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European Futures for Energy Efficiency

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649342 EUFORIE

Report of the roundtable results: Foresight analyses of European energy efficiency vision and strategy

WP7 Deliverable D7.2

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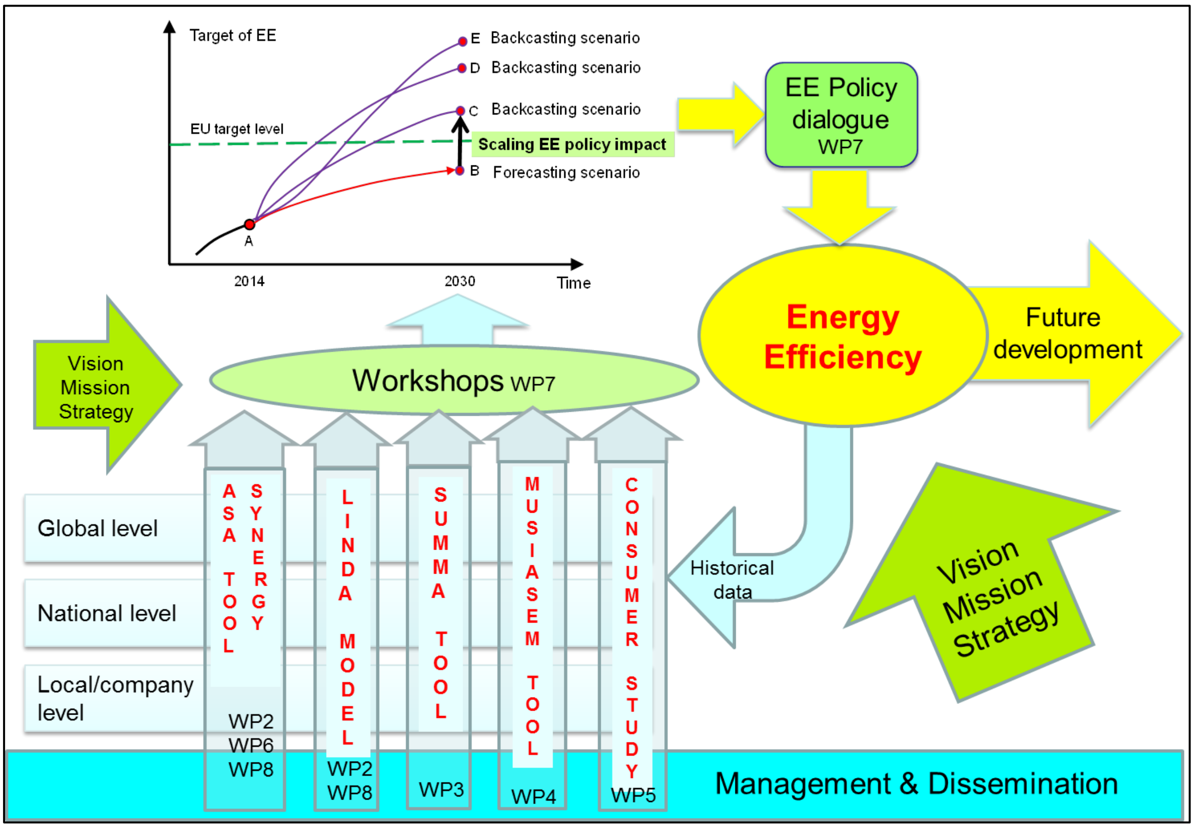
The EUFORIE project

The strategic goal of the EUFORIE project is to provide useful and accurate information and knowledge in the field of energy efficiency for the EU Commission and stakeholders in the Member States. The tangible objectives are the following:

1. To provide energy and energy efficiency trends and their drivers, synergies and trade-offs between energy efficiency related policies, as well as energy efficiency scenarios (WP2).
2. To provide data about implementation of energy efficiency in specific processes, sectors and entire systems, in order to understand bottlenecks/efficiency drops and suggest improvements (WP3).
3. To carry out analyses of efficiency of provision, from making useful energy carriers from primary energy sources, and from conversion of energy carriers to end uses across macro-economic sectors (WP4).
4. To identify policy instruments and other measures leading to significant reduction in the energy consumption of households (WP5).
5. To analyse the relationship between investments and change in energy efficiency, and to develop indicators to describe changing energy efficiency at the company level (WP6).
6. To carry out participatory foresight for European stakeholders of energy efficiency with a target of providing ideas for the energy efficiency vision and strategy in the European Union (WP7).
7. To compare energy efficiency policy instruments and measures and their impacts in China and the European Union (WP8).

The EUFORIE Work Packages relate to each other. The project applies different quantitative and qualitative analysis methods to energy efficiency in the EU and its Member States at different levels and from different perspectives. These analyses provide input for foresight activities, which serve European energy efficiency vision and strategy process by generating useful information. Management (WP1) and dissemination (WP9) run in parallel with the research and innovation activities.



Executive summary

This report provides the results from the roundtable dealing with the most important and policy relevant results from the EUFORIE project. The roundtable discussion was held on 27th of September 2018 as a back to-back event after the European Modeling Platform for Energy (EMP-E) conference in Brussels, Belgium. This report includes the results from the roundtable discussion after four presentations on mostly methodological aspects of energy, material, and environmental performance analysis of different systems, from households and companies to EU Member States and the Community as a whole.

The original target of the roundtable discussion was to find a “common sense” how the energy efficiency could be approached and enhanced in a best possible way in preparation of a European vision and strategy on energy efficiency. During the implementation of the project it become clear for the EUFORIE consortium that a proper performance analysis regarding energy and material use, as well as related environmental impacts at different levels in the EU and its Member States is needed first. Then the next step includes targets, policies and measures for promoting energy efficiency. Thus, the most important outcome of the EUFORIE project is a set of methods that enable a proper energy, material and environmental performance analysis. Several examples of these analyses have been already done in the EUFORIE project, but the analysis needs to be continued, especially in the EU Member States.

The roundtable discussion did not challenge the initial assumption of the EUFORIE project that without better analysis of energy, material and environmental performance, there is a serious risk of false choices in setting policy targets and activities for implementing them such as policy measures. The methods developed and applied in the EUFORIE project were seen as potential ones for a better performance analysis at different levels, but the challenge to communicate them and the results effectively to policy planning in the EU and in the Member States remains as a major challenge. In addition, the roundtable discussion provided the EUFORIE project important ideas and challenges to take into account in further activities. For example, a possibility to use open data in LCA is an interesting option, s integrating bio-physical and economic energy modelling approaches. An important issue not directly dealt with in the EUFORIE project is the social dimension of the performance analysis, which hopefully, will be included and highlighted in the next EU framework programme under construction, called as “Horizon Europe”.

The results are useful for policy makers in the European Union and in the EU Member States, and they are of interest to all stakeholders including researchers, NGOs and energy industry and companies who are interested in energy and environmental policies and the role of the concept of energy efficiency in it.

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Abbreviations

Abbreviation	Explanation
BAU	Business as usual (scenario)
CO_2	Carbon dioxide (emissions)
DG CLIMA	Directorate-General Climate Action
DG ECFIN	Directorate-General Economic and Financial Affairs
DG EMPL	Directorate-General Employment, Social Affairs and Inclusion
DG ENER	Directorate-General Energy
DG ENV	Directorate-General Environment
EASME	Executive Agency for Small and Medium-sized Enterprises
EC	European Commission
EMA	Emergy Analysis
EMP-E	European Modelling Platform for Energy
EU	European Union
EUFORIE	European Futures for Energy Efficiency
FEC	Final energy consumption
GDP	Gross Domestic Product
GDP_{min}	Minimum GDP set by social sustainability in the Sustainability Window analysis
GDP_{max}	Maximum GDP set by environmental sustainability in the Sustainability Window analysis
LCA	Life-cycle assessment/analysis
LDC	Least developed country/countries
MAGIC	Moving Towards Adaptive Governance in Complexity: Informing Nexus Security (EU Horizon 2020 project)
m^2	Square meter
m^3	Cubic meter
NEEAP	National energy efficiency action plan
PEC	Primary energy consumption
SERI	Sustainable Europe Research Institute
SuWi	Sustainability Window (analysis)
UAB	Universitat Autonoma de Barcelona (Autonomous University of Barcelona)
U.S.	United States (of America)
WP	Work Package

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Policy context: Energy efficiency in the EU

Energy efficiency is usually considered as a means to tackle energy-related negative environmental impacts (such as harmful emissions in the air), and to reduce energy consumption. In the policy context, it has gained a status of a policy goal as such, and the EU energy efficiency targets have highlighted this status. Energy efficiency can be improved in both energy production and consumption, and there are many technologies and policy instruments available for producing more economic output with less energy (see e.g. Future Energy 2017; ODYSSEE-MURE 2017). To implement the EU directive on energy efficiency (EC 2012), the EU Member States prepare their National Energy Efficiency Action Plans (NEEAPs), where estimates on primary and final energy consumption are presented, as well as planned energy efficiency measures and the improvements the EU Member States expect to achieve. The achievements are reported in the Annual Reports by the EU Member States. The Commission also publishes progress reports about the achievements in energy efficiency; the most recent one was published in November 2017 (EC 2017).

Based on the 2014 NEEAPs, and other information provided by the Member States, the EU has collected the estimated primary and final energy consumption as well as the 2020 targets for all EU-28 Member States (Table 1). These targets have been called as energy efficiency targets. On 30 November 2016, the Commission (EC 2016) proposed an update to the Energy Efficiency Directive including a new 30 % energy efficiency target for 2030. The proposal includes also measures to update the Directive to make sure that the new target will be met (EC 2016). However, indicative national targets for the EU Member States in relation to fulfillment of the new 30 % energy efficiency target in 2030 are not available yet.

Figure 1 and Figure 2 show the needed primary and final energy consumption trends (average annual change in percentage) needed to meet the existing 2020 targets set in the EU-28 as a whole and in the individual Member States based on the estimated GDP change during the period 2014-2020. When looking at Figures 1 and 2, the targets for primary energy consumption and final energy consumption in 2020 do not seem to be ambitious, although the differences between individual Member States are significant. Some Member States may even increase their energy consumption and still meet the indicative target. The existing 2020 targets on primary energy consumption and final energy consumption of all EU-28 Member States are presented in Table 1. The targets set individually by the Member States are tied to the 2020 target of the whole EU. The EU has listed a set of adopted measures to improve energy efficiency such as (EC 2018):

- an annual reduction of 1.5 % in national energy sales
- energy efficient renovations to at least 3 % of buildings owned and occupied by central governments per year
- mandatory energy efficiency certificates accompanying the sale and rental of buildings
- minimum energy efficiency standards and labelling for a variety of products such as boilers, household appliances, lighting and televisions (eco-design)
- preparation of NEEAPs every three years by EU countries
- planned rollout of 200 million smart electricity meters and 45 million gas meters by 2020
- energy audits at least every four years in large companies
- protecting the rights of consumers to receive easy and free access to real time and historical data on energy consumption
- guidelines on good practice in energy efficiency published by the EC.

