



Multi Actor Multi-Criteria analysis of emission abatement and energy efficiency measures in container terminals



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Multi Actor Multi-Criteria analysis of emission abatement and energy efficiency measures in container terminals

- 1 Stakeholder integration for emission abatement in container terminals
- 2 Multi-Actor Multi-Criteria Analysis (MAMCA)
- 3 Emission Abatement Decisions in Container Terminals
- 4 Results and Discussion



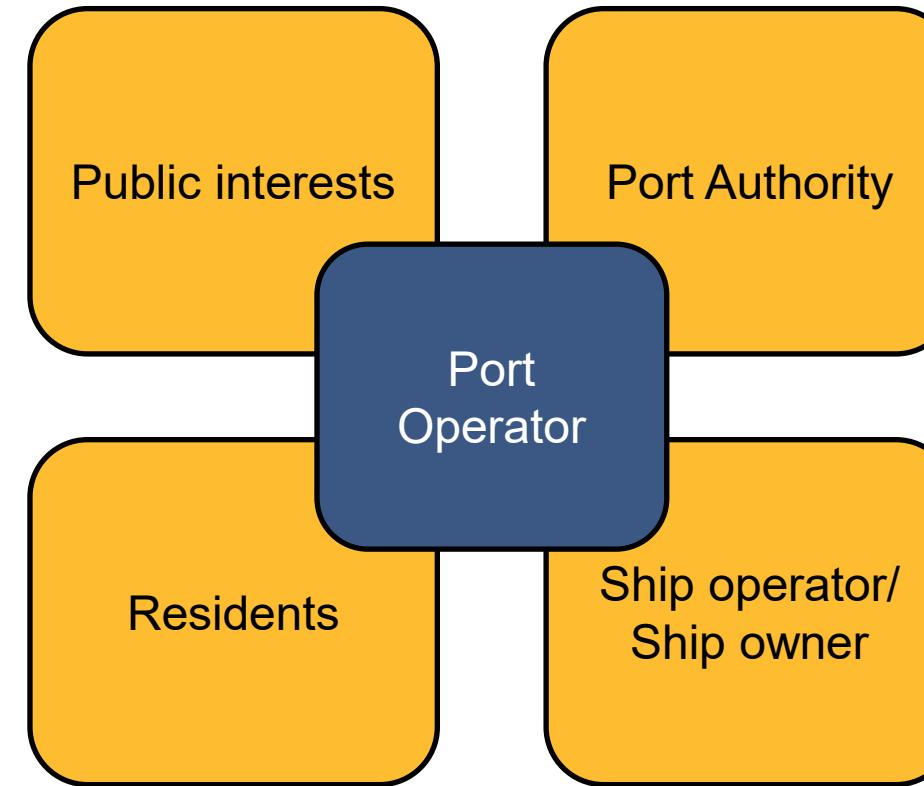
Stakeholder integration for emission abatement in container terminals

Roadmap to sustainable port operations

Identification, evaluation and selection of possible energy efficiency and emission abatement measures proves to be multidimensional and complex

Use of MCDA methods useful for evaluating alternatives in terms of qualitative and quantitative criteria.

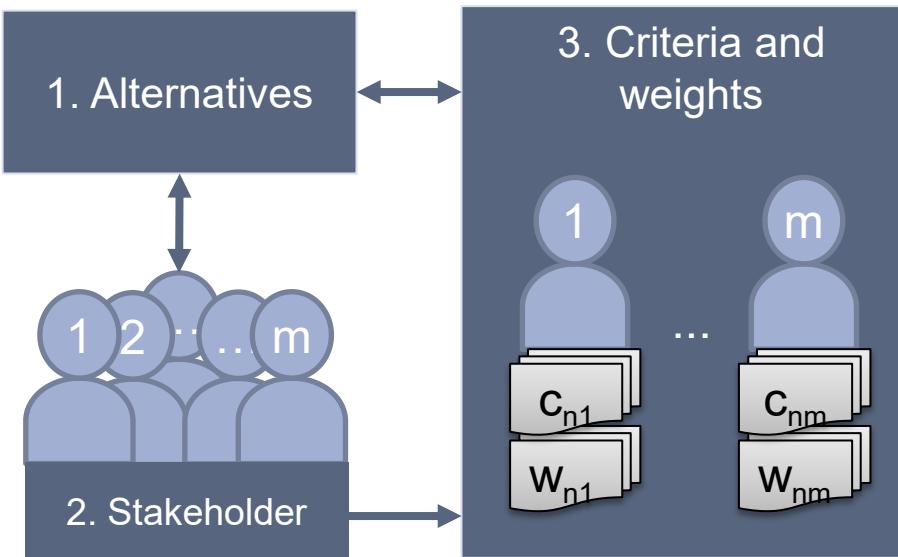
Stakeholder in Container Terminals





Workflow: Multi-Actor Multi-Criteria Analysis (MAMCA)

