A Novel Approach for Non-Energy Benefits: Cases from Industry

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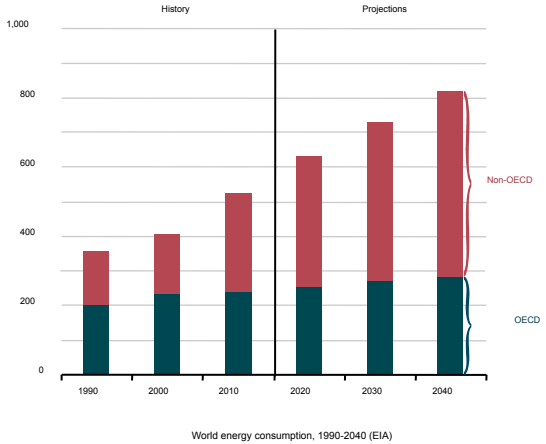
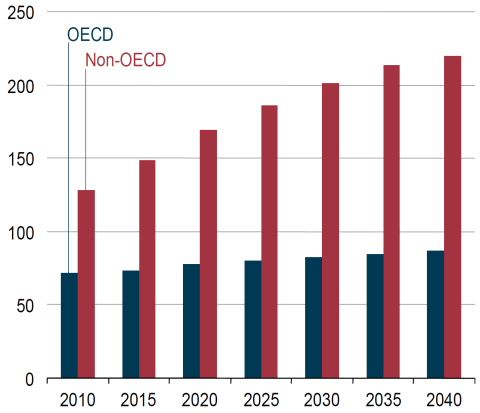
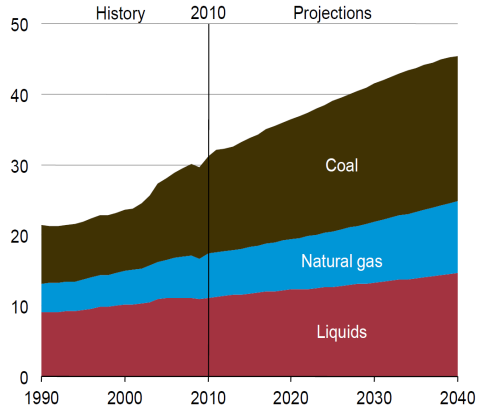
Introduction



World energy consumption, 1990-2040 (EIA)

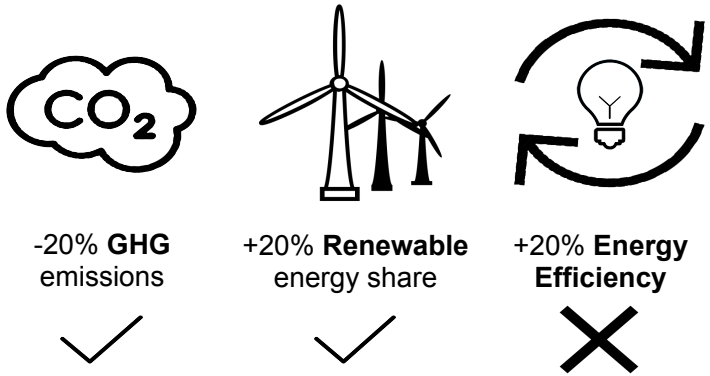


World industrial sector energy consumption, 2010-2040 (EIA)



World energy-related carbon dioxide emissions by fuel type, 1990-2040 (EIA)

Policies actually exist, as
Europe 20-20-20



-20% **GHG** emissions

+20% **Renewable** energy share

+20% **Energy Efficiency**

The research ground

Energy Efficiency Measures (**EEMs**)

Low implementation rate due to several barriers

Lack of knowledge about the **overall impact of the EEMs** on the plant in the **industrial decision maker perspective**.

Exclusive consideration of the **Non-Energy Benefits** as means for overcoming barriers

Literature review

- Consideration of just **positive** impacts (NEBs)
- Not consideration of the area where benefits are perceived
- Few attempts for **quantifying** the benefits
- Quantification exclusively in monetary units
- Poor consideration for the **negative** impacts
- **Disturbance** is not considered
- Absence of a **structured analysis**

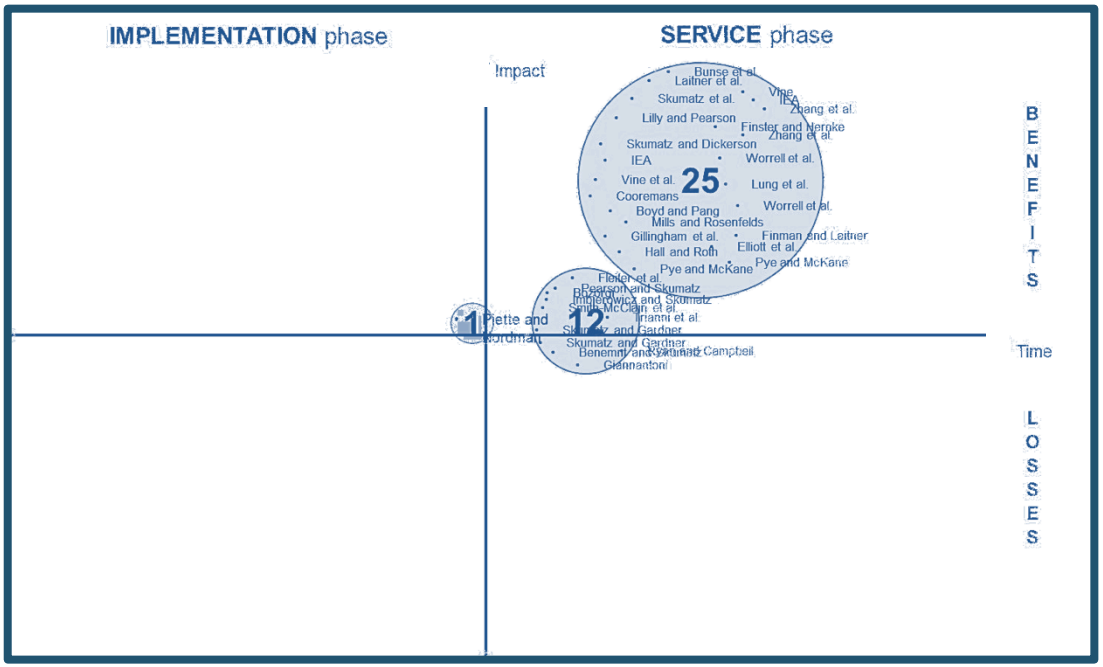
Industrial decision maker **cannot accomplish** proper **decision making**!