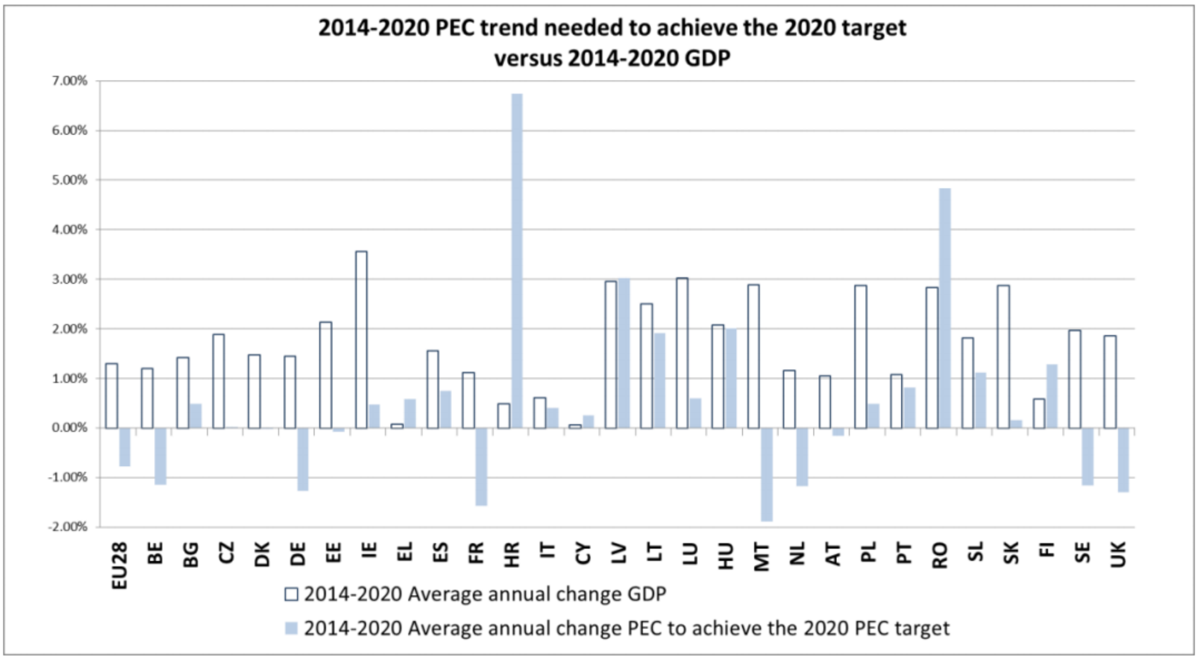

Figure 1. Average annual registered and forecast GDP 2014-2020 vs. average annual reductions in primary energy consumption 2014-2020 necessary to reach national indicative primary energy consumption targets in percentage (source: EC 2015).

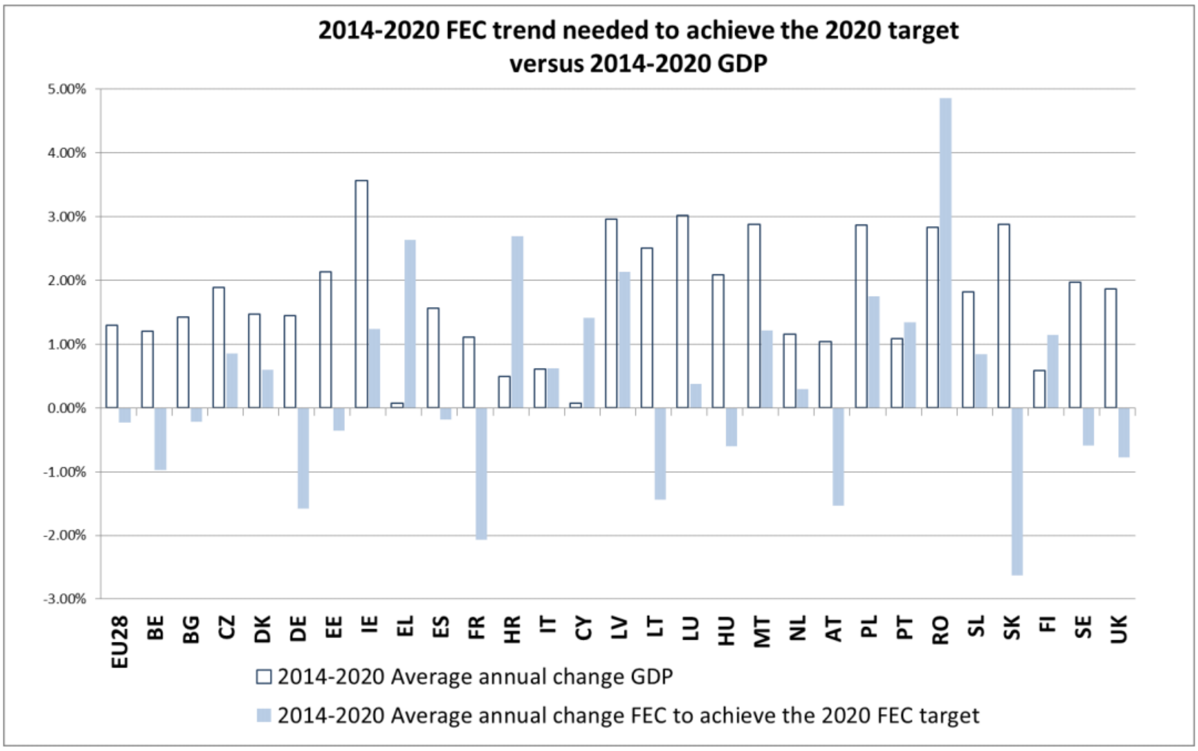

Figure 2. Average annual registered and forecast GDP 2014-2020 vs. average annual reductions in final energy consumption 2014-2020 necessary to reach national indicative final energy consumption targets in percentage (source: EC 2015).

Table 1. Indicative targets of primary and final energy consumption in the EU Member States 2020. Source: EC 2015. Primary/final energy consumption ratio added by the authors.

EU Member State	Energy consumption in 2020 as notified from Member States in 2013, in the NEEAP 2014 or in a separate notification to the European Commission in 2015		
	Primary energy consumption, Mtoe	Final energy consumption, Mtoe	Primary/final energy consumption ratio
Austria	31.5	25.1	1.25
Belgium	43.7	32.5	1.34
Bulgaria	16.9	8.6	1.97
Croatia	11.5	7.0	1.64
Cyprus	2.2	1.8	1.22
Czech Republic	39.6	25.3	1.57
Denmark	17.8	14.8	1.20
Estonia	6.5	2.8	2.32
Finland	35.9	26.7	1.34
France	219.9	131.4	1.67
Germany	276.6	194.3	1.42
Greece	24.7	18.4	1.34
Hungary	24.1	14.4	1.67
Ireland	13.9	11.7	1.19
Italy	158.0	124.0	1.27
Latvia	5.4	4.5	1,20
Lithuania	6.5	4.3	1.51
Luxembourg	4.5	4.2	1.07
Malta	0.7	0.5	1.40
Netherlands	60.7	52.2	1.16
Poland	96.4	71.6	1.35
Portugal	22.5	17.4	1.29
Romania	43.0	30.3	1.42
Slovakia	16.4	9.0	1.82
Slovenia	7.3	5.1	1.43
Spain	119.8	80.1	1.50
Sweden	43.4	30.3	1.43
United Kingdom	177.6	129.2	1.37
Sum of indicative targets EU-28	*1526.9*	*1077.5*	*1.42*
EU-28 target 2020	*1483.0*	*1086.0*	*1.37*

EUFORIE roundtable

Background, implementation and participants

The idea of the roundtable was to invite stakeholders to discuss how the results of the EUFORIE project could be used in policy formulation. The agenda, venue and potential participants were discussed and planned in collaboration with the EC/EASME. This discussion resulted a back-to-back half-day event with the European Modelling Platform for Energy (EMP-E) conference (25-26 September) on 27 September 2018 in Brussels, but a different venue from the EMP-E conference. Potential participants included major stakeholder groups administration/policy makers, industry/economic actors, academia, and NGOs/citizens, so a so-called Quartet Helix stakeholder grouping was followed.

This joint arrangement with the EMP-E conference granted the EUFORIE project an opportunity to use the registered participants of the EMP-E conference as a major target group for the roundtable. The roundtable invitation was put in the EMP-E conference website in early 2018, and invitation was also sent to the registered participants via the conference information channels. Personal invitations and following reminders were sent to those who had participated in the earlier events of the EUFORIE project, and to a set of Brussels-based energy-related organizations. The agenda (Annex 1) and background materials of the roundtable were placed in the EUFORIE website[1] at an early stage. The roundtable was announced also on the UTU/FFRC webpage, and in the EUFORIE Twitter and Facebook accounts. Finally, the EUFORIE coordinator participated in the EMP-E conference on 25 September, and presented in the day-closing session briefly the EUFORIE project (presentation slides are available in Annex 7 of this report), and the roundtable discussion. The five minutes presentation did not raise questions or comments in the audience. Some EUFORIE-related issues such as came up later in the context of discussion on topics for the next EMP-E conference. Copies of the EUFORIE project leaflet and Policy Briefs were available in the EMP-E conference as well.

The venue of the EUFORIE roundtable was Turku-Southwest Finland European Office (Avenue Palmerston 26, B-1000 Brussels, Belgium) with a small meeting room (Figure 3 and Figure 4). The participants included the EASME Project Adviser, 8 representatives from the EUFORIE beneficiaries, and one external participant, altogether 10 persons (Annex 2).

[1] EUFORIE website: http//www.euforie-h2020.eu.
Direct link to the roundtable agenda: http://www.utu.fi/en/units/euforie/news/Pages/roundtable-27092018.aspx

Figure 3. The roundtable venue: Turku-Southwest Finland European Office in Brussels, Belgium.

Figure 4. The roundtable discussion.

