Sustainable Asset Valuation (SAVi)
North Sea offshore wind asset, the Netherlands

Results

October 2017

Dr. Andrea M. Bassi
Georg Pallaske
David Uzsoki
Oshani Perera

DO NOT SHARE - CONFIDENTIAL

IISD
International Institute for Sustainable Development

Table of Contents

Section I **Introduction to the Sustainable Asset Valuation Tool (SAVi)**

Section II **SAVi at Work: Offshore Wind Farm in The Netherlands**

Section III **Extended Cost Benefit Analysis**

A. What does the SAVi Extended Cost Benefit Analysis demonstrate?

B. Scenarios used in the Extended Cost Benefit Analysis

C. Results of the Extended Cost Benefit Analysis

Section IV **SAVi Financial Assessment**

A. What does the SAVi Financial Assessment demonstrate?

B. Financial Assumptions & Scenarios used in the Application of SAVi

C. Results of the Financial Feasibility Assessment

Section I

Introduction to the Sustainable Asset Valuation Tool (SAVi)

The challenge, and our solution

THE CHALLENGE

Conventional cost-benefit analysis and project finance valuation methodologies ignore a range of material risks, intangibles and externalities.

THE SOLUTION

IISD has developed the Sustainable Asset Valuation (SAVi) facility to assess the environmental, social, economic and governance (ESEG) risks and co-benefits of infrastructure projects.

Target Audiences

Governments and Cities

Investors

Citizens

Questions we can answer for governments and cities

- How does environmental, social and economic performance increase value for money for tax payers?
- Is sustainable infrastructure systematically more expensive to build? Can these costs be recuperated during the user phase?
- Do sustainable assets trigger positive externalities such as higher GDP, Green GDP, employments, innovation, productivity, etc?
- Will this asset help realize sustainable development?

Questions we can answer for investors:

- How climate + ESG risks affect the project's internal rate of return (IRR)

- How climate + ESG risks affect the project's credit ratios:

  - debt service coverage ratio (DSCR),

  - loan life coverage ratio (LLCR)

SAVi for Citizens

How will this infrastructure asset improve living conditions, livelihoods and further prospects?

SAVi: Infrastructure Asset Types

Focus sectors selected based on volume of project lending (global loans by sector):

Energy

Roads

Buildings

Water

Sector	Volume (US$m)
Power	110,915.8
Oil & Gas	44,311.6
Transportation	43,278.6
Petrochemicals	14,485.2
Leisure & Property	7,683.7
Industry	6,557.5
Mining	4,058.5
Water & Sewerage	3,371.1
Telecommunications	942.7
Waste & Recycling	851.1
Total	**236,455.8**

What can SAVi calculate for these assets?

Extended Cost Benefit Analysis

- Impact of climate related risks
- Gross Margin
- Positive and Negative Externalities

Financial Feasibility

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Debt Service Coverage Ratio (DSCR)
- Loan Life Coverage Ratio (LLCR)

SAVi provides a bespoke assessment to each asset

The financial feasibility of infrastructure assets are evaluated individually.

SAVi is therefore customerised to each asset.

IISD builds the data profile for each infrastructure asset in collaboration with asset owners

We work with investors/public asset owners to

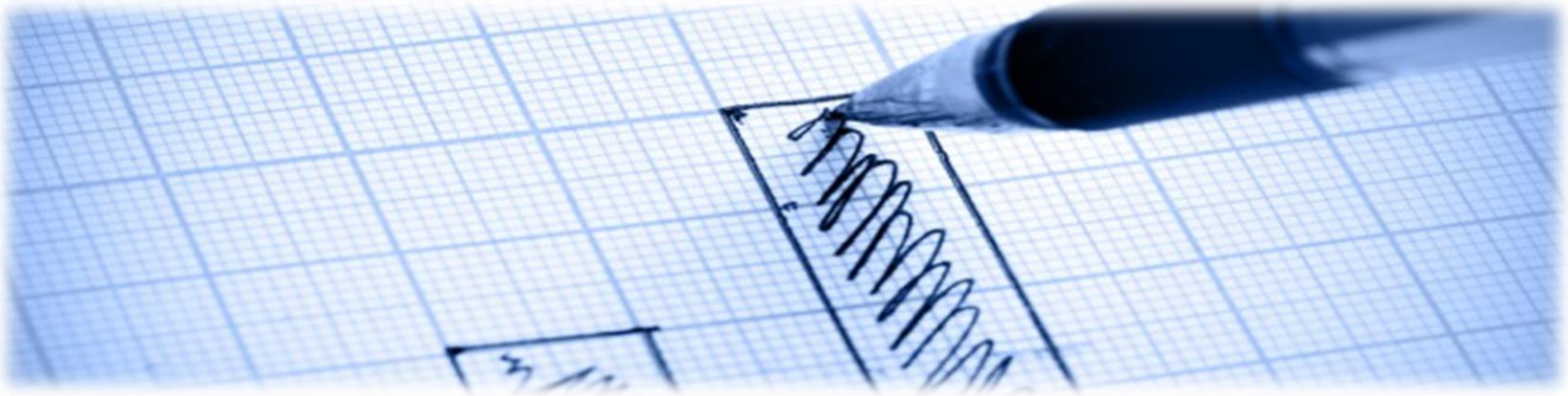
- ✓ obtain and ‘clean’ all project data.
- ✓ -determine the public data sources for developing proxies
- ✓ -determine the environmental, social and economic externalities that are material to assert owners, investors and stakeholders.

How is SAVi Built?

