Socio-Economic Assessment of MUOPs

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Stepwise Approach of Information Integration

Considerations for the Final Design:

- Legal
- Policy (MSP, MSFD, HD, BD, CFP, Energy & Climate Regulation)
- Technical
- Environmental
- Financial, Economic, Social

Stakeholder Analysis: Final Design

•**Social Cost Benefit Analysis:**

- Monetary Valuation of Socio-economic and Environmental externalities (Value Transfer+ Life Cycle Assessment)
- Financial costs and revenues

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- Comparison of discounted economic benefits and costs
- Risk Analysis

Methodology for Integrated Socio-economic Assessment -Case Study Specific

Scoping Phase

Boundaries; Key Impacts; Key Stakeholders; Information Availability

STEP 1: Socio-economic characterisation per case study

Wind and Wave power production	Aquaculture production

STEP 2: Monetizing Externalities (into financial flows)

Value transfer and Life Cycle Assessment

STEP 3: Policy recommendations based on economic tools

Social Cost-Benefit Analysis

Monetizing Δ in Ecosystem Services

Policy and Technological Change

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Changes on the Environment: EIA, LCA

↓

Impacts on human welfare

↓

Economic value of environmental changes

Monetizing Δ in Ecosystem Services

Policy and Technological Change

↓

Changes on the Environment: **EIA**, LCA

↓

Impacts on human welfare

↓

Economic value of environmental changes

Based on experts and environmental assessments, the ecosystem services affected were identified

Monetizing Δ in Ecosystem Services

Policy and Technological Change

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Changes on the Environment: **EIA**, LCA

↓

Impacts on human welfare

↓

Economic value of environmental changes

Value Transfer method was used to transfer adjusted values from other study sites to our policy site.

Monetizing Δ in Ecosystem Services

Policy and Technological Change

↓

Changes on the Environment: EIA, **LCA**

↓

Impacts on human welfare

↓

Economic value of environmental changes

Each platform's CO_2 -eq emissions were compared to those that would have been produced via traditional (not renewable) energy sources as the result of producing same amount of electricity and aquaculture products.

Monetizing Δ in Ecosystem Services

Policy and Technological Change

↓

Changes on the Environment: EIA, **LCA**

↓

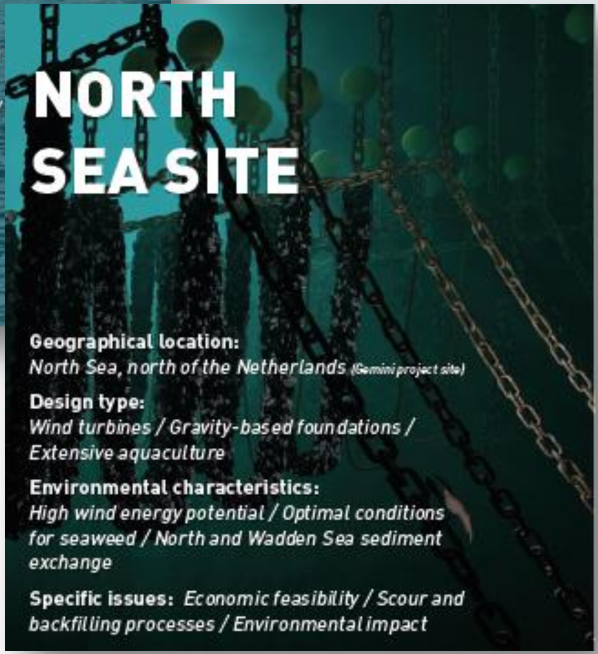
Impacts on human welfare

↓

Economic value of environmental changes

Social cost of carbon was used to estimate the benefits produced from this comparison.

Social Cost Benefit Analysis



The Atlantic CS
Monetizing Externalities

Research and Education Externalities (Cultural Service)

Pugh, D., & Skinner, L. (2002)

This study estimated the value added for research and development in the marine sector, including education and training during the period of 1994-2000.

Benefit Transfer: 1.20 € per individual

Environmental Externalities: CO_2–eq Emissions (LCA)

Function	Parameter	Amount
Wind & Wave Electricity Production	Amount of CO_2-eq production per 1 kWh	**20.4g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**

* ENTSO-E: European Network of Transmission System Operators for Electricity

The Atlantic CS

Assuming affected population: 695,727

Estimated economic benefit per year: 834,872.4 € per year

Research and Education

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CO_2–eq Emissions (LCA Results)

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The Atlantic CS
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sector, including education and training during the

Benefit Transfer: 1.20 € per individual

Amount of CO_2-eq saved per 1 kWh: 799,6g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 17,991€

CO_2–eq Emissions (LCA Results)

Function	Parameter	
Wind & Wave Electricity Production	Amount of CO_2-eq production per 1 kWh	**20.4**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
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The Atlantic CS
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Function	Parameter	
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Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**

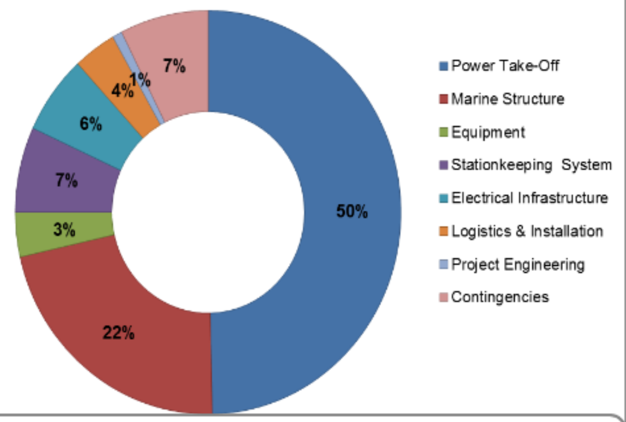
Amount of CO_2-eq saved per 1 kWh: 441,6g

Social Cost of Carbon: 22.5 € per tCO_2-eq

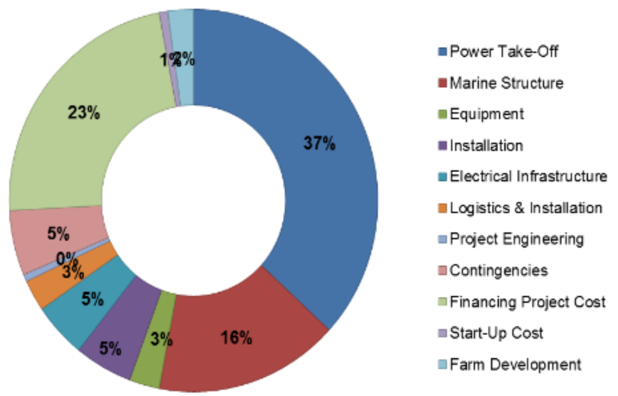
Estimated economic benefit per 1GWh: 9,936€

The Atlantic CS
Financial Data

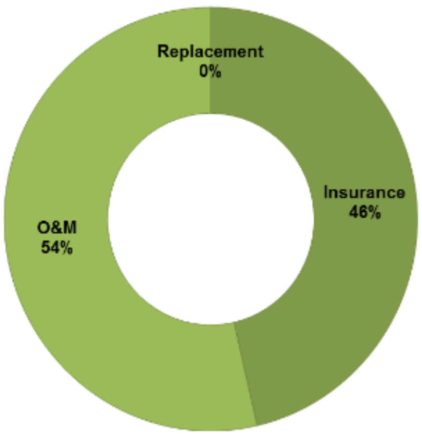
EPCI BUDGET



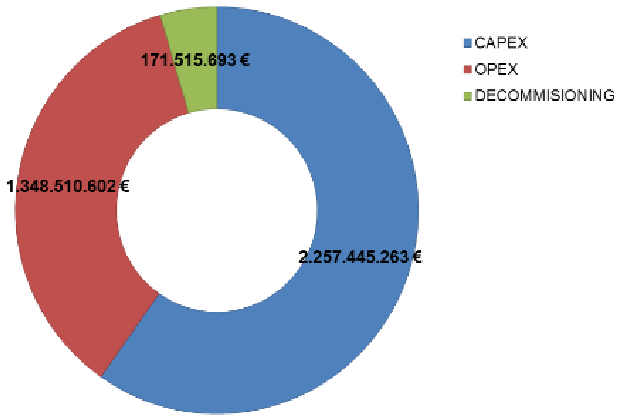
CAPEX



OPEX



PROJECT BUDGET



The Atlantic CS

Financial & Economic Data

INVESTMENT															
Offshore wind turbine															
		YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Equipment			1,145,808,527.34												
Construction															
Labor															
Other															
Total Investment Costs															

OPERATION															
		YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Energy															
Energy-Output (WIND)	GWH		0	809.09	770.06	848.50	652.15	767.07	833.36	834.30	648.57	686.30	816.84	721.87	751.08
Energy-Output (WAVE)	GWH		0	1.22	1.16	1.36	1.21	1.13	1.17	1.48	1.11	1.43	1.24	1.28	1.39
Energy-Price				0.15	0.15	0.15	0.15	0.15	0.16	0.17	0.17	0.17	0.17	0.17	0.17
Energy-Revenue			0	121,546,610.95	115,684,077.21	127,479,994.55	98,004,159.79	115,229,685.96	133,525,494.09	142,082,257.57	110,444,576.15	116,915,058.16	139,072,835.35	122,936,082.62	127,919,315.98
Energy-Labor															
Energy-Raw Material															
Energy-Energy															
Energy-Other															
Energy-Maintenance															
Energy Operating Costs			0	24,309,322.19	32,391,541.62	35,694,398.47	27,441,164.74	32,264,312.07	37,387,138.34	39,783,032.12	30,924,481.32	32,736,216.28	38,940,393.90	34,422,103.13	35,817,408.48
Mussels															
Net Operating Revenues															
Research and Education -revenue		695727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13	695,727.13
CO2 emissions (WIND)	Total cost reduction compared to coal usage (I / year)	799.6	0.00	14,556,351.59	13,854,231.90	15,265,438.40	11,732,839.63	13,800,356.24	14,993,059.69	15,009,846.40	11,668,390.34	12,347,277.64	14,695,736.93	12,987,139.05	13,512,674.68
	Total cost reduction compared to ENTSO-E network (I / year)	441.6	0.00	8,039,125.64	7,651,361.69	8,430,737.36	6,479,767.36	7,621,607.45	8,280,309.10	8,289,580.01	6,444,173.56	6,819,106.81	8,116,104.84	7,172,487.00	7,462,727.79
	SCC (I / year per tn)	22.5													
CO2 emissions (WAVE)	Total cost reduction compared to coal usage (I / year)	799.6	0.00	21,948.93	20,916.32	24,512.15	21,779.29	20,292.29	21,047.58	26,635.34	19,894.18	25,774.19	22,259.43	23,114.26	24,951.28
	Total cost reduction compared to ENTSO-E network (I / year)	441.6	0.00	12,121.87	11,551.58	13,537.48	12,028.18	11,206.95	11,624.08	14,710.06	10,987.08	14,234.47	12,293.35	12,765.45	13,780.00