	Books	Papers and conference proceedings	Time
Studies consulted	14	97	1993 - 2015
Studies presented	0	38	1996 - 2015

Authors	Year	Type	Focus	Implementation/ Service phase	Benefits/ Losses
Benemnt and Skumatz	2007	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits and Losses
Boyd and Pang	2000	Journal - Energy policy	Industrial sector	Service phase	Benefits
Bozorgi	2015	Journal - Energy efficiency	Real estate	Service phase	Benefits and Losses
Bunse et al.	2011	Journal of Cleaner Production	Industrial sector	Service phase	Benefits
Cooremans	2011	Journal - Energy efficiency	Industrial sector	Service phase	Benefits
Elliott et al.	1997	Conference proceedings	Industrial sector	Service phase	Benefits
Finman and Laitner	2001	Conference proceedings	Industrial sector	Service phase	Benefits
Finster and Hernke	2014	Journal of Industrial Ecology	Industrial sector	Service phase	Benefits
Fleiter et al.	2012	Journal - Energy policy	Industrial sector and policy makers	Service phase	Benefits and Losses
Giannantoni	2009	Conference proceedings	Policy makers	Service phase	Benefits and Losses
Gillingham et al.	2004	Report	Policy makers	Service phase	Benefits
Hall and Roth	2004	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits
Hall and Roth	2003	Report	Policy makers	Service phase	Benefits
Heffner and Campbell	2012	Report	Policy makers	Service phase	Benefits and Losses
IEA	2015	Report	Policy makers	Service phase	Benefits
IEA	2014	Report	Policy makers	Service phase	Benefits
Imbierowicz and Skumatz	2004	Conference proceedings	Policy makers	Service phase	Benefits and Losses
Laitner et al.	2001	Conference proceedings	Industrial sector	Service phase	Benefits
Lilly and Pearson	1999	Report	Industrial sector	Service phase	Benefits
Lung et al.	2005	Conference proceedings	Industrial sector	Service phase	Benefits
Worrell et al.	2002	Report	Industrial sector	Service phase	Benefits
Mills and Rosenfelds	1996	Journal - Energy	Industrial sector	Service phase	Benefits
Pearson and Skumatz	2002	Report	Commercial sector	Service phase	Benefits and Losses
Piette and Nordman	1996	Conference proceedings	Commercial and Industrial sector	Service phase / Implementation phase	Benefits and Losses
Pye and McKane	1999	Conference proceedings	Industrial sector	Service phase	Benefits
Pye and McKane	2000	Journal - Resources, Conservation and Recycling	Industrial sector	Service phase	Benefits
Ryan and Campbell	2012	Report	Policy makers	Service phase	Benefits and Losses
Skumatz and Gardner	1997	Report	Industrial sector	Service phase	Benefits and Losses
Skumatz and Dickerson	1998	Conference proceedings	Industrial sector	Service phase	Benefits
Skumatz and Gardner	2005	Conference proceedings	Commercial and Industrial sector	Service phase	Benefits and Losses
Skumatz et al.	2000	Conference proceedings	Residential sector	Service phase	Benefits
Smith-McClain et al.	2006	Conference proceedings	Residential and commercial sector	Service phase	Benefits and Losses
Trianni et al.	2014	Journal	Industrial sector	Service phase	Benefits and Losses
Vine	2011	Report	Policy makers	Service phase	Benefits
Vine et al.	2000	Journal - Energy	Insurance, industrial sector, policy makers	Service phase	Benefits
Worrell et al.	2003	Journal - Energy	Industrial sector	Service phase	Benefits
Zhang et al.	2015	Journal - Applied Energy	Industrial sector	Service phase	Benefits
Zhang et al.	2014	Journal - Energy	Industrial sector	Service phase	Benefits

Research gaps

- Existence of just one contribution starting to account for the **implementation** phase
- All the studies proposed concentrate on the **same quarter**
- **No structured analysis** of the impacts
- Bottom-up approach
- Absence of **relationships of EEM with the surrounding environment** where it should be adopted



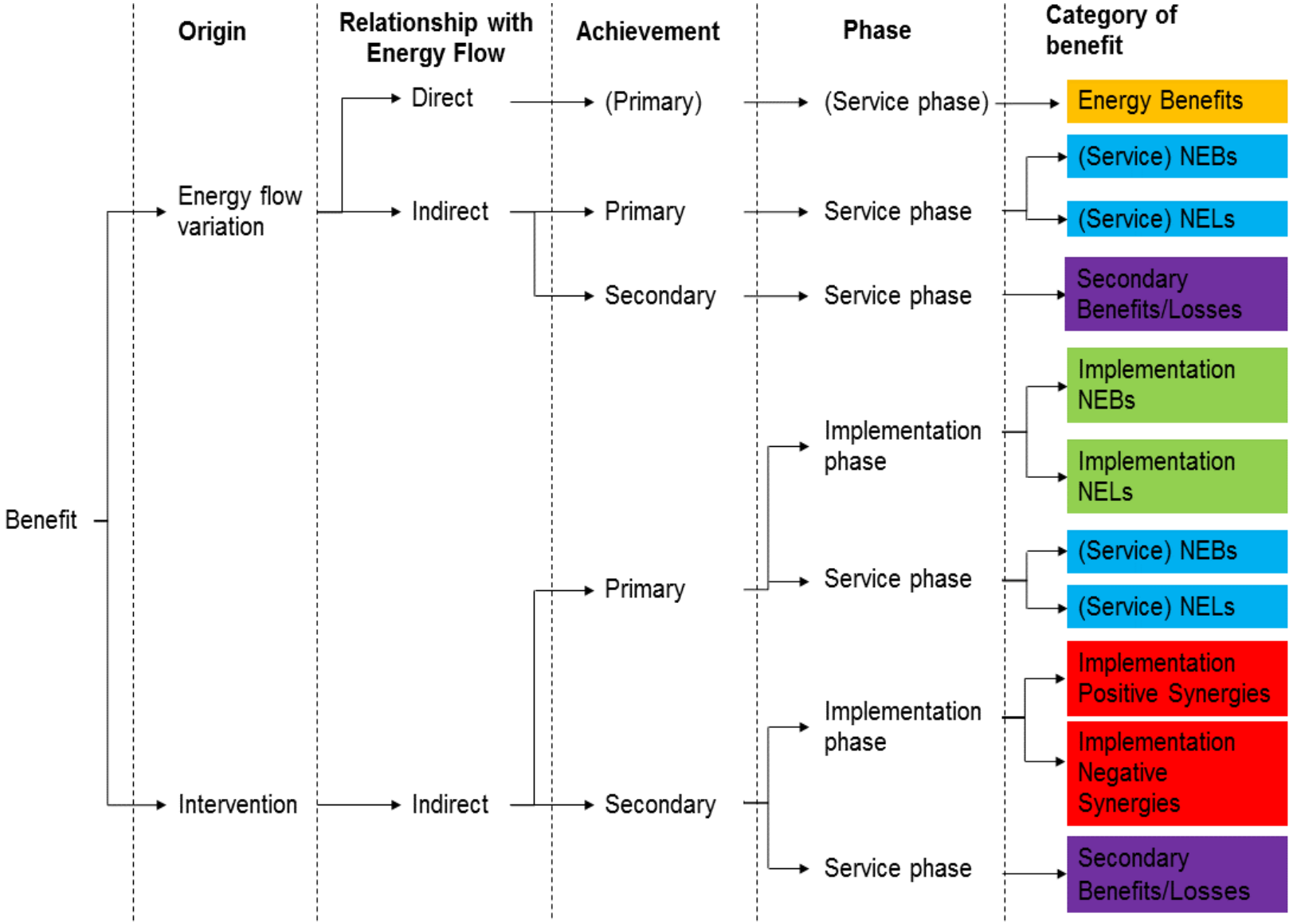
NEEDS for a novel APPROACH:

1.New framework
2.New impacts characterization

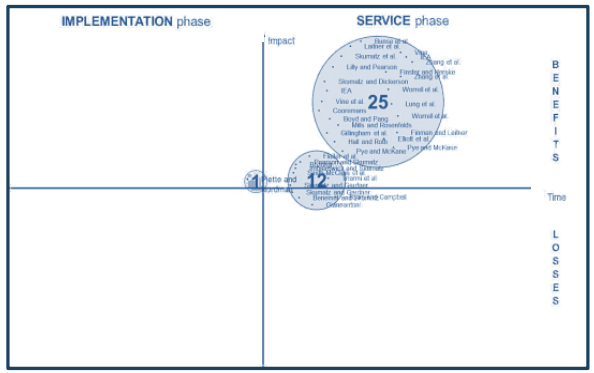
Beneficiaries:

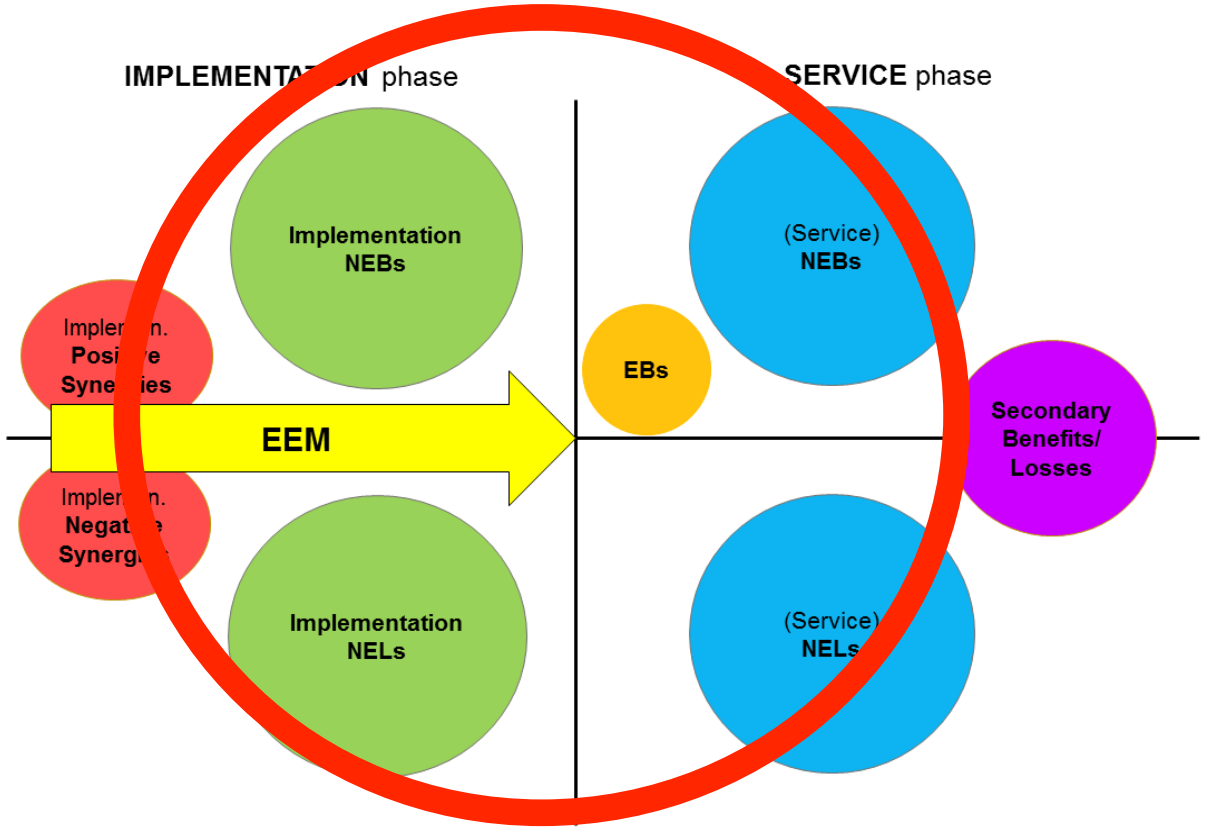
1. Policy makers
2. EESC (Energy Efficiency Supply Chain) actors

Novel definition of Benefit



Novel framework





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WHAT ARE THE ATTRIBUTES OF A NON-ENERGY BENEFIT?

Characterization of Non-Energy Benefits

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Type and beneficiary of the impact

- Type of impact
- Targeted Area
- Extension of the impact

Persistence of the impact

- Duration of the impact
- Resilience of the impact
- Maintainability of the impact
- Stability of the impact

Temporal aspects

- Peak of the benefit
- Frequency of implementation

Perception of the impact

- Perception from the local community
- Perception from the customers
- Perception of the operators

Other

- Generation of cash flow
- Synergies with other-than-energy resources
- Magnitude of the impact

Characterization definition detail

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Macro-category	Characteristic	Description	Evaluation
Type and beneficiary of the impact	Type of impact	Indication of the area of interest the benefit refers to, maintaining continuity with respect to the past. Defined exploiting (Lunget al., 2005), (Bunseet al. 2011), (Piette and Nordman 1996), (Worrell et al. 2003), (Mills and Rosenfeld 1996) and (Skumatz and Dickerson 1998), with proper changes.	Production, Maintenance, other industrial operations, work environment, corporate (other), environmental, economical and social impacts)
	Targeted area	Indication of the area of the organization where the benefit is perceived the most. The areas proposed are not only physical departments of the organization.	Indication of the area
	Extension of the impact	Indication of the number of beneficiaries in the area of the benefit that are involved from its manifestation. The last two properties are defined to describe the beneficiary, as suggested by ((Ryan and Campbell 2012), (Heffner and Campbell 2011), (Skumatz et al. 2000).	Indication of the number of beneficiary individuated
Persistence of the impact	Duration of the impact	Indication of the duration of the benefits, considered from the beginning of the service phase (in case of service benefits) or from the beginning of the life of the measure (in case of intervention-originated benefits). Property defined consequently to (Heffner and Campbell 2011).	Time horizon based on the life of the EEM
	Resilience of the impact	Description of the intrinsic ability of the benefit to adapt and react before, during and after the system changes. (Shiraliet al. 2015).	Five values qualitative scale
	Maintainability of the impact	Indication of the need for additional maintenance of the benefit with respect to the tasks scheduled for the EEM. According to De Leon et al. (2012), it is evaluated through weighted average, considering the ergonomics of the tasks, the standardization of spare parts and, finally, the velocity of execution.	0-4 scales
	Stability of the impact	Indication of the evolution with respect to the time axis of the magnitude of the impact on the plant.	Indication of the behavior
Temporal Aspects of the impact	Peak of the benefit	Indication of the moment when the benefit has a peak in the magnitude of the impact.	Time horizon based on the life of the EEM
	Frequency of exploitation	Indication of the possibilities to get advantage of a benefit according to its duration and maintainability.	Range of frequencies
Perception of the impact	Perception from the local community	Indication of the perception form the local community of the benefit.	Boolean evaluation (yes/ no)
	Perception from the customers	Indication of the perception form the customers of the benefit.	Boolean evaluation (yes/ no)
	Perception of the operators	Indication of the perception form the operators of the benefit.	Boolean evaluation (yes/ no)
Other	Generation of cash flow	Indication of the possibility to generate a cash flow thanks to the benefit arisen. The cash flow can be a cash inflow or, alternatively, a reduction of the cash outflows.	Boolean evaluation (yes/ no)
	Synergies with other-than-energy resources	Indication of possible synergies with other-than-energy resources as the labor, the equipment, the waste, etc.	Definition of the source(s) involved and the type of synergy
	Magnitude of the impact	Indication of the measured magnitude of the impact of the benefit on the organization.	Evaluation considering units from economical, environmental or societal valorization