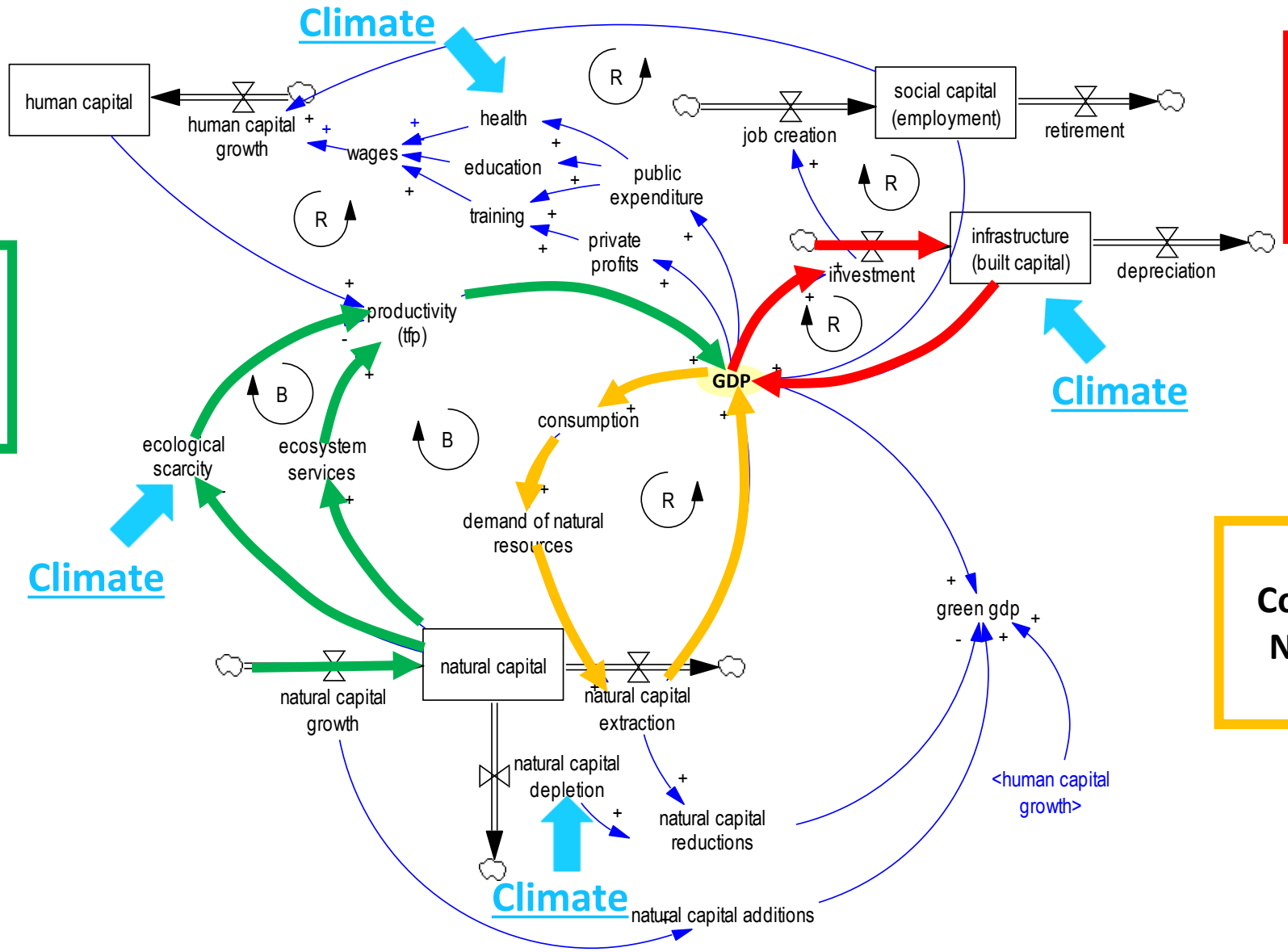
SAVi is built to combine the outputs of two simulation software:

1. **The System Dynamics simulation is built on Vensim**
2. **The Project finance model is built on Excel following Corality Smart Methodology**

IISD have developed the 2 models in-house.



System Dynamics Modelling



Impact of Infrastructure Investments on GDP…

Impact of Natural Capital Stock on Productivity and GDP…

Impact of Consumption on Natural Capital and GDP…

Project Finance Modelling

Assumptions

Financial Feasibility Assessment

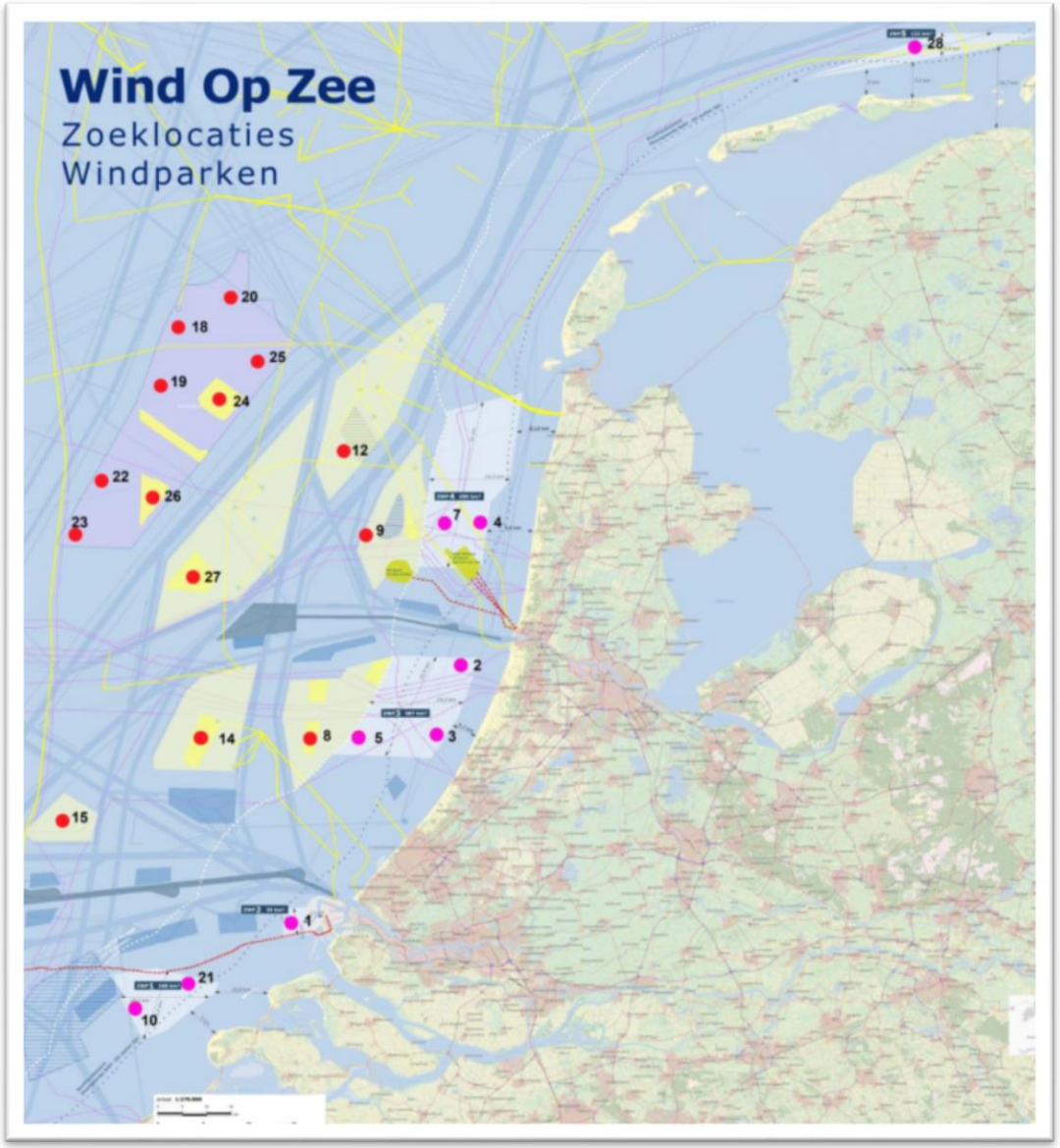
	Integrity Ok	Signal Ok		
Price (Nominal)				
Selected case	*Selection*	High case		
Period			2018	2019
Base case	EUR / MWh		54.00	54.00
High case	EUR / MWh		168.90	168.90
Low case	EUR / MWh		44.00	44.00
Selected	EUR / MWh		168.90	168.90
Sensitivity flex	%	-	-	-
Price	EUR / MWh		168.90	168.90
Operational Expenditure				
Fixed Costs				
Spare	EUR M p.a.	-		
Spare	EUR M p.a.	-		
Spare	EUR M p.a.	-		
Spare	EUR M p.a.	-		
Spare	EUR M p.a.	-		
Variable Costs				
Average operating expense	EUR / MWh	11.42		
SAVi externalities	EUR / MWh	38.14		
Fuel costs	EUR / MWh	42.63		