The Atlantic CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Wave

	mean NPV (3%)	st.dev NPV (3%)	mean NPV (4%)	st.dev NPV (4%)	mean IRR	st.dev IRR
Wind (Coal)	849,470,474.47	44,430,442.61	706,564,380.13	41,298,125.64	13.63%	0.86%
Wind (ENTSO-E)	760,080,006.68	43,250,317.42	623,877,389.65	40,965,292.18	12.54%	0.80%
Wave (Coal)	-392,995,362.89	16,240,898.77	-389,440,742.43	16,787,778.68	-	-
Wave (ENTSO-E)	-392,762,115.79	16,668,616.53	-390,505,552.28	16,750,771.88	-	-
Wind & Wave (Coal, Coal)	442,343,771.94	58,288,143.94	305,730,883.29	55,184,066.20	6.92%	0.62%
Wind & Wave (ENTSO-E, ENTSO-E)	355,399,160.92	56,008,811.17	225,915,262.55	54,937,265.13	6.17%	0.56%

Time horizon: 21 years

The Atlantic CS

Social Cost Benefit Analysis

Baseline: Nothing

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Time horizon: 21 years

The Atlantic CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Wave

Risk analysis or risk assessment in cost benefit analysis aims at addressing **uncertainty associated with the future cash flows of a project**.

Uncertainty of future cash flows is a natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations.

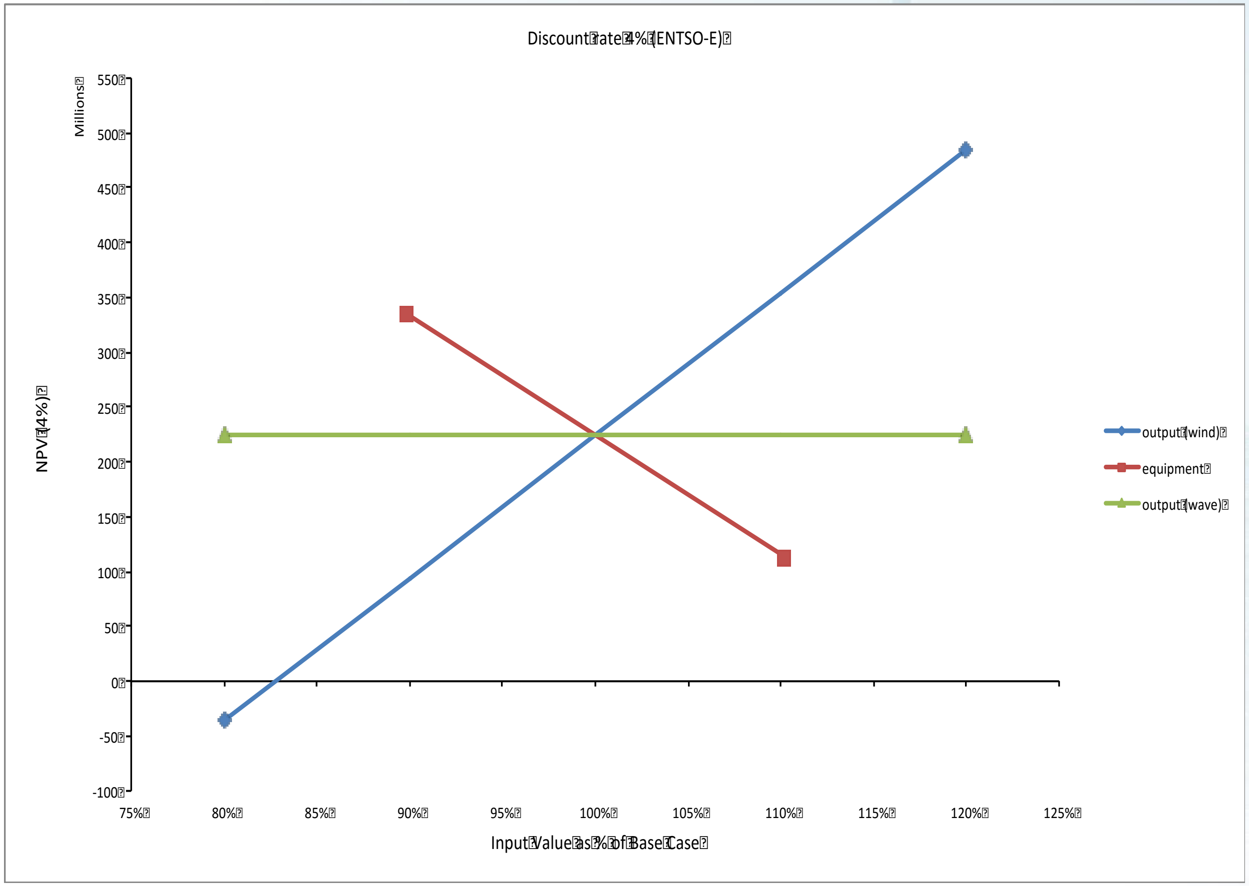
Sensitivity analysis is a technique that indicates how much the NPV will change in response to a given change in variables that affects the cash flow of the project, other things held constant.

The Atlantic CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Wave



Sensitivity Analysis on SCBA (4% discount rate, comparison with ENSTSO-E energy production)

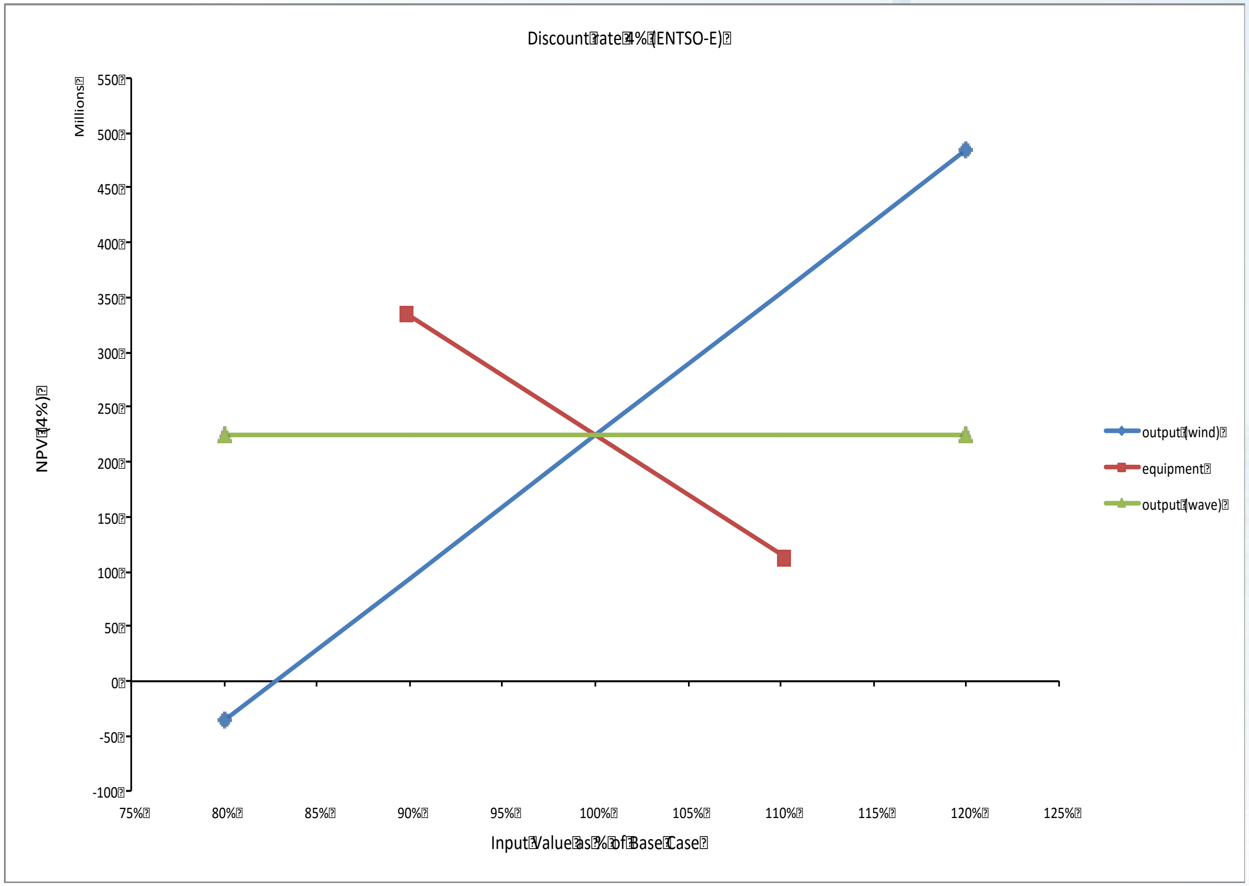
The Atlantic CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Wave

The results suggest that the critical variables are **wind output** and **equipment**.



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The Atlantic CS

Risk Analysis: Monte Carlo Simulations

Baseline: Nothing

MUOP: Wind&Wave

Sensitivity analysis does not allow for statistical inference and hypothesis testing with respect to the NPV of the project. **Monte Carlo** analysis does and it is regarded as more sophisticated method.

The **Monte Carlo method** is a computational algorithm which is based on random sampling. To use the method specific subjective probability distributions (e.g. uniform, triangular, normal) to important cash flow variables should be assigned.

