Cost - benefit analysis of plasma technologies

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Plasma based technologies sustainability analysis

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Cost-benefit analysis

- Aspects of the plasma technologies
  - In order to reach a conclusion about all aspects of the plasma technologies a common unit has to be defined; i.e., there must be a "bottom line."

- Costs and benefits
  - The most convenient common unit is money. This means that all benefits and costs of an implemented project should be measured in terms of their equivalent money value.
  - A programme may provide benefits which are not directly expressed in monetary terms.

Plasma based technologies sustainability analysis

- Past choices
  - Most challenging is to find past choices which reveal tradeoffs and equivalencies in preferences.
- Benefits from an higher efficiency cleaning technology
  - Monetary benefits that can be established by evaluating the different housing payments among more polluted areas and less which polluted areas taking into account the same characteristics and location.
- Value of cleaner air
  - Generally, the value of cleaner air to people as revealed by the hard market choices seems to be less than their rhetorical valuation of clean air.

The main benefits after implementing the plasma technologies

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Avoided payments for air pollution

Avoided external costs

Health benefits

Cost calculation

Taxes for pollution

Administration and capital costs etc.

Report on cost-benefit analysis

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Cost-benefit analysis of selected examples regarding the main pollution service.

Information search for cost and market analysis concerning sea water cleaning from oil and oil – type slicks.

Cost models and investment preparation document for one important applied field will be prepared.

Plasma technologies

Plasma technologies for flue gas treatment

Plasma technologies for water treatment

Plasma technologies for odour reduction

Methods for pollution control

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Electron beam flue gas treatment	• Removal of SO_2 and NOx • NOx treatment using low-energy secondary emission electron gun • oxidative decomposition of aromatic hydrocarbons • an overview and research needs
Arc	• For destruction of hazardous waste • Modeling • Plasma pyrolysis of medical waste

Non-thermal-plasmas

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Electrostatic precipitators	• Review • Application in cement industry
Corona	• Pulsed streamer corona • DC corona streamers induced by UV irradiation • Scale-up for a coal fired power plant • Plasma based total treatment of waste and low-grade fuels • Kinetic • Analysis of non-thermal plasmas used for pollution control
DBD	• NOx, SO2, VOCs (Reviews)

Non-thermal-plasmas

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High frequency discharge	• Oxidation of activated carbon and methane using a high-frequency pulsed plasma
Glow discharge	• DC glow discharge in atmospheric pressure air as a source for pollution control
Microwave	• Microwave-plasma discharge within the flue gas as a potential pollution-control method
Micro-hollow cathode	• Applications for plasmachemical synthesis and pollution control become feasible

Indirect plasma methods

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UV	• Pollution and odour control
Ozone	• Ozone injection for NOx control: numerical simulation • Removal of SO_2 and NOx • Effect of ozone injection on the catalytic reduction of nitrogen oxides

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Electron beam flue gas treatment (EBFGT)

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Administration and capital costs

Costs		EBFGT industrial plant, Chengdu, 90MW unit	EBFGT industrial plant, Hangzhou, 90MW unit	EBFGT industrial plant, Beijing, 150MW unit	EBFGT industrial plant, Pomorzany, 120 MW unit
Total capital cost	MEuro	8,02	8,02	8,37	14,77
Unit capital cost	Euro/kWe	88,97	88,97	55,91	112,53
Unit operation cost	Euro/ton SO_2	84,45	84,45	39,27	746,72