Section II

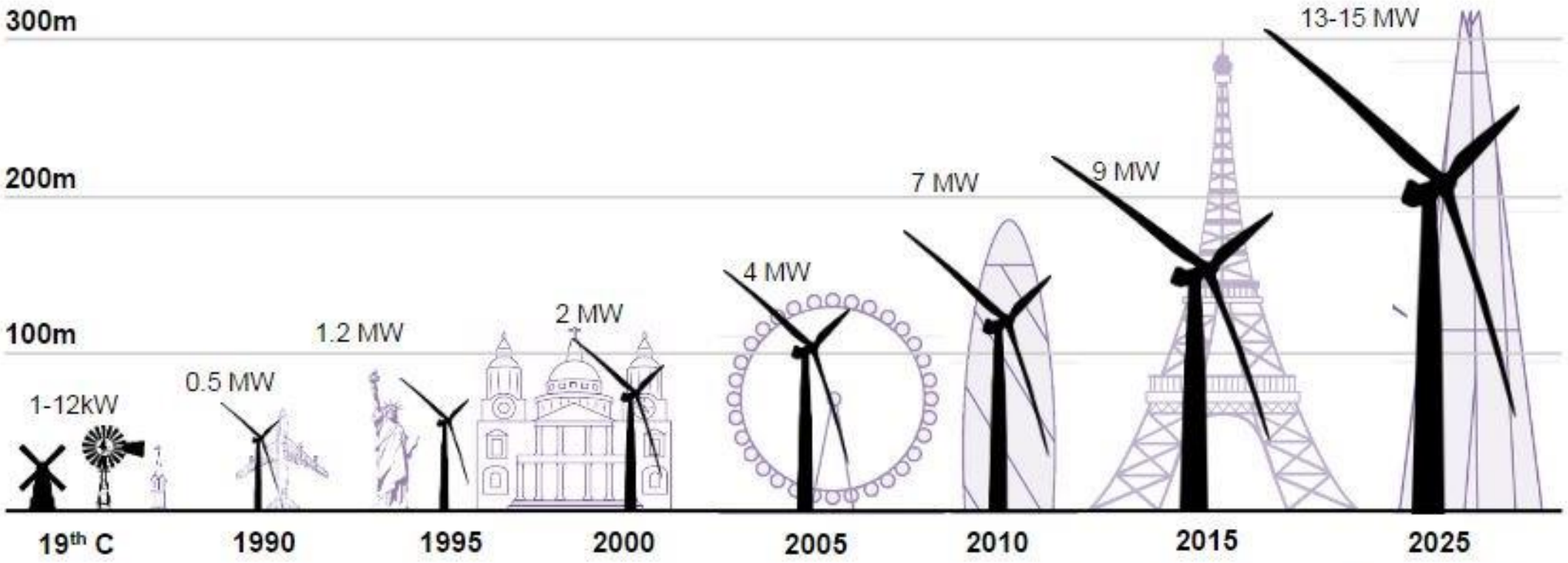
SAVi at Work: Offshore Wind Farm in The Netherlands

SAVi Pilot with RWS: Offshore Wind in the North Sea

- Large-scale project plan: assessment based on **14,000 MW capacity** from offshore wind
  - 4,000 MW within 12-nm zone
  - 10,000 MW outside 12-nm zone
- Total production: **58,690,000 MWh / Year**
- Timing of investments
  - Construction period: 2018-2030 (**1,166 MW per year**)
  - Replacement period (wind): 2038 – 2050 (pole, turbine and blades)



Evolution of wind turbine heights and output



Sources: Various; Bloomberg New Energy Finance

Conducted Analysis with SAVi

Extended CBA

- Project Costs
- Project Benefits
- Positive and Negative Externalities
- Levelized Costs of Electricity

Comparative Assessment – Offshore Wind vs:

- Coal
- Gas
- Nuclear
- Biomass
- Hydro
- Solar
- Onshore Wind

Scenario Analysis

- Conventional
- SAVi+
- Climate Change Risk: 1.5°C temp. increase
- Transitional Risk: Carbon Tax

Financial Feasibility

- Net Present Value (NPV)
- Internal Rate of Return (IRR)
- Gross Margin
- Debt Service Coverage Ratio (DSCR)
- Loan Life Coverage Ratio (LLCR)

Section III

SAVi at Work:

Offshore Wind Farm in The Netherlands

Extended Cost Benefit Analysis

Section III

A. What does the SAVi Extended Cost Benefit Analysis demonstrate?

Scope of the the Extended Cost Benefit Analysis (1/4)

The Extended Cost Benefit Analysis (CBA) goes beyond traditional cost benefit analysis by quantifying a wide range of environmental, social and economic externalities, impact of both physical and transitional climate related risks of the North Sea offshore wind asset and its alternatives in order to have a single scale of comparison for evaluation.

The Levelized Cost of Electricity (LCOE) is a measure of a power source which attempts to compare different methods of electricity generation on a consistent basis. It is an economic assessment of the average total cost to build and operate a power-generating asset over its lifetime divided by the total energy output of the asset over that lifetime. The LCOE can also be regarded as the average minimum cost at which electricity must be sold in order to break-even over the lifetime of the project.

Scope of the the Extended Cost Benefit Analysis (2/4)

How does the Levelized Cost of Electricity (LCOE) of the North Sea offshore wind asset **change when environmental, social and economic externalities are accounted for?**

These externalities are aggregated and referred to as the **SAVi+ evaluation. SAVi+** includes:

- **Valuation of emissions:** Valuation of $PM_{2.5}$, SO_2, and NO_x emissions based on health impacts
- **Labor income:** Income spending from additional employment created, average income per worker and share of income (discretionary) spent locally
- **Land use:** Opportunity costs of land used for power generation is calculated based on the productivity per hectare of agriculture land and the land required for power generation capacity
- **Military base Petten:** Additional payments to adjust and maintain operations at the military base
- **Loss of fisheries:** Extra costs for fisheries due to loss of efficiency
- **Recreation:** Less profits from recreational activities due to negative impact on tourist satisfaction & spending behavior
- **Sand mining:** The construction of wind farms will constrain the ability to harvest sand and cause extra costs for additional mileage and partial unavailability of supplies
- **Seaweed:** Seaweed is an additional source of revenue in the case of offshore wind farms

These externalities were identified by the Ministry of Infrastructure and the Environment in the Netherlands as being the most material to Dutch taxpayers

Scope of the the Extended Cost Benefit Analysis (3/4)

How does the Levelized Cost of Electricity (LCOE) of the North Sea offshore wind asset **change when climate risks are accounted for** in the financial assessment?