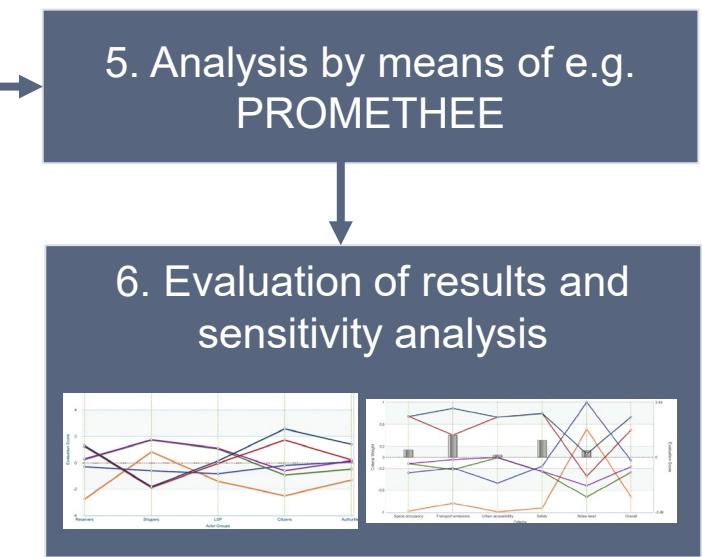
Decision Problem



Performance values

4. Performance values	Value	Unit
c_{11}
⋮	⋮	⋮
c_{nm}

Evaluation and analysis



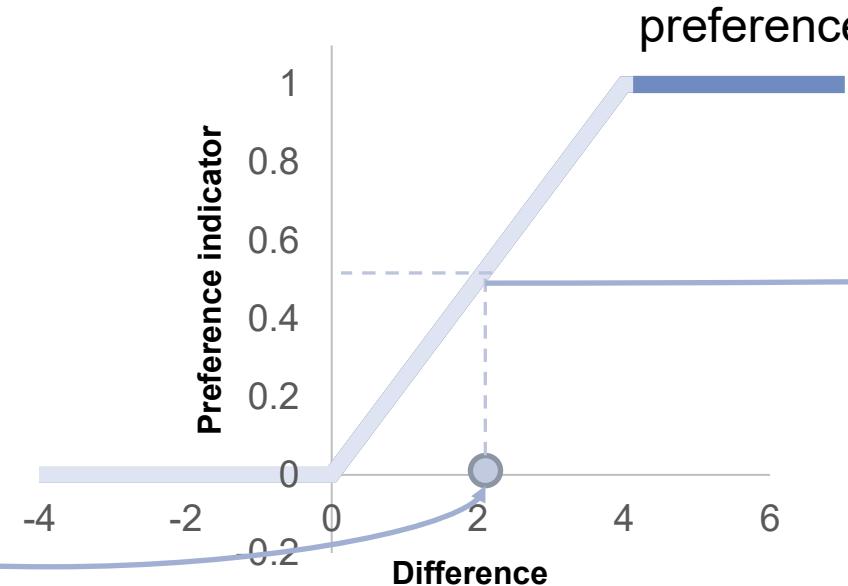
The PROMETHEE II-Method

Input: Decision table, weights

Decision table	A1	A2	A3
CO2- Emissions	6	10	8
Differences of alternatives			
A1	A2	A3	
A1	0	4	2
A2	-4	0	-2
A3	-2	2	0

a	$g_1(\cdot)$...	$g_k(\cdot)$
a_1	$g_1(a_1)$...	$g_k(a_1)$
:	:	..	:
a_n	$g_1(a_n)$...	$g_k(a_n)$