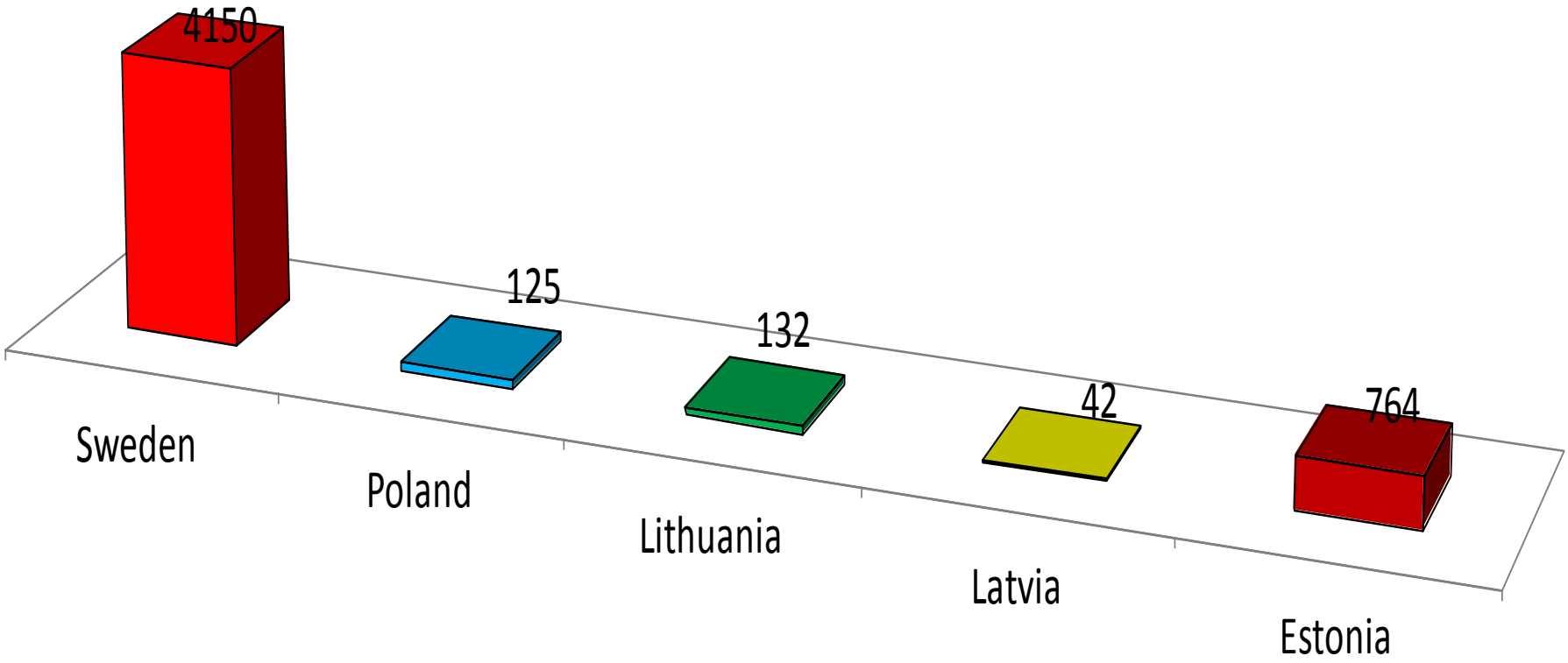
Source: Calinescu, a.o. Electron beam technologies for reducing SO_2 and NO_x emissions from thermal power plants

Tax Rates for Air Pollution in Baltic Sea region

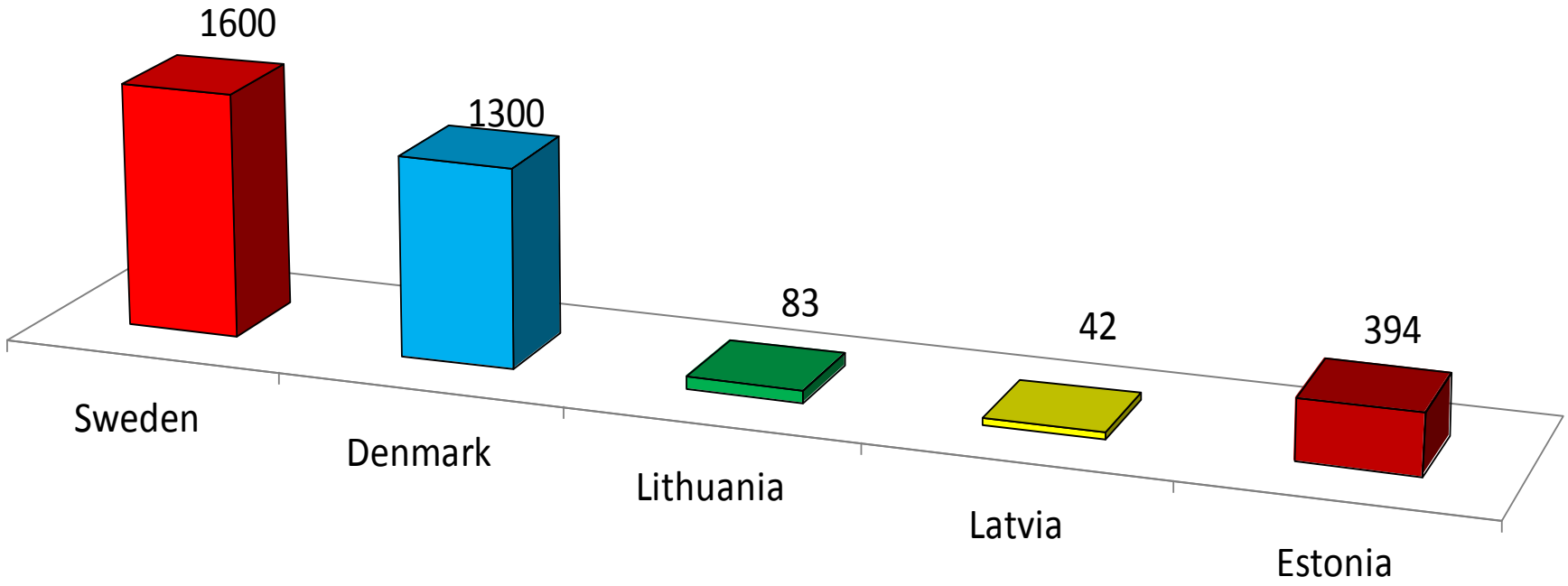
Country	Tax rate, NO_x (Euro per ton)	Tax rate, SO_2 (Euro per ton)
Sweden	4 150	1 600
Denmark		1 300
Poland	125	
Lithuania	132	83
Latvia	42	42
Estonia	764	394