Physical Risk: The IPCC estimate of a global temperature increase of 2°C results in a temperature increase of 1.5°C in The Netherlands

- Impact of temp. increase on fossil fuel based **electricity generation** and **fuel costs**
- Higher air and water temperatures **increase cooling loads and costs**
- In times of extreme heat, operations can be **temporally disrupted**
- Higher temperatures require the use of **additional fuel** to maintain production levels due to incomplete combustion (**assumption: a decrease of 0.5% in electricity generation, an increase of 0.56% in fuel costs)**

Transitional Risk: Imposition of a **carbon tax of EUR 12.73 / MWh** throughout the operation of the North Sea offshore wind asset. The total burden of the carbon tax is estimated by multiplying electricity generation by its CO_2 intensity, and by the tax per ton of CO_2.

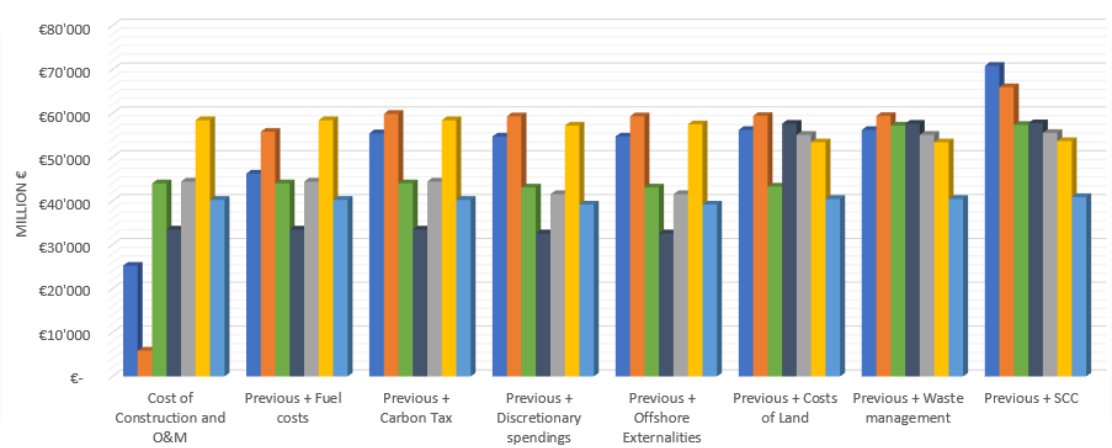
Scope of the the Extended Cost Benefit Analysis (4/4)

How does the Levelized Cost of Electricity (LCOE) of the North Sea offshore wind asset **compare to other electricity generation technologies?**

- **Electricity generation technologies** are covered by the comparative assessment:
  - Coal
  - Gas
  - Nuclear
  - Biomass
  - Hydro
  - Solar
  - Onshore wind
- **Comparability**: the same generation capacity for all installed technologies are assumed
- **Performance evaluation**: based on the externalities and the climate risks mentioned before; discount factor: 5.5%

Section III

B. Assumptions & scenarios used in the Extended Cost Benefit Analysis



System Dynamics model assumptions: Extended Cost Benefit Analysis assessment

We calculated the Extended Cost Benefit Analysis of the North Sea offshore wind asset based on several assumptions. A summary is provided here, and more detail can be found in … [Add the name of the other PPT?] for wind as well as all other technologies analysed.

Variable	Unit of measure	SAVi (inside 12nm)		SAVi (outside 12nm)	
Capital costs	Euro / MW	3‘089‘000		3‘950‘000	
O&M costs	Euro / MW / Year	116'000		122'500	
Lifespan of capacity	Years	20		20	
Max construction	MW/year	1,166		1,166	
Carbon emissions per MW (lifecycle)	Ton / MW	Approx. 700'000		Approx. 700'000	
Load factor	%	47.3%		48.1%	
Development capital costs	**Year**	**2015**	**2020**	**2030**	**2040**
Energieakkord	*%*	*100%*	*83%*	*55%*	*39%*
Electricity price (Euro / MWh)	**Year**	**2015**	**2020**	**2030**	**2040**
Energieakkord	*Euro / MWh*	*54*	*63*	*72*	*74*
Construction start	Year	2018		2022 (up to 4,000 MW)	
Construction end	Year	2022		2030 (up to 10,000 MW)	

System Dynamics model assumptions: Extended Cost Benefit Analysis assessment

1	Capital and O&M cost
2	Fuel costs
3	CC impacts on fuel costs
4	Carbon tax
	Subtotal (1)
5	Income spending
6	Defense payments
7	Fisheries
8	Sand mining
9	Recreation
10	Real estate
11	Land use
12	Waste management
13	Social Cost of Carbon
14	*Valuation of emissions (SA*
	Value of externalities
	Subtotal (1 + 2)
15	**Revenues**
	Costs and Benefits

A

Project level CBA:
Includes capital, O&M, and fuel costs in a Conventional CBA.
Adds climate change impacts on fuel costs and a carbon tax in SAVi assessments.

B

Positive and negative externalities related to each technology analyzed.

