The need of harmonization in energy efficiency policies: building a taxonomy for European industry

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Abstract

The EE Directive 2012/27/EU (EED) [EED1 2012] and its update with Directive 2018/2002/EU [EED2 2018] have been the starting point for both the development and the update of EE (EE) laws and regulations in all the European Union (EU) Member States (MS). Moreover, CO_2 emission reduction goals at 2020 and 2030 have oriented MS towards stricter regulations on energy production and consumption. However, the application of the EED is not uniform across the different MS, and large differences persist in how national policy makers are responding to the achievement of emission reduction goals. Harmonization among different countries represents therefore a huge challenge.

The EU-MERCI project (acronym for "EU coordinated MEthods and procedures based on Real Cases for the effective implementation of policies and measures supporting EE in the Industry"), funded by the European Commission under the Horizon 2020 programme (Grant Agreement nr. 693845), tries to address such issues by developing a methodology to harmonize data from EE projects from different sources in several MS. Such a methodology can be used as a basis for all EE policies and regulations across the EU and represents a fundamental tool of the project, as it allowed the building the core products of the project, which are the EU-MERCI Database and Platform (http://www.eumerci-portal.eu/).

After highlighting the initial difficulty in aligning data on implemented projects incentivised through different policies in different MS, this paper describes the proposed harmonization methodology, which comprises a detailed "taxonomy", developed by EU-MERCI partners in order to allocate EE projects in pre-defined categories and to easily perform both the statistical analysis of almost 3,000 collected records and the extraction "Good Practices" of energy efficiency in the EU industry. A discussion about the integration of the methodology in local policies will be concluding the paper.

Introduction

Since the agreement of the EU Energy Efficiency Directive (EED), energy efficiency (EE) has been one of the main concerns of European governments, that have to implement policies to support a global reduction in energy consumption[1]. To reach the desired objective, the industrial sector plays a key role, being responsible for more than one quarter of the overall consumption of the European Union. However, each Member State has adopted the EED and its subsequent update in a different way, so the computation of energy savings achieved by each EE measure is not harmonized and, very often, not comparable: in the different policies, savings can be either deemed, calculated or measured and, in the first two cases, their real value is not verified against reality. This might lead to over- or under-estimation of the actual energy savings achieved in industry but, more important, in the Member State and in the EU. Thus, there is a strong need of harmonization of the different methods to catalogue EE measures, evaluate the baseline consumption and account for achieved energy savings. This need

1. https://europa.eu/european-union/topics/energy_en

emerged also during the EU-MERCI project while working on the building of the industrial EE measures database which could be useful both to statistically analyse the performances of implemented energy efficiency measures and to extract the most promising ones as "Good Practices": during the collection of raw data about EE measures implemented under different EU MS policies and obligation schemes, in fact, we faced serious difficulties in cataloguing such data into a standardized database. Thus, a huge harmonization work of the raw data was needed both in order to understand which information were the most relevant and to convert them into the fields of the database. This paper shows the main result of the harmonization work, that is the building of a standardized taxonomy, that could be adapted and replicated in all EU MS.

Database building

SELECTED SECTORS

Once established that the boundary of the analysis is EE in industry, with interest only on the EE measures related to process and auxiliary equipment and not to the building envelope or office heating and cooling, it was necessary to define which industrial sectors were to be included in the analysis.

The first step has been to understand which industrial segments were to be analysed. The main focus has been put on manufacturing, since it represents a significant energy consumer in the industrial sector. Then, following the methodology developed in [ICF1 2015], a ranking of manufacturing activities according to the following parameters has been performed:

- Overall energy consumption of the sector;
- EE economic potential (Pay Back Time – PBT < 5years):
- Technical potential (EE results technically achievable without considering PBT);
- Energy cost over value added of the sector;
- Number of employees;
- Value added.

This led to the selection of the following sectors: Chemical (NACE C20), Iron and Steel (NACE C24.1, 24.2, 24.3, 24.51, 24.52), Petroleum and Coke (NACE C19), Pulp and paper (NACE C17), Food and beverage (NACE C10, C11), Non-metallic minerals (NACE C23), Machinery (NACE C25-28), Non-ferrous metals (NACE C24.4, 24.53, 24.54).