Apply preference function to differences



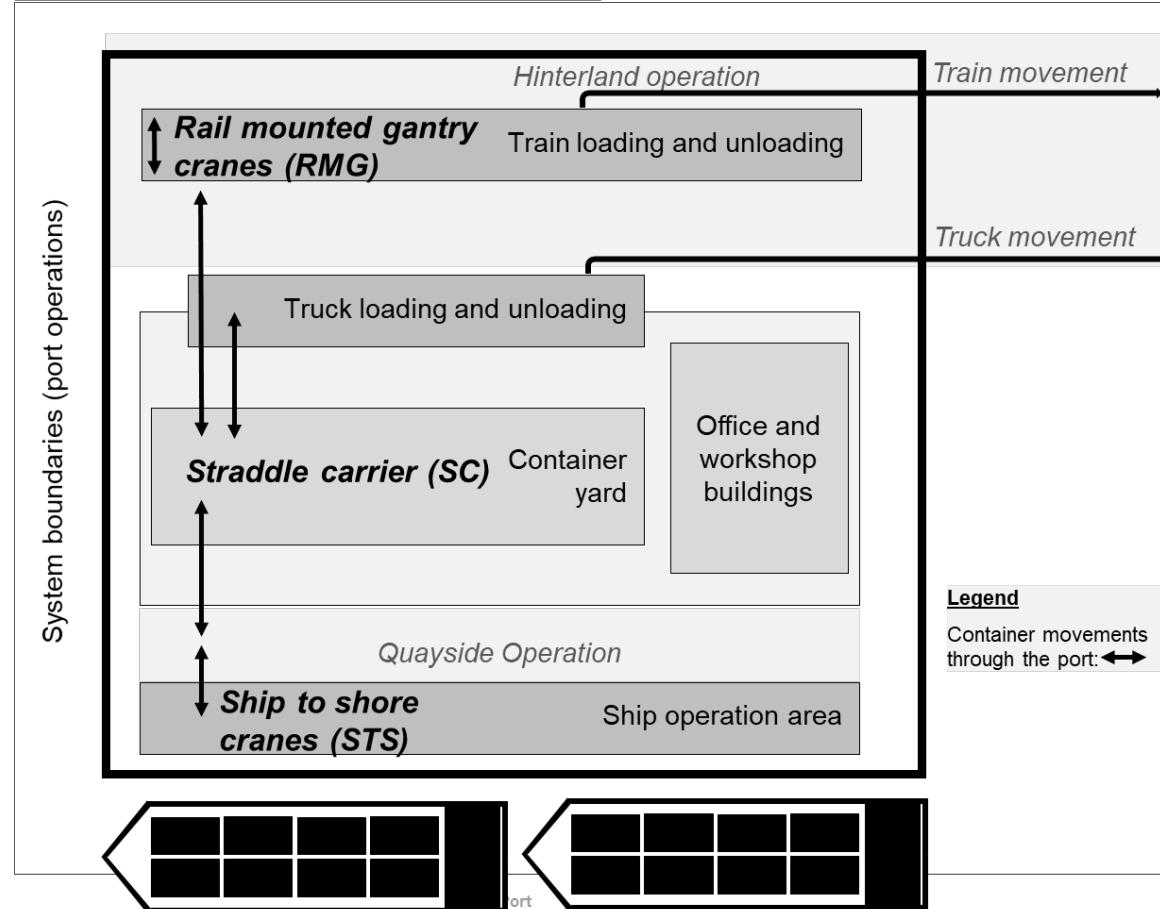
Aggregate preference indicators

	A1	A2	A3
A1	0	1	0,5
A2	0	0	0
A3	0	0,5	0



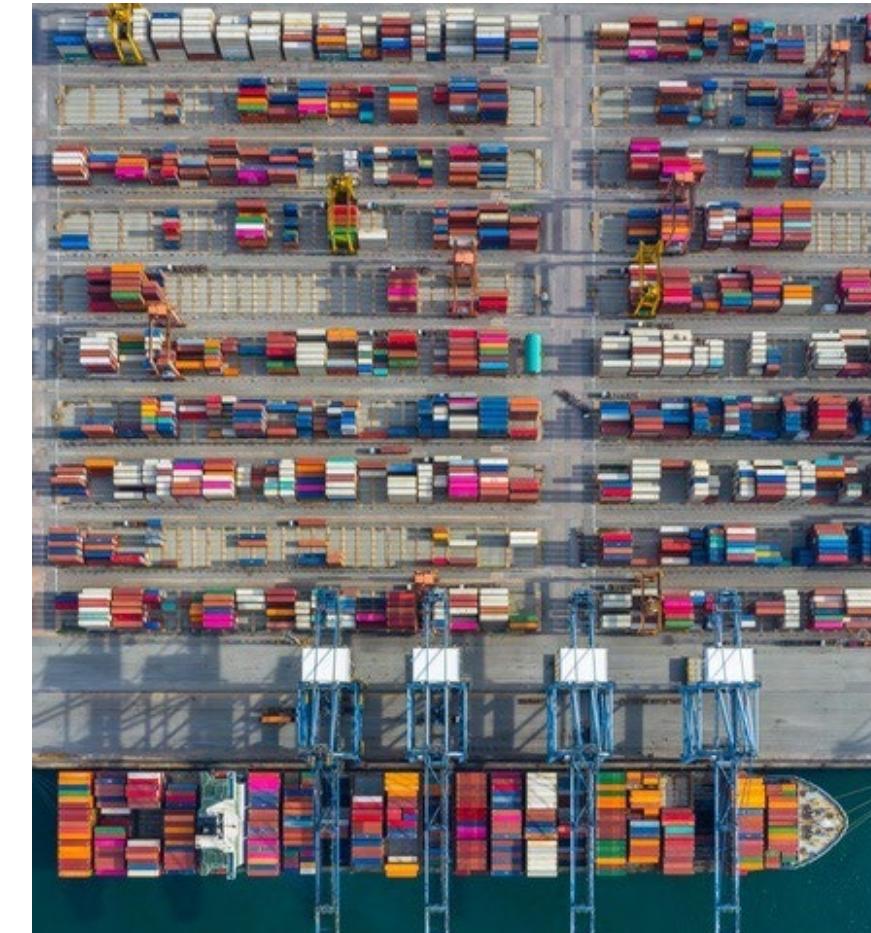
General structure of container terminals

Schematic layout of a terminal



Source: Steenken et al. 2004

Container ship with terminal and yard



Source: www.porttechnology.org



Selected Energy Efficiency Measures in Container Terminals

Measures

Specification

Solar photovoltaics

- Installation of photovoltaics on the roof of the administration building.



Photo by Sungrow EMEA on Unsplash

LNG power pack

- An LNG-fueled generator located in a mobile container allows vessels to switch off their auxiliary engines while the ship is docked.
- It can deliver a power supply of up to 30 MW.

Onshore power supply

- Vessels at berth use shore power instead of relying on electricity generated by the vessels' own (auxiliary) engines
- the actual GHG emission reduction potential depends on the grid's electricity generation mix



Photo by Kalmar: Fast Charge SC

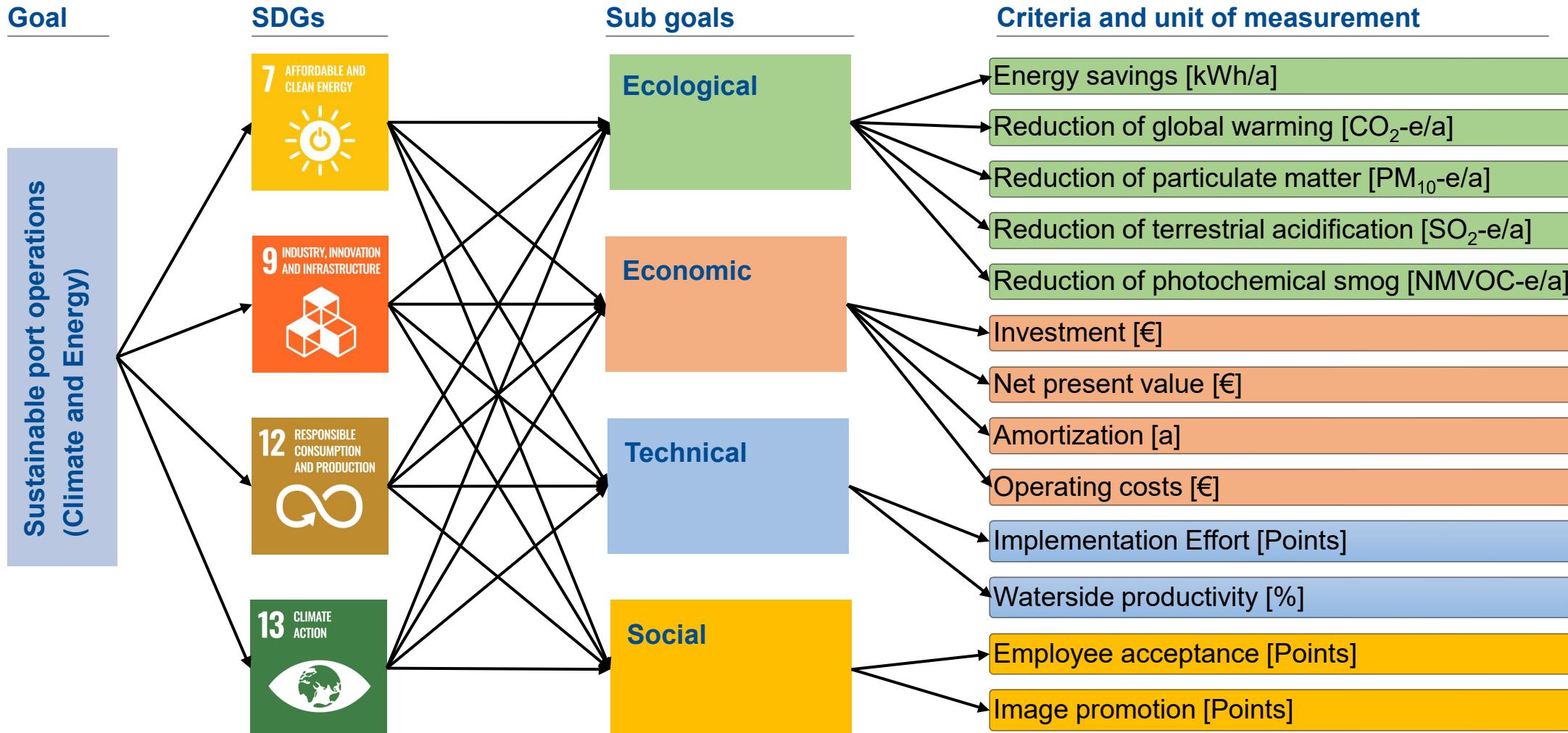
Full electric propulsion

- Use electric horizontal transportation equipment at the terminal.

