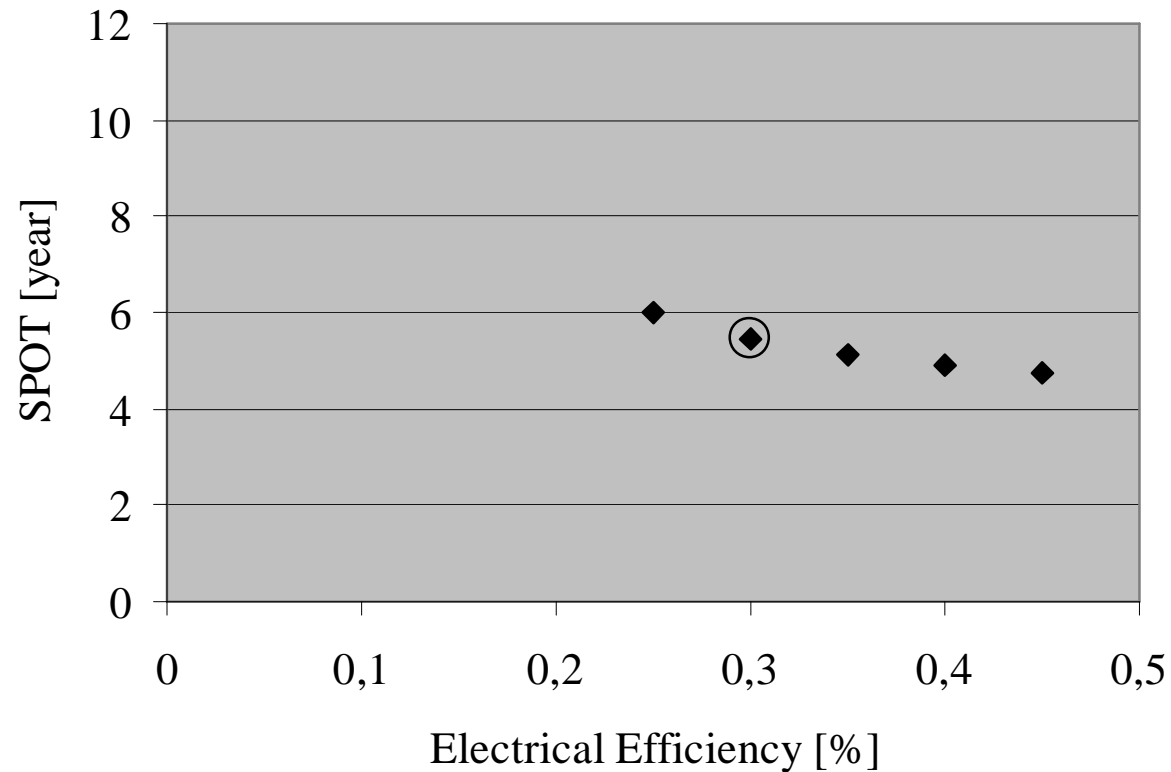
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Electrical Efficiency @ 80 % Total Efficiency