AVAILABLE DATA SOURCES

Several sources were available for project partners to extract useful data that could lead to the selection of "Good Practices" of EE in the industrial sector. For four MS (Italy, Poland, Austria and the UK) data were immediately available to project partners, that are/were in charge of assessing the measures that applied for public subsidies and incentives. For other Member States, some data were made available either by project partners or through cooperation agreements. All of them were assessed in order to understand which information could be extracted and whether this could be useful for further statistical analysis and "Good Practices" selection.

The data sources were coming from the following countries, thanks to the role of different project partners in the performing, collection and/or evaluation of national EE incentives requests:

- Austria: 1,000 projects financed either under the funds of Kommunalkredit Public Consulting (KPC) or under KlimaAktiv (KA) scheme from 2008 to 2016;
- Bulgaria: 1 sample audit available from BSERC, possibility to ask for more if deemed suitable for the project goals;
- Cyprus: 86 energy efficiencyEE projects implemented from 2006 to 2014, data collected by CRES;
- Germany: 2,900 energy efficiencyEE measures catalogued in the EEFIG DEEP Database, obtained through a data exchange agreement with ISI Fraunhofer;
- Italy: 2,000 White Certificates (WC) applications evaluated by RSE from 2005 to 2016;
- Poland: 200 evaluated WChite Certificates applications evaluated by KAPE from 2012 to 2016;
- Romania: 17 implemented energy efficiencyEE projects (year unknown) made available by ENERO;
- Sweden: 2,400 energy efficiencyEE projects implemented from 2004 to 2010;
- UK: 16,000 energy audits performed by Carbon Trust in the schemes "Energy Efficiency Advice" (EEA) from 2005 to 2016.

RELEVANT FIELDS SELECTION

After analysing all the available information in the different data sources, a selection of the relevant fields was performed. The criteria used for the analysis were chosen according to the principle that they should be useful in assessing the energy, environmental and economic impact of the described EE measures. Other two important aspects to be considered were the ease in performing a statistical analysis as well as the type of policies and schemes used to support the measures. The final criterion was the availability of reliable information in the different data sources. At general level, the selected fields categories were those reported in Table 1.

For all these categories, several fields were defined, in order to have a database as complete as possible.

SELECTED DATA SOURCES AND EE MEASURES CATEGORIZATION

Considering the needed information, a selection of the available sources was performed, that led to the inclusion of only five of them: Italian White Certificates, Polish White Certificates, Austrian KPC and KlimaAktiv and Brittish EEA. The other sources were either not sufficiently complete for the purpose of the analysis lacking one or more fields, and/or had only few records, so were not statistically significant for the represented country.

Once the data sources had been defined, the next step was to categorize EE measures in a way that they could be analysed in a simplified and standardized way: all of them contained full descriptions, that are very useful to understand the characteristics of the measure, but not useful to perform the statistical analyses of the database.

Table 1. Selected fields categories for the database.

Field type	Description
General	These fields serve to identify the data set record in the EU-MERCI repository (anonymized) and in the data set owner database (e.g. ID number).
Company	Anonymous information on the concerned industry: dimensions and typology of the manufacturing activities carried out.
Measure	Detailed description, taxonomy and involved energy carriers of the implemented EE measure.
Baseline & implementation	Way of evaluation of the energy consumption before implementing the EE measure and its value (process consumption), for each involved energy carrier.
Savings	Values of saved energy by the implementation of the EE measure, for each involved energy carrier.
Investment & energy costs	Information on costs and financing of the measure, and on the receipts from achieved savings.
EED Implementation	Information on the scheme referred to by the implemented measure and on its correlation with the EED provisions.

Table 2. KPIs summary.