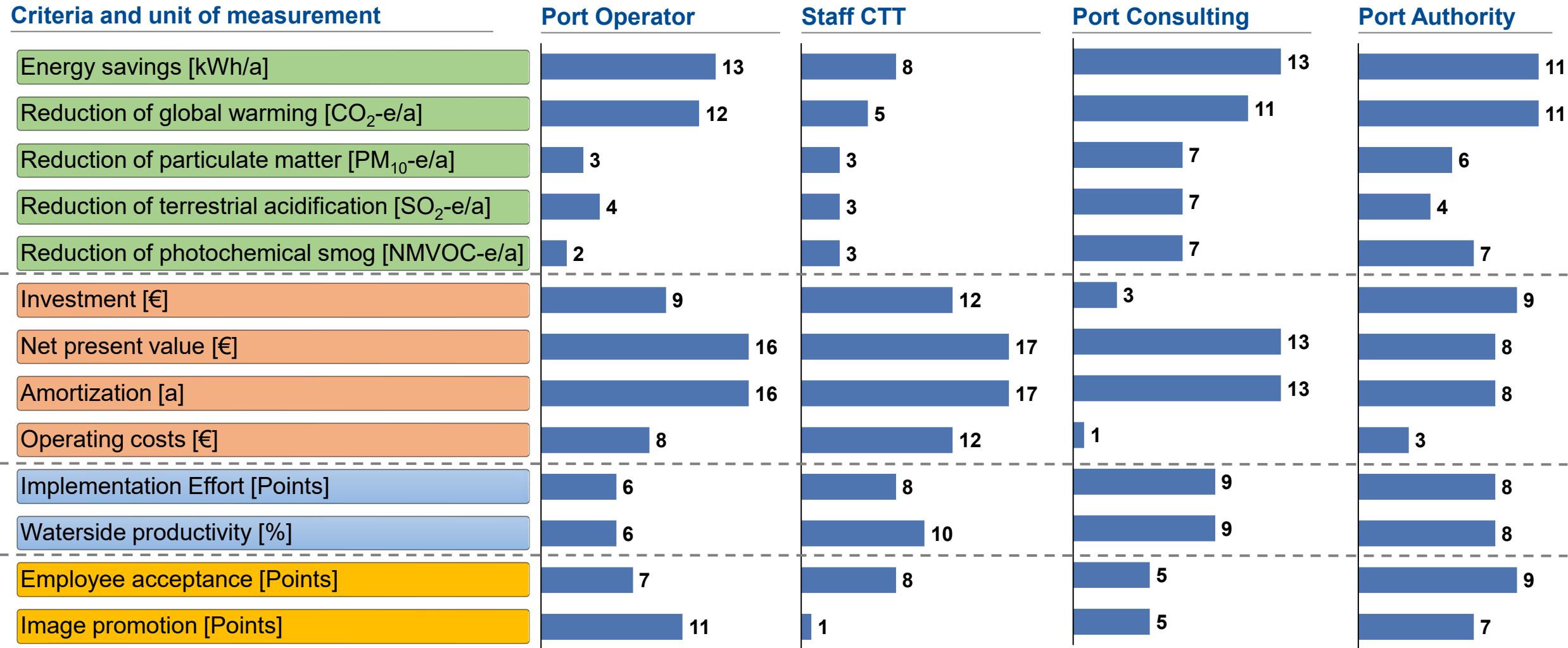
Source: Pohl et. al. 2020



Sustainability Assessment Criteria at the CTT



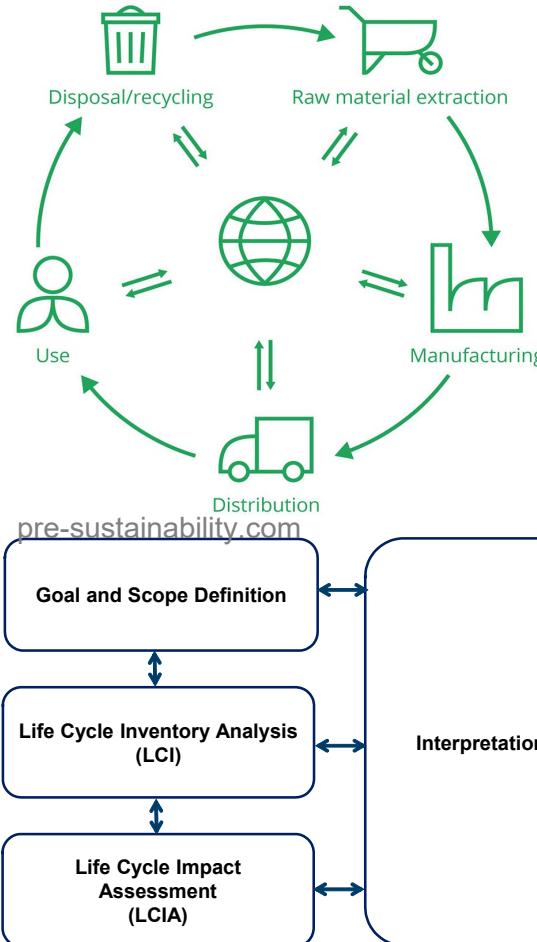
Stakeholder Weights at the CTT



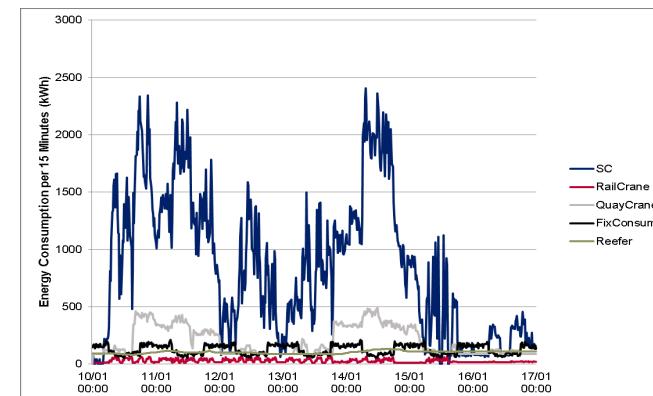
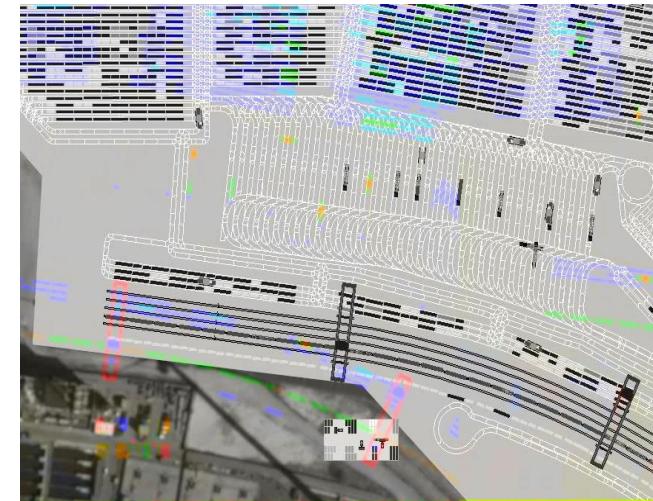