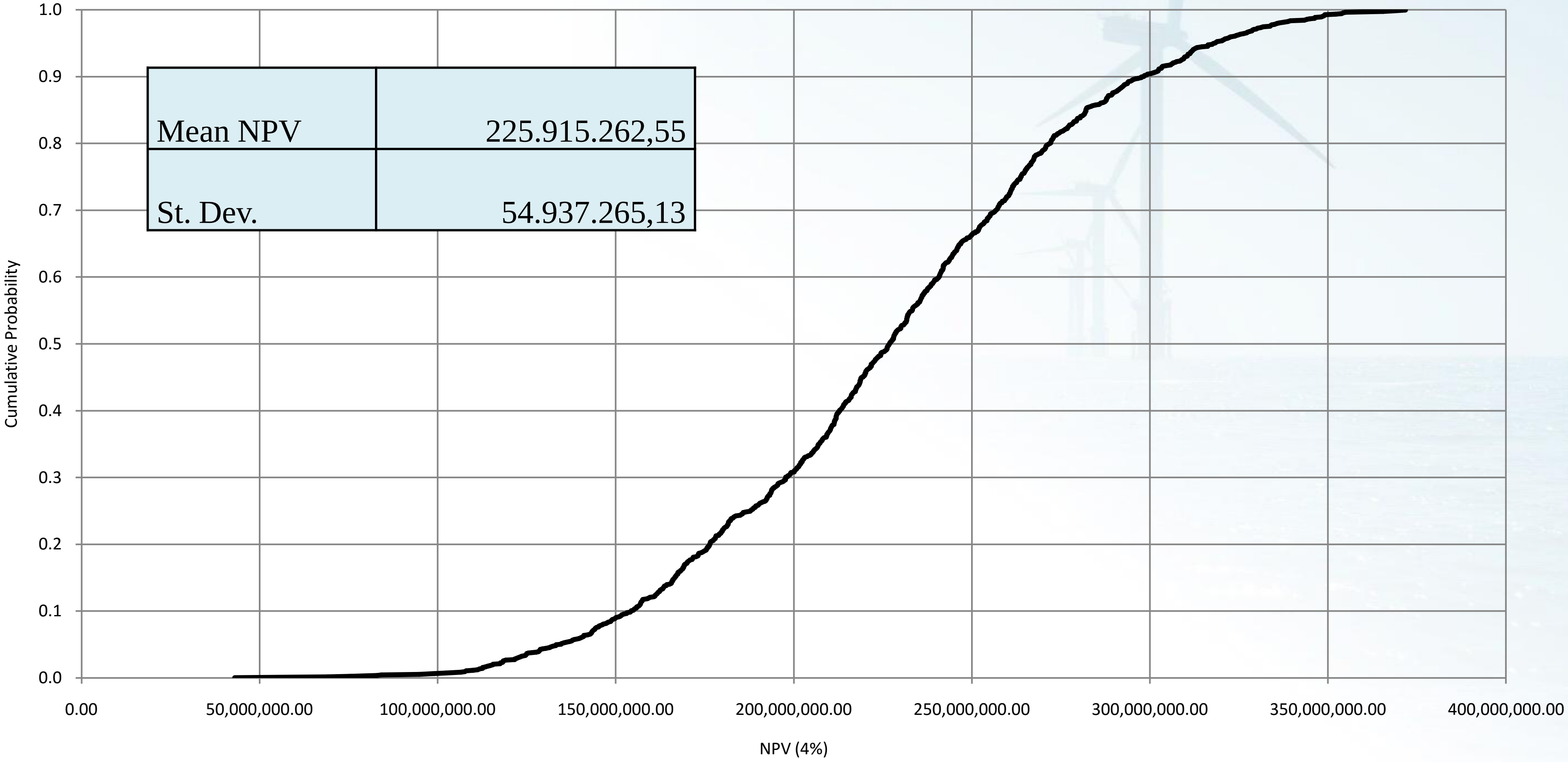
Both methods are consistent

The Atlantic CS

Risk Analysis: Monte Carlo Simulations

Baseline: Nothing

MUOP: Wind&Wave



Mean NPV	225.915.262,55
St. Dev.	54.937.265,13

The Baltic CS
Monetizing Externalities

Environmental Externality:
Artificial Reefs Effect (Habitat Service)

Ressurreição, A. et al. (2012)

This study uses a contingent valuation method to estimate the public's willingness to pay (WTP) to avoid loss in the number of marine species (algae and marine invertebrates). Onetime payment.

Benefit Transfer: 31.44 € per individual

Environmental Externality: CO_2–eq Emissions (LCA)

Function	Parameter	Amount
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**9.32g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Fish Production	Total amount of CO_2-eq production per 1t	**3.64t**

The Baltic CS
Monetizing Environmental Externalities

Artificial Reefs Effect (Habit

Ressurreição, A. et al. (2012)

This study uses a contingent valuatio ... blic's willingness to pay (WTP) to avoid loss in the number ... and marine invertebrates). Onetime payment.

Benefit Transfer: 31.44 € per individual

Assuming affected population: 370,000

Total estimated economic benefit per year: 11,632,800 €

CO_2–eq Emissions (LCA Results)

Function	Parameter	Amount
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**9.32g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
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The Baltic CS
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Benefit Transfer: 31.44 € per individual

Amount of CO_2-eq saved per 1 kWh: 810.68g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 18,240.3€

CO_2–eq Emissions (LCA Results)

Function	Parameter	
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**9.32g**
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The Baltic CS

Monetizing Environmental Externalities

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This study uses a contingent valuation method to estimate the public's willingness to pay (WTP) to avoid loss in the number of marine species [illegible] invertebrates). Onetime payment.

Benefit Transfer: 31.44 € per individual

Amount of CO_2-eq saved per 1 kWh: 452.6g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 10,183.5€

CO_2–eq Emissions (LCA Results)

Function	Parameter	
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
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The Baltic CS
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CO_2–eq Emissions (LCA Results)

Function	Parameter	Amo
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**9.3**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Fish Production	Total amount of CO_2-eq production per 1t	**3.64t**

Social Cost of Carbon:
22.5 € per tCO_2-eq

Estimated economic cost per t: 81.9€

The Baltic CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Salmon

Million euros	**mean NPV(3%)**	**st.dev NPV(3%)**	**mean NPV(4%)**	**st. de NPV(4%)**
Energy (Coal)	1283.97	115.22	1018.85	110.61
Energy (ENTSO-E)	1062.20	112.29	823.60	107.31

Time horizon: 22 years

The Baltic CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Salmon

No Data for Salmon Production.
However, salmon production was said to be marginally profitable.

Million euros	mean NPV(3%)	st.dev NPV(3%)	mean NPV(4%)	st. de NPV(4%)
Energy (Coal)	1283.97	115.22	1018.85	110.61
Energy (ENTSO-E)	1062.20	112.29	823.60	107.31

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The Baltic CS

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Time horizon: 22 years

The Baltic CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Salmon

No information regarding operating costs

Million euros	AOC(3%)	AOC(4%)
Energy (Coal)	102.01	90.53
Energy (ENTSO-E)	84.39	73.18

Time horizon: 22 years

The Baltic CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Salmon

Risk analysis or risk assessment in cost benefit analysis aims at addressing **uncertainty associated with the future cash flows of a project**.

Uncertainty of future cash flows is a natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations.

Sensitivity analysis is a technique that indicates how much the NPV will change in response to a given change in variables that affects the cash flow of the project, other things held constant.

The Baltic CS

Risk Analysis: Sensitivity Analysis

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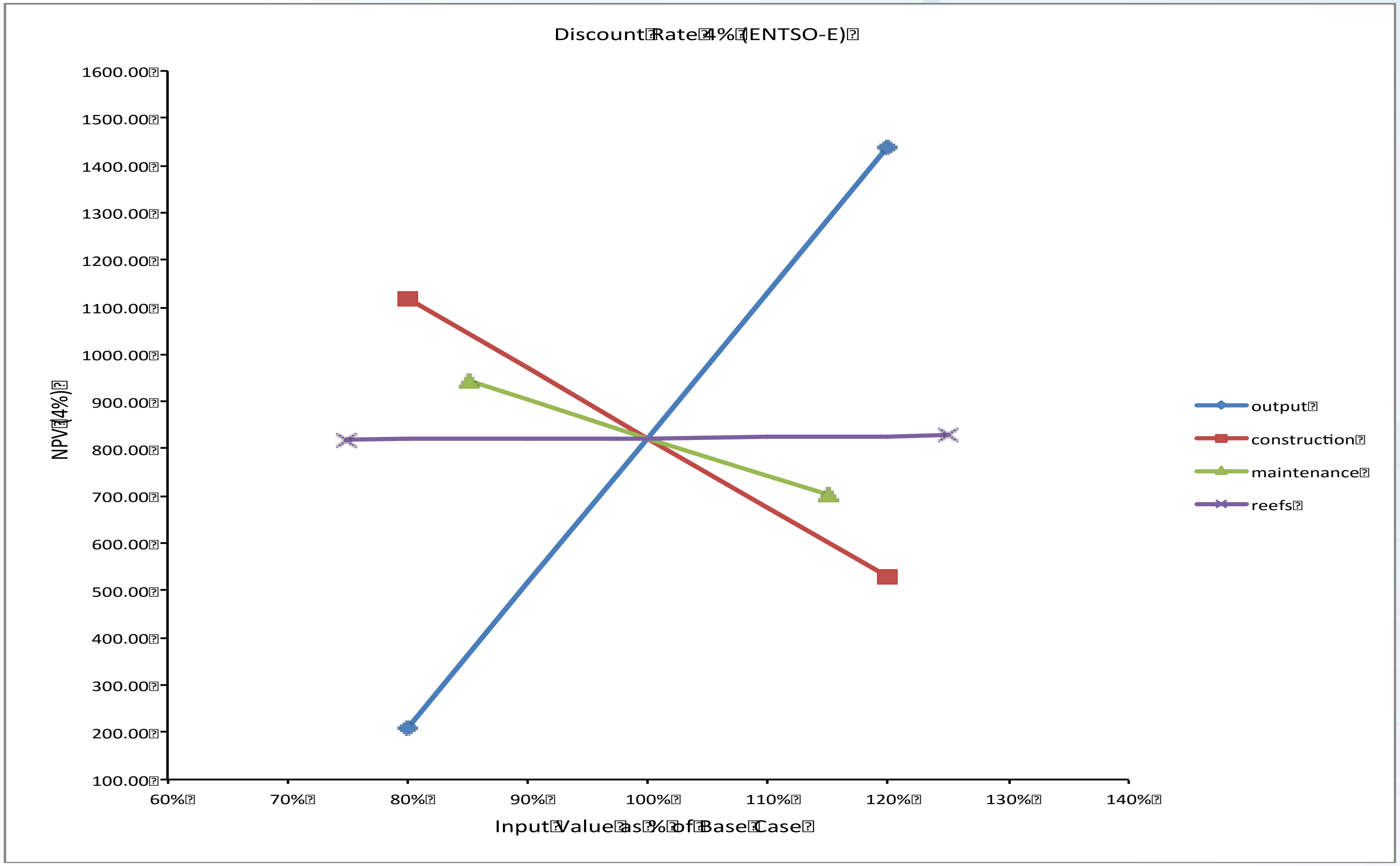