Roundtable input

The input of the roundtable included all the material and results available in the EUFORIE website http://www.euforie-h2020.eu. In addition, the key policy messages from the EUFORIE workshops, questionnaires and interviews reported earlier was a major input (Vehmas et al 2017):

- "Energy efficiency is a popular catchword, but as a concept it is a relative one and its operationalization is strongly dependent on the context where the concept is applied. From a scientific point of view, the difficulty of operationalization goes hand in hand with the level of aggregation. At the macro level of society (national level), where policy targets are usually set, operationalization is almost impossible.
- There is also overlapping between different fields of policies, where energy efficiency is a topic: In energy policy, energy efficiency has been promoted over 40 years for economic reasons. In environmental and climate policies, energy efficiency has been seen as a means to limit CO_2 emissions and environmental impacts in general – but this is seriously threatened by the Jevons paradox, which says simply that saved energy will be consumed elsewhere. In economic and employment policies, attention has been paid to an energy efficiency (service) market, motivated by potential job creation and economic growth. These issues make energy efficiency unclear as a policy target.
- Absolute targets to reduce energy consumption (and related environmental impacts) from a measured level are better than relative targets or targets set in relation to a projected absolute consumption in the future (as the current EU target). Targets should be set at a level where monitoring is possible.
- Indicators of energy efficiency, such as energy intensity, should be calculated by preferring the use of physical variables. Mixing physical and economic variables is problematic. Economic growth usually seems to decrease energy intensity, even though there is no real improvement in energy efficiency, but other things such as structural change or financial transactions instead.
- Different policy instruments promoting energy efficiency may be useful in driving and supporting technological change and change in consumer behavior and lifestyle, which are important elements in reaching targets set on energy consumption or on related environmental impacts. There are many promising policy instruments, but what is needed is a monitoring system where the costs, benefits, and other effects of the use of the policy instruments in different EU Member States would be collected on a regular basis. However, there is no ultimate policy instrument, and the opinions on them vary a lot between different EU Member States and between different stakeholders.
- Technologies for improving energy efficiency are available, for energy production and consumption, but the major problem seems to be that energy efficient technologies are not taken into use for economic reasons – usually payback periods are too long. It seems that the best drivers for energy efficiency are higher energy prices, and government policies are needed especially in cases where energy prices remain at a low level."

In the roundtable invitation, background materials were mentioned and placed on the EUFORIE website in a form of Policy Briefs, which were closely related to the titles of presentations in the roundtable agenda:

- Euforie Policy Brief 1: Household Energy Efficiency Measures – Shortcomings and Opportunities

- Euforie Policy Brief 2: Informing Energy Efficiency Policies: Methodological Stumbling Blocks
- Euforie Policy Brief 3: How to Assess the Energy Performance of Cities?
- Euforie Policy Brief 4: Sustainability performance indicators for energy and raw material use, and environmental impacts

The major content of the roundtable was the four presentations based on selected results from each EUFORIE beneficiary and related discussion between the roundtable participants. The agenda of the roundtable is in Annex 1, and the presentation slides cab be found in Annexes 3-6 of this report.

Minutes of the roundtable discussion

EUFORIE roundtable on27th of September 2018, 9:00-13:00, Turku-Southwest Finland European office, Avenue Palmerston 26, B-1000 Brussels, Belgium. Chair: Dr. Jyrki Luukkanen (University of Turku).

From energy efficiency to energy performance: the end-use matrix

Mario Giampietro (Autonomous University of Barcelona) gave a presentation under the title "From energy efficiency to energy performance: The end-use matrix". The presentation slides are in Annex 3 of this report. EUFORIE Policy Briefs 2 and 3 relate to this presentation. See also Giampietro et al (2017a; 2017b; 2017c).

The questions after the presentation dealt with the sources of data used in the presented examples, data transparency in the Multi-Scale Integrated Analysis of Societal and Ecosystem Metabolism (MUSIASEM) approach and possibilities for anticipation. The approach uses publicly available data. The end-use matrix can be made not only for energy, but also for food and water[2]. There was also some discussion on imports and exports, especially related to the agriculture sector, and the European leakage of carbon and energy intensive industries.

The rationale behind the end-use matrix is that

- intensity depends on the mix of economic activities, and
- from biophysical starting points, neither different types of primary energy (chemical energy in fuels, potential energy in hydro, kinetic energy in wind etc.) nor energy carriers (electricity, heat, and combustion fuels) can be summed up.

A question of the policy message for decision makers in relation to the presentation was asked. The answer was ready: The policy makers need a better analysis of performance than the current one based on too aggregated focus. Otherwise, decisions on e.g. policy targets and instruments may be based on false assumptions. Different energy sources are suitable for different purposes in a society, and there are significant constraints for a transition from non-renewable energy sources (fossil fuels) to renewable energy sources and especially to intermittent energy sources with the low predictability of availability such as current solar and wind technologies. The availability and predictability improvements are, of course, possible in the future. Replacing fossil fuels and nuclear totally with renewables seems not be possible with the current energy consumption patterns. There may be significant costs such as environmental costs, which are not necessarily included in current energy models used in policy planning at Member State level, and land use required by renewable and intermittent energy sources raise a question of land use efficiency, in addition to energy, material and environmental efficiencies.

Moreover, EU leaves policy implementation at the disposal of Member States – this cannot be continued forever in the future. The comparison between China and EU made in the EUFORIE project shows, among other things, a rough conclusion that the energy performance in China shows more technology development and improvement than the performance of EU, where focus is more on

[2] This will be done in the EU Horizon 2020 project MAGIC (Moving towards Adaptive Governance in Complexity: Informing Nexus Security) coordinated by UAB (https://magic-nexus.eu/)

changing the energy mix of the Member States. Thus, EU needs to take a stronger role in policy implementation in the future.

This challenges especially the communication between research results (such as those from the EUFORIE project) and the EU. The energy, material and environmental performance of the EU Member States, and especially the mixture of related efficiencies, is a complex issue, which has relevance for many different actions of the EU. Thus, also other Directorate-Generals (DGs) in addition to DG ENER need to be involved, in the long run, e.g. DG CLIMA, DG ECFIN, DG EMPL and DG ENV, preferably also other DGs and the European Parliament. Communication between different EC DGs requires in practice concrete information to be shared. This fact could and should be taken more seriously and more actively in the future.

Several communication-related short-run and longer term questions about the EUFORIE results came up, such as the following:

- To whom to communicate with the above mentioned policy message of the EUFORIE project
- How to continue after the project has ended?
- How to involve politicians in practice?
- How to challenge the hegemonic discourse of energy (efficiency) policy?

These questions could not be answered in the EUFORIE roundtable. Because of their importance and relevance, they are listed here as “take-home challenges”, issues to think about every time when the future of energy policy is considered.

Some discussion was about an easy-to-use tool (or toolkit) that could help the policy makers. The discussion turned quickly to modelling[3], and the EUFORIE beneficiaries learnt that the gap between existing models and the analysis presented within the EUFORIE results is not properly known but not necessarily as large as expected. Many issues have been integrated in the existing energy models, which, however, are mostly economic models, not biophysical models. An interesting option is open modelling. The EUFORIE beneficiaries were interested in whether the human activity figures are integrated to existing energy models, but this was not discussed in the EUFORIE roundtable because there is no short answer and the lack of time resources did not enable detailed discussion on the energy models not applied in the EUFORIE project.

Towards an online energy performance calculator in support to policy scenarios

Sergio Ulgiati (Parthenope University of Naples) gave a presentation under the title “Towards an online energy performance calculator, in support to policy scenarios”. The presentation slides are in Annex 4 of this report. EUFORIE Policy Brief 3 relates to this presentation. See also Ulgiati et al (2018a; 2017; 2018b).

[3] The EUFORIE roundtable was organized as a back-to-back event with the European Modelling Platform for Energy (EMP-E) conference in Brussels.

The EUFORIE project provides a tool for analyzing energy efficiency via life cycle analysis (LCA) and emergy assessment (EMA)[4], and has produced three different scenarios: (1) BAU, (2) technology-based efficiency improvement, and (3) eco-efficiency implementation. EMA is used for assessing the costs of different alternatives in terms of environmental cost, not monetary cost. The BAU scenario gives the starting values as benchmark, and explores sensitivity to data errors (data uncertainties and unavailability of data). Technology-based efficiency improvement includes reduction of selected energy and material input flows by technology improvement. Eco-efficiency implementation includes substitution of energy and material "hotspots" with renewable or less environmentally costly input flows.

In the general discussion after the presentation, integration of circular economy and "Industry 4.0" (a technology-driven approach) was suggested, and tools for it could be developed in the future. Important would be identification of potential winners and losers (in terms of economic sectors) in circular economy. On the other hand, circular economy was also criticized as wishful thinking; a physical fact is that circular economy regarding energy is an impossibility. UN sustainable development goals and organizing global value networks (in the EU, India, China, U.S.) based on the circular economy are important if circular economy will be taken seriously. If the message to policy makers is that circular economy should be taken seriously, a strong leadership is needed. There are already some actual players in the field.

The presentation about the prototype tool of urban performance calculator included examples of scenario calculation for electricity, natural gas, steel and iron, and "complete variation" in the city of Naples. The target group of the tool is policy makers and other stakeholders interested in urban performance. Further development of the tool is a potential topic for a new research project. Regarding the use of the tool it was reminded that the capacity of policy makers should not be overestimated. An interesting option would be gaming at different "levels", with a possibility to take into account more things when the game proceeds from lower to higher levels. This could be included in a new research project. Also the possibility to play with different lifestyles etc. could be an interesting option for further tool development. In this context it was asked again: Who is the recipient?

One potential recipient group relates to ecosystem services. Modellers is another recipient group, but there are different interests and some modellers may see the tool as a threat. This is because significant change in performance such as replacing fossil energy by e.g. windfarms (an example of replacing baseload capacity with intermittent capacity) requires a totally different society from the current Western one designed to consume fossil energy as much as possible. In this regard, further development of the tool needs to meet persons who dare to go "out of the box". Further development of the tool could also help creating business from moving towards a different system of production and consumption. The forthcoming Italy-China business week in December 2018 in Naples gathering 800 professors and entrepreneurs together may offer some possibilities to promote further development of the tool.

Furthermore, availability of data was discussed too because it causes problems in many EU projects. There is open data available for life cycle analysis (LCA). Projects on open LCA data (e.g.

[4]Emergy is a concept developed by Howard T. Odum. Emergy accounting converts the thermodynamic basis of all forms of energy, resources and human services, which are needed to produce a specific product or service, into equivalents of a single form of energy, usually solar (Odum 1996). This single form of energy is called as emergy, or "energy cost" as used in the EUFORIE project (see Ulgiati et al 2017c).

www.openlca.org) are based on voluntary companies and other actors providing real-time data for the database. The data of Naples used in the EUFORIE project is not publicly available.

Policy options for supporting efficiency and sufficiency of household energy consumption

Joachim Spangenberg (SERI Germany) gave a presentation under the title “Policy options supporting efficiency and sufficiency in household energy consumption”. The presentation slides are in Annex 5 of this report. EUFORIE Policy Brief 1 relates to this presentation. See also Trotta & Lorek (2018), Spangenberg (2018), Lorek & Spangenberg (2018) and Lorek (2018).