Performance Values

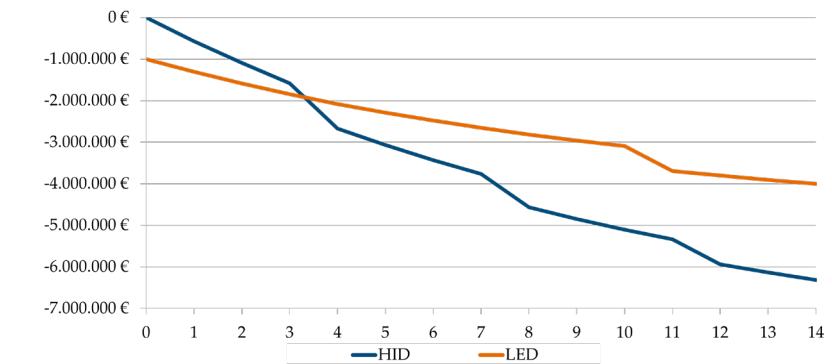
Life Cycle Assessment



Simulation model of the CTT



Financial Accounting and expert interviews

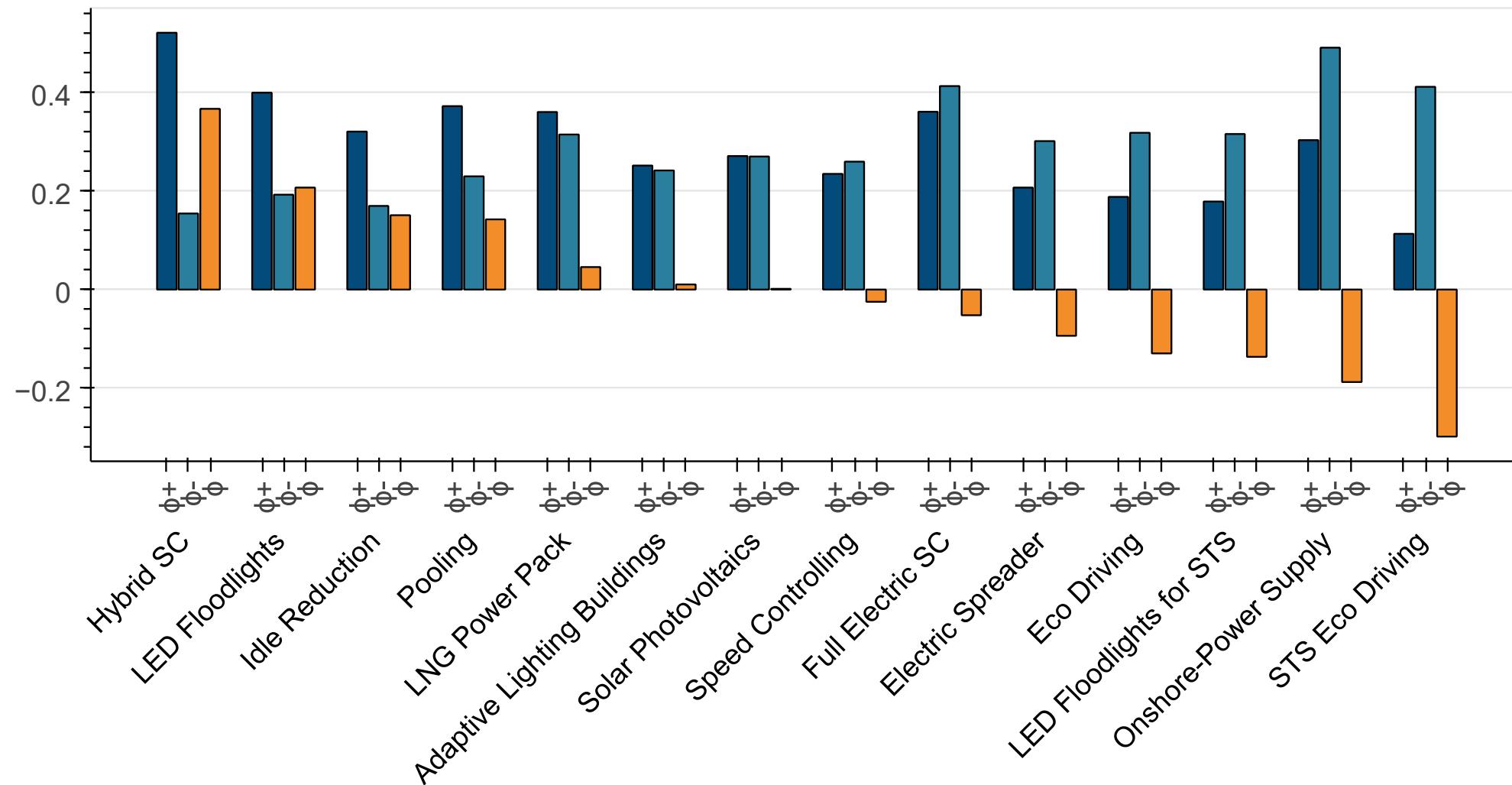


Implementation Effort [Points]