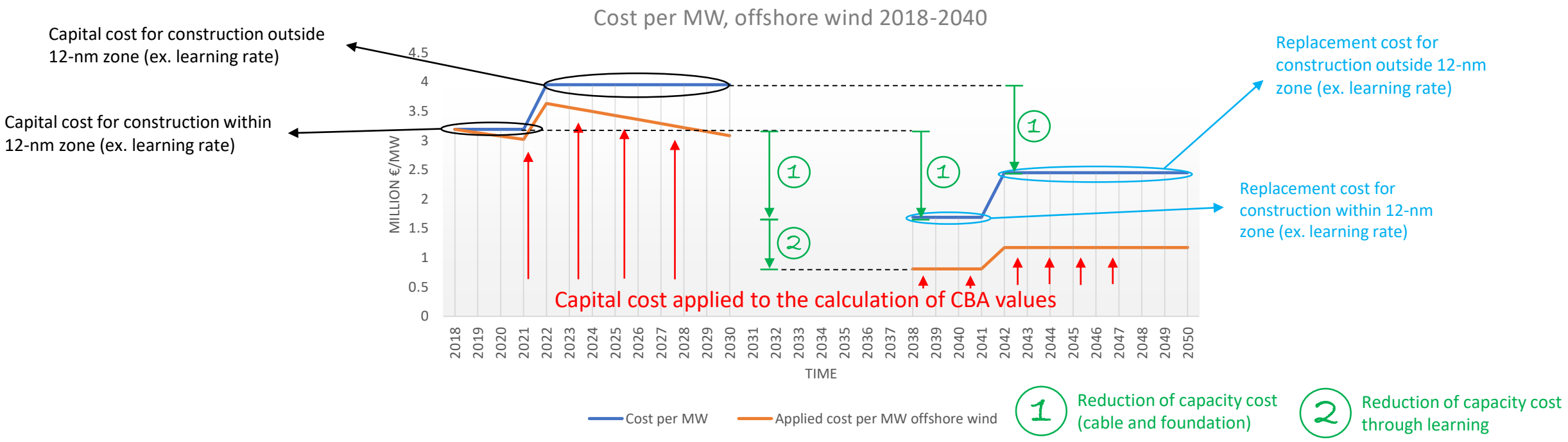
C

Summary of costs and benefits, estimation of the SAVi CBA.

Specific calculations were made for each of the items of the Extended Cost Benefit Analysis (left).
These are based on available studies and databases, used both for determining equations and numerical assumptions.
A full documentation of the approach, with an explanation of the method and assumptions used to estimate each item of the Extended Cost Benefit Analysis for all technologies is available in the following PowerPoint presentation.

System Dynamics model assumptions: Extended Cost Benefit Analysis assessment

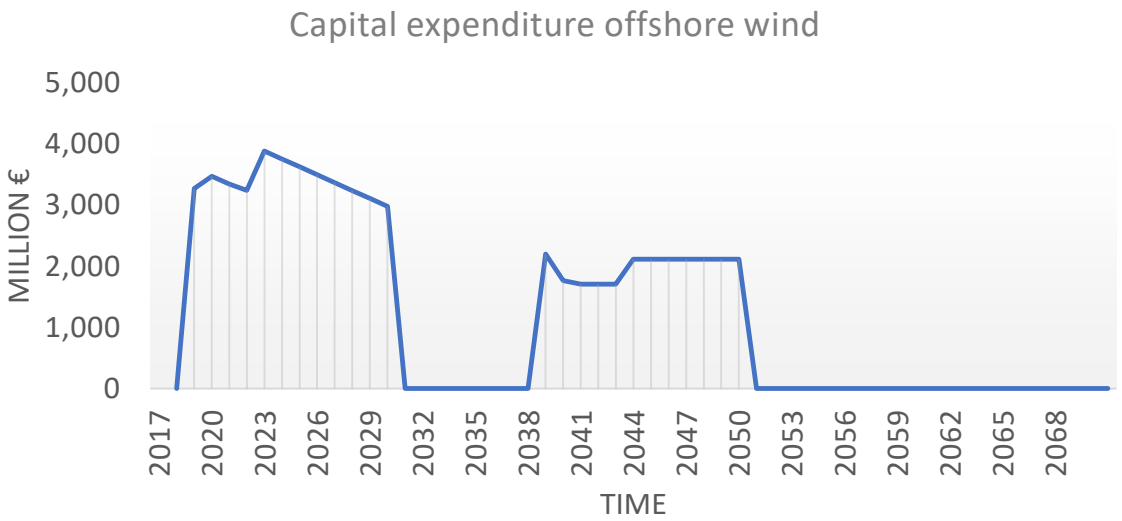
The System Dynamics models simulates over time, from 2000 to 2050. As a result, many of the assumptions used are not static and change over time, such as capital costs. Below is the example of capital costs for offshore wind, which decline over time.

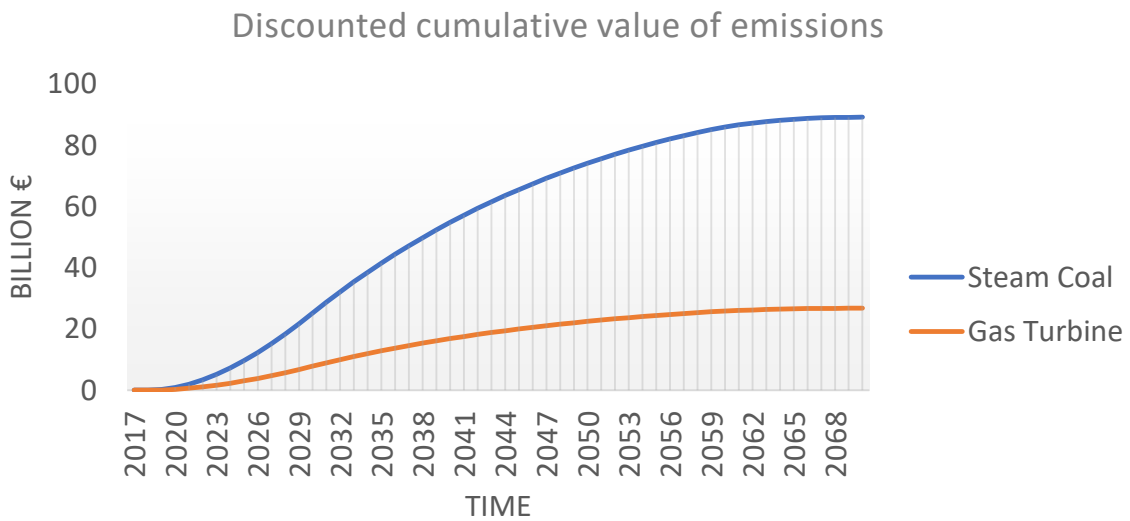


The orange line represents the capital cost used in the model. It is based on the cost of (a) cable and foundation and (b) pole, blades and turbine, and considers an annual learning rate.

System Dynamics model assumptions: Extended Cost Benefit Analysis assessment

- The SAVi model includes stocks and flows (for manufactured, social and natural capital) and captures dynamics over time (2000 – 2068).
- To illustrate how the model forecasts scenarios, and the value of selected indicators, the following graphs show (i) capital investment in offshore wind (a flow accumulating into the stock of capacity) and (b) the cumulative economic value of emissions (growing as a result of annual energy use).





Scenarios used in the Extended Cost Benefit Analysis

We used 4 scenarios to assess the Extended Cost Benefit Analysis of the North Sea offshore wind asset:

Scenarios	Assumptions
Scenario 1	Conventional cost benefit analysis, which incorporates the capital, operation and maintenance expenditures and fuel costs
Scenario 2	Conventional cost benefit analysis
	The SAVi+ evaluation
Scenario 3	Conventional cost benefit analysis
	The SAVi+ evaluation
	The impact of a temperature increase of 1.5°C
Scenario 4	Conventional cost benefit analysis
	The SAVi+ evaluation
	The impact of a temperature increase of 1.5°C
	Carbon tax

Section III

C. Results of the Extended Cost Benefit Analysis

Valuation of Externalities

Table below demonstrates the valuation of externalities in EUR/MWh for the North Sea offshore wind asset and the other energy technologies. These externalities were identified by the Ministry of Infrastructure and the Environment in the Netherlands as being the most material to Dutch taxpayers.