☐ Characteristic defined/inspired thanks to the existing literature ■ Characteristic previously undefined

Creation of the novel approach

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EEM	Impact or				Energy flow variation originated benefits									Intervention originated benefits										Energy flow variation o			Intervention originated benefits								
					Direct benefits			Indirect benefits						Indirect benefits										Indirect benefits			Indirect benefits								
								Service phase						Implementation phase						Service phase				Service phase			Implementation phase						Service phase		
					Energy Benefits			(Service) NEBs)			(Service) NELs			Implementation NE			Implementation NE			(Service) NEBs)			(Service) NELs			Secondary benefits			Implementation Positi			Implementation Negat			Secondary benefits		
		Category	Axis	Weight	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val
		Type and	Type of the benefit																																
			Targeted area of the benefit																																
			Extension of the benefit																																
		Persisten	Duration of the benefit																																
			Resilience of the benefit																																
			Ergonomics of the task	Werg																															
			Standardization of spare parts	WStd																															
			Velocity of execution of the task	WVel																															
			Maintainability of the benefit	(Sum = 1.)																															
			Stability of the impact																																
		Tempor	Peak of the benefit																																
			Frequency of benefit exploitation																																
		Percepti	Perception from the local community																																
			Perception from the customers																																
			Perception from the operators																																
		Other	Generation of cash flow																																
			Synergies with other-than-energy re	sources																															
			Magnitude of the impact																																

STRUCTURE MATRIX-LIKE

- Flexible
- Modular
- Scalable
- Ease to calibrate on the basis of the industrial decision-maker perspective

Validation

Objectives:

- ✓ **Completeness**
  - Extension
  - Absence of overlapping
  - Homogeneous level of detail
- ✓ **Usability**
  - Modularity
  - Flexibility
  - Adaptation to different contexts and technologies
- ✓ **Capability of increasing knowledge about the EEMs**
  - Additional impacts recognized
  - Support for the decision making phase

1.Literature validation

- Completeness
- Usability

2.Empirical validation

- Completeness
- Usability
- Capability of increasing knowledge for decision-maker

EEM	Impact or				Energy flow variation originated benefits									Intervention originated benefits									Energy flow variation o			Intervention originated benefits								
					Direct benefits			Indirect benefits						Indirect benefits									Indirect benefits			Indirect benefits								
					Service phase									Implementation phase						Service phase			Service phase			Implementation phase						Service phase		
					Energy Benefits			(Service) NEBs)			(Service) NELs			Implementation NE			Implementation NE			(Service) NEBs)			(Service) NELs			Secondary benefits			Implementation Positi			Implementation Nega			Secondary benefits		
		Category	Axis	Weight	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val	Econ. Val.	Env. Val.	Soc. Val
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Literature Validation

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Selection of seven EEMs with:

- Different cross-cutting technologies
- Capability of involvement Production, Operations & Maintenance, Work Environment
- Diffusion in industry sector
- Different levels of corporate involvement

EEM detail	Cross-cutting technology	Productivity	Operation and maintenance	Working environment	Corporate involvement	Likelihood of success	Indirect effects
Size electric motors for peak operating efficiency	Motors	Proven	Decreased	Improved	Low	Medium	Yes
Use multiple speed motors or adjustable frequency drive (afd) for variable pump, blower and compressors loads	Motors	Proven	Decreased	Improved	Low	High	Yes
Upgrade controls on compressors	Compressed air	Proven	N/A	N/A	Low	Medium	Yes
Utilize daylight whenever possible in lieu of artificial light	Lighting	Proven	N/A	Improved	Wide	Medium	N/A
Use photocell controls (photo sensors)	Lighting	Proven	Increased	Improved	Low	High	N/A
Improve air circulation with destratification fans/other methods	HVAC	Proven	N/A	Improved	Low	Medium	Yes
Make a practice of turning off lights when not needed	Lighting	N/A	Increased	N/A	Wide	Medium	N/A

