Cost benefit calculation tool onshore power supply

Methodological note

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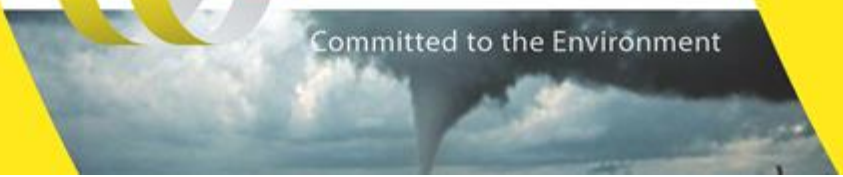

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Dutch Ministry of Infrastructure and environment

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1 Introduction

The Dutch government is developing its national implementation plan in the context of Directive 2014/94, also called the 'Clean power for transport' Directive. Regarding Onshore power supply (OPS) the Directive states:

Member States shall ensure that the need for shore-side electricity supply for inland waterway vessels and seagoing ships in maritime and inland ports is assessed in their national policy frameworks. Such shore-side electricity supply shall be installed as a priority in ports of the TEN-T Core Network, and in other ports, by 31 December 2025, unless there is no demand and the costs are disproportionate to the benefits, including environmental benefits.

This implies that the Dutch government needs to accommodate demand for onshore power supply (OPS) if the cost/benefit ratio is positive.

As part of the development of a national implementation plan, the Dutch Ministry of Infrastructure and environment asked CE Delft to upgrade and expand the OPS-tool available on the website: www.onshorepowersupply.org.

The most important adaptations are:
- update of investment costs and other data;
- uptake of categories river cruising and fishing trawler;
- financial valuation of emissions (CO_2, PM, NO_x and SO_2) and noise.

The purpose of this note is to illustrate the methodological framework of the tool and to illustrate the data used for the calculations.

The following deliverables have been developed:
- XLS calculation tool;
- Powerpoint presentation showing the tools' results;
- methodological note.

2 Methodological framework and formula

2.1 General formula

The following general formula is used for cost calculation:

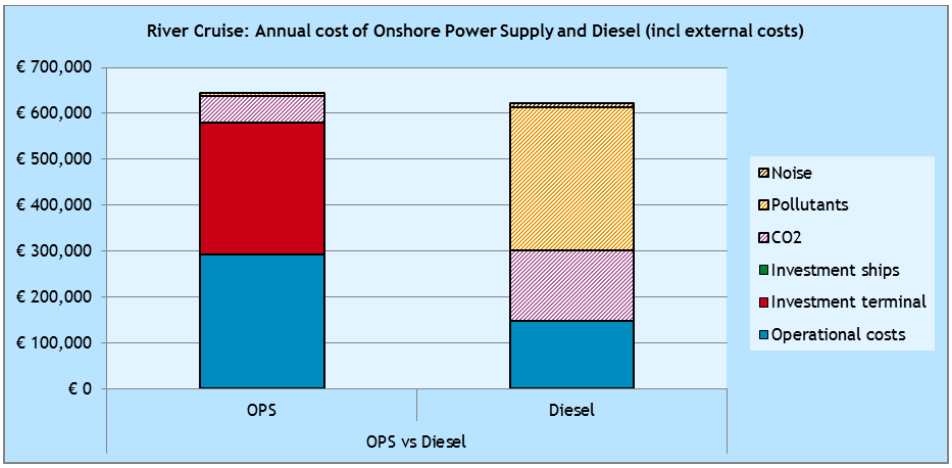
$$\text{Annual costs} = I_{terminal}{}^{An} + I_{ships}{}^{An} + \text{O\&M} + \text{fuel costs} + \text{ext. cost}$$

Where:

$I_{terminal}{}^{An}$	=	Annualised investment costs for terminal
$I_{ships}{}^{An}$	=	Annualised investment costs for ships
O&M	=	Maintenance, expressed as saved maintenance in case of OPS
fuel costs	=	Costs of the consumption of fuel or electricity
Ext. costs	=	External costs. These are the monetized costs of the emitted pollutants for OPS and diesel generator. External costs are only calculated in case of socio-economic perspective.

The annual cost for both diesel and OPS are presented graphically in the tool, illustrating the various cost components. An example is shown see Figure 1.

Figure 1 Example of presentation of results



2.2 The tool's framework

The tool allows to calculate the annual costs of both auxiliary diesel generator and onshore power supply (OPS). The costs are calculated on a complete project basis, with the viewpoint and interest of the various actors. The costs are expressed as annual costs in EUR (2015).

The calculations are categorised by the following fields:

A	General information
B	Settings
C+D+E	Investment costs terminal
F	Investment costs ships
G	Electricity costs
H	Saved maintenance costs
I+J	Emissions, noise and external costs

A General information

In this field, the OPS project is defined. The following information needs to be filled in, that all together defines the number of hours connected at berth, and the required investments:

- rated power of connection (MW);
- number of connections/outlets;
- number of unique ships that use OPS;
- number of calls on average per ship per year;
- average number of hours at berth connected per call.

B Settings

Under settings the project scope can be defined:

- Perspective: a choice can be made between business case and socio economic case. In the latter, CO_2, pollutant emissions (NO_x, PM and SO_2) and noise are monetized. The socio economic perspective is mainly interesting from the viewpoint of government and society, while industry rather assesses on the basis of business costs.
- External cost level: with these settings, that are only relevant in a socio economic assessment, one can adjust the cost level. This depends on the local population density for air pollutants. Power plant emissions are always monetized with low population density figures. Regarding greenhouse gas (GHG) emissions, the timeline taken into account can be adapted. On the long term, the carbon price is expected to increase

significantly due to stricter climate policy and increased damage to ecosystems.
- Scope of emissions: The user can choose to only take local terminal emissions into account (Tank-To-Wheel), or to focus on the entire chain (including distant power plant emissions, Well-To-Wheel).