Sensitivity Analysis on SCBA (4% interest rate, comparison with ENSTSO-E energy production)

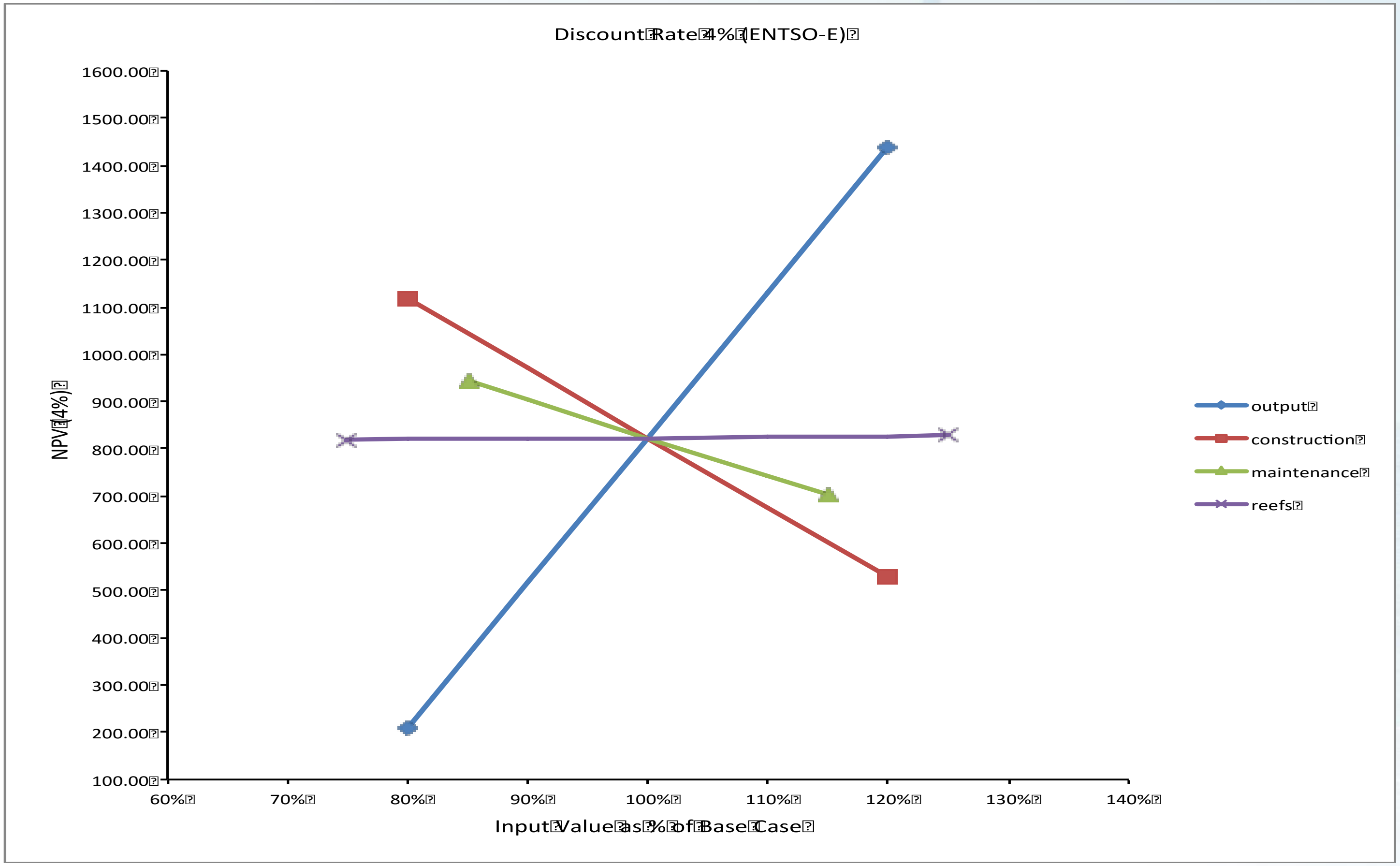
The Baltic CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Salmon

The results suggest that the critical variables are the **energy output** and **construction cost.**



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Baseline: Nothing

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Sensitivity analysis does not allow for statistical inference and hypothesis testing with respect to the NPV of the project. **Monte Carlo** analysis does and it is regarded as more sophisticated method.

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<u>Both methods are consistent</u>

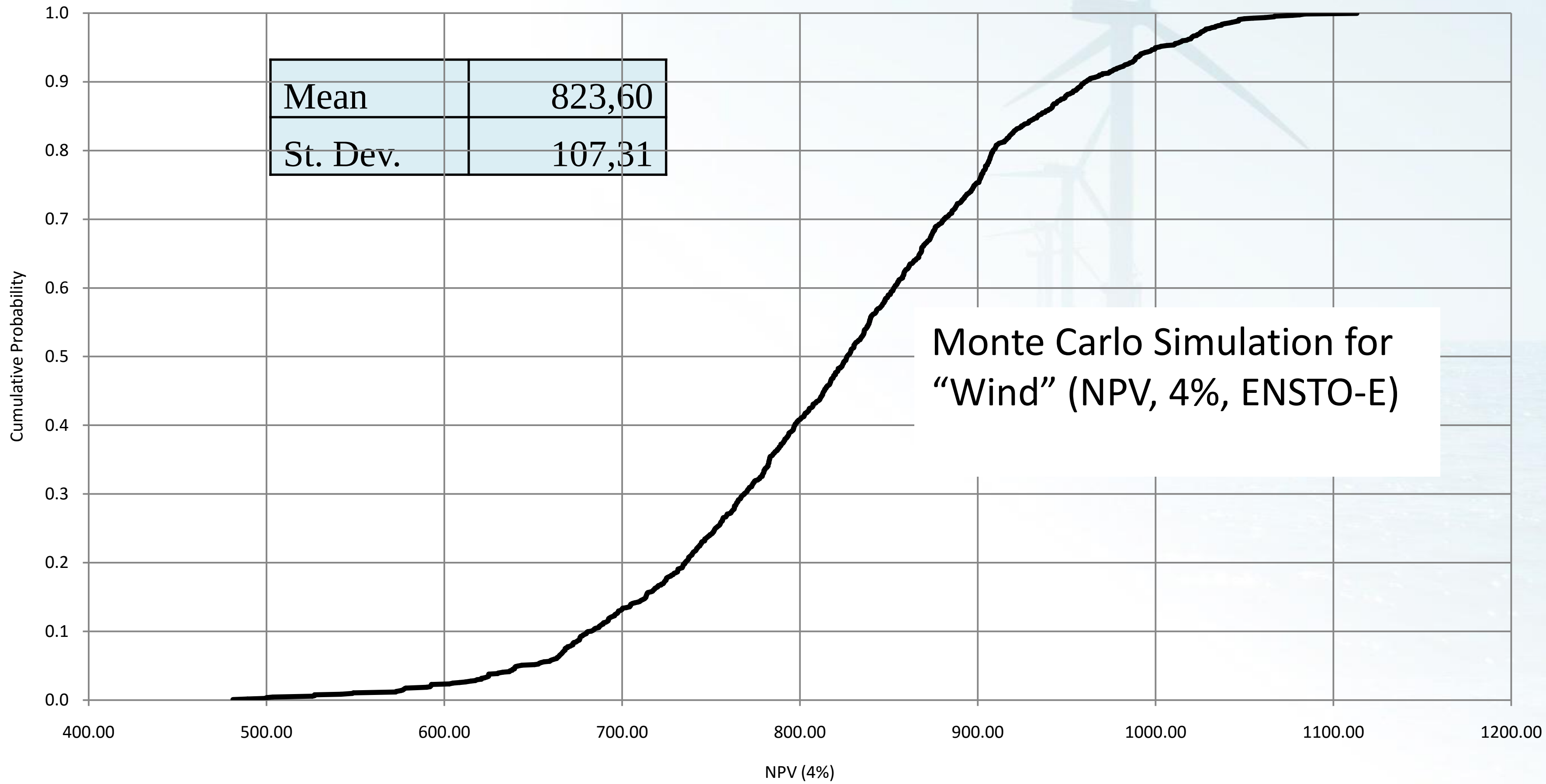
The Baltic CS

Risk Analysis: Monte Carlo Simulations

Baseline: Nothing

MUOP: Wind&Salmon

Mean	823,60
St. Dev.	107,31



The Mediterranean CS
Monetizing Externalities

CO_2–eq Emissions (LCA)

Function	Parameter	Amount
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**5.23g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**799.6g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Fish Production	Total amount of CO_2-eq production per 1t	**2.41t**

The Mediterranean CS

Monetizing

Amount of CO_2-eq saved per 1 kWh: 794.37g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 17,873€

CO_2–eq Emissions (LCA)

Function	**Parameter**	**A**
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**5.2**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**799.6g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Fish Production	Total amount of CO_2-eq production per 1t	**2.41t**