Source: OECD

Tax rate NO_x, Euro per ton



Tax rate SO_2, Euro per ton



Cost Comparison of Various Emission Control Methods

Emission control method, 120 MW unit	Investment cost, Euro/kWe	Annual operation Cost, Euro/MWe
Wet flue gas desulphurization	84	2110
Selective Catalytic Reduction	77	3234
Combination of methods:		
Wet FGD + SCR	162	5343
Electron beam treatment EBFGT	113	5167

Source: Calinescu, a.o. Electron beam technologies for reducing SO_2 and NO_x emissions from thermal power plants

Investment and operation costs of combination of conventional methods

Flue gas treatment method, > 300 MW unit	Investment cost, Euro/kW	Annual operational cost, Euro/MW
Wet SO_2 scrubbing:		
Selective Catalytic Reduction	42 – 71	2 676 – 3 240
Selective Non Catalytic Reduction	42 – 71	1 760 – 2 113
Combination of methods:		
Wet de-SO_2 + SCR	176 – 247	11 660 – 23 005
Wet de-SO_2 + SNCR	144 – 190	10 747 – 21 882

Source: Basfar, a.o. EBFGT Technology for Simultaneous Removal of SO_2 and NO_x from Combustion of Liquid Fuels

Plasma technologies for water treatment

Pulsed Arc Electrohydraulic Discharge (PAED)

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The pulsed arc electrohydraulic discharge (PAED) technology was evaluated as an industrial wastewater treatment solution for its efficacy as a cost-effective alternative to other wastewater treatments, such as:

- **Ozone**
- **Ultraviolet radiation**
- **Chlorination**

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Operating and maintenance costs for wastewater treatment are largely dependant on the manufacturer of the particular device, the site, the capacity of the treatment facility, and the characteristics of the wastewater to be disinfected.

The PAED system achieved anticipated operating costs between 1,5 Euro/m^3 to 11 Euro/m^3

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OPERATION COSTS OF OTHER METHODS

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Water treatment technology	Operational and maintenance cost, Euro/m^3
Chlorination	0,001
Ultraviolet Disinfection Lamps	0,01
Ozone Disinfection	0,07

Source: BoydTechnologies. Feasibility assessment PAED

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Plasma technologies for odour reduction

Non-thermal plasma

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Non-thermal plasma

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Non-thermal plasma (NTP) methods

are very hot topics because of:

- **high removal efficiency,**
- **energy yields,**
- **good economy.**

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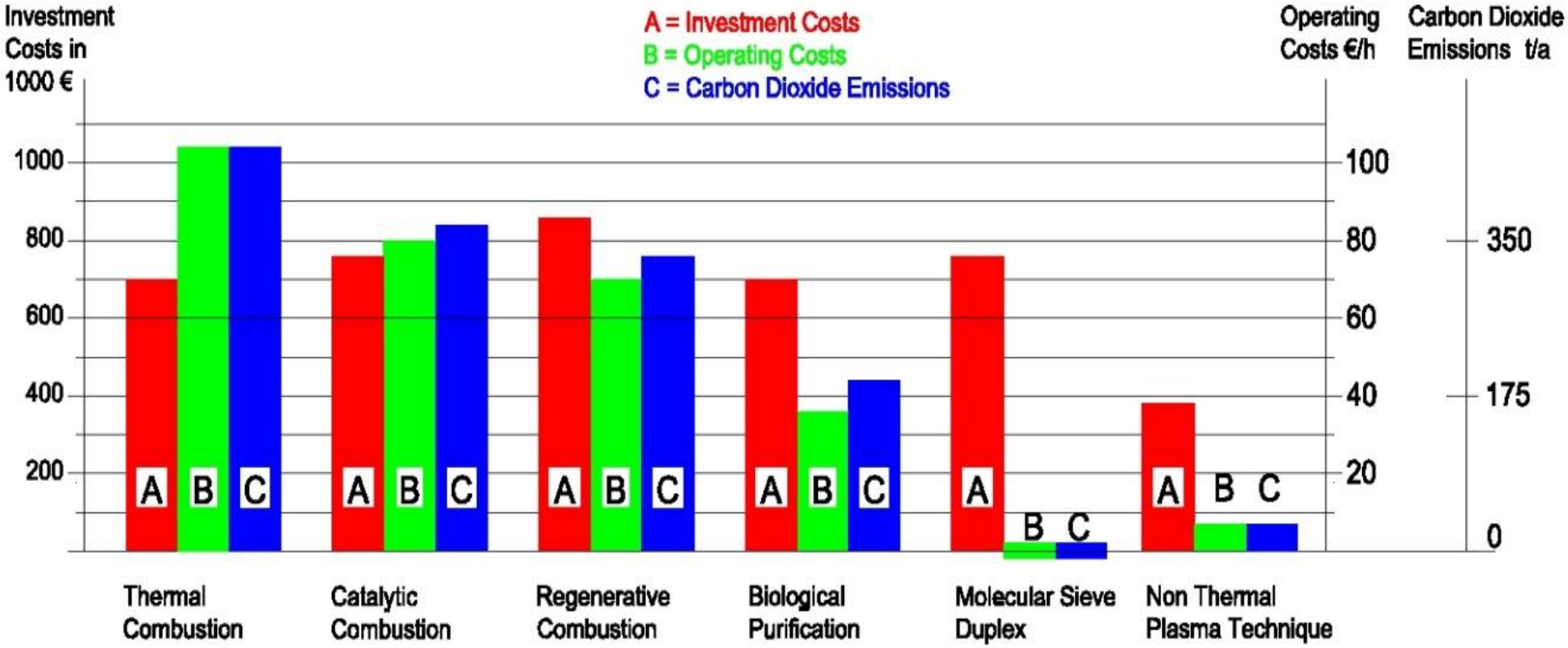

Source: Rolf Rafflenbeul. Non Thermal Plasma Plants: Experiences from the Industrial Praxis of Air Purification

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Information search for cost and market analysis concerning sea water cleaning from oil and oil – type slicks

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Technologies of oil removal and recovery from sea surface

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There are several technologies of oil removal and recovery from sea surface, such as:

weir skimmers,

disc (adhesive) skimmers,

sorption skimmers.

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VIKOMA

Komara Mini

Capacity-1 to 7m^3/hr

Komara Duplex

Capacity-7 to 15m^3/hr

Komara 20

Capacity-15 to 23m^3/hr

Komara Midi

Capacity-22 to 30m^3/hr

Komara Maxi

Capacity-30 to 52m^3/hr

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

Morris Skimmers

MI-2 (E, HE, HD), 30 dm3/min

MI-11/24, 300 dm3/min

MI-50, 1000 dm3/min

MI-30, 140 dm3/min

MI-14/18, 30 dm3/min

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

RO-CLEAN DESMI

Disc skimmer DBD 2 (25 kg), 33 dm3/min

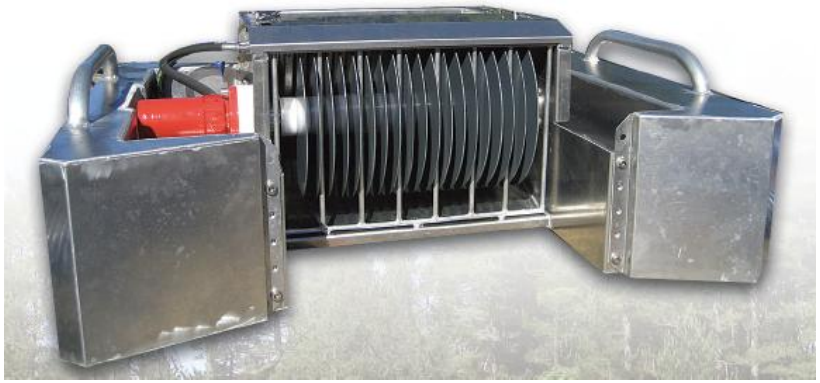
Weir skimmer Mini-Max (22 kG), 510-830 dm3/min