First questions after the presentation dealt with the criteria of selecting promising policy instruments, and time frame of the selection. The policy instrument was selected as a promising one, if it was seen to serve fulfilment of all the six criteria mentioned in the presentation (set up from a perspective of a building, where a household is located):

“To minimise energy consumption while maintaining a good supply of energy services, a building must be

- built in a heat conservation and appropriating way, based on local or regional planning
- capable of keeping heat within the building envelope, by means of isolated walls and roofs, adequate windows, doors and shutters
- equipped with service providing installations requiring only low inputs
- offering energy security, as standard heat storage tanks offer supply for about 2 hours per m^3 of storage , external supply or in-house storage must be available
- used accordingly, which required adequate behaviour based on relevant knowledge, motivation and skills (management)
- part of an efficiency enhancing energy supply system.”

The discussion dealt with the time frame of the analysis and the results of energy consumption in households. Selection of the promising policy instruments was made in a policy situation three years ago, from the set of policy instruments in use in Finland, Italy, Hungary, Spain, and the UK (case Member States) in the year 2015. However, energy efficiency has one major weakness when looked at from the energy producers and sellers point of view: the cleanest energy is energy not used at all, but then there appears to be nothing to sell and thus no profit for the producer/seller.

Regarding the figures presenting energy consumption for heating per square meter (m^2) in the presentation, climate differences affect the results. According to the short discussion, these differences were taken into account in the analysis.

A flexible indicator for energy, material and environmental performance

Jarmo Vehmas (University of Turku) gave a presentation under the title “A Flexible indicator for energy, material and environmental performance”. Presentation slides are in Annex 6 of this report. EUFORIE Policy Brief 4 relates to this presentation. See also Vehmas & Ameziane (2017) and Vehmas (2018).

In the discussion after the presentation, different input and output indicators were dealt with, because efficiency of a system is a ratio between system outputs and inputs. Especially choosing only gaseous emissions as output indicators of environmental impact was pointed out to be a limited choice from the environmental sustainability point of view.

Aggregated indicators on energy and material consumption as well as on environmental impacts were discussed as well; to keep the analyses simple and their number small, aggregation is an opportunity although it always means loss of information. Monetary indicators on production (economic activity) offer an opportunity to aggregate the indicators of production and even consumption patterns, but their use is often problematic. However, there may be situations, where monetary valuation is applied even to human life. Decision making on investments in life-supporting equipment in hospitals is a practical example of this.

Speaking about sustainability loosely in the context of the energy, material and environmental performance analysis may be risky, because the presented flexible analysis shows only if the performance during the studied period is away from, or towards a pre-defined reference level of the chosen performance indicator in the studied system – nothing more. However, a company may change in many ways over time, and one example of this was brought out in the discussion. A German energy company RWE, one of the EUFORIE case companies, moved its renewable energy business into a new company (Innogy), after the end of the six-year period studied in EUFORIE. The longer the studied period, the more organisational changes may take place in a company. There is a large number of other examples such as purchases of production units, decommissioning of production sites, and merging of large companies – in addition to investments and other changes at the operational level in companies.

Social sustainability needs to be included in the sustainability analyses, which have been focused too much on environmental sustainability only. The basic idea of taking all three dimensions of sustainability, i.e. environmental, economic, and social – as defined by the Brundtland Commission (WCED 1987) – into account at the same time, is simply that environmental sustainability sets an upper limit, and social sustainability sets a lower limit to economic development. This is the core idea of a "doughnut economy" (Raworth 2012; 2017). A quantification and operationalization of the doughnut economy, called as Sustainability Window (SuWi) analysis, has been later introduced by Luukkanen et al (2015; 2018a; 2018b) in University of Turku, Finland.

Figure 5. The doughnut model of economy. Source: Raworth (2012; 2017).

The Sustainability Window (SuWi) analysis (Figure 6) has been developed especially for the needs of developing countries, and empirical analyses have been made first for China (Luukkanen et al 2015), and then for two Asian countries Cambodia (Luukkanen et al 2018a) and Laos (Luukkanen et al 2018b) in the Mekong area. The recent analyses include also weak and strong versions of the Sustainability Window (Luukkanen et al 2018a; 2018b), because of their relevance in the least developed countries (LDCs). Figure 6 presents the idea of the strong Sustainability Window, which was developed first (cf. Luukkanen et al 2015).

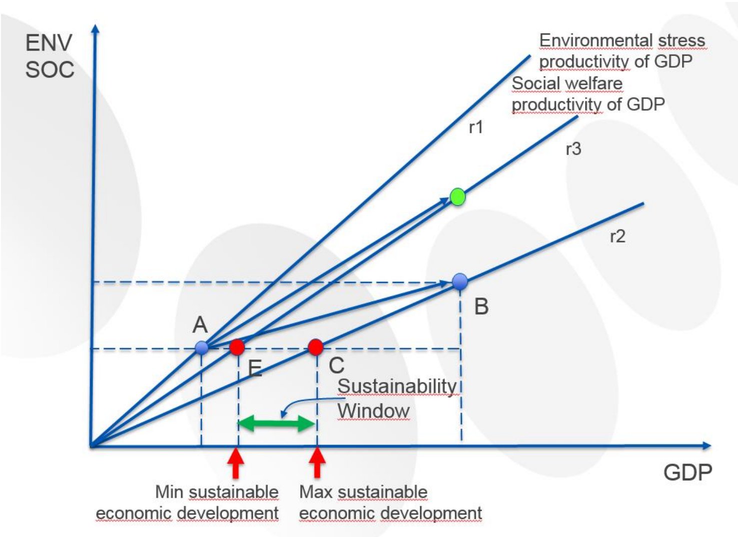

Figure 6. The Sustainability Window (SuWi) framework. Source: Luukkanen et al (2015).

The empirical challenge of the Sustainability Window analysis lies in the selection of indicators used in the analysis, especially in regard the indicators of social sustainability in the Western countries such as the EU and its Member States. A series of variables can be used as indicators of both social and environmental sustainability, and different choices among the available variables provide different results regarding the existence and size of the Sustainability Window. A pragmatic suggestion could be that the lowest and highest lower limit and the lowest and higher upper limit resulting from the use of different indicators included in the analysis, could provide the range of policy relevant information on the sustainability window. From this perspective, selections may reveal preferences regarding the importance of different dimensions of sustainability.

An empirical example of Sustainability Window (SuWi) analysis for the European Union as a whole is presented in Figure 7 for the EUFORIE project. In the example covering the period 2005-2015, income equity sets the lower limit to GDP change and the upper limit is set by CO_2 emissions (Figure 7). The existence and size of the Sustainability Window depends on the indicators of environmental and social sustainability chosen for the analysis. Typically, several pairs of indicators are used in empirical analyses (Luukkanen et al 2015; 2018a; 2018b). The economic dimension is typically described by GDP in real prices, but also other choices are possible if relevant data is available.

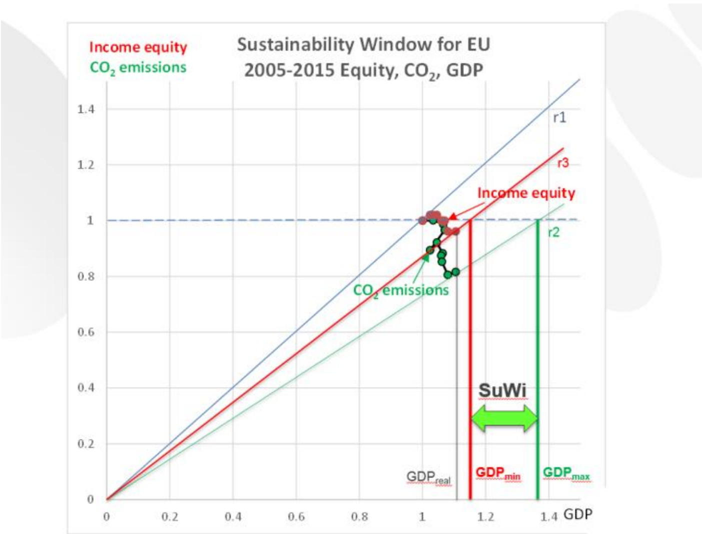

Figure 7. An example of empirical Sustainability Window (SuWi) analysis for the EU-28 in the period 2005-2015. Social lower limit (GDP_{min}, red) set by income equity, and environmental upper limit (GDP_{max}, green) set by CO_2 emissions. With these indicators, the Sustainability Window exists, and the real GDP remains outside (below) the Sustainability Window during the studied period 2005-2015.

Conclusions

The new EU framework programme after the current Horizon 2020 Research and Innovation programme is under construction with a preliminary title “Horizon Europe”. Results achieved in the EUFORIE project might be relevant and useful in the preparation of the new framework programme, depending on whether the energy, material, and environmental performance at the level of the EU Member States and other levels are available as potential subjects of biophysical and socio-economic research or not. Possible themes based on the results from the EUFORIE project and the related roundtable include at least the following (in order of appearance in the roundtable discussion):

- Better performance analysis of the EU and its Member States applying the tools and methods developed in the EUFORIE project; such as the production and end-use matrices for different Member States; LCA and EMA for cities and other systems, and the flexible performance indicators for companies
- Open models: transparent modelling of energy, material and environmental performance of the EU Member States, performance of different economic sectors, companies, and households; integration of bio-physical models and economic models
- Easy-to-use tools (user interface!) for energy. material, and environmental performance analysis; e.g. city-level performance analysis based on the LCA and EMA approaches applying open data, when possible
- Conceptualization, operationalization and analysis of energy and material sufficiency
- Time variant and dynamic modelling of energy, material and environmental performance; over time changing parameters of the model and structure of the economy, even changing structure of the model
- Heating sector and multiple technologies (CHP and district heating, air and water source heat pumps, other heating technologies); future transition towards efficient heat production
- Better inclusion of social sustainability in the performance and sustainability analyses; analysis of the “doughnut economy” via quantified applications such as the Sustainability Window (SuWi) analysis.

Since the major result from the EUFORIE project is the need for better performance analysis regarding energy efficiency, among other things such as material and environmental performance, there are no straightforward policy suggestions regarding energy efficiency but those listed above in relation to the next EU framework programme. However, communication remains an important challenge and there for the take-home questions deserve their place here in the conclusions of the roundtable results:

- To whom to communicate with the above mentioned policy message of the EUFORIE project
- How to continue after the project has ended?
- How to involve politicians in practice?
- How to challenge the hegemonic discourse of energy (efficiency) policy

The input from the EUFORIE project can be repeated also in the conclusions from the EUFORIE roundtable discussion, because the input summarizes important results from the EUFORIE project:

- Energy efficiency is a popular catchword, but as a concept it is a relative one and its operationalization is strongly dependent on the context where the concept is applied. From a scientific point of view, the difficulty of operationalization goes hand in hand with the level of aggregation. At the macro level of society (national level) where policy targets are usually set, operationalization is almost impossible.