The Mediterranean CS
Monetizing Externalities

Amount of CO_2-eq saved per 1 kWh: 456.77g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 10,277€

CO_2–eq Emissions (LCA)

Function	Parameter	
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**79**[illegible]
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Fish Production	Total amount of CO_2-eq production per 1t	**2.41t**

The Mediterranean CS
Monetizing Externalities

CO_2–eq Emissions (LCA)

Function	Parameter	Amount
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**5.23g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**79**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**4**
Fish Production	Total amount of CO_2-eq production per 1t	**2.41t**

Social Cost of Carbon:
22.5 € per tCO_2-eq

Estimated economic cost per t: 55.22€

The Mediterranean CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Fish

	mean NPV(3%)	st.dev NPV(3%)	mean NPV(4%)	st.dev NPV(4%)	mean IRR	st.dev IRR
Fish	16,052,583.76	6,179,906.34	12,140,351.31	5,589,853.89	8.91%	2.35%

Time horizon: 22 years

The Medi

Social Co

Ba

MU

No Data for Wind Function.
Energy produced will not cover the high investment costs of the MUOP.
The MUOP project is not financially sustainable in the short run

	mean NPV(3%)	st.dev NPV(3%)	mean NPV(4%)	st.dev NPV(4%)	mean IRR	st.dev IRR
Fish	16,052,583.76	6,179,906.34	12,140,351.31	5,589,853.89	8.91%	2.35%

Time horizon: 22 years

The Mediterranean CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Fish

	mean NPV(3%)	st.dev NPV(3%)	mean NPV(4%)	st.dev NPV(4%)	mean IRR	st.dev IRR
Fish	16,052,583.76	6,179,906.34	12,140,351.31	5,589,853.89	8.91%	2.35%

Time horizon: 22 years

The Mediterranean CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Fish

Risk analysis or risk assessment in cost benefit analysis aims at addressing **uncertainty associated with the future cash flows of a project**.

Uncertainty of future cash flows is a natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations.

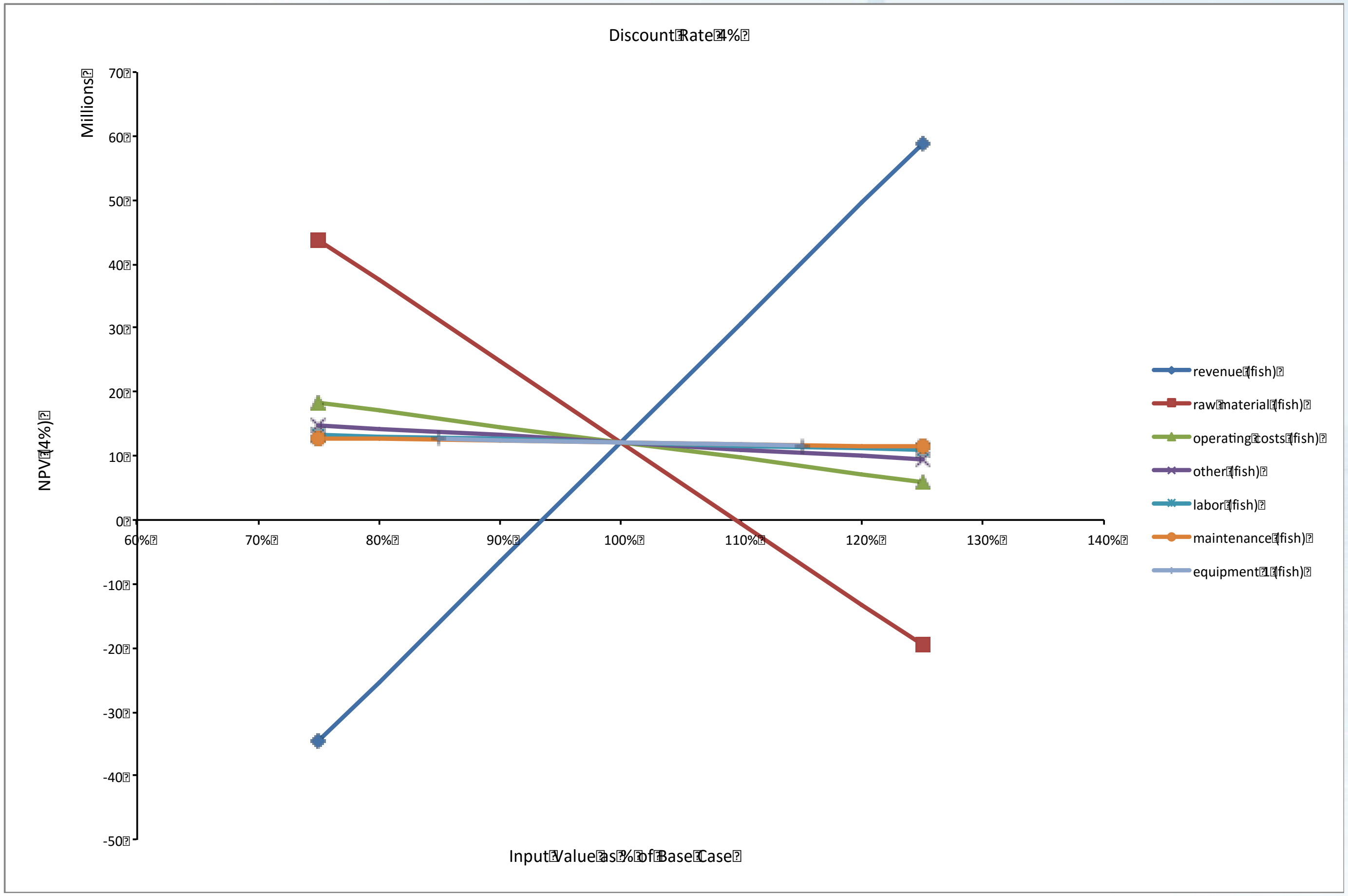
Sensitivity analysis is a technique that indicates how much the NPV will change in response to a given change in variables that affects the cash flow of the project, other things held constant.

The Mediterranean CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Fish



Sensitivity Analysis on SCBA (4% interest rate)

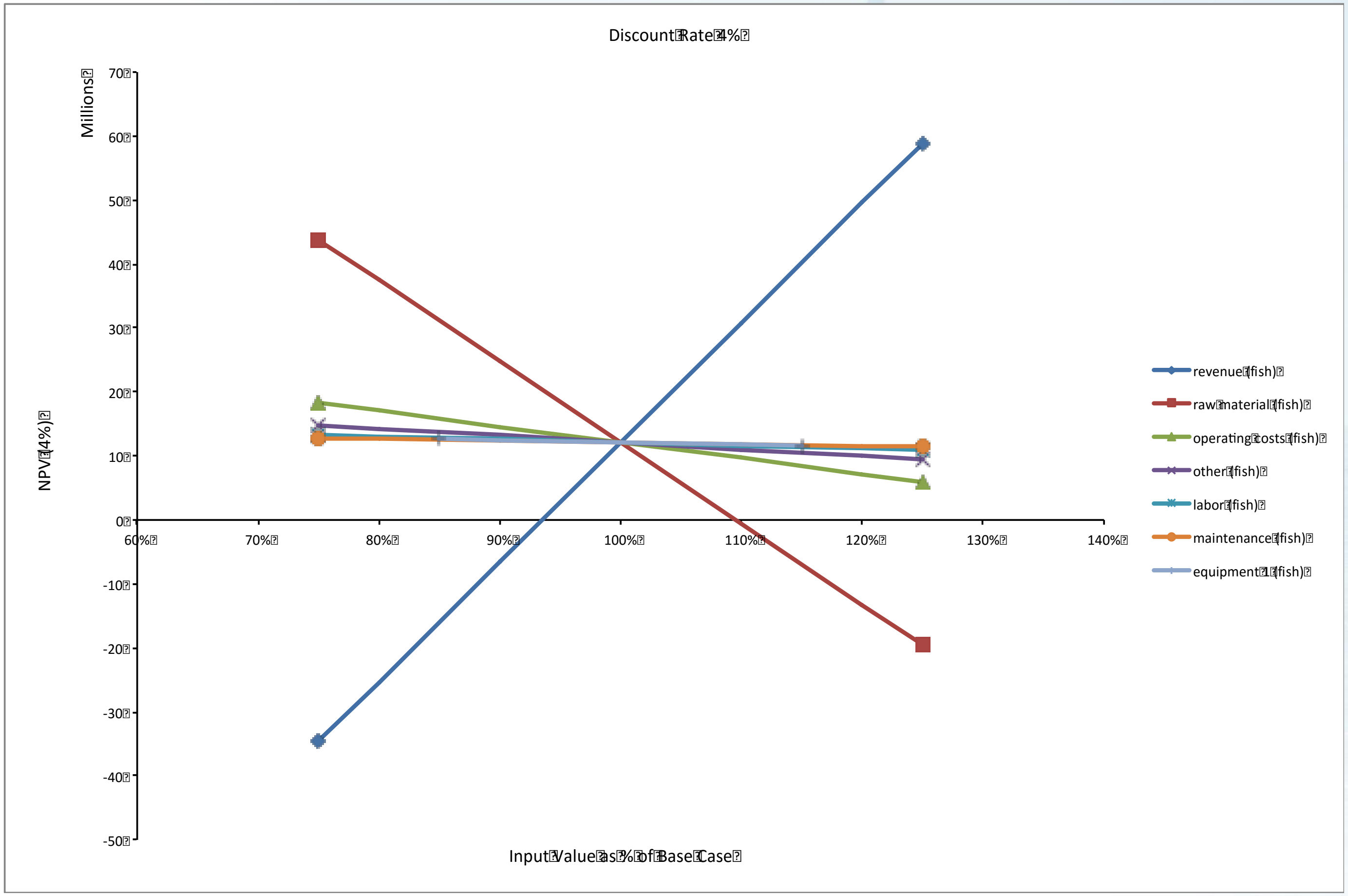
The Mediterranean CS

Risk Analysis: Sensitivity Analysis

Baseline: Nothing

MUOP: Wind&Fish

The results suggest that the critical variables are the **raw material cost** and **fish revenues**.