Literature Validation

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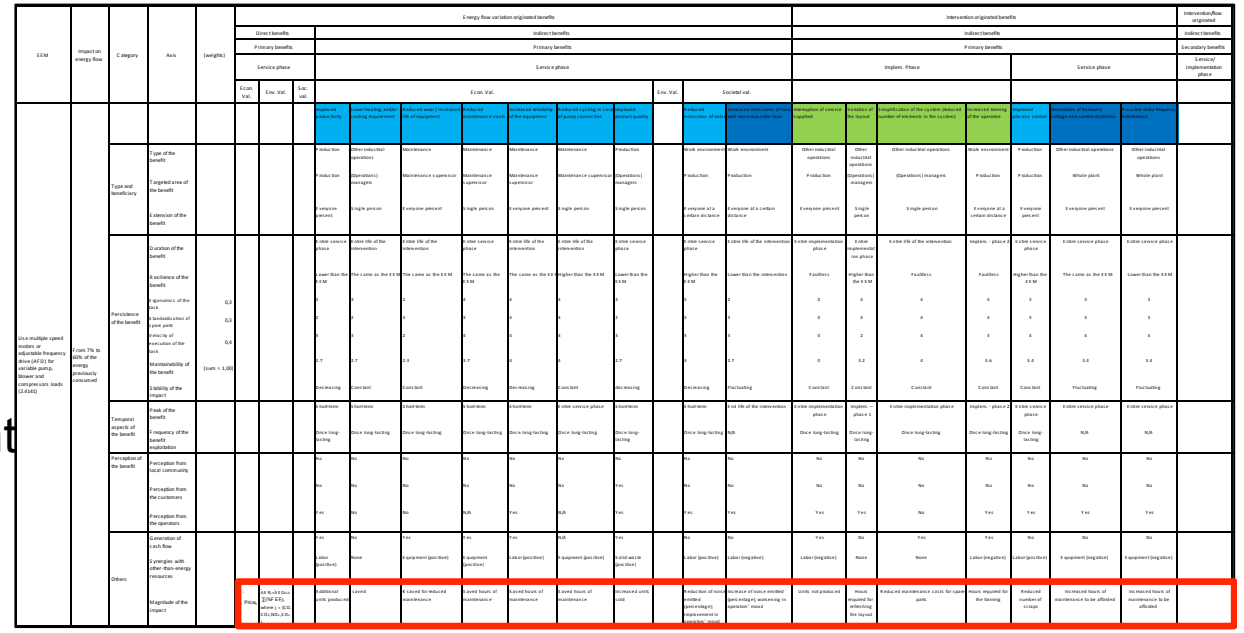
Description	Energy saving	Energy benefits	Service NEBs	Service NELs	Implementation NEBs	Implementation NELs	Secondary Benefits/ Losses
Size electric motors for peak operating efficiency	From 5% to 30% of the electric energy consumption	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Longer bearing life (FO, EcVal); Reduced cooling load (FO, EcVal); Reduced heat dissipation (FO, SVal); Reduced emitted noise/vibration(FO, SVal); Reduced part load oper. issues (IO); Higher reliability (IO); Improved protection settings (IO)	A direct-on-line starter may be needed (IO); Harder control (IO); Need for a proper gearbox (IO)	Monitoring of the state of the system (IO)	Interruption of production (IO); Modification to the layout (IO)	
Use multiple speed motors or adjustable frequency drive (afd) for variable pump, blower and compressors loads	**From 7% to 60% of the energy consumption**	**$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$**	**Improved productivity (FO, EcVal); Lower heating/cooling requirements (FO, EcVal); Increased life of equipment (FO, EcVal); Reduced maintenance costs (FO, EcVal); Increased reliability (FO, EcVal); Reduced cycling with pump connection (FO, EcVal); Improved product quality (FO, EcVal); Reduced emissions of noise (FO, SVal); Increased noise with non-sinusoidal load (FO, SVal); Improved process control (IO)**	**Generation of harmonic voltage and current distortion (IO); Possible radio frequency interference (IO)**	**Simplification of the system (IO); Increased training of the operators (IO)**	**Interruption of service supplied (IO); Variation of the layout (IO)**	
Upgrade controls on compressors	Up to 15% - 20% of energy consumed	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Lower heating/cooling requirement (FO, EcVal); Reduced emitted noise/vibration(FO, SVal); Reduction of part load operations (IO); Increased reliability of the equipment (IO); Reduced need for cycling of load/unload (IO); Increased equipment life (IO); Higher system stability (IO)	-	Improved monitoring of the system state (IO); Possibility to create a network of compressors (IO)	Issue in connecting compressors of different firms (IO); Interruption of service supplied (IO)	
Utilize daylight whenever possible in lieu of artificial light	Reduce up to the 70% the electric load for lighting purposes	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Increased comfort for the operators (IO); Fluctuation in the light utilization (IO); Increased addiction to external conditions (IO); Improved productivity (IO); Lower heating requirements (IO); Better mood of the operators (IO)	Unsatisfactory conditions with paperwork (IO); Higher cooling requirements (IO); HID becomes inadequate (IO); Need to prevent water leakage (IO); Need for reducing the glare's effect (IO); Need for a proper light control (IO); Condensation issues (IO)	Flexibility of the layout of the skylights (IO)	Structural changes needed for the installation (IO),Need for proper calibration (IO); Increased training of the operators (IO); Reduced comfort for the operators during installation (IO)	
Use photocell controls (photo sensors)	Occupancy sensors can save 10% to 25% of a facility's lighting energy use	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Adjustment of lighting cond., keeping constant conditions (IO); Higher flexibility of lighting (IO)	Reduced reliability of the equipment (FO, EcVal); Increased comfort for the operators (FO, SVal): Increased addiction to external conditions (IO); Frequent switching in case of unstable weather (IO)		Proper calibration of the sensors required (IO); Issues with sensors positioning (IO)	Reduction of useless switching with definition of a dead-band (SB)
Improve air circulation with destratification fans/other methods	Every degree added on the thermostat can save 6%-8%, reaching 16-32% of total saving	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Lower heating/cooling requirements (IO); Prevention of coil freezing (IO); Prevention of damages at ducts with freezing weather (IO); Uniformity of environmental conditions (IO); Improved thermal comfort (IO); Reduced emitted noise/ vibration (IO); Increased control on the temperature (IO); Increased comfort for the operators (IO)		Improved monitoring of the system state (IO)	Variation of the layout (IO)	Improved of work environ. with economizer cycle (SB)
Make a practice of turning off lights when not needed	Up to 5% of energy previously required for lighting purpose	$\Delta En \cdot Price_{En}$ $\Delta En \cdot CO_{2\,Not\ Emitted}$	Reduced reliability of the measure (IO); Permits the check of the effects of other control systems (IO)	Increased need for labor (FO, EcVal); Reduced equipment life (IO)		Training of the operators required (IO)	Quick discover of premature switching and discomfort (SB); Facilitated monitoring of operations and occupancy (SB); Easier to determine the proper time delay (SB)
IO: Intervention-originated; FO: Flow variation-originated; EcVal: Economical valorization; EnVal: Environmental valorization; SVal: Societal valorization							

Literature Validation:
Use multiple speed motors or adjustable frequency drive

- Information extracted from available literature
- Complete description of the measure achieved
- Consideration of different categories of benefits
- Capability of providing different evaluations for impacts of the same category



- Non-Energy Benefits intervention-originated or Energy flow variation originated
- Non-Energy Losses intervention-originated
- Non-Energy Benefits intervention-originated or Energy flow variation originated
- Different magnitude evaluations

Empirical Validation – investigated sample

Firm	Employees	Annual Sales	Sector	Energy intensity	Energy manager	Environmental certifications
A	600	€ 165.000.000	10.73 – production of pasta, cuscus and other similar coarse-grained products	5,00%	No	None
B	1.550	€ 410.000.000	31.09 – furniture production	2,30%	Yes	UNI EN ISO 14001:2004
C	515	€ 170.650.000	24.10 – iron and steel industry	6,00%	Yes	UNI EN ISO 14001:2004
D	145	€ 80.000.000	23.13 – glass production	50,00%	Yes	UNI EN ISO 14001:2004
E	90	€ 13.000.000	23.12 – glass transformation and manufacturing	10,00%	No	UNI EN ISO 14001:2004
F	430	€ 53.000.000	31.09 – furniture production	3,60%	No	None
G	200	€ 40.000.000	18.12 – printing and other connected services	0,36%	No	UNI EN ISO 14001:2004
H	110	€ 79.500.000	23.99 – production of products with non-metallic minerals	1,90%	Yes	UNI EN ISO 14001:2004
I	37	€ 5.300.000	31.09 – furniture production	0,60%	No	None
J	685	€ 300.000.000	31.09 – furniture production	2,90%	Yes	UNI EN ISO 14001:2004
K	153	€ 32.500.000	28.1 – production of machine with general use	0,90%	No	UNI EN ISO 14001:2004
L	116	€ 39.000.000	27.1 – production of motors, generators, electric transformer and instruments for energy management and distribution	0,87%	Yes	UNI EN ISO 14001:2004
M	54	€ 11.000.000	25.73 – tools production	0,91%	No	None