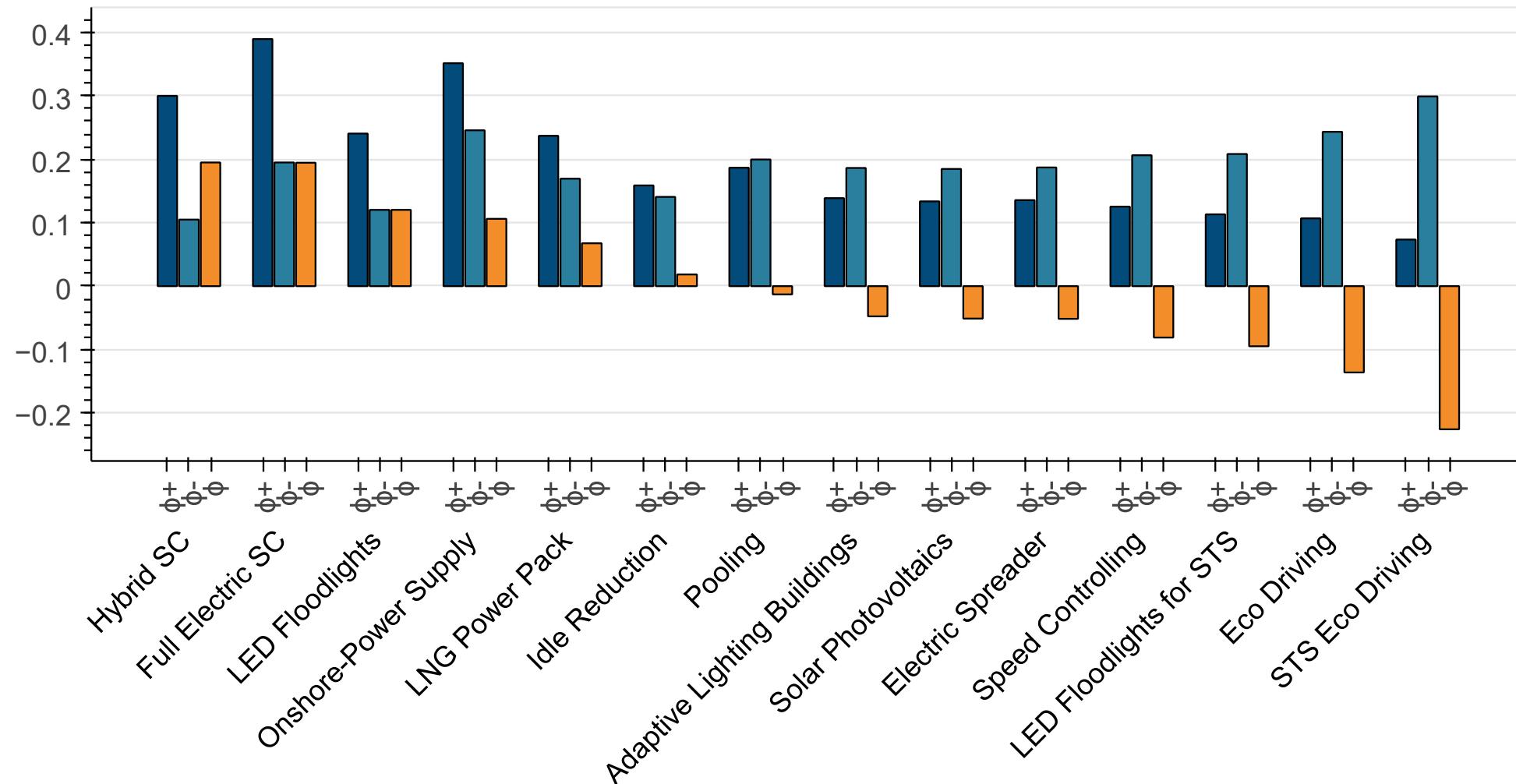
Employee acceptance [Points]

Image promotion [Points]

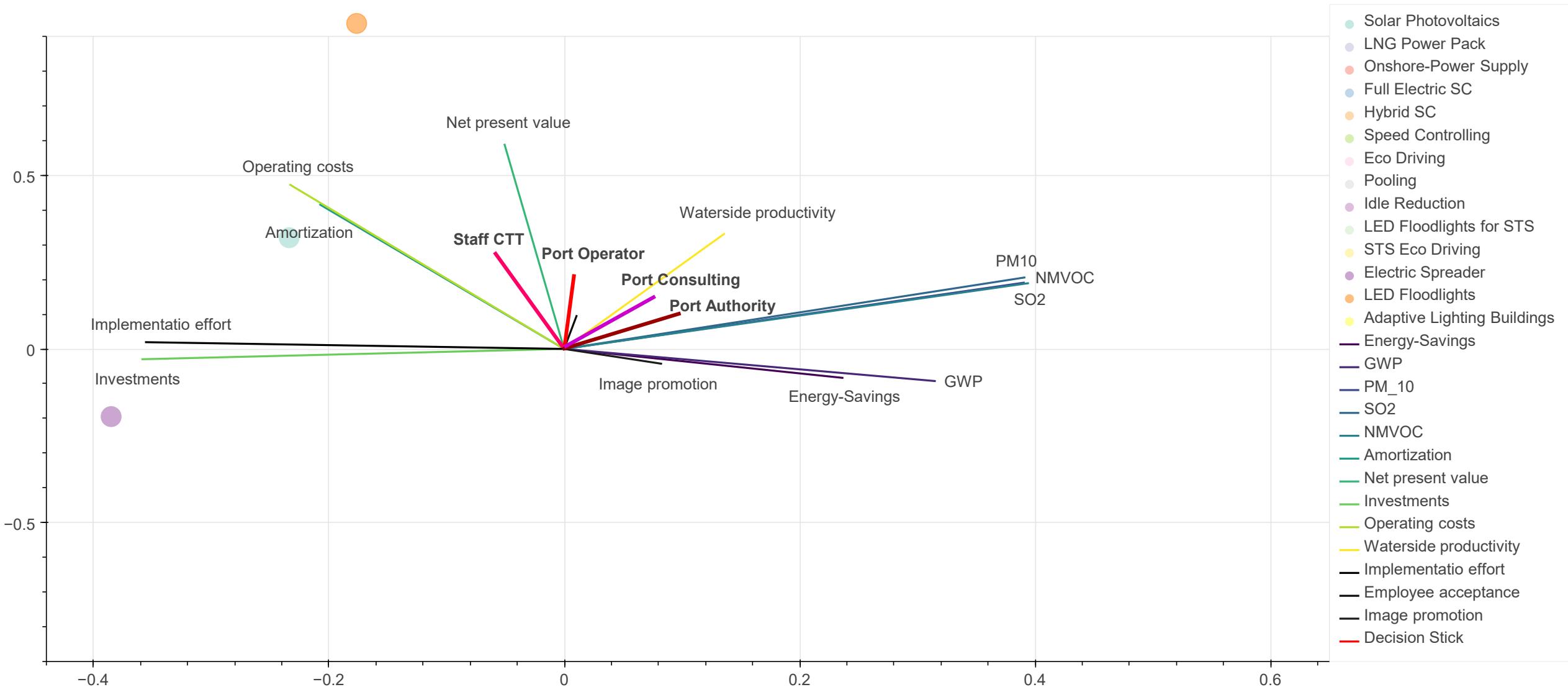
Results – Port Operator: Outranking Flows