Weir skimmer Ro-Weir (3.5 kG), 500 dm3/min

Weir skimmer Terrapin (8.5 kG), 165 dm3/min

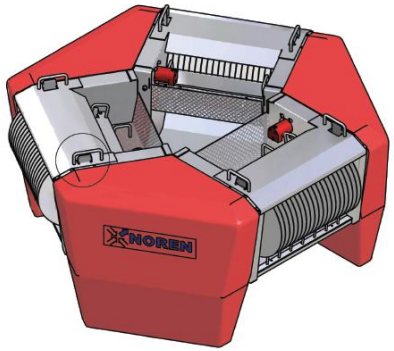
Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

NOREN Bergen

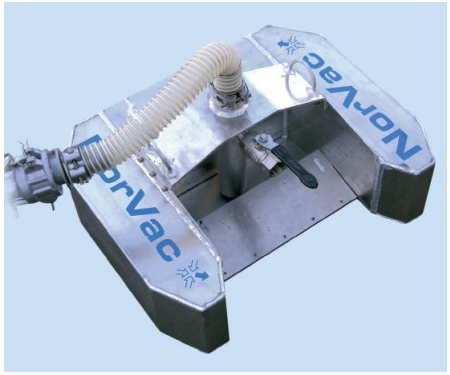


Miniskimmer (45 kg), 250 dm3/min

NorMar 30 Weir skimmer, up to 500 dm3/min



NorMar 50 Disc skimmer (140 kg), up to 1000 dm3/min



NorVac Weir Vacuum skimmer (8 kg), sucking speed 13 cm/s

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

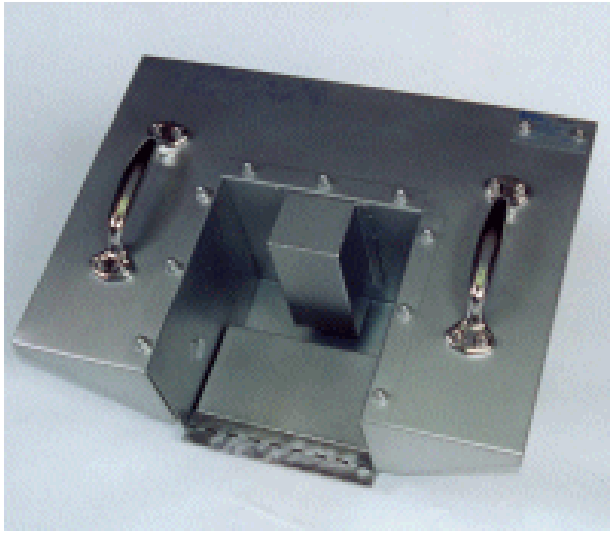
Megator

Alpha 1½” weir skimmer (9 kg), up to 150 dm3/min

Tri-skimmer (37 kg), 200 dm3/min

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

Skimoil



FWS-A2 Series

FWS-A81 Series

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

Action Petroleum Spill Recovery

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Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

Cost calculations

Two approaches can be applied for the oil removal from seawater in harbours:

- **using own skimmer to collect oil and transport it for the further utilisation;**
- **using a service company specialized in oil spills combat and management.**

Prices of skimmers

Skimmer Model	Manufacturer	Capacity, dm^3/min	Price, Euro
Komara Miniskimmer	VIKOMA	115	13 000
MI-2HD	Morris Skimmers	30	9 980
Terrapin	RO-CLEAN DESMI	165	5 600
OE-140	RO-CLEAN DESMI	83	9 930
NorMar Miniskimmer	AllMaritim	250	26 000
BOSS 2.2	Recovered Energy	8.3	3 453
TriSkimmer	Megator	200	3 100
AP-30	Action Petroleum	580	6 695

Source: Miroslaw Dors. Cost and market analysis concerning sea water cleaning from oil in harbours

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Thank you for attention

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