KPIs category	KPIs Description
Technical KPIs	Primary Energy Savings (PES, [toe]): permits comparison the savings coming from different energy carriers (e.g. electricity, natural gas, etc) and countries.
	Energy Consumption Improvement (ECI, %): the % of PES over the baseline (in Primary Energy).
	Energy Intensity Reduction (EIR, [toe/k€/y]): how much the EE measure has contributed to reduce Energy Intensity of the sector.
Economic KPIs	Simple Payback Time (PBT, [years]): calculated considering only economic savings related to energy savings (no incentives/subsidies)
	Cumulative Cash Flow (CCF, [€]): calculated considering only economic savings related to energy savings (no incentives/subsidies) over the technical life of the measure.
	Share of Project Costs Subsidized (SPCS, %): shows the amount of subsidies/ incentives over investment cost.
Advanced KPIs	Renewable Energy Use (REU, %): the percentage of savings associated to the installation of renewable energy sources technologies, in order to reduce plants dependence on the electric network and fossil fuels (extra-power sold to the grid is not accounted for)
	Cost of Energy Savings (CES, [€/toe/y]): the capital invested in the implemented efficiency project over the achieved yearly savings.
	Cost of Carbon Savings (CCS, [tonCO_2/toe/y]): the capital invested in the implemented efficiency project per ton of saved direct CO_2 emissions.

Thus, emerged the need to build a system that allowed to categorize each and every record in a pre-defined way: the so-called taxonomy, divided in two types (generic and specific), on three levels each.

KPIS DEFINITION AND DATA SELECTION

The last step of database building and harmonization was the definition of Key Performance Indicators (KPIs), that allow to understand the performance of each measure and to compare them. KPIs then represented the key element of the selection procedure to identify the "Good Practices".

FINAL STRUCTURE OF THE DATABASE

Through the different steps of fields definition, it was possible to select the EE measures to insert in the database. A first review was done by excluding some sectors in the manufacturing industry. Then, the verification of the general structure of the data sources led to the exclusion of some countries. The next selection was performed based on the possibility to classify the selected measure at least in the generic taxonomy. Finally, the last step was based on the available data to calculate KPIs: being the goal of the database building the comparison of EE measures and the definition of "Good Practices", unavailability of all KPIs meant that the measure was not fit for purpose. So, at the end, the selected measures were:

Taxonomy and harmonization

As highlighted above, one of the most important steps in database building was the creation of a way to classify EE measures in a way that allowed to perform statistical analyses and to compare the measures.

Table 3. Records per each sector, per Member State.

Sector (NACE code)	Italy	UK	Poland	Austria	Total
Iron & Steel (24.1-24.3 & 24.51-24.52)	110	49	17	3	179
Non-ferrous Metals (24.4 & 24.53-24.54)	37	62	14	4	117
Coke& Petroleum (19.2)	32	8	1	0	41
Cement & Ceramics (23.2-23.4)	180	62	22	3	267
Pulp& Paper (17.1-17.2)	135	112	1	34	282
Machinery (25-28)	58	376	4	296	734
Food&Beverages (10)	102	316	112	286	816
Glass (23.1)	77	25	2	4	108
Chemical (20)	123	185	25	29	362
Total	854	1,195	198	659	2,906

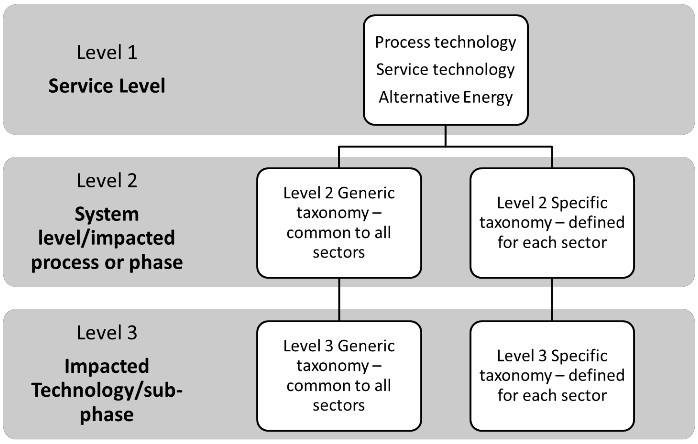

Figure 1. Taxonomy structure.

In order to do so, several trials have been performed, that led to the definition of two types of taxonomy (generic and specific) based on three levels, that went from the overall system (process or auxiliary, for example) to the involved sub-phase or equipment. A schematic of the taxonomy structure is reported in Figure 1. Further details are explained in the next paragraphs.