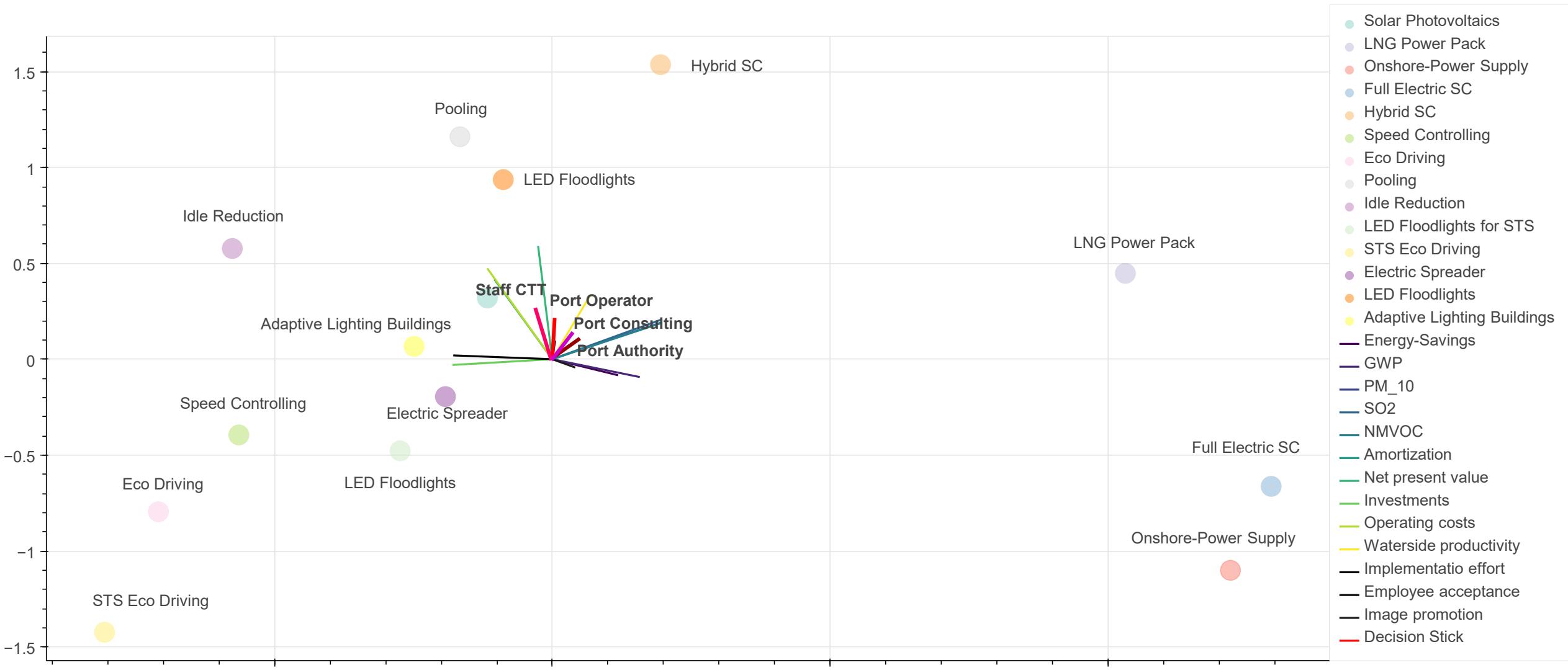
Results – Port Authority: Outranking Flows