Sensitivity Analysis on SCBA (4% interest rate)

The Mediterranean CS

Risk Analysis: Monte Carlo Simulations

Baseline: Nothing

MUOP: Wind&Fish

Sensitivity analysis does not allow for statistical inference and hypothesis testing with respect to the NPV of the project. **Monte Carlo** analysis does and it is regarded as more sophisticated method.

The **Monte Carlo method** is a computational algorithm which is based on random sampling. To use the method specific subjective probability distributions (e.g. uniform, triangular, normal) to important cash flow variables should be assigned.

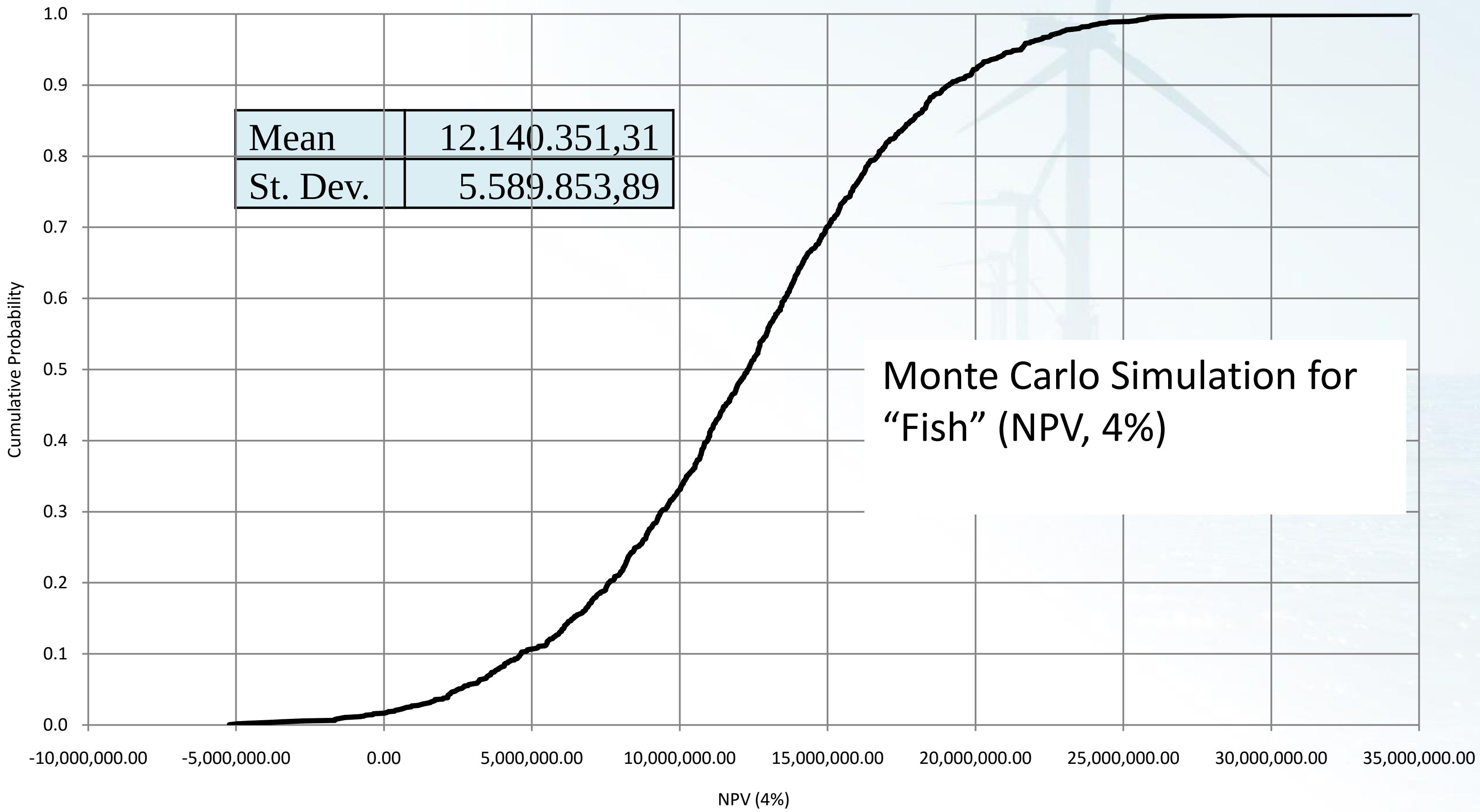
Both methods are consistent

The Mediterranean CS

Risk Analysis: Monte Carlo Simulations

Baseline: Nothing

MUOP: Wind&Fish



The North Sea CS
Monetizing Environmental Externalities

CO_2–eq Emissions (LCA)

Function	Parameter	Amount
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**10g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Mussel Production	Total amount of CO_2-eq production per 1kg	**0.622kg**
Seaweed Production	Total amount of CO_2-eq production per 1kg	**0.0192kg**

The North Sea CS

Monetizing Environment

Amount of CO_2-eq saved per 1 kWh: 810g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 18,225€

CO_2–eq Emissions (LCA Results)

Function	**Parameter**	**A**
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	**10g**
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820g**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Mussel Production	Total amount of CO_2-eq production per 1kg	**0.622kg**
Seaweed Production	Total amount of CO_2-eq production per 1kg	**0.0192kg**

The North Sea CS
Monetizing Environmental Externalities

Amount of CO_2-eq saved per 1 kWh: 452g

Social Cost of Carbon: 22.5 € per tCO_2-eq

Estimated economic benefit per 1GWh: 10,170€

CO_2–eq Emissions (LCA Results)

Function	Parameter	
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	**820[illegible]**
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Mussel Production	Total amount of CO_2-eq production per 1kg	**0.622kg**
Seaweed Production	Total amount of CO_2-eq production per 1kg	**0.0192kg**

The North Sea CS
Monetizing Environmental Externalities

CO_2–eq Emissions (LCA Results)

Function	Parameter	
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	**462g**
Mussel Production	Total amount of CO_2-eq production per 1kg	**0.622kg**
Seaweed Production	Total amount of CO_2-eq production per 1kg	**0.0192kg**

Social Cost of Carbon:
22.5 € per tCO_2-eq

Estimated economic cost per t: 14€

The North Sea CS
Monetizing Environmental Externalities

CO_2–eq Emissions (LCA Results)

Function	Parameter	Am
Wind Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
Coal Based Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
ENTSO-E Electricity Production	Amount of CO_2-eq production per 1 kWh	[illegible]
Mussel Production	Total amount of CO_2-eq production per 1kg	**0.622**
Seaweed Production	Total amount of CO_2-eq production per 1kg	**0.0192kg**

Social Cost of Carbon:
22.5 € per tCO_2-eq

Estimated economic cost per t: 0.432€

The North Sea CS

Financial & Economic Data

INVESTMENT														
Offshore wind turbin	Units													
	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Equipment	M I / year													
Construction	M I / year													
Labor	M I / year													
Other	M I / year													
Energy Investment	M I / year	**2800**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Mussels	Units													
	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Equipment	M I / year	7.11				7.11					7.11			
Construction	M I / year													
Labor	M I / year													
Other	M I / year	4										0.39		
Mussels Investment	M I / year	**8.65**	**0.00**	**0.00**	**0.00**	**7.11**	**0.00**	**0.00**	**0.00**	**0.00**	**7.11**	**0.39**	**0.00**	**0.00**
Seaweed	Units													
	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Equipment														
Construction														
Labor														
Other														
Seaweed Investment	**M I / year**	**257.30**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**30.49**	**0**	**0**	**0**
Off shore hotel and support center														
	YEAR	1	2	3	4	5	6	7	8	9	10	11	12	13
Equipment	M I / year													
Construction	M I / year													
Labor	M I / year													
Other	M I / year													
Total Investment Costs														

OPERATION													
	YEAR	1	2	3	4	5	6	7	8	9	10	11	12
Energy	Units	1	2	3	4	5	6	7	8	9	10	11	12
Energy-Output (Yearly produ	GWh/y		2599.14	2787.87	2374.53	2774.77	2888.25	2693.81	2521.28	2734.50	2432.68	2494.90	2887.00
Energy-Capacity installed	MW		600	600	600	600	600	600	600	600	600	600	600
Energy-Price	I/MWh		170	170	170	170	170	170	170	170	170	170	170
Energy-Revenue	M I / year	**0**	**441.85**	**473.94**	**403.67**	**471.71**	**491.00**	**457.95**	**428.62**	**464.86**	**413.56**	**424.13**	**490.79**
Energy-Labor	M I / year												
Energy-Raw Material													
Energy-Energy													
Energy-Other (transportation	M I / year												
Energy-Maintenance													
Energy Operating Co	M I / year		**103.59**	**97.04**	**100.32**	**87.15**	**108.14**	**100.96**	**94.02**	**90.95**	**90.81**	**121.18**	**85.60**
Energy Decommissioning													
Mussels	Units	1	2	3	4	5	6	7	8	9	10	11	12
Mussels-Output	ton WW/year		49666.44	48099.62	48035.63	46667.04	49568.23	47859.04	45654.33	47191.78	50056.91	49858.25	47148.64
Mussels-Price	I / ton		913.35	939.12	951.95	942.37	929.26	939.56	938.71	941.78	945.41	927.93	932.69
Mussels-Revenue		**0.00**	**45.36**	**45.17**	**45.73**	**43.98**	**46.06**	**44.97**	**42.86**	**44.44**	**47.32**	**46.26**	**43.97**
Mussels-Labor	M I / year		16.43	15.92	15.89	15.44	16.40	15.84	15.11	15.62	16.56	16.50	15.60
Mussels-Raw Material													
Mussels-Mussels													
Mussels-Other (transportation	M I / year		36.49	35.34	35.29	34.28	36.42	35.16	33.54	34.67	36.78	36.63	34.64
Mussels-Other (Administration, Tax payments, SAR, Insurance, Licenses, Other Fees, etc.) Also part of other fixed costs (preventive and inspection	M I / year		272.29	263.70	263.35	255.85	271.76	262.38	250.30	258.73	274.43	273.35	258.49
Mussels-Maintenance	M I / year		5.88	5.70	5.69	5.53	5.87	5.67	5.41	5.59	5.93	5.91	5.58
Mussels Operating Costs		**0.00**	**29.46**	**43.06**	**27.97**	**35.29**	**36.83**	**36.94**	**47.42**	**33.33**	**35.51**	**15.14**	**53.05**
Mussels Decommissioning													
Seaweed	Units	1	2	3	4	5	6	7	8	9	10	11	12
Seaweed-Output	ton DM/year		77998.62	81173.63	80028.46	79888.66	81426.64	80327.27	80796.84	78591.29	78938.91	82326.49	77924.06
Seaweed-Price	I / ton DM		466.18	340.95	410.76	257.36	416.36	509.94	402.38	465.16	491.24	437.47	309.93
Seaweed-Revenue	M I /year	**0.00**	**36.36**	**27.68**	**32.87**	**20.56**	**33.90**	**40.96**	**32.51**	**36.56**	**38.78**	**36.02**	**24.15**
Seaweed-Labor	M I / year		4.41	4.59	4.53	4.52	4.61	4.55	4.57	4.45	4.47	4.66	4.41
Seaweed-Raw Material	M I / year												
Seaweed-Seaweed	M I / year		50.70	52.76	52.02	51.93	52.93	52.21	52.52	51.08	51.31	53.51	50.65
Seaweed-Other (harvesting an	M I / year		10.92	11.36	11.20	11.18	11.40	11.25	11.31	11.00	11.05	11.53	10.91
Seaweed-Other (Administration, Tax payments,													