GENERIC AND SPECIFIC TAXONOMY

The first type of defined taxonomy was the so-called "Generic taxonomy": it means that it is applicable to all sectors, and it has the aim to specify which type of EE measure has been implemented. It has been developed in order to categorize the different types of interventions, by specifying, for example, whether there was a heat recovery or the installation of an inverter and so on.

On the other hand, specific taxonomy has been developed then for each analysed sector, with the aim to insert the implemented EE measure in the process/auxiliary system where it was implemented. This allowed to understand, for each process phase and/or equipment, which types of interventions have been done and how.

THE THREE LEVELS OF TAXONOMY

In order to go in detail on the type of EE measure and the affected process phase/equipment, taxonomy has been divided in three levels, of which the first is common to Generic and Specific taxonomy, while the other two are divided. The three levels can be described as:

- L1: the part of the plant where the measure has been applied to (e.g. "Process technology" or "Service technology" or "Alternative Energy production").
- L2: the phase of the process where the measure has been put in place, both in general terms applicable to all sectors ("Generic taxonomy", e.g. "Heat recovery and cooling") and in sector-specific terms ("Specific taxonomy", e.g. "Papermaking").
- L3: the sub-phase of the process or the technology involved in the measure, both in general terms applicable to all sectors ("Generic taxonomy", e.g. "Heat recovery by heat exchanger") and in sector-specific terms ("Specific taxonomy", e.g. "Drying section").

Then, a last specification has to be made in order to further classify each EE measure: some records involve only one type of intervention and/or one phase/equipment, while others combine different interventions or are affecting several phases of the process. Thus, each record has been classified either as "Single" or "Combined". For combined records, taxonomy is doubled (e.g. "Generic Taxonomy – L2 – A" and "Generic Taxonomy – L2 – B") in order to fully describe the measure.

TAXONOMY CLASSIFICATION RESULTS

The selection of data sources and projects made itpossible to classify, at least at "Generic" level, all the records that have been defined, as reported in Table 4.

The lower level of classification for specific taxonomy are mostly related to the fact that, for many records, especially in the Austrian and English data sources, it was difficult to allocate the intervention to a specific phase. However, the taxonomy proved to be very effective in classifying each EE measure into pre-defined categories: this proved to be very useful in many ways:

- It allowed us to perform a statistical analysis of the database, both at general level and for each sector, that led to understand, which were the most frequently implemented EE measures and on which phases;
- It helped identifying "Good practices" using, other than the KPIs, a "recurrence" parameter that highlighted when a measure was applied several times on a certain phase;
- At "Generic" level, it allowed to compare different sectors, in terms of type of implemented interventions.

Database harmonization

Together with Taxonomy, another important point in the building of the database was the harmonization of the original data sources, that contained similar information but organized in different ways.

TECHNICAL LIFETIME VS. REAL LIFETIME

The first issue was to establish the "lifetime" of the implemented measure, in order to calculate economic KPIs, in particular CCF. In some schemes (e.g. Italian WC), the "Technical Life" of the intervention is related to the period of time in which, by policy, the implemented project can generate energy savings. The technical lifetime depends only on the type of intervention and it is pre-defined by the scheme (e.g. "Intervention on automation systems" – IND-E has a technical lifetime of 15 years, while other categories, e.g. "Intervention on process optimization and layout" – IND-FF have a technical lifetime of 20 years). In other countries (e.g. the UK), this parameter was reported considering the involved equipment, and reflects more accurately the real lifetime of the plant and its capability to generate energy savings.

BASELINE

Baseline was another important point in order to compare the % savings achieved by the implemented measures. Baseline is the consumption before the intervention, that for some cases is directly measured, for others (e.g. for old technologies), is equal to the market average. None of the EE measures under the different schemes had it easily retrievable, so a deep analysis of all incentive requests and their attachment was needed. Moreover, it was decided to use process baseline, and not overall site baseline, in order to be able to replicate the results on other plants with the same process, but with different layouts.

SAVINGS: DEFINITION AND VERIFICATION

Savings definition and verification was one of the main problems in database building: each policy has a different approach to savings, that goes from calculated to scaled to measured. Since it was impossible to convert from one type to the other, it was decided to keep the value reported in the original data source and to indicate whether it was deemed, calculated or measured according to the definitions in EED Article 7.