60 ENERGY EFFICIENCY MEASURES ANALYZED

Empirical Validation – sampled EEMs and firms

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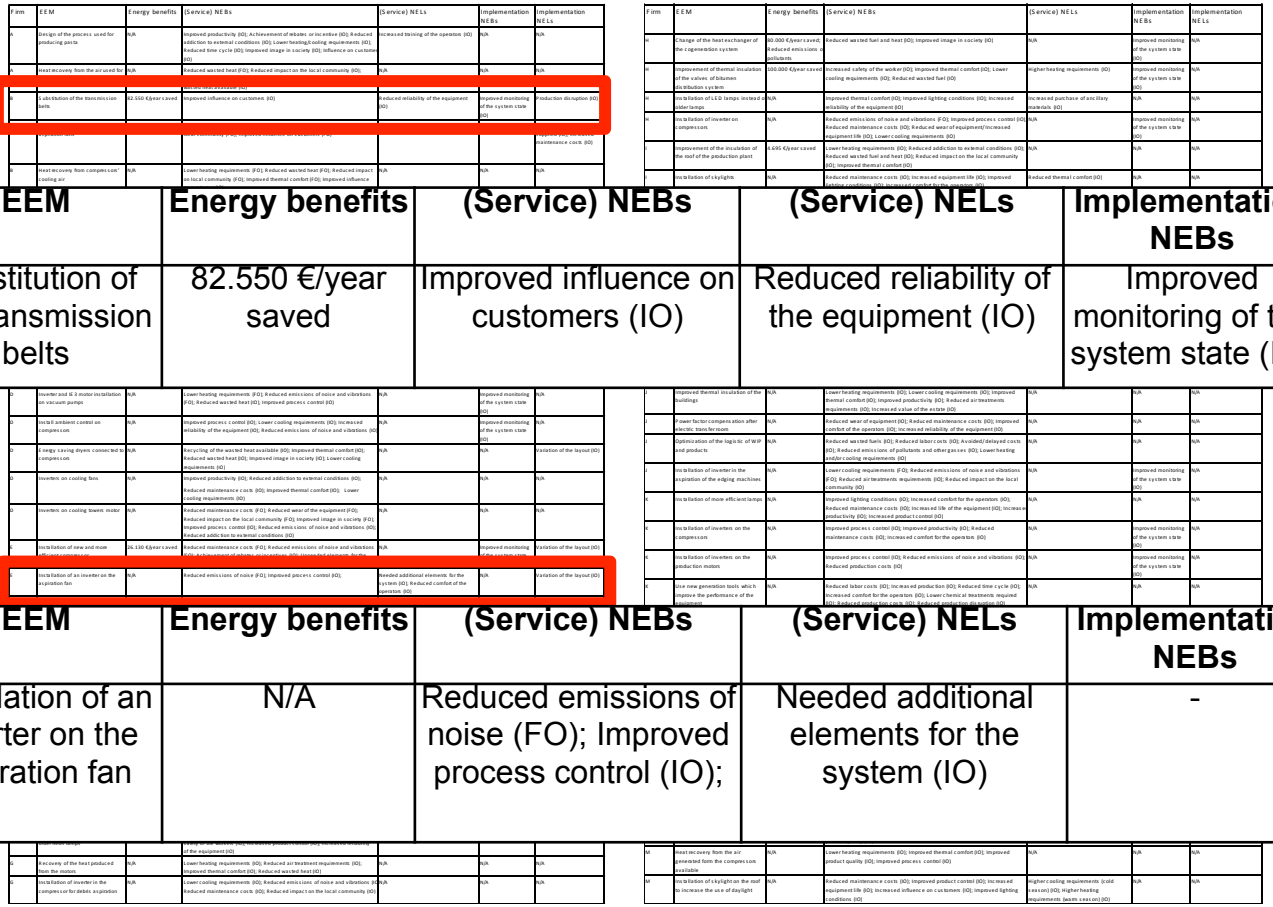


Firm	EEM	Energy benefits	(Service) NEBs	(Service) NELs	Implementation NEBs	Implementation NELs
B	Substitution of the transmission belts	82.550 €/year saved	Improved influence on customers (IO)	Reduced reliability of the equipment (IO)	Improved monitoring of the system state (IO)	Production disruption (IO)

Firm	EEM	Energy benefits	(Service) NEBs	(Service) NELs	Implementation NEBs	Implementation NELs
E	Installation of an inverter on the aspiration fan	N/A	Reduced emissions of noise (FO); Improved process control (IO);	Needed additional elements for the system (IO)	-	Variation of the layout (IO)

Empirical Validation: Substitution of the transmission belts, firm B

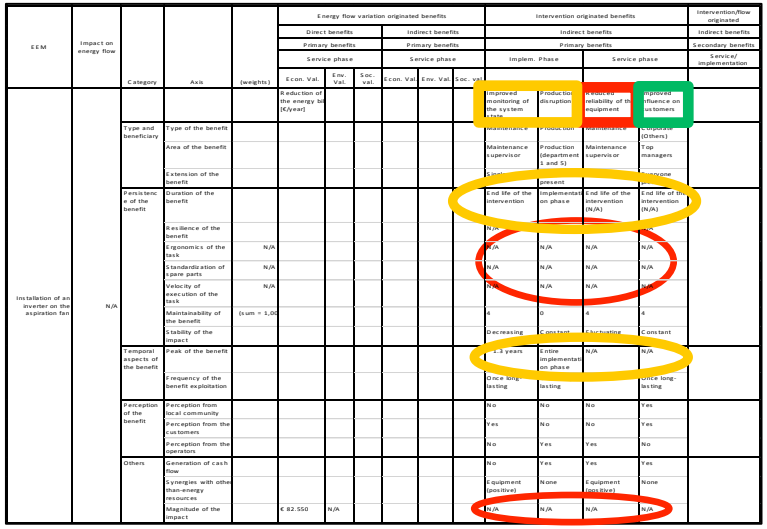
Firm	Employees	Annual Sales	Sector	Energy intensity	Energy manager	Environmental certifications
B	1.550	€ 410.000.000	31.09 – furniture production	2,30%	Yes	UNI EN ISO 14001:2004

Notes about the framework:

- Change in the perspective: consideration of benefits involving the production and the work environment are admitted to exist
- Identification of benefits and losses not considered in the evaluation phase

Notes about the characterization:

- New evaluation scales for duration of the benefit and the frequency of benefit exploitation
- Proposed an overall evaluation of the maintainability
- Not interested in the resilience
- Proposed impact of the benefit on PBT