- There is also overlapping between different fields and sectors of policies, where energy efficiency is an essential topic: In energy policy, after the oil shocks of the 1970s, energy efficiency has been promoted for economic reasons. In environmental and climate policies from the late 1980s, energy efficiency has been seen as a means to limit CO_2 emissions and environmental impacts in general – but this is seriously threatened by the Jevons paradox, which says simply that saved energy will be consumed elsewhere. In economic and employment policies, attention has been paid to energy efficiency (service) market creation, motivated by potential job opportunities and economic growth. These issues make energy efficiency a multi-dimensioned and practically quite an unclear entity from the perspective of target setting.
- Absolute targets to reduce energy consumption (and related environmental impacts) from a measured level are better than relative targets, or targets set in comparison to a projected consumption in the future (as the current EU energy efficiency target). Targets should be set at a level, where monitoring is possible.
- Indicators of energy efficiency, including also energy intensity, should be calculated by preferring the use of physical variables. Mixing physical and economic variables is problematic when change over time is looked at. Economic growth usually seems to decrease energy intensity, even though there might not necessarily be any real improvements in energy production or consumption technologies (technical efficiency), but other things such as structural change or financial transactions instead which have nothing to do with energy efficiency.
- Different policy instruments promoting energy efficiency may be useful in driving and supporting technological change and change in consumer behavior and lifestyle, which are important elements in reaching targets set for primary and final energy consumption, or for related environmental impacts. There are many promising policy instruments, but what is needed, is a monitoring system where the costs, benefits, and other effects of the use of the policy instruments in different EU Member States would be collected on a regular basis. However, there is no ultimate policy instrument, and the opinions on them vary a lot between different EU Member States and between different stakeholders.
- Technologies for improving energy efficiency are available, for energy production and consumption, but the major problem seems to be that energy efficient technologies are not taken into use – mostly for economic reasons. Usually payback periods are too long for economic actors operating in a short term only. It seems that the lessons learnt during the 1970s oil shocks are still relevant – the best driver of energy efficiency is high (increasing) real price of energy. Government policies are needed especially during those periods, when energy price stays at a low level.

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Annex 1. The roundtable agenda

EUFORIE
European Futures for Energy Efficiency

From physics to policy: Overcoming misperceptions in energy policy
Roundtable discussion

When: Thursday, 27th of September 2018, 9:00-13:00
Where: Turku-Southwest Finland European Office
Avenue Palmerston 26, B-1000 Brussels, Belgium
Registration: https://konsta.utu.fi/Default.aspx?tabid=88&tap=4879

Preliminary agenda

9:00 Opening and introduction of participants

9:15 From energy efficiency to energy performance: The end-use matrix
Mario Giampietro, Autonomous University of Barcelona

10:00 Towards an online energy performance calculator, in support to policy scenarios
Sergio Ulgiati, Parthenope University of Naples

10:45 Break and refreshments

11:00 Policy options supporting efficiency and sufficiency in household energy consumption
Joachim Spangenberg, SERI Germany

11:45 A Flexible indicator for energy, material and environmental performance
Jarmo Vehmas, University of Turku

12:30 Conclusions and follow-up

13:00 Lunch

This project is supported by the European Commission Horizon2020 Research and Innovation Programme

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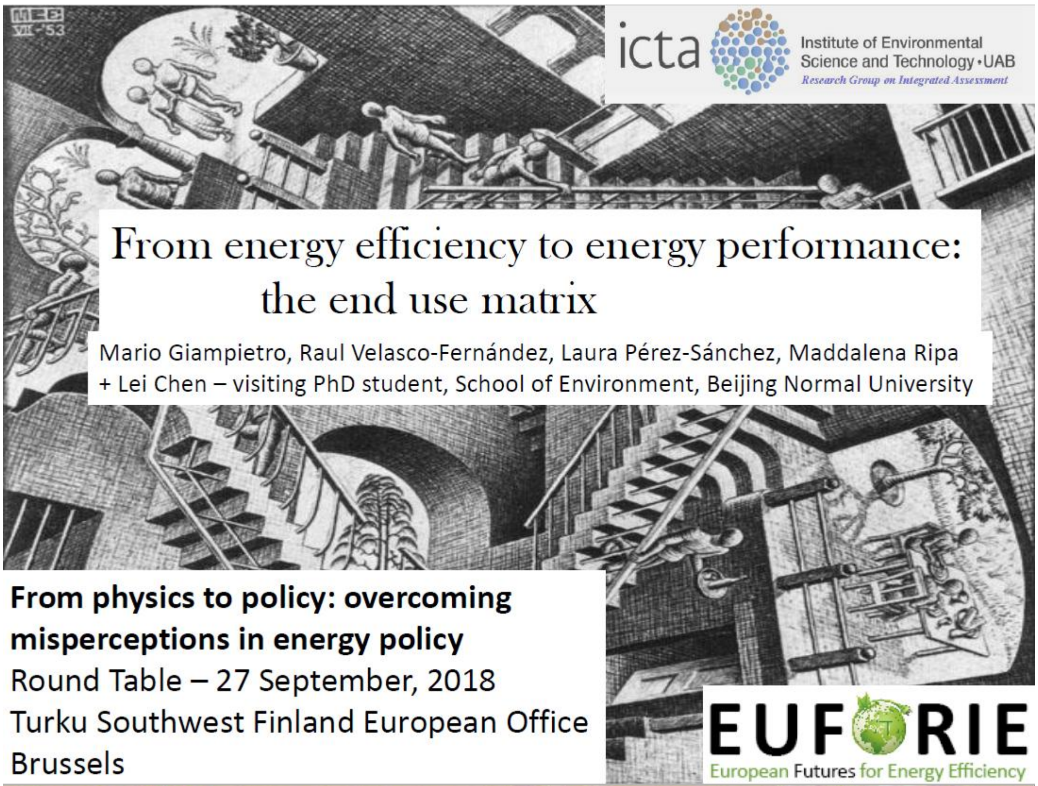
Annex 2. Roundtable participants

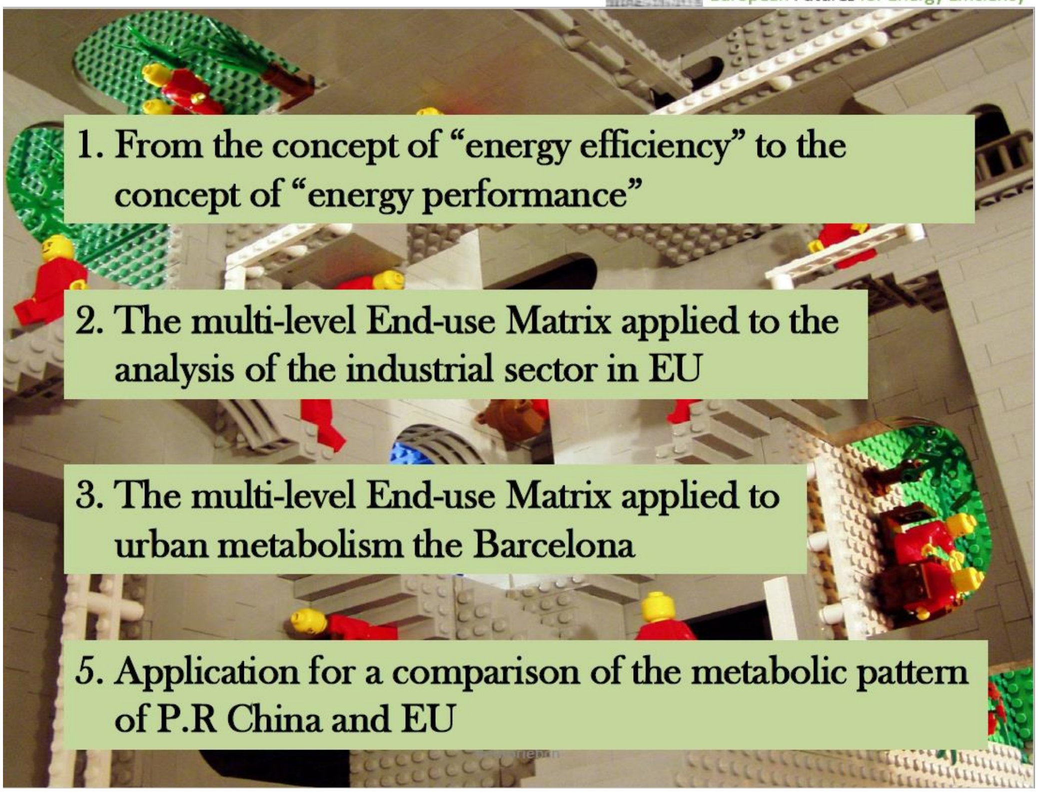
LIST OF PARTICIPANTS

Jarmo Vehmas	Univ. of Turku	Finland
Jyrki Luukkanen	Univ. of Turku	Finland
Jari Kaivo-oja	University of Turku	Finland
Paula Paquel	EASME	Belgium
Robbie Morrison	—	Germany/New Zealand
Raúl Velasco-Fernández	Univ. Autónoma Barcelona	Spain.
GABRIELLA FIORENTINO	UNIVERSITY OF NAPLES "PARTHENOPE"	ITALY
SERGIO ULGIATI	"	"
Joachim Spangenberg	SERI Germany	Germany
Mario GIAMPIETRO	UAB-ICTA	Catalonia (Spain)

10

Annex 3. Presentation slides of "From energy efficiency to energy performance: the end-use matrix"





1. From the concept of "energy efficiency" to the concept of "energy performance"

Mario Giampietro, M., Velasco-Fernández R. and Dunlop T

A critical appraisal of energy efficiency measurements: the need for a new accounting approach. – ***under review***