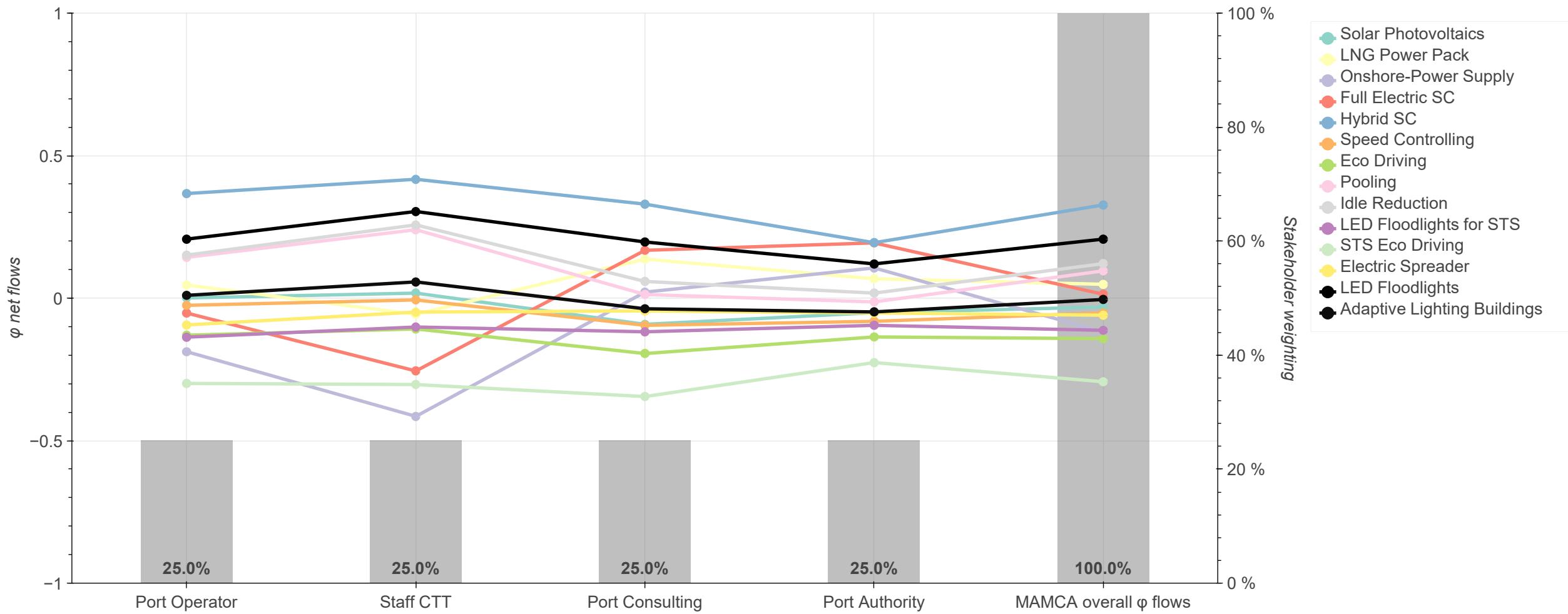
Results – PROMETHEE: GAIA-Plane



Results – PROMETHEE: GAIA-Plane



Results – Multi Actor Analysis



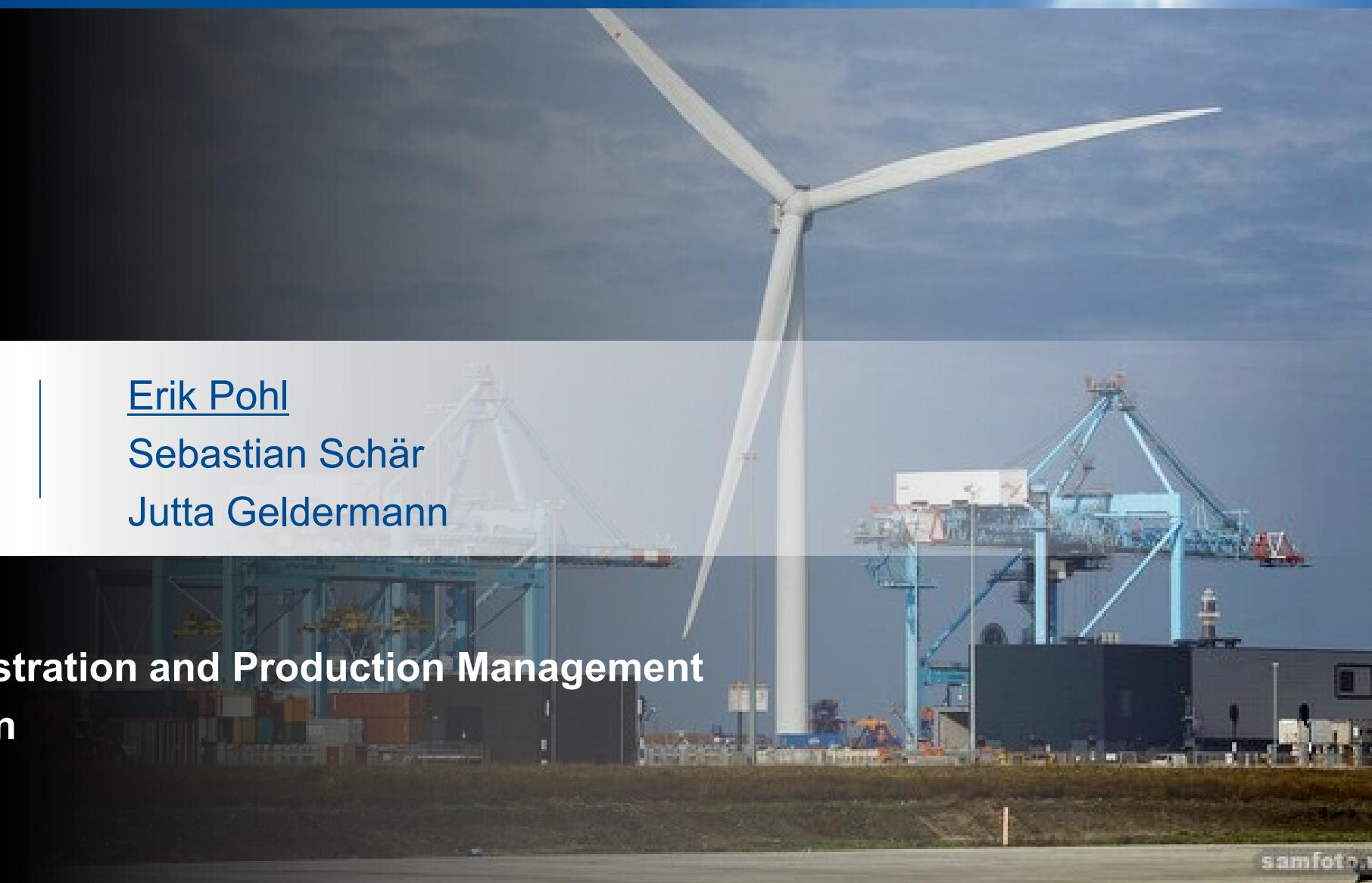
Thank You!



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Energy Efficiency Measure`s Performance Values

Measure/Criterion	Energy- Savings	GWP	PM_10	SO2	NMVOCS	Amortization	Net present value	Investments	Operating costs	Waterside productivity	Implementation effort	Employee acceptance	Image promotion
Solar Photovoltaics	0,00%	2,21%	-0,24%	0,25%	-0,03%	4,37%	35,98%	5,45%	-5,57%	97,14%	62,50%	100,00%	75,00%
LNG Power Pack	0,00%	90,39%	94,61%	100,00%	71,18%	7,21%	34,87%	24,37%	-549,59%	97,14%	87,50%	66,67%	75,00%
Onshore-Power Supply	62,74%	68,61%	59,69%	58,90%	60,38%	100,00%	-821,38%	100,00%	-1217,54%	97,14%	100,00%	33,33%	100,00%
Full Electric SC	100,00%	100,00%	100,00%	93,02%	100,00%	100,00%	-107,37%	16,89%	-22,37%	97,14%	100,00%	66,67%	100,00%
Hybrid SC	23,69%	29,02%	18,65%	15,79%	17,24%	2,78%	100,00%	8,45%	100,00%	97,14%	25,00%	100,00%	75,00%
Speed Controlling	-0,01%	-0,02%	-0,01%	-0,01%	-0,01%	1,00%	1,70%	0,00%	1,87%	92,33%	25,00%	33,33%	50,00%
Eco Driving	2,00%	-0,53%	-0,45%	-0,45%	-0,46%	3,81%	-0,20%	0,03%	0,00%	96,44%	25,00%	33,33%	50,00%
Pooling	4,08%	0,10%	0,06%	0,06%	0,06%	1,57%	26,10%	5,32%	80,65%	100,00%	62,50%	33,33%	50,00%
Idle Reduction	0,24%	0,04%	0,01%	0,01%	0,01%	1,00%	4,50%	0,00%	74,11%	97,14%	25,00%	66,67%	50,00%
LED Floodlights for STS	-0,01%	-0,07%	-0,07%	-0,04%	-0,03%	7,19%	0,45%	0,93%	2,12%	97,14%	37,50%	100,00%	50,00%
STS Eco Driving	-0,35%	-2,13%	-1,32%	-1,31%	-1,25%	100,00%	-0,22%	0,12%	0,00%	95,97%	25,00%	33,33%	50,00%
Electric Spreader	0,33%	0,96%	0,14%	0,14%	0,18%	100,00%	6,98%	2,49%	13,42%	97,14%	25,00%	100,00%	50,00%
LED Floodlights	3,07%	4,69%	0,93%	1,09%	0,68%	3,14%	21,31%	-3,10%	62,18%	97,14%	37,50%	100,00%	75,00%
Adaptive Lighting Buildings	0,44%	0,71%	0,18%	0,19%	0,12%	0,00%	-0,19%	0,31%	1,40%	97,14%	50,00%	33,33%	50,00%