The North Sea CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Mussels&Seaweed

From year 2 until year 15 the price of energy was 170 €/MWh, while form year 16 until the final year drops to 43€/MWh.

Million euros	mean NPV (3%)	st. dev. NPV (3%)	mean NPV (4%)	st. dev. NPV (4%)	mean IRR	st.dev IRR
Energy (Coal)	1252.50	98.08	1009.27	90.96	9.79%	0.51%
Energy (ENTSO-E)	1020.93	95.92	799.64	91.46	8.68%	0.50%
Seaweed	-614.58	110.99	-573.86	106.82	-	-
Mussels	122.47	32.94	110.95	29.47	135.80%	71.95%
En_Se (Coal)	621.71	150.92	444.01	137.16	6.64%	0.86%
En_Se (ENTSO-E)	410.14	149.67	212.48	141.39	5.43%	0.89%
En_Mu (Coal)	1369.55	105.73	1123.43	96.44	10.30%	0.49%
En_Mu (ENTSO-E)	1140.58	105.49	904.54	94.57	9.23%	0.50%
Se_Mu	-490.53	116.32	-459.30	108.17	-	-
All (Coal)	755.70	156.77	539.25	146.77	7.25%	0.84%
All (ENTSO-E)	527.13	150.41	332.75	144.37	6.01%	0.86%

Time horizon: 20 years

The North Sea CS

Social Cost Benefit Analysis

Baseline: Nothing

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The North Sea CS

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All (ENTSO-E)	527.13	150.41	332.75	144.37	6.01%	0.86%

Time horizon: 20 years

The North Sea CS

Social Cost Benefit Analysis

Baseline: Nothing

MUOP: Wind&Mussels&Seaweed

If the price was to drop to 43€/MWh for the entire duration of the project, then the energy project is marginal.

Million euros	NPV (3%)	NPV (4%)	IRR
Energy (Coal)	45.76	-68.81	3%
Energy (ENTSO-E)	-183.93	-281.52	1%

Time horizon: 20 years

The North Sea CS

Risk Analysis: Sensitivity Analysis

Baseline: Wind

MUOP: Wind&Mussels&Seaweed

Risk analysis or risk assessment in cost benefit analysis aims at addressing **uncertainty associated with the future cash flows of a project**.

Uncertainty of future cash flows is a natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations.

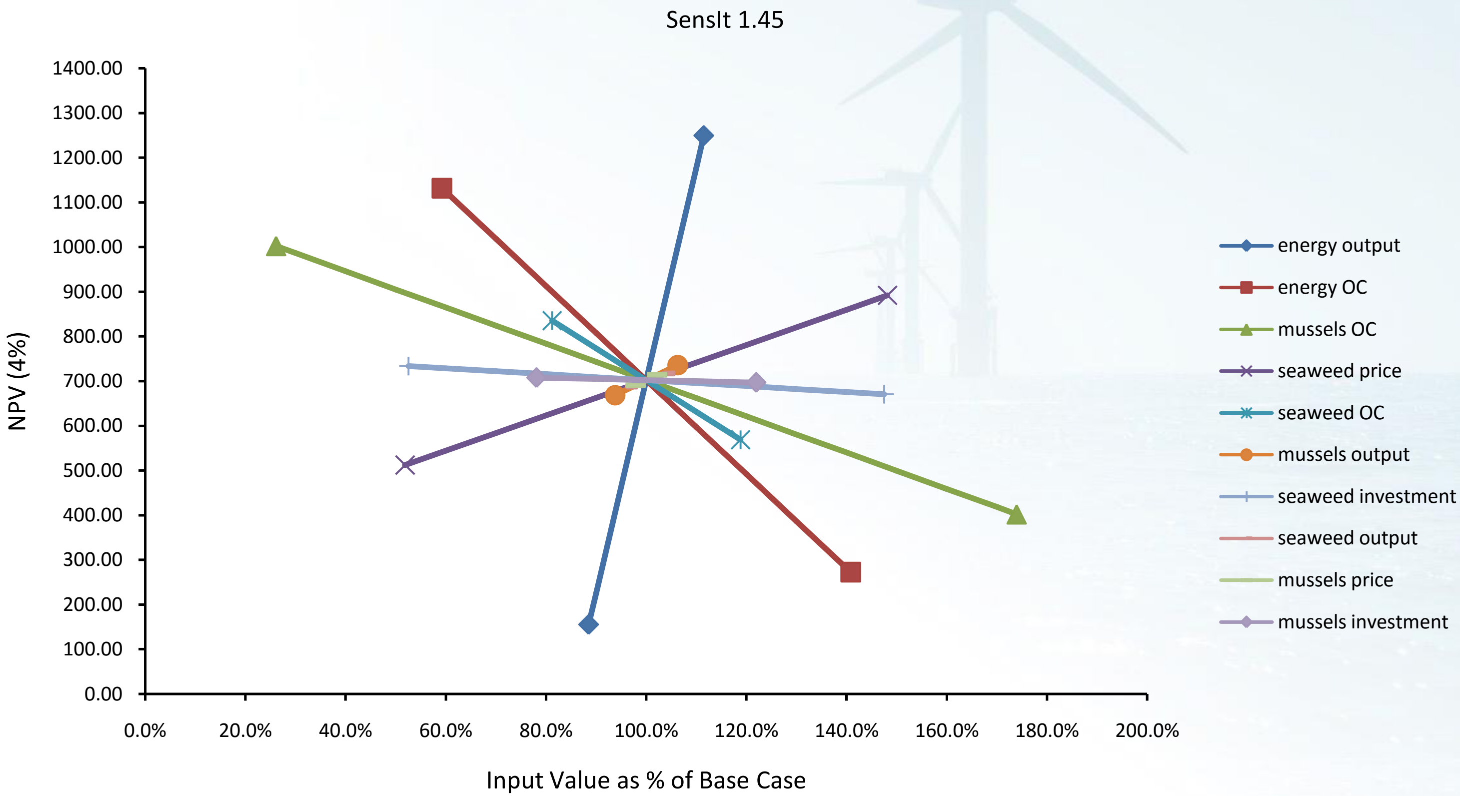
Sensitivity analysis is a technique that indicates how much the NPV will change in response to a given change in variables that affects the cash flow of the project, other things held constant.

The North Sea CS

Risk Analysis: Sensitivity Analysis

Baseline: Wind

MUOP: Wind&Mussels&Seaweed



Sensitivity Analysis on SCBA (4% interest rate, comparison with ENSTSO-E energy production)