This point posed a serious problem, related to the comparison of data that, despite being in the same unit of measure, were computed in different ways: while for the Italian WC mechanism baseline and savings must be demonstrated with metering equipment and periodically reported, for the other cases savings were deemed ex-ante, so making it impossible to determine whether the EE measures achieved what was declared.

LEVEL OF DETAIL IN THE DESCRIPTION

Also the level of detail available in the description represented an issue. For some countries (especially Italy and the UK) there was a detailed description both in the summary incentive request and in all the related attachments. On the other hand, for some schemes, especially Austrian KPC, the description was composed by few words, making it very difficult to allocate the measure in the correct process phase (so, lacking specific taxonomy classification).

IMPLEMENTED MEASURES

Strongly connected to the level of detail in the description is the type of implemented measure. The measures described in the Italian source all fell in the category of "RVC-C". This means that they are quite complex, not standardized and every single

Table 4. Taxonomy classification results.

Level	Generic Taxonomy	Generic Taxonomy (%)	Specific Taxonomy	Specific Taxonomy (%)
L1 A – Single	2,372	100 %	2,372	100 %
L2 A – Single	2,372	100 %	705	30 %
L3 A – Single	2,345	99 %	673	28 %
L1A – Combined	534	100 %	534	100 %
L1B – Combined	526	99 %	526	99 %
L2A – Combined	534	100 %	207	39 %
L2B – Combined	485	91 %	155	29 %
L3A – Combined	534	100 %	187	35 %
L3B – Combined	508	95 %	140	26 %

saved toe[2] had to be proven. Moreover, all incentivised measures respond to the criterion of "additionality" with regards to the business-as-usual. For the other mechanisms, especially the English EAA, the measures were of mixed complexity, with some trivial ones (the most trivial have been removed) and some more complex. For Austrian KPC measures, it was mostly impossible to go deep into the technical complexity of the measure. Finally, there was no way to assess their additionality.

COST OF IMPLEMENTATION

Cost of implementation was available only for most of the measures in the Italian data source (at least those implemented after 2010) and for some in the other sources (mostly in the UK and sometimes in Poland), while for all the others it was not available. In this way, several EE measures lack the calculation of economic KPIs, except those related to the obtained incentives and subsidies.

Conclusions and policy recommendations

Considering the analysis performed on the database, and the huge effort to build and use the taxonomy and to harmonize the different data source, some policy recommendations can be formulated. The recommendations are obviously related to the field of application that stays in the boundary of the project, which are manufacturing plants, with large interventions in EE, that have a significant impact on the energy consumption of industrial processes.

NEED OF HARMONIZATION OF THE INFORMATION

The first important step, that should be achieved by all EU MS, is to harmonize the current legislation regarding EE measures implemented in industry. In particular, the different incentive schemes, while taking into account the specificity of the country economic situation, shall define categories of incentivisation, that respond to the same criteria.

First of all, there is the need of a clear definition of which type of savings shall be declared: considering the important targets that the EU MS have agreed regarding EE by 2030, linked to the overall goal to halt climate change, there is the strong need to make sure that all the declared savings are actually achieved. In particular, this becomes relevant when considering projects like those inserted in the database, that are mostly large ones, with high savings and high impact on the process and site consumption. This requirement applies also to baseline definition and estimation/calculation, that is the first step that allows to determine achieved savings. A second point is the need to understand the technical complexity of the measure and its additionality: standard definitions of the complexity of EE measures, and their level of additionality, are needed at EU level, in order to classify them and have comparable incentives schemes and rewards for the best achieving projects. Finally, in the spirit of ease of comparison and evaluation of the equipment and measures that are high-energy saving achievers, the adoption of standardized taxonomies (of which the one developed in EU-MERCI project could be a basis) could lead to a more uniform evaluation of the most important EE measures performed in each country.

CONCLUSIONS

The developed methodology for EE measures database building and harmonization and taxonomy development in EU-MERCI project could serve as a basis for a general evaluation, at EU level, on the reliability of current EE policies and schemes. In particular, a general harmonization is needed in order to be sure to get comparable results at EU level and to achieve the goals of decarbonisation, that are becoming more stringent every day.

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2. Toe stands for ton of oil equivalent.