ISSN: 1364-0321

Renewable & Sustainable Energy Reviews

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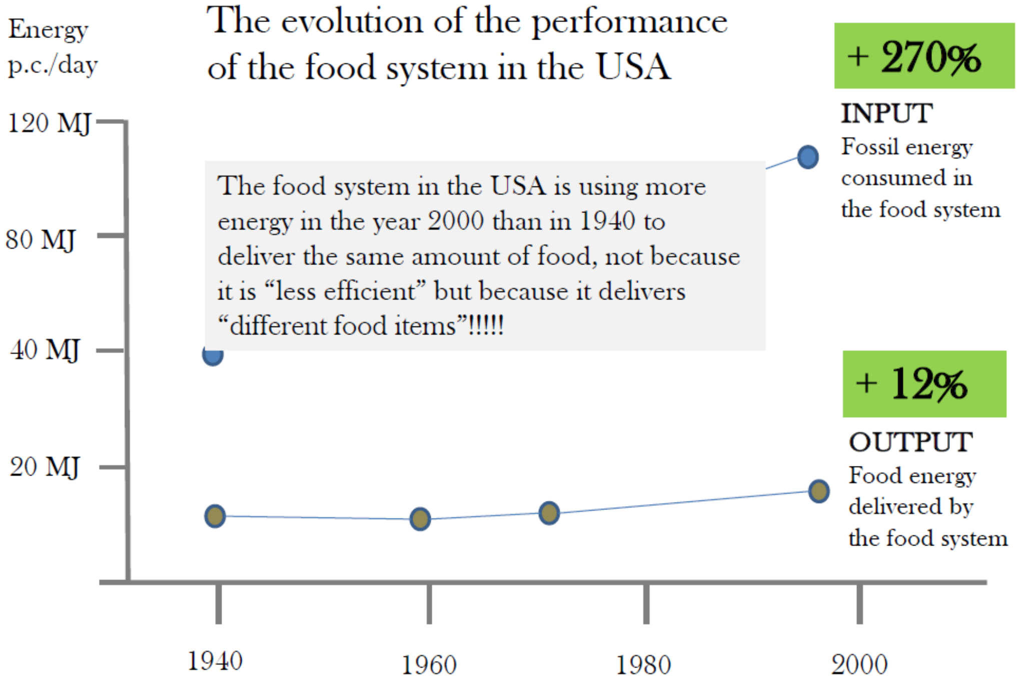
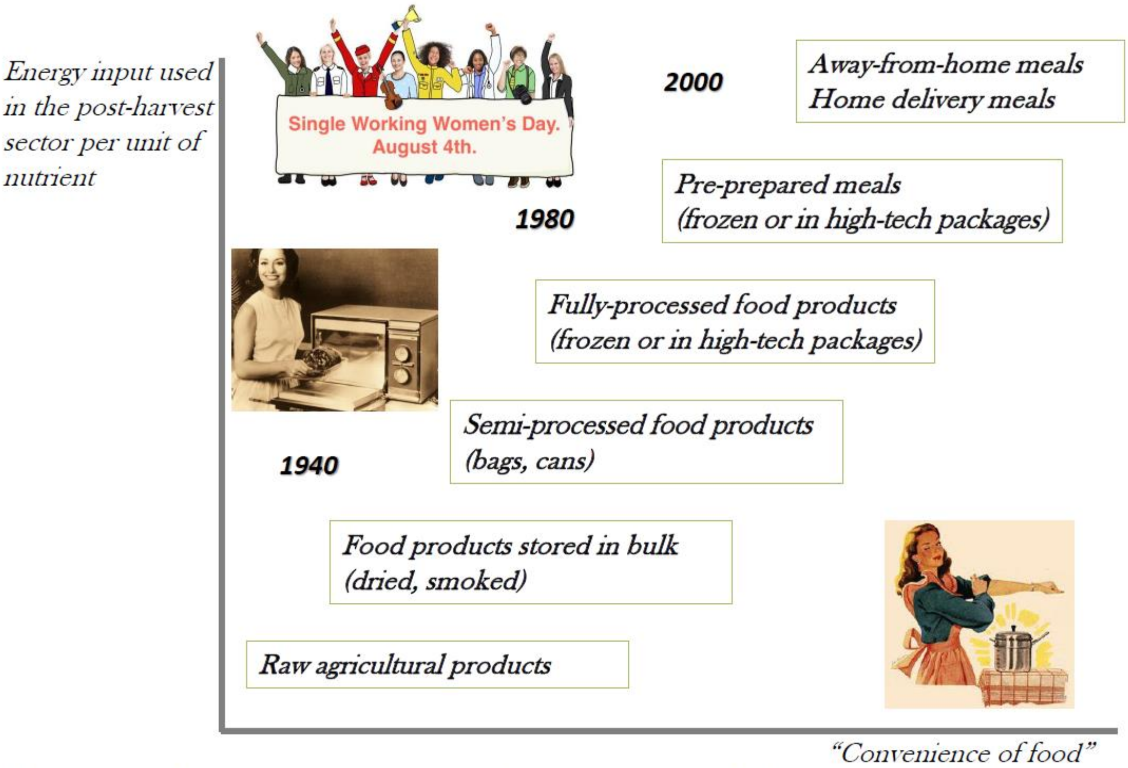
Is the technical progress in the food system wrong?





Increased energy consumption may result in more efficiency

The new Energy Efficiency Directive (2012/27/EU – EED) has an "energy efficiency target" of reducing by 20% the Unions Primary energy consumption by 2020

Is reducing energy consumption a proxy for efficiency?

European Environment Agency

EU greenhouse gas emissions: more than half way to the '20 % target by 2020'

Press Release — Published 02 Jun 2010 — Last modified 13 Apr 2011, 09:56 PM

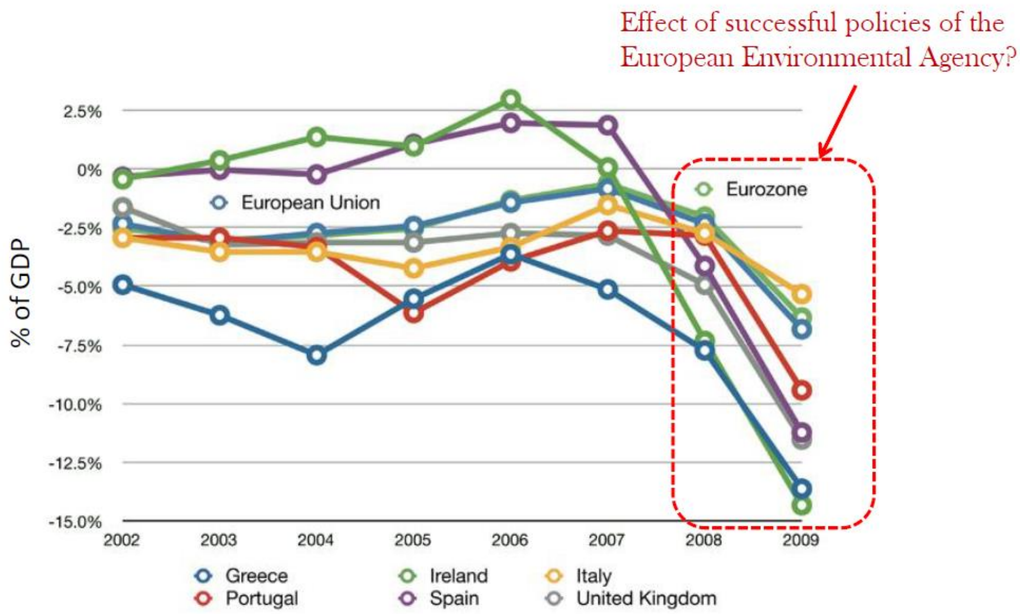
PDF

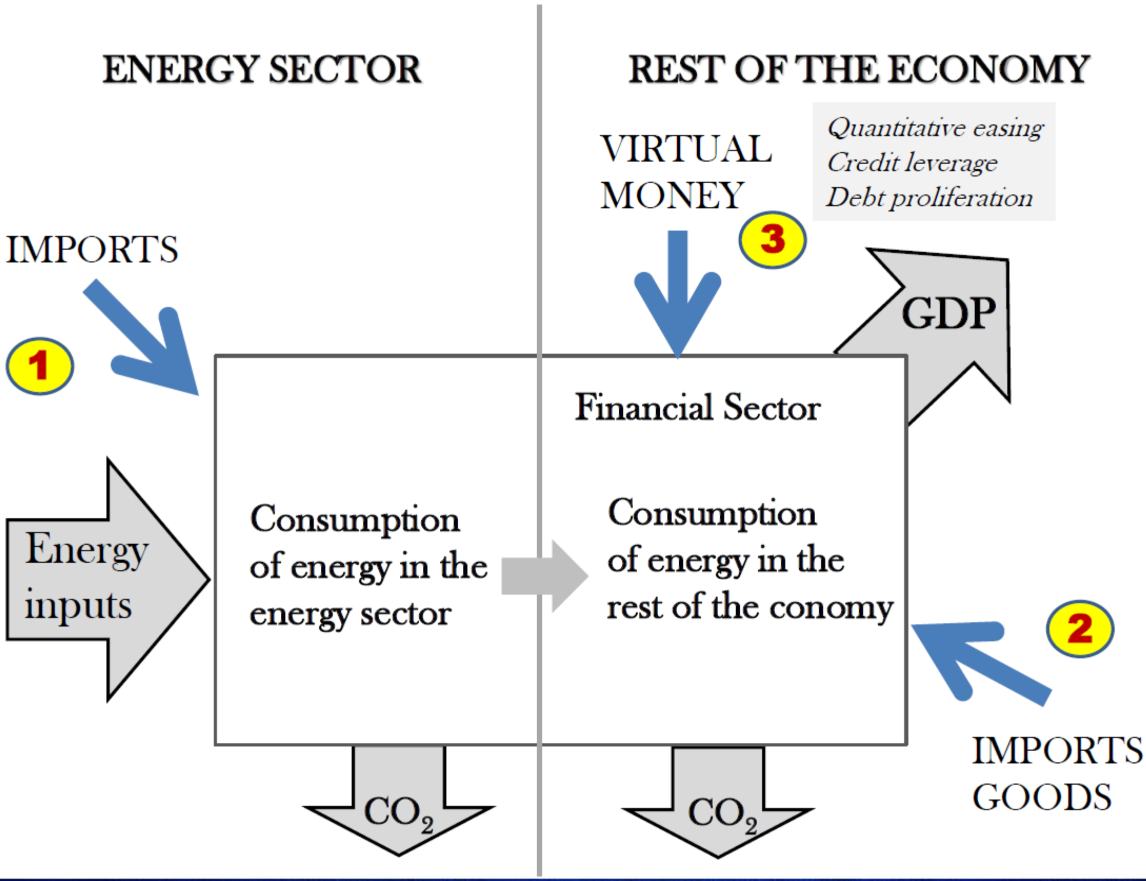
Topics: Climate change

The European Union's greenhouse gas (GHG) inventory report, compiled by the European Environment Agency (EEA), shows that emissions have not only continued their downward trend in 2008, but have also picked up pace. The EU-27's emissions stood 11.3 % below their 1990 levels, while EU-15 achieved a reduction of 6.9 % compared to Kyoto base-year levels.

'The GHG inventory report shows that the EU is well on track to meet its emission reduction targets with domestic policy measures only. Our policies and tools seem to be working' said

Emissions have been reduced because the economy collapsed, and this affected the consumption of fossil energy . . .