Externalities / Technologies	Wind (off)	Coal	Gas	Nuclear	Biomass	Hydro	Solar	Wind (on)
Income spending	**2.16**	1.01	0.76	1.27	4.27	1.23	4.02	1.48
Military base Petten	**- 0.02**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Fisheries	**- 0.01**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Sand mining	**- 0.04**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Recreation	**- 0.32**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Real estate	**0.00**	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Land use	**5.58**	-2.03	-0.12	-0.27	-840.37	-34.21	-18.48	-1.74
Waste management	**0.00**	0.00	0.00	-19.00	0.00	0.00	0.00	0.00

- The positive valuation of “Income spending” indicates the generation of additional employment and related discretionary spending (a portion of the additional income generated) in The Netherlands
- The negative valuations “Military Base”, “Fisheries” and “Sand mining” are lower than initially expected
- The positive valuation in “Land use” indicates the opportunity cost of land as the wind asset is located offshore
- The valuation on “Recreation” is negative given that the turbines are visible from the shore. Real estate is neutral because no change in real estate value has been observed in coastal areas.

Extended Cost Benefit Analysis: Levelized Cost of Electricity Generation

Below are the results (all values expressed in EUR/MWh) of 4 scenarios for the projected levelized cost of electricity (LCOE) of the North Sea offshore wind asset. We also compare the LCOE of the offshore wind asset to the LCOE of the other energy technologies that can be used by the government of The Netherlands.

Scenarios	Wind (off)	Coal	Gas	Nuclear	Biomass	Hydro	Solar	Wind (on)
Scenario 1: Conventional CBA With cost of financing	**82.63** **96.96**	64.40 68.69	76.53	62.34	99.27	47.41	63.04	57.09
Scenario 2: Conventional CBA, SAVi+	**75.28**	186.22	112.25	80.43	959.15	80.39	77.49	57.36
Scenario 3: Conventional CBA, SAVi+, 1.5°C temp increase	**75.28**	187.13	114.51	80.43	959.15	80.39	77.49	57.36
Scenario 4: Conventional CBA, SAVi+, 1.5°C, carbon tax	**75.28**	199.03	119.78	80.43	959.15	80.39	77.49	57.36

- **Scenario 1** indicates that the most expensive options are offshore wind and biomass. The indication of the cost of financing for offshore wind and coal shows the impact of required financing on the LCOE (wind: 14.33, coal: 4.29).
- **Scenario 2** shows higher LCOE values for wind and solar. Biomass worsens due to its land requirements.
- **Scenario 3** indicates increasing LCOE values for coal and natural gas. This is due to higher operating costs caused by a changing climate (1.5 °C increase in air temperature, water temperature rising to above 26°C).
- **Scenario 4** indicates that the LCOE becomes 64% higher for coal and 59% for gas, with carbon taxes and externalities.

Extended Cost Benefit Analysis: Levelized Cost of Electricity Generation

Table below illustrates the % difference of each scenario relative to Scenario 1 (Conventional CBA). for the projected levelized cost of electricity (LCOE) of the North Sea offshore wind asset.

Scenarios	Wind (off)	Coal	Gas	Nuclear	Biomass	Hydro	Solar	Wind (on)
Scenario 2: Conventional CBA, SAVi+	**-9%**	189%	47%	29%	866%	70%	23%	0%
Scenario 3: Conventional CBA, SAVi+, 1.5°C temp increase	**-9%**	191%	50%	29%	866%	70%	23%	0%
Scenario 4: Conventional CBA, SAVi+, 1.5°C, carbon tax	**-9%**	209%	57%	29%	866%	70%	23%	0%

- **Scenario 2** shows LCOE changes for biomass, hydropower and solar power (due to high land requirements), coal and gas (for high carbon intensity) and for nuclear power (due to waste management). The LCOE of onshore wind does not change, while the LCOE of offshore wind declines (due to minimal negative impact on several externalities and the positive one on seaweed production).
- **Scenario 3** indicates increasing LCOE values for coal and natural gas. This is due to higher operating costs caused by a changing climate (1.5 °C increase in air temperature, water temperature rising to above 26°C). This change is very small when compared to other externalities.
- **Scenario 4** indicates increasing LCOE values for coal and natural gas, proportional to their carbon intensity. No other technology is affected.

Extended Cost Benefit Analysis: Relevance of externalities

Table below illustrates the share of project costs that are (a) capital, O&M and fuel costs and (b) externalities for the SAVi scenario. It shows how relevant externalities are for the technologies analyzed.

Cost item	Wind (off)	Coal	Gas	Nuclear	Biomass	Hydro	Solar	Wind (on)
Capital O&M and fuel costs	**108.9%**	78.5%	91.0%	76.8%	10.8%	58.0%	80.0%	98.4%
Externalities	**-8.9%**	21.5%	9.0%	23.2%	89.2%	42.0%	20.0%	1.6%

- Wind: limited or no land use (onshore vs offshore) and externalities generate positive benefits (e.g. seaweed cultivation)
- Coal and gas: high cost of emissions
- Nuclear: high burden of waste management
- Biomass, hydro and solar: large land use, for feedstock energy, managing water flow and ground mounted solar panels

Extended Cost Benefit Analysis: Gross margin

Table below illustrates the results of 2 scenarios for the projected Gross Margin of the North Sea offshore wind asset. We also compare the Gross Margin of the offshore wind asset to the results of the other energy technologies that can be used by the government of The Netherlands.

Scenarios	Wind (off)	Coal	Gas	Nuclear	Biomass	Hydro	Solar	Wind (on)
Scenario 1: Conventional CBA	**-10%**	13.0%	-6.0%	19.0%	-29.0%	56.0%	18.0%	30.0%
Scenario 4: Conventional CBA, SAVi+, 1.5°C, carbon tax	**-1.8%**	-64.1%	-40.3%	-8.5%	-92.5%	-9.1%	-4.8%	29.5%

- **Scenario 1** indicates that the economically viable options, when considering assumed electricity prices, are hydropower, onshore wind, nuclear power, solar power and coal-fired generation.
- **Scenario 4** indicates that, when considering externalities, climate impacts and a carbon tax, the only economically viable option is onshore wind. Close to parity are offshore wind and solar power. Many of the options that were previously economic (such as coal) are now not economically viable.

Section IV

SAVi Financial Assessment

Section IV

A. What does the SAVi Financial Assessment demonstrate?

Scope of SAVi Financial Assessment (1/4)

How does the financial viability of the North Sea offshore wind asset **change when environmental, social and economic externalities are accounted for** in the financial assessment?