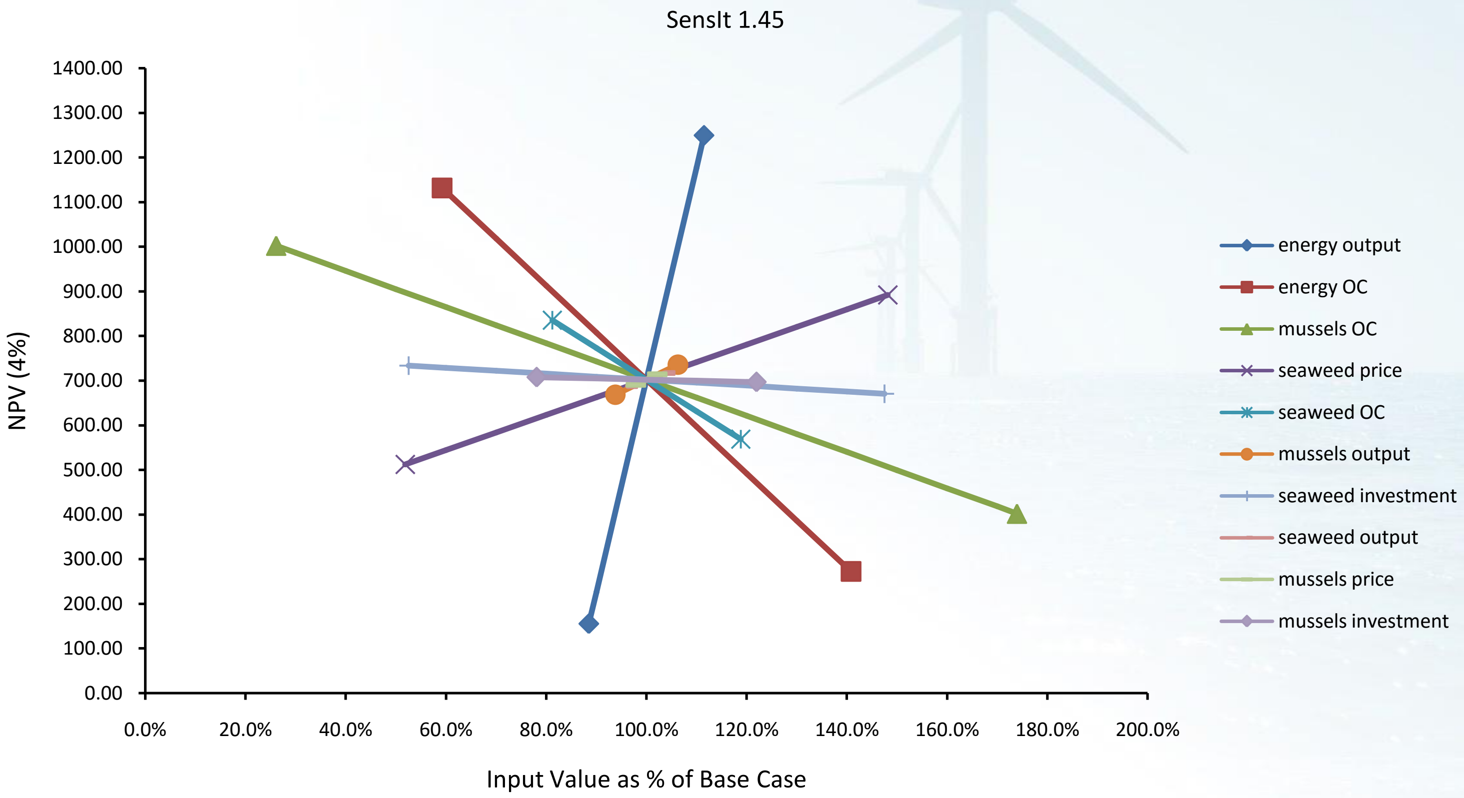
The North Sea CS

Risk Analysis: Sensitivity Analysis

Baseline: Wind

MUOP: Wind&Mussels&Seaweed

The results suggest that the critical variables are the **energy operation cost** and **energy output.**



Sensitivity Analysis on SCBA (4% interest rate, comparison with ENSTSO-E energy production)

The North Sea CS

Risk Analysis: Monte Carlo Simulations

Baseline: Wind

MUOP: Wind&Mussels&Seaweed

Sensitivity analysis does not allow for statistical inference and hypothesis testing with respect to the NPV of the project. **Monte Carlo** analysis does and it is regarded as more sophisticated method.

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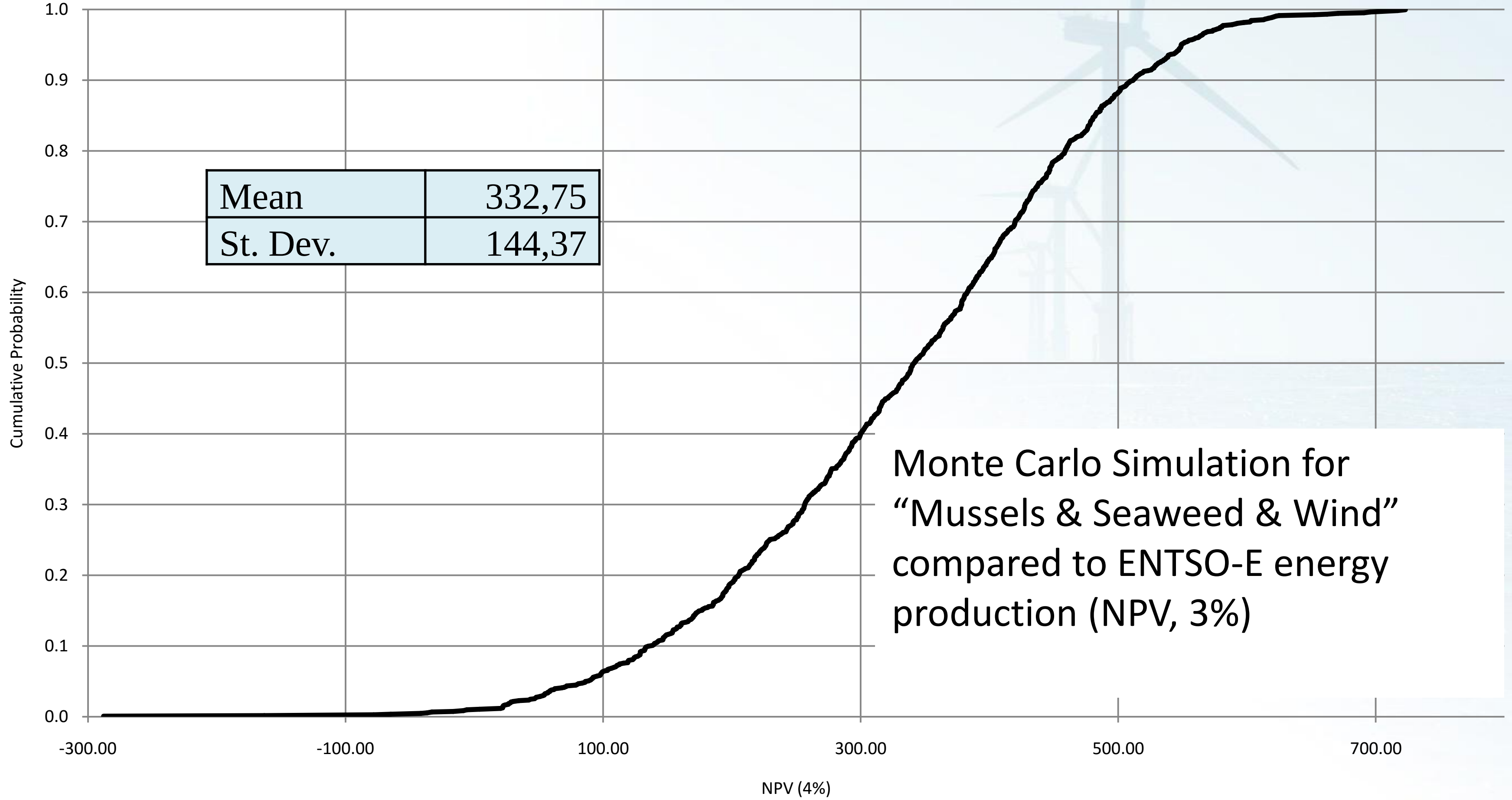
Both methods are consistent

The North Sea CS

Risk Analysis: Monte Carlo Simulations

Baseline: Wind

MUOP: Wind&Mussels&Seaweed



Mean	332,75
St. Dev.	144,37

Social Cost Benefit Analysis: Summary

Atlantic Site
Wind & Wave: Positive NPV, R&D benefits
Wave: Negative NPV, high investment cost and low revenues

Baltic Site
Wind & Salmon: Potentially positive NPV

Mediterranean Site
Fish: Positive NPV
Energy: Potentially negative NPV, low energy productivity
Fish & Energy: Potentially negative NPV in the short-run

North Site
Energy & Seaweed & Mussels: Positive NPV
Seaweed: Negative NPV

Risk Analysis

Sensitivity Analysis

Risk analysis or risk assessment in cost benefit analysis aims at addressing **uncertainty associated with the future cash flows of a project**.

Uncertainty of future cash flows is a natural consequence of the fact that these cash flows represent forecasts based on current knowledge and future expectations.

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Risk Analysis
Monte Carlo Simulations

Sensitivity analysis does not allow for statistical inference and hypothesis testing with respect to the NPV of the project. **Monte Carlo** analysis does and it is regarded as more sophisticated method.

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<u>Both methods are consistent</u>

Sensitivity Analysis: Summary

Atlantic Site (Multi use)
The results suggest that the critical variables are **wind output** and **equipment**.

Baltic Site (Single use)
The results suggest that the critical variables are the **energy output** and **construction cost**.

Mediterranean Site (Single use)
The results suggest that the critical variables are the **raw material cost** and **fish revenues**.

North Site (Multi use)
The results suggest that the critical variables are the **energy operation cost** and **energy output.**

Applied Socio Economic Assessment using Web Based Tools: Integrating Legal, Technical, Environmental, Financial , Economic Aspects

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PHOEBE KOUNDOURI – AUEB , LSE, ICRE8

YANNIS IOANNIDIS, EVDOKIA MAILLI – MADgIK (Management of Data, Information and Knowledge group), UoA

About the application

Decision making process for the Socio Economic Assessment of MUOP on different Mermaid Sites

- Web based analytics platform
- Open Source Technologies
- Can take advantage of cloud based technologies

Common practice shortcomings

Disparity of data and multiple non comparable methodologies

- **Multiple Stakeholders**
- **Multidisciplinary Project**
- Lack of ubiquitus language
- Manual data handling
- Manual assessment with industry standard packages for commercial products
- Non comparable methodologies (Data collection, data cleaning, data analysis, results interpretation)

Application advantages

Streamlined robust methodology

- Formalized language that enables correct workflow from data collection to results production and interpretation
- Automated assessment
- Cost saving
- Faster analysis
- Extending data analysis ability to a larger and / or more refined parameter space

Application extra features

Immediate comparison of scenarios

- Automated parameter comparison
- Capability of producing alternative scenario with / without Socio – Economic Externalities
- Clear user friendly workflow
- Techical & Legal Feasibility assessment / Environmental Impact Assessment interactive questionnaires

Future work

Expansion to

- Other projects with different Socio – Economic Activities
- Different domains
- Different geographical areas

Automated data preprocessing

Performance optimization

Online functionality with connection to external data repositories

Integration with MADgIK software

AITION : Advanced analytics platform

DCV: Data cleaning and curation

EXAREME / MADIS: Scalable cloud based data flow processing

Web Application demo

Watch a video demonstrating the application

CASE STUDY: ATLANTIC

ATLANTIC SITE FACTSHEET

Geographical location	Atlantic Ocean, north of Spain
Surface area of study site	100 km²
Offshore distance	3 - 20 km
Depth	50 - 250 m
Substrate	mix of sandy and rocky seabed
Water temperature	10 - 20°C
Max. tidal currents	1.5 cm/s
Wave heights	Mostly < 6 m
Mean wave energy potential	20 kW/m on 50 m depth
Average wind speed	7.5 m/s

“ Assessing the feasibility of the MUOPs implementation requires the application of an interdisciplinary framework of analysis accomodating long-run effects “

“MUOPs could provide a more efficient and sustainable use of marine space in the future”