ENERGY SECTOR
REST OF THE ECONOMY
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Quantitative easing
Credit leverage
Debt proliferation
IMPORTS
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Consumption of energy in the energy sector
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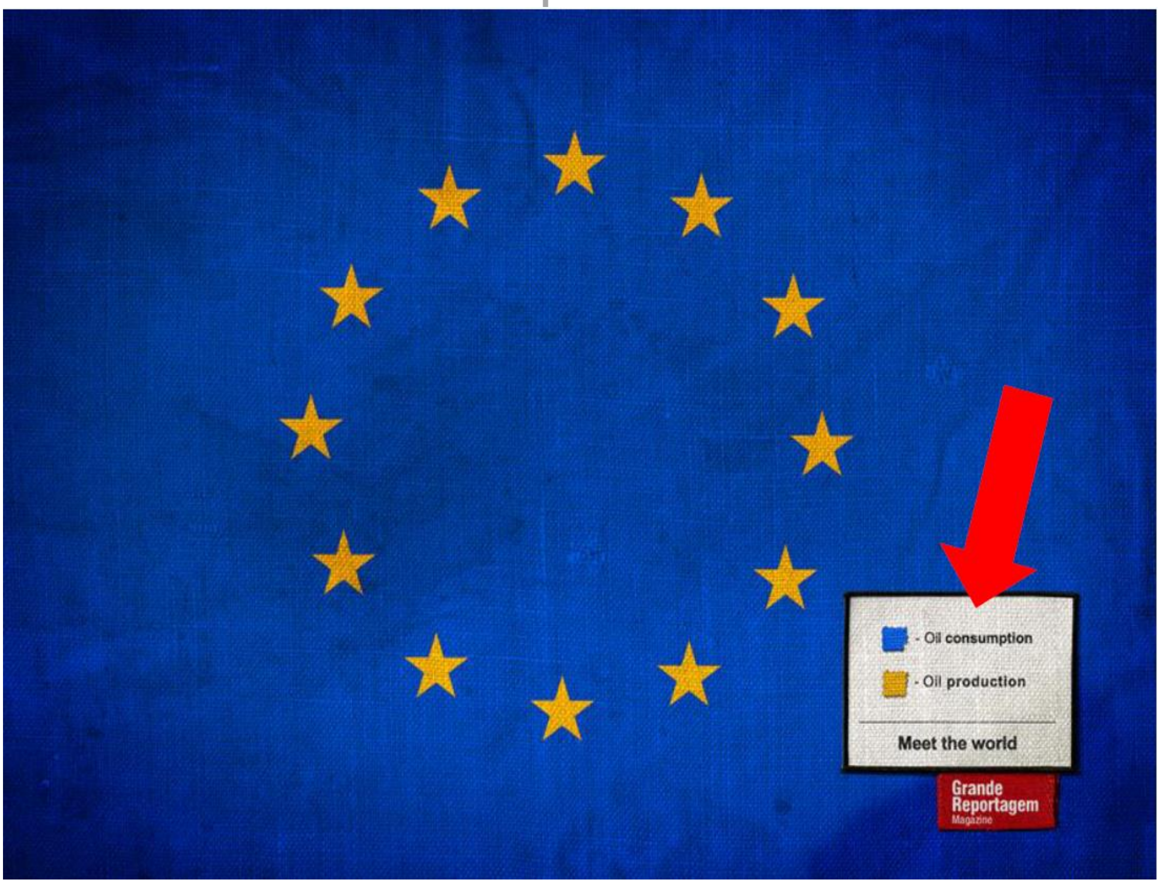
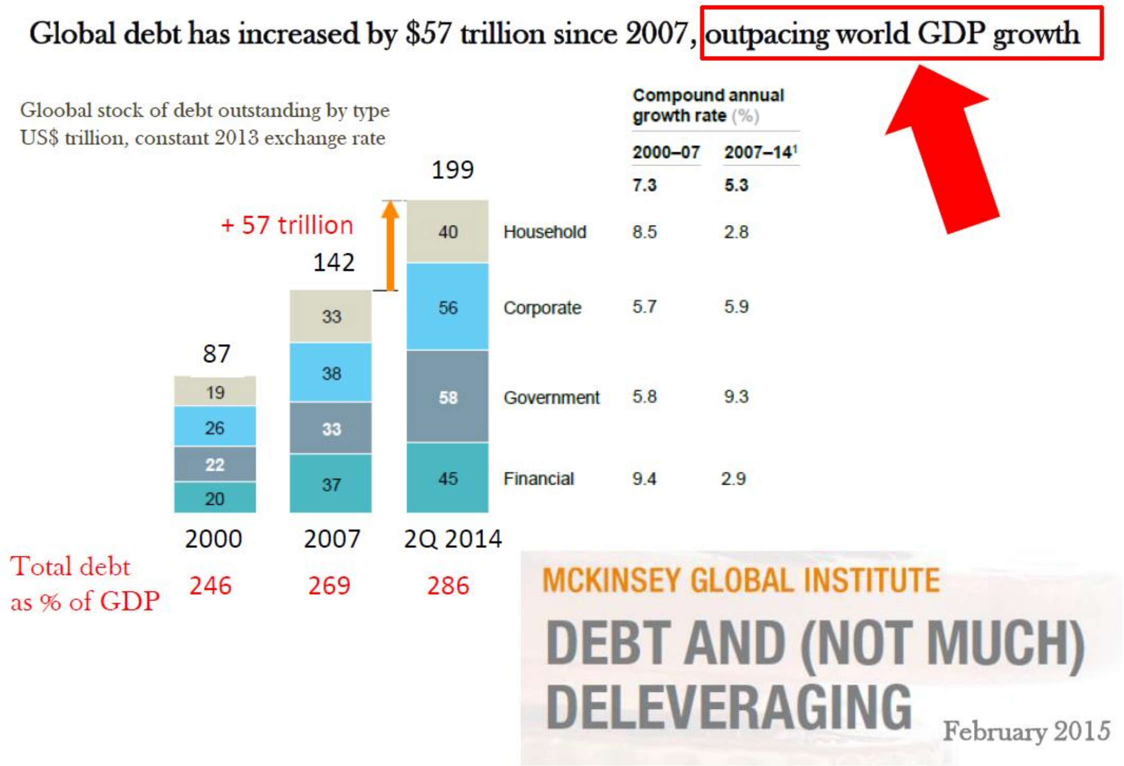

- Oil consumption
- Oil production
Meet the world
Grande Reportagem



http://www.mckinsey.com/insights/economic_studies/debt_and_not_much_deleveraging

"Energy efficiency" cannot be measured using simple "output"/"input" ratios such as:

* GDP/energy consumption

* GDP/CO_2 emissions

The hidden context of energy efficiency measurements: the need for a new accounting approach

Mario Giampietro[a, b*], Raúl Velasco-Fernández[a, c*] and Tessa Dunlop[a, d]

2. The multi-level End-use Matrix applied to the analysis of the industrial sector in EU

Energy 161 (2018) 559–572

Contents lists available at ScienceDirect

Energy

journal homepage: www.elsevier.com/locate/energy

Analyzing the energy performance of manufacturing across levels using the end-use matrix

Raúl Velasco-Fernández [a,*], Mario Giampietro [a,b], Sandra G.F. Bukkens [a]

[a] Institut de Ciència i Tecnologia Ambientals (ICTA), Universitat Autònoma de Barcelona, 08193 Bellaterra, Spain
[b] ICREA, Passeig Lluís Companys 23, 08010 Barcelona, Spain

10% of PW

1 hours of PW/16 hours Non-PW → hour of PW < 7%

2012 EU27+N	HA (10^9 h/year)		HA per Capita (h)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)		ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	EEI (MJ/€)
Average Society	4.422	x	8760	2,6	4,3	3,9	2,6	=	11.415	19.110	17.243	11.631	6,4

The end-use matrix for EU27 + Norway

EU 27 + N	HA hours/y	x	EMR elect MJ/h	EMR heat MJ/h	EMR fuel MJ/h	EJP €/h	=	Electricity PJ/y	Heat PJ/y	Fuels PJ/y	GVA 10^9€/y	HA %	GVA %
Whole Society	4.422		2,6	4,3	3,9	2,6		11.415	19.110	17.243	11.631	100%	100%

Level n

Whole SocietyEconomic Energy Intensity = 6.4 MJ/€

		x					=						
Household	4.167		0,74	1,7	1,9	0		3.098	7.078	7.889	0	94%	0%
Paid Work	255		33	47	37	46		8.317	12.033	9.354	11.631	5,8%	100%

Level n-1

Paid Work Economic Energy Intensity = 4.1 MJ/€

		x					=						
Agriculture, Forestry & Fishing	21		8,0	15	26	9,3		171	326	556	198	8,4%	1,7%
Energy & Mining	3,9		280	612	17	122		1.092	2.386	68	475	1,5%	4,1%
Manufacturing & Construction	65		57	103	7,1	36		3.706	6.664	459	2.347	25%	20%
Service & Government	172		19	15	48	50		3.348	2.657	8.271	8.611	68%	74%

Level n-2

Agriculture Forestry & Fishing	*Economic Energy Intensity =* 7.9 MJ/€
Energy and Mining	*Economic Energy Intensity =* 12.0 MJ/€
Manufacturing and Construction	*Economic Energy Intensity =* 7.5 MJ/€
Service and Government	*Economic Energy Intensity =* 2.7 MJ/€

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Iron & Steel	0,97	397	1.484	33	34
Non-Ferrous Metals	0,47	264	129	13	20
Chemical & Petrochemical	2,4	590	901	111	163
Non-Metallic Minerals	1,8	216	1.011	47	52
Food & Tobacco	6,1	321	534	60	177
Textile & Leather	2,9	71	89	12	47
Paper, Pulp & Print	1,9	422	757	29	66
Transport Equipment	4,3	157	95	15	178
Machinery	13	376	258	37	453
Wood & Wood Products	1,3	78	175	6	27
Non-specified Industry	4,8	297	198	153	130
Construction	14	58	103	122	406

Level n-3

	H.A. hours/y	EMR elect MJ/h	EMR heat MJ/h	EMR fuel MJ/h	EJP €/h
Manufacturing & Construction	65	3.706	6.664	459	2.347
Service & Government	172	3.348	2.657	8.271	8.611

Level n-2

Services & Government	166	3.115,6	2.255	607	6.827,1
Transport Services	6,3	232,0	401	7.663	109

Level n-3

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Level n-3

Agriculture & Forestry	20	168,9	322	495	187,8
Fishing	0,23	2,0	4	61	8

	H.A. hours/y	EMR elect MJ/h	EMR heat MJ/h	EMR fuel MJ/h	EJP €/h
Agriculture, Forestry & Fishing	21	171	326	556	198
Energy & Mining	4	1.092	2.386	68	475

Level n-2

Energy Sector	2,7	844	2.191	45	363
Mining & Quarrying	0,34	58	32	24	11

Level n-3

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EU27+N	HA (10^9 h/year)	EMR elec (MJ/h)	EMR heat (MJ/h)	EMR fuel (MJ/h)	EJP (€/h)
Manufacturing & Construction	65	57	103	7,1	36

2012

Level n-2

Can we move to a lower level?