These externalities are aggregated and referred to as the **SAVi+ evaluation. SAVi+** includes:

- **Valuation of emissions:** Valuation of $PM_{2.5}$, SO_2, and NO_x emissions based on health impacts
- **Labor income:** Income spending from additional employment created, average income per worker and share of income (discretionary) spent locally
- **Land use:** Opportunity costs of land used for power generation is calculated based on the productivity per hectare of agriculture land and the land required for power generation capacity
- **Military base Petten:** Additional payments to adjust and maintain operations at the military base
- **Loss of fisheries:** Extra costs for fisheries due to loss of efficiency
- **Recreation:** Less profits from recreational activities due to negative impact on tourist satisfaction & spending behavior
- **Sand mining:** The construction of wind farms will constrain the ability to harvest sand and cause extra costs for additional mileage and partial unavailability of supplies
- **Seaweed:** Seaweed is an additional source of revenue in the case of offshore wind farms

These externalities were identified by the Ministry of Infrastructure and the Environment in the Netherlands as being the most material to Dutch taxpayers

Scope of SAVi Financial Assessment (2/4)

How does the financial viability of the North Sea offshore wind asset **change when climate risks are accounted for** in the financial assessment?

Physical Risk: The IPCC estimate of a global temperature increase of 2°C results in a temperature increase of 1.5°C in The Netherlands

- Impact of temp. increase on fossil fuel based **electricity generation** and **fuel costs**
- Higher air and water temperatures **increase cooling loads and costs**
- In times of extreme heat, operations can be **temporally disrupted**
- Higher temperatures require the use of **additional fuel** to maintain production levels due to incomplete combustion (**assumption: a decrease of 0.5% in electricity generation, an increase of 0.56% in fuel costs)**

Transitional Risk: Imposition of a **carbon tax of EUR 12.73 / MWh** throughout the operation of the North Sea offshore wind asset. The total burden of the carbon tax is estimated by multiplying electricity generation by its CO_2 intensity, and by the tax per ton of CO_2.

Scope of SAVi Financial Assessment (3/4)

How does the North Sea offshore wind asset **compare to a less sustainable electricity generation technology?**

Coal fired electricity generation:

- Selected as a basis for asset comparison
- **Purpose** of using a coal power plant comparator: demonstrate how the performance of a fossil fuel based technology compares with the performance of the North Sea offshore wind asset as renewable energy source
- **Comparability**: the same generation capacity for both the North Sea offshore wind asset and the coal power plant is assumed
- **Performance evaluation**: based on the externalities and the climate risks mentioned before

Scope of SAVi Financial Assessment (4/4)

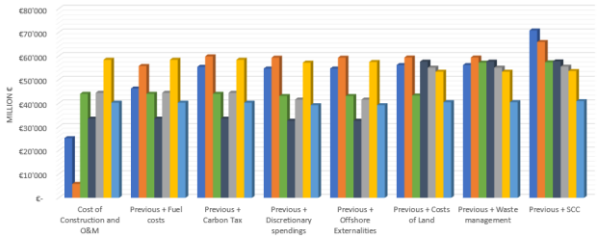
How do key project finance indicators **change when climate risks are included** in the assessment?

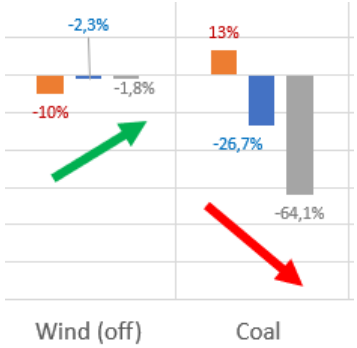
Key project finance indicators demonstrate whether the project cash flows are sufficient to service debt and to cover operating costs. The following indicators are included:

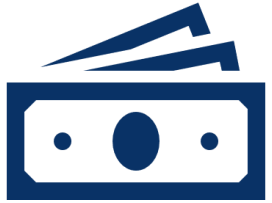
- **Equity Internal Rate of Return (IRR):** It is an indicator for the profitability prospects of a potential investment. The IRR is the discount rate that makes the net present value (NPV) of all cash flows from a particular project equal to zero. Cash flows net of financing gives us the equity IRR.
- **Debt Service Coverage Ratio (DSCR):** It is a measure of the cash flow available to pay current debt obligations. The ratio states net operating income as a multiple of debt obligations due within one year, including interest and principal.
- **Loan Life Coverage Ratio (LLCR):** It is a financial ratio used to estimate the ability of the borrowing company to repay an outstanding loan. It is calculated by dividing the NPV of the cash flow available for debt repayment by the amount of senior debt outstanding.
- **Equity Net Present Value (NPV):** It is the difference between the present value of cash inflows net of financing costs and the present value of cash outflows. It is used to analyze the profitability of a projected investment or project.

Section IV

B. Financial Assumptions & Scenarios used in the Application of SAVi







Financial assumptions: conventional project finance assessment

We calculated the financial feasibility of the North Sea offshore wind asset based on the following 25 assumptions. This is referred to as the 'conventional assessment' moving forward.

Conventional assessment assumptions (1/3)
Construction time: 4 years
Operation time: 40 years, turbines built in construction year(n) becoming operational in year(n+1)
Construction costs: EUR 12,019,370,000 (foundation, turbines, cables, electrics and other costs)
Operational capex: EUR 5,939,960,000 (replacing turbines after 20 years of use)
Operational expenditure: EUR 28 / MWh
Total capacity 4GW
Load factor: 47.30%
Efficiency: 100%
Price: EUR 168.90 / MWh (based on the 600MW Gemini offshore wind farm

Conventional assessment assumptions (2/3)
Gearing target for debt sizing: 70% debt, 30% equity
Credit ratio target for debt sizing: LLCR: 2.00x ; DSCR: 1.30x
Senior debt tenor: 20 years (a second 20 year loan will be taken to cover the operational capex
Senior debt grace period: 1 year
Senior debt interest margin: during construction: 3.00% ; during operation: 2.75 - 3.25%
Senior debt upfront fee: 0.25%
Senior debt commitment fee: 0.75%
Senior debt refinancing: at the end of construction, 2x during operations
Repayment terms: Annuity based

Financial assumptions: conventional project finance assessment continued

Conventional assessment assumptions (3/3)
Discount rate project: 4.50%
Discount rate equity: 6.50%
Base EUR interest rate: 2018-2019: 0.00% ; 2020: 0.50% ; 2021: 1.00% ; 2022+: 1.50%
Cost escalation: assumed to be factored in the variable opex
Corporate tax rate: 25%
Accounting depreciation: using straight line depreciation
Tax depreciation: using reducing balance depreciation

Financial assessment scenarios

We used 4 scenarios to assess the financial feasibility of the North Sea offshore wind asset:

Scenarios	Assumptions
Scenario 1	Project finance assessment (conventional), i.e. financial assumptions listed in the section entitled “Financial assumptions”
Scenario 2	Conventional assessment
	The SAVi+ evaluation
Scenario 3	Conventional assessment
	The SAVi+ evaluation
	The impact of a temperature increase of 1.5°C
Scenario 4	Conventional assessment
	The SAVi+ evaluation
	The impact of a temperature increase of 1.5°C
	Carbon tax

Section IV

C. Results of the Financial Feasibility Assessment

Financial Feasibility Assessment (1/5)

Equity Internal Rate of Return (IRR)

Table below illustrates the projected IRR of the North Sea offshore wind asset and the coal plant comparator. Scenarios 2,3,4 demonstrate that the North Sea offshore wind asset has a more attractive IRR.
Note the percentage differences in the final column.