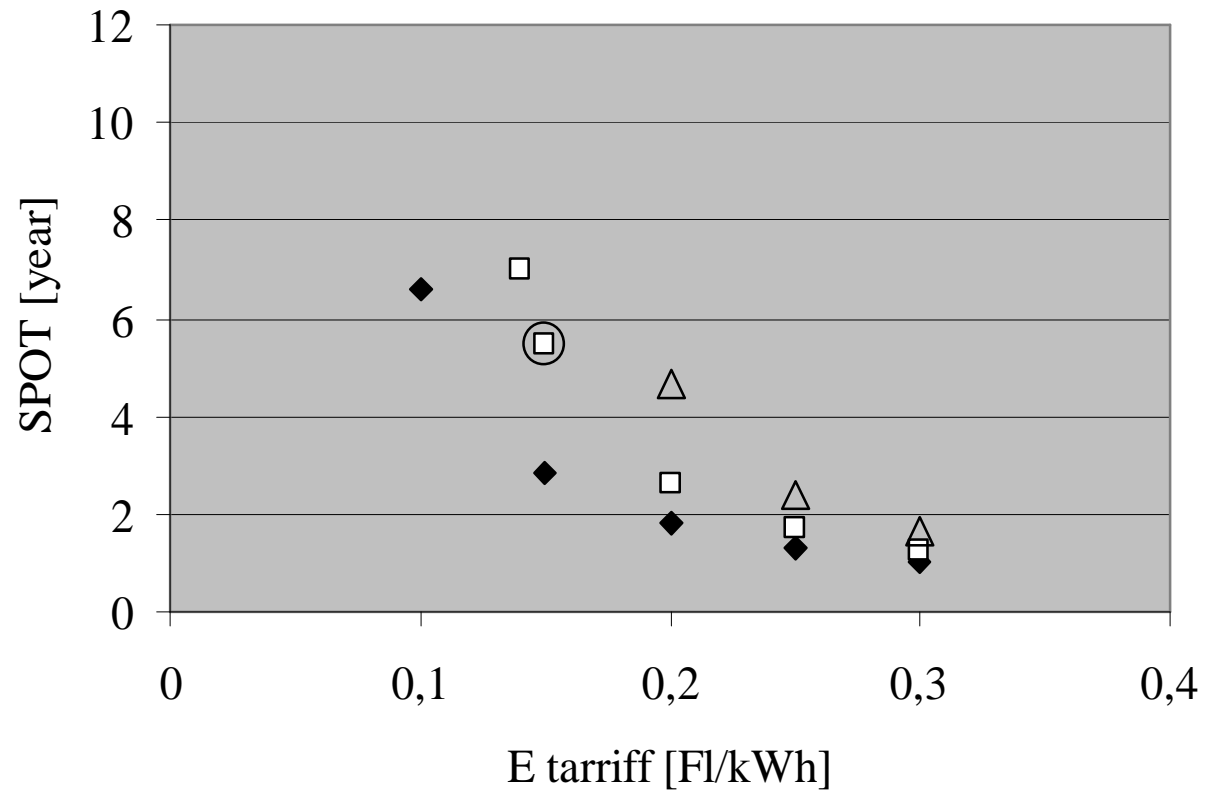


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Energy Tarriffs

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◆ gas @ 0,25/m3 □ gas @ 0,50/m3 △ gas @ 0,75/m3 ○ Base case

Applications for small gas turbines

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- **Pure electrical power demand**
 - base load power
 - small industries, offices, hotels, apartment buildings, grocery stores, laundries
 - telecom services
 - rural areas (distributed systems)
 - stand-by power (hospitals, offices, UPS-systems)
 - peak shaving
 - mobile power
- **Cogeneration systems**
 - traditional systems
 - absorption cooling
 - mechanical drive of refrigeration systems
 - trigeneration systems
 - direct use of exhaust heat for e.g. combustion air
- **Specific applications, based on fuel capabilities**
 - on-offshore applications
 - landfill gas, sewage gas, biogas,
- **Hybrid propulsion systems (buses, trucks, cars)**

Market Estimate [MW]

Small Gas Turbine Project

Application	1998 Installed Capacity [MW _e]	Forecast 2010 low [MW _e]	Forecast 2010 high [MW _e]
Horticulture	1007	2000	3000
Utility & Residential Buildings	340	1000	2000
Industry	45	200	400
Other	106	200	300
Co-generation total	1498	3400	5700
ICT network power	-	400	1000
Oil & Gas Industry (Satellite platforms)		5	10
Oil & Gas Industry (Flare gas application)		3,5	7
Oil & Gas Industry (Small gas fields)		45	90
Hybrid Propulsion			
Marine application			
Total:	1498	3853,5	6807

Market Estimate

[# units]



Small Gas Turbine Project

Application	# gt low	# gt high	Average unit size [kWe]
Horticulture	800	1800	1000
Utility & Residential Buildings	600	1600	100
Industry	150	700	500
ICT network power	200	500	2000
Oil & Gas Industry (Satellite platforms)	50	100	100
Oil & Gas Industry (Flare gas application)	50	100	70
Oil & Gas Industry (Small gas fields)	30	60	1500
Hybrid Propulsion			
Marine application			
Total:	1880	4860	

Demonstration projects

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- Greenhouse CHP and CO₂-fertilization
- Wet natural gas burning on satellite platforms
- Flare gas burning at chemical sites
- Burning of sewage gas/landfill/biomass gas
- CHP/cooling systems in offices/elderly homes
- Preheating of industrial furnaces
- Combination with organic Rankine cycle
- Combination with fuel cells
- Powerpacks for marine cooling application
- Hybrid propulsion system for buses