Unavailable information

Change in the evaluation proposed

New Non-Energy Loss identified

Known Non-Energy Benefit

Known impacts for implementation phase

Empirical Validation: Substitution of the transmission belts, firm B

Firm	Employees	Annual Sales	Sector	Energy intensity	Energy manager	Environmental certifications
B	1.550	€ 410.000.000	31.09 – furniture production	2,30%	Yes	UNI EN ISO 14001:2004

Implementation:

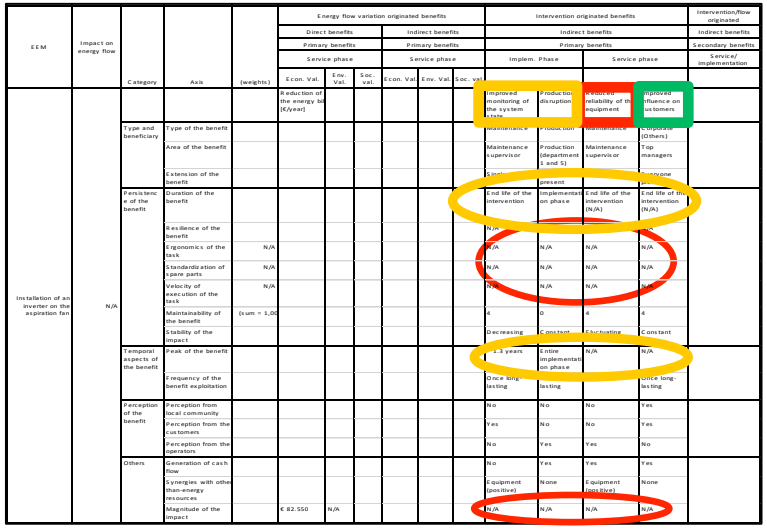
(+) Improved monitoring of the system;

(-) Production disruption

Service:

(+) Reduced reliability of the equipment;

(-) Improved influence on customers



Unavailable information

Change in the evaluation proposed

New Non-Energy Loss identified

Known Non-Energy Benefit

Known impacts for implementation phase

Empirical Validation: Substitution of the transmission belts, firm B

EEM	Impact on Energy Flow				Intervention originated benefits			
					Indirect benefits			
					Implementation phase		Service phase	
					Improved monitoring	Production disruption	Improved influence on customers	Reduced reliability
		Category	Axis	Weight	Econ	Econ	Econ	Econ
Substitution of transmission belts	635*10^3 kWh	Type and Beneficiary	Type of the benefit		Maintenance	Production	Corporate	Maintenance
			Targeted area of the benefit		Maintence supervisor	Production (dept. 1 & 5)	Top managers	Maintence supervisor
			Extension of the benefit		Single person	Everyone on the line	Everyone	Single person
		Persistence of the benefit	Duration of the benefit		End life of the intervention	Impl. Phase	End life of the intervention	End life of the intervention
			Resilience of the benefit		N/A	N/A	N/A	N/A
			Ergonomics of the task	Werg	N/A	N/A	N/A	N/A
			Standardization of spare parts	WStd	N/A	N/A	N/A	N/A
			Velocity of execution of the task	WVel	N/A	N/A	N/A	N/A
			Maintainability of the benefit	(Sum = 1.00)	4	0	4	4
			Stability of the impact		Decreasing	Constant	Constant	Fluctuating
		Temporal aspects	Peak of the benefit		~ 1.3 years	Entire impl. Phase	N/A	N/A
			Frequency of benefit exploitation		Once long-lasting	Once long-lasting	N/A	Once long-lasting
		Perception of the benefit	Perception from the local community		No	No	Yes	No
			Perception from the customers		Yes	No	Yes	No
			Perception from the operators		No	Yes	No	Yes
		Other	Generation of cash flow		No	Yes	Yes	Yes
			Synergies with other-than-energy resources	\	Equipment (+)	None	None	Equipment (+)
			Magnitude of the impact		N/A	N/A	N/A	N/A

Empirical Validation: Installation of an inverter on the aspiration fan, firm E

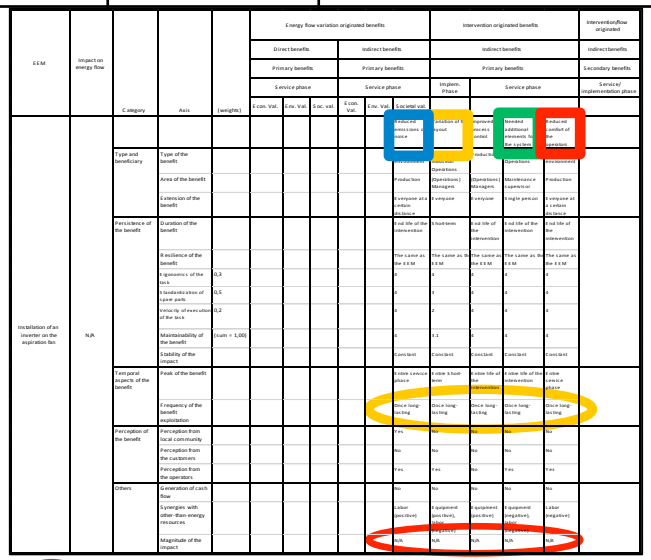
Firm	Employees	Annual Sales	Sector	Energy intensity	Energy manager	Environmental certifications
E	90	€ 13.000.000	23.12 – glass transformation and manufacturing	10,00%	No	UNI EN ISO 14001:2004

Notes about the framework:

- Definition of further impacts not considered in decision phase
- Revision of impacts not correctly forecasted in the decision making phase
- Increased the interest towards the EEMs thanks to the highlighting of the wideness of the impacts

Notes about the characterization:

- Proposed a change in the evaluation scale of the frequency of benefit exploitation
- Proposed the change of some options among the available ones
- Poor knowledge about resilience



Unavailable information
Change in the evaluation proposed
Reconsidered Non-Energy Loss identified
Known Non-Energy Loss
Known impacts for implementation phase
Known impacts for implementation phase

Empirical Validation: Installation of an inverter on the aspiration fan, firm E

Firm	Employees	Annual Sales	Sector	Energy intensity	Energy manager	Environmental certifications
E	90	€ 13.000.000	23.12 – glass transformation and manufacturing	10,00%	No	UNI EN ISO 14001:2004

Implementation:

(-) Layout change

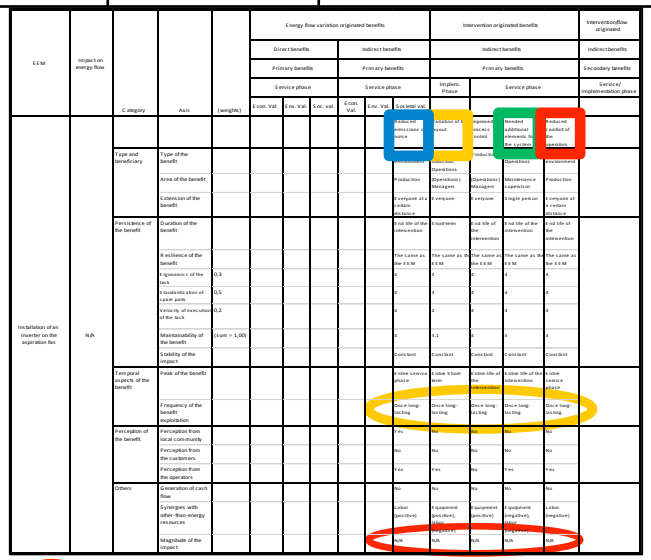
Service:

(+) Reduced noise emissions;

(+) Improved process control;

(-) Need of additional equipment;

(-) Reduced comfort.