C+D+E Investment costs terminal

In this field, various investment cost categories can be filled out.
Total investment costs are calculated into annual costs, using an annuity calculation method, using an interest rate (6%) and depreciation period (ten years).

In addition, maintenance and electricity contracting (mainly kW contract costs and kW max.) costs are calculated, being 5% and 10% of investment costs respectively. Various case studies confirm the validity of this approach.

F Investment costs ships

Investment costs for ships manly consist of voltage regulators, cable reel system, switchgear, cabling, automation and modifications. Costs can be specified per ship type. Investment costs for ships are calculated into annual costs as for terminal costs.

G Electricity and fuel costs

This field holds the power consumption and fuel and electricity costs.
Raw energy costs and taxation have been split. Electricity prices and eventually taxes and fuel costs are multiplied by the average power or fuel consumption and the annual time at berth (A), to arrive at total electricity and fuel consumed.

H Saved maintenance

Maintenance may be saved due to less running hours of the auxiliary engines. The number of running hours and maintenance saved per running hour are multiplied.

I+J Emissions and external costs

The tool allows to take a variety of power sources for electricity generation into account, ranging from coal fired power to sustainable sources as wind and sun. Also the Dutch consumption mix can be chosen. For auxiliary engines, emission factors can be chosen on the basis of a ship's age or applicable IMO emission standards.

The tool allows (B) to switch between local emissions (ship only) and complete chain emissions (including extraction of energy source and processing).

Multiplication of annual power consumption and emission factors results in the annual emissions for various components for both OPS and diesel (CO_2, NO_X, PM and SO_2).

The annual emissions are subsequently monetized using shadow prices. These shadow prices represent the costs to society. In case of air pollutants the shadow prices mainly represent health cost and for CO_2 these costs represent the costs of climate change.

Noise costs can be quantified using the number of people affected by ship noise and the noise reduction as a result of shutting down the ship's auxiliary engines. Quantification of noise reduction is difficult because the impact on

annoyance depends on the other noise sources available. For financial valuation, a low value (representing noise exposure above 70 dB(A) or a high value (representing noise exposure above 70 dB(A)) can be chosen. The latter value also includes health damage costs.

3 The tools' options; develop your own case

The tool is filled with 'default' data, showing generic results. The default data per ship type are based on case studies in the Netherlands. An overview of the case studies is presented in Table 2.

The tool does not present definite conclusions on the costs and benefits of OPS for the various ship types. Instead, a methodology is presented that can be used to analyse various costs and benefits depending on the local circumstances. The default data that are presented in the tool are an example of cost and benefits for these cases, but any other case could generate other results for specific situations.

Therefore, all operational characteristics, investment cost data and energy cost data can be adapted. The tool allows to build fully tailored scenario's for specific situations. As an example, the tool allows to assess the impact of fuel price changes, electricity tax cuts, sustainable electricity and coordinated investments in various ports.

Only the emission factors and external costs factors cannot be changed, as this is part of the methodological framework.

The following characteristics can be adapted, by choosing one of the predefined values or an own specific value:

Project definition
- rated power of connection;
- number of connections/outlets;
- number of unique ships that use OPS;
- number of calls on average per ship per year;
- average number of hours at berth connected per call.

Settings
- interest rate (three rates predefined, or own value);
- depreciation period;
- terminal investment costs;
- maintenance and contracting;
- ship investment costs.

Operational costs
- electricity price;
- electricity tax (three Dutch tax levels predefined, or own value);
- diesel price (three levels predefined, or own value).

Pollution
- average power/fuel consumption at berth (kW or tonnes fuel/hour);
- electricity mix or electricity source (various sources);
- diesel engine emissions (various options for engine specifications: < 1995; 1995-1999; tier 1; tier 2).

4 Data and sources used

General information, investment cost data and operational characteristics have been gathered by means of interviews with experts representing industry and port authorities. The resulting data has been compared with available feasibility studies for the various applications, which that are available on www.onshorepowerupply.org.

Environmental impact data and data on external cost have been retrieved from representative studies. The following sources have been used:

Table 1 References used

Data set	Source
Ship emission factors	Sea shipping 2013: NCP, 12 mile zone, port areas and Ospar region II, Marin, 11 May 2015
Electricity generation emission factors	RE-DISS II, 2014. European Residual Mixes 2013: Results of the calculation of Residual Mixes for purposes of electricity disclosure in Europe for the calendar year 2013, s.l.: European Commission
External cost data	Externe en infrastructuurkosten van verkeer - een overzicht voor Nederland in 2010 (CE Delft, 2014). The cost data are corrected for Consumer Price Index development and real GDP per capita developments to cost factors for 2015

Table 2 shows the cases that were used as default input data in the tool per ship type.

Table 2 Default cases in the tool

Ship type	Case	Additional remarks
RoRo	OPS connection of Stena in Hoek van Holland	Investment costs of the terminal were corrected for specific circumstances that cannot be generalised
Container	Representative for connection at container terminal at Maasvlakte II	Hypothetical case
Sea Cruise	Representative for connection in Amsterdam or Rotterdam	Hypothetical case
River Cruise	OPS connection in Port of Amsterdam	Data based on feasibility study, but corrected for actual investment costs and operation of OPS. Based on the feasibility study it is assumed that river cruise ships are equipped with an OPS connections and ship specific investments are not required*
Trawler	OPS connection in IJmuiden	Data based on actual investment costs and operation of OPS

* Using the tool options, an additional scenario could be built in which investments for a part of the river cruise ships are included.