Scenarios	IRR Offshore wind	IRR Coal plant comparator	Difference in IRR
Scenario 1: Convention assessment (CA)	35.54%	36.58%	- 1.04%
Scenario 2: CA, SAVi+	35.42%	25.41%	+ 10.01%
Scenario 3: CA, SAVi+, 1.5°C temp. increase	35.42%	25.21%	+ 10.21%
Scenario 4: CA, SAVi+, 1.5°C, carbon tax	35.42%	20.87%	+ 14.55%

Under Scenario 1, the coal power plant comparator has a higher equity IRR than North Sea offshore wind asset, suggesting that the coal option is more profitable for project sponsors (i.e. shareholders).

However, under Scenarios 2,3,4 when the **costs of externalities** measured by SAVi, the physical climate risks (water and air temperature increase) and transitional climate risks (carbon tax of EUR 12.73 / MWh), are included, the North Sea offshore wind asset has a significantly higher (and steadily increasing) IRR.

Financial Feasibility Assessment (2/5)

Minimum Debt Service Coverage Ratio (DSCR)

Table below illustrates the minimum DSCR of the North Sea offshore wind asset and the coal plant comparator. Note: under all the scenarios the coal comparator has a higher minimum DSCR. This is because the capital expenditure (CAPEX) of coal plants are lower than that of offshore wind.

Scenarios	DSCR Offshore wind	DSCR Coal plant comparator	Difference in DSCR
Scenario 1: Convention assessment (CA)	2.48x	4.22x	**- 1.74x**
Scenario 2: CA, SAVi+	2.47x	3.02x	**- 0.55x**
Scenario 3: CA, SAVi+, 1.5°C temp. increase	2.47x	3.00x	**- 0.53x**
Scenario 4: CA, SAVi+, 1.5°C, carbon tax	2.47x	2.60x	**- 0.13x**

The coal power plant comparator has a higher minimum DSCR throughout all scenarios assessed. This is due to the lower capex and thus lower debt burden to project cash flows in each quarter over the coal project's life time of 40 years. **While the minimum DSCR is lower for the North Sea offshore wind asset, it always stays comfortably higher than the DSCR lockup ratio of 1.15x.** Getting close to the lockup ratio would raise a red flag for lenders and potentially trigger relevant debt covenants (e.g. cash sweeps, etc.).

Financial Feasibility Assessment (3/5)

Average Debt Service Coverage Ratio (DSCR)

Table below illustrates the average DSCR of the North Sea offshore wind asset and the coal plant comparator. Scenarios 2,3,4 demonstrate that the North Sea offshore wind asset has a higher average DSCR, indicating that the project revenues can comfortably cover debt payments.

Scenarios	DSCR Offshore wind	DSCR Coal plant comparator	Difference in DSCR
Scenario 1: Convention assessment (CA)	**4.80x**	5.37x	**- 0.57x**
Scenario 2: CA, SAVi+	**4.78x**	3.77x	**+ 1.01x**
Scenario 3: CA, SAVi+, 1.5°C temp. increase	**4.78x**	3.75x	**+ 1.03x**
Scenario 4: CA, SAVi+, 1.5°C, carbon tax	**4.78x**	3.21x	**+ 1.57x**

The average debt service coverage ratio (DSCR), indicating the financial robustness of the project during the tenor of the loan, is higher for the coal power plant comparator under the base case scenario. However, when the cost of externalities measured by SAVi, the physical climate risks (water and air temperature increase) and transitional climate risks (carbon tax of 12.73 EUR / MWh) are included then the wind project has a higher average DSCR.

Financial Feasibility Assessment (4/5)

Minimum Loan Life Coverage Ratio (LLCR)

Table below illustrates the minimum LLCR of the North Sea offshore wind asset and the coal plant comparator. Note: under all the scenarios the coal comparator has a higher minimum LLCR. This is because the capital expenditure (CAPEX) of coal plants are lower than that of offshore wind.

Scenarios	LLCR Offshore wind	LLCR Coal plant comparator	Difference in LLCR
Scenario 1: Convention assessment (CA)	**2.94x**	4.98x	**- 2.04x**
Scenario 2: CA, SAVi+	**2.93x**	3.50x	**- 0.57x**
Scenario 3: CA, SAVi+, 1.5°C temp. increase	**2.93x**	3.47x	**- 0.54x**
Scenario 4: CA, SAVi+, 1.5°C, carbon tax	**2.93x**	2.98x	**- 0.05x**

Similarily to the minimum DSCR, the coal power plant comparator has a higher minimum LLCR throughout all scenarios assessed. This is due to the lower capex and thus lower debt burden to project cash flows, in each quarter, over the coal project's life time of 40 years. Note, however, that the **minimum LLCR of the North Sea offshore wind asset always stays comfortably higher than the LLCR lockup ratio of 1.10x.** Getting close to the lockup ratio would raise a red flag for lenders and potentially trigger relevant debt covenants (e.g. cash sweeps, etc.).

Financial Feasibility Assessment (5/5)

Equity Net Present Value (NPV)

Table below illustrates the equity NPV of the North Sea offshore wind asset and the coal plant comparator. Scenarios 2,3,4 demonstrate that the North Sea offshore wind asset has a higher equity NPV. This indicates better profitability of the renewable asset when externalities and climate risks are included.

Scenarios	NPV Offshore wind (EUR Mio)	NPV Coal plant comparator (EUR Mio)	Difference in NPV (EUR Mio)
Scenario 1: Convention assessment (CA)	11,896	10,479	**+ 1,417**
Scenario 2: CA, SAVi+	11,844	5,712	**+ 6,132**
Scenario 3: CA, SAVi+, 1.5°C temp. increase	11,844	5,736	**+ 6,108**
Scenario 4: CA, SAVi+, 1.5°C, carbon tax	11,844	4,053	**+ 7,791**

When assessing the projects using the equity NPV, the North Sea offshore wind project is more attractive even under the base case scenario. When the cost of externalities measured by SAVi, the physical climate risks (water and air temperature increase) and transitional climate risks (carbon tax of 12.73 EUR / MWh) are included then the wind project's equity NPV becomes more than double than the one of the coal power plant, demonstrating the financial attractivness of the renewable option.

Thank You for Your Attention!

References