Human Activity in Paid Work (jobs)

Consumption EC per hour of work (intensive variables)

Generation of GVA associated with jobs

	HA Mh/year	(electr.) EMR MJ/h	(fuels) EMR MJ/h	(heat) EMR MJ/h	EJP €/h
Iron & Steel	0,97	397	1.484	33	34
Non-Ferrous Metals	0,47	264	129	13	20
Chemical & Petrochemical	2,4	590	901	111	163
Non-Metallic Minerals	1,8	216	1.011	47	52
Food & Tobacco	6,1	321	534	60	177
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Paper, Pulp & Print	1,9	422	757	29	66
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Non-specified Industry	4,8	297	198	153	130
Construction	14	58	103	122	406

Level n-3

EUFORIE European Futures for Energy Efficiency

#euforiebcn

The sub-sector Paper, Pulp and Print in EU 22 - 2012

Paper, Pulp and Print	HA (10⁹h/year)		EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)		ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	VA (10^9 €)	%HA/ HA_EU-22	%VA/ VA_EU-22	EEI (MJ/€)
EU-22	1937	x	218	391	15	34	=	422	757	29	66	100%	100%	29,7
Austria	48		358	1.040	8,5	57		17	49	0,40	2,7	2,5%	4,1%	37
Belgium	38		279	380	26	60		11	14	0,96	2,3	1,9%	3,4%	20
Bulgaria	29		44	255,9	6,8	6,3		1,29	7,5	0,20	0,19	1,5%	0,3%	64
Croatia	21		48	101	7,5	12		1,03	2,2	0,16	0,25	1,1%	0,4%	21
Czech Republic	63		[illegible]	[illegible]	3,20	16		6,0	17	0,20	0,99	3,2%	1,5%	36
Finland	50		1.386	3.095	61	67		69	154	3,0	3,3	2,6%	5,0%	106
Germany	445		192	285	5,0	39		85	127	2,2	17	23%	26%	21
Greece	27		72	49,3	30	20		1,9	1,3	0,80	0,54	1,4%	0,8%	14
Hungary	42		47	71	2,8	13		2,0	3,0	0,12	0,53	2,2%	0,8%	16
Ireland	14		55	9,0	6,2	38		0,77	0,13	0,087	0,53	0,7%	0,8%	4
Italy	232	x	142	123	8,8	36	=	33	28	2,0	8,3	12%	13%	14
Latvia	7,4		16	23	0	11		0,12	0,17	0	0,08	0,4%	0,1%	6,0
Lithuania	12		38	72	3,6	12		0,46	0,86	0	0,14	0,6%	0,2%	16
Netherlands	64		140	221	0,0	47		9,0	14	0	3,0	3,3%	4,5%	13
Norway	15		968	527	101	56		15	8,1	1,6	0,9	0,8%	1,3%	58
Poland	150		91	245	11	18		14	37	1,7	2,6	7,7%	4,0%	30
Portugal	47		216	896	43	26		10	42	2,0	1,2	2,4%	1,8%	63
Romania	59		25	29	2	6,5		1,5	1,7	0,13	0,4	3,1%	0,6%	16
Slovakia	21		174	538	3,9	19		3,6	11	0,08	0,4	1,1%	0,6%	56
Spain	174		[illegible]	[illegible]	26	32		19	55	4,5	5,7	9,0%	8,5%	20
Sweden	77		1.069	2.023	98	57		83	157	7,6	4,4	4,0%	6,7%	90
United Kingdom	302		129	88	4	35		39	26	1,1	11	16%	16%	13

EUFORIE European Futures for Energy Efficiency

#euforiebcn

Paper, Pulp & Print, Year 2010

Compared with the average values of the in Europe

	EMR_{el}	EMR_{ht}	EMR_{f}
'taly	0,6	0,4	0,5
Spain	0,3	0,5	1,5
Sweeden	4,5	4,9	6,2
Finland	5,8	7,1	2,8
UK	0,5	0,2	0,2
Germany	0,8	0,8	0,4
Hungary	0,2	0,2	0,1
Norway	4,2	1,7	9,1
Bulgaria	0,2	0,5	0,5

2 HOW OPEN ARE THESE SECTORS?

much higher than the average

1 **Different technological processes are included in the same category**

much lower than the average

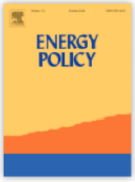
#euforiebcn

3. The multi-level End-use Matrix applied to urban metabolism the Barcelona

Characterizing the metabolic pattern of urban systems using MuSIASEM: the case of Barcelona

Pérez-Sánchez, L., Giampietro, M., Velasco-Fernández R. and Ripa M.

JUST ACCEPTED IN PRODUCTION



ISSN: 0301-4215

Energy Policy

The International Journal of the Political, Economic, Planning, Environmental and Social Aspects of Energy

Senior Editors: Stephen P. A. Brown, Michael Jefferson

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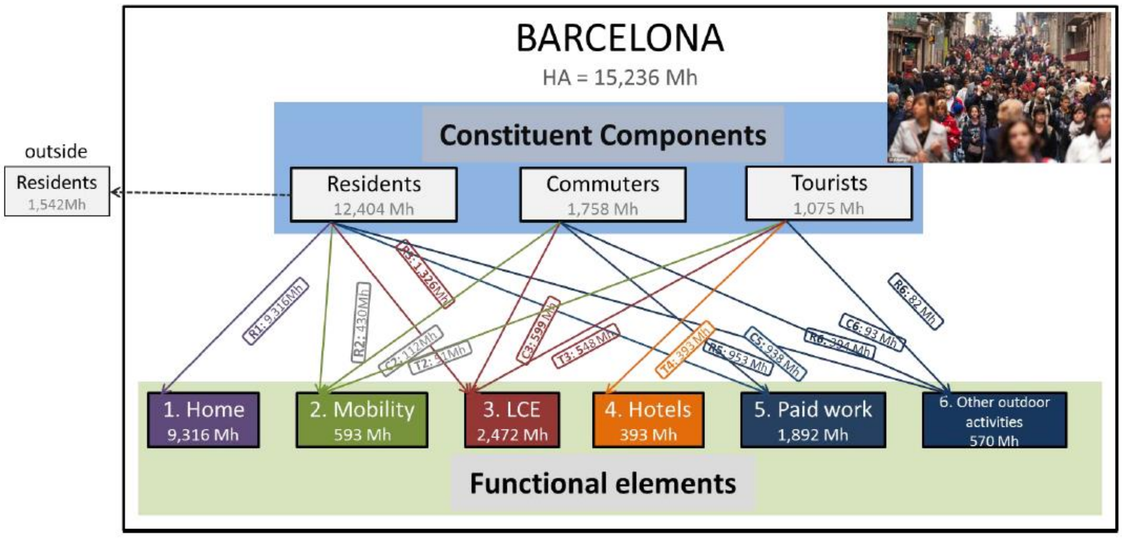
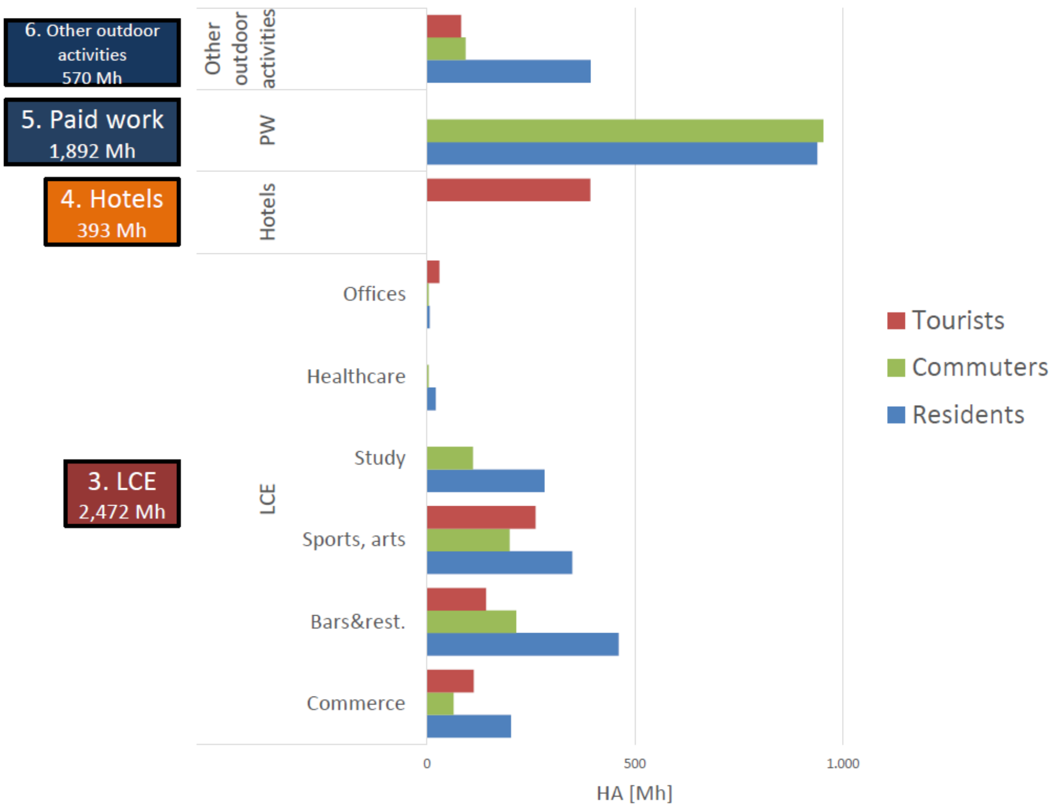
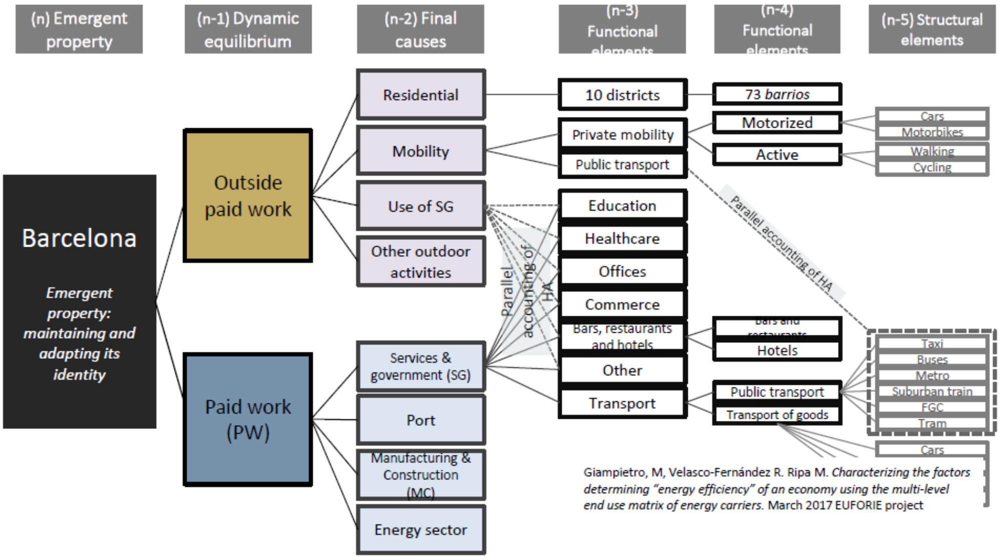
Who is expressing activities using energy in Barcelona?

Can we measure the level of energy use as GJ per capita per year?