Unavailable information

Change in the evaluation proposed

Reconsidered Non-Energy Loss identified

Known Non-Energy Loss

Known impacts for implementation phase

Known impacts for implementation phase

Empirical Validation: Installation of an inverter on the aspiration fan, firm E

POLITECNICO MILANO 1863

EEM	Impact on Energy Flow				Energy flow-derived B	Intervention originated benefits			
					Indirect benefits	Indirect benefits			
					Service phase	Implementation phase	Service phase		
					Reduced noise emissions	Variation of layout	Improved process control	Needed additional elements	Reduced comfort
		Category	Axis	Weight	Soc. Val	Econ.	Econ.	Econ.	Societal
Installation of an inverter for the aspiration fan	N/A	Type and Beneficiary	Targeted area of the benefit		Production	Operations manager	Operations manager	Maintenance supervisor	Production
			Extension of the benefit		Everyone at a certain distance	Everyone	Everyone	Single person	Everyone at a certain distance
		Persistence of the benefit	Duration of the benefit		End life of the EEM	Short -term	End life of the EEM	End life of the EEM	End life of the EEM
			Resilience of the benefit		The same as the EEM	The same as the EEM	The same as the EEM	The same as the EEM	The same as the EEM
			Ergonomics of the task	0.3	4	4	4	4	4
			Standardization of spare parts	0.5	4	3	4	4	4
			Velocity of execution of the task	0.2	4	2	4	4	4
			Maintainability of the benefit	(Sum = 1.00)	4	3.1	4	4	4
			Stability of the impact		Constant	Constant	Constant	Constant	Constant
		Temporal aspects	Peak of the benefit		Entire service phase	Short -term	Entire service phase	Entire service phase	Entire service phase
			Frequency of benefit exploitation		Once long-lsatint	Once long-lasting	Once long-lasting	Once long-lasting	Once long-lasting
		Perception of the benefit	Perception from the local community		Yes	No	No	No	No
			Perception from the customers		No	No	No	No	No
			Perception from the operators		Yes	Yes	No	Yes	Yes
		Other	Generation of cash flow		No	No	No	No	No
			Synergies with other-than-energy resources		Labor (+)	Equipment (+), Labor (-)	Equipment (+)	Equipment (+), Labor (-)	Labor (-)
			Magnitude of the impact		N/A	N/A	N/A	N/A	N/A

Validation results

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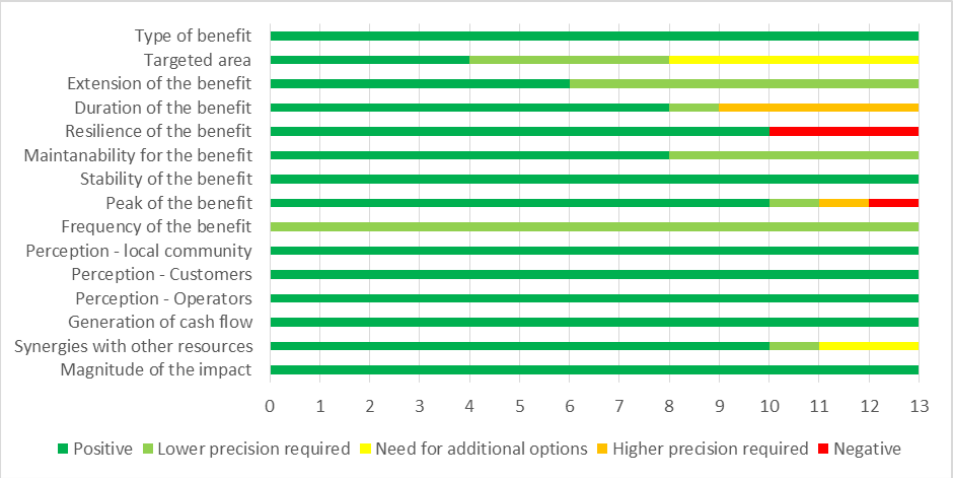
Literature Validation

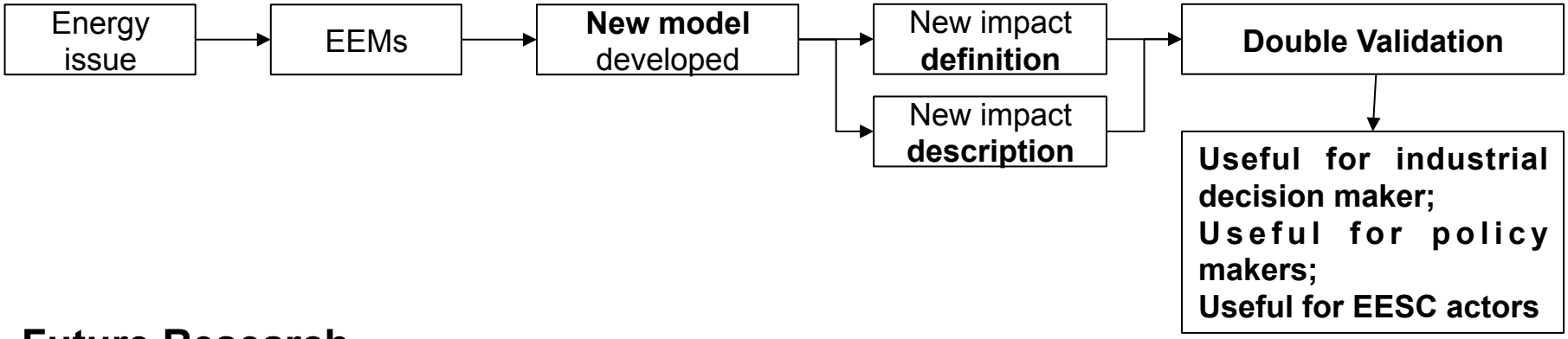
- Confirmed capability of describing different types of impacts
- Confirmed modularity of the analysis
- Confirmed usability

Empirical Validation

- Confirmed capability of describing different types of impacts
- Confirmed usability
- Confirmed modularity of the analysis
- Confirmed adaptability to different contexts and technologies
- Confirmed ability of improving the study of the EEMs
- Confirmed the possibility of defining additional impacts



Conclusions and future research



Future Research

- Detailed analysis of the Secondary Benefits/Losses and Implementation Synergies
- Enlarging investigated sample
- Different level of the management
- Comparisons with cluster of enterprises by single EEM
- Cluster investigations by factors (sector, size, etc.)

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Industrial Efficiency, Berlin, Sept 12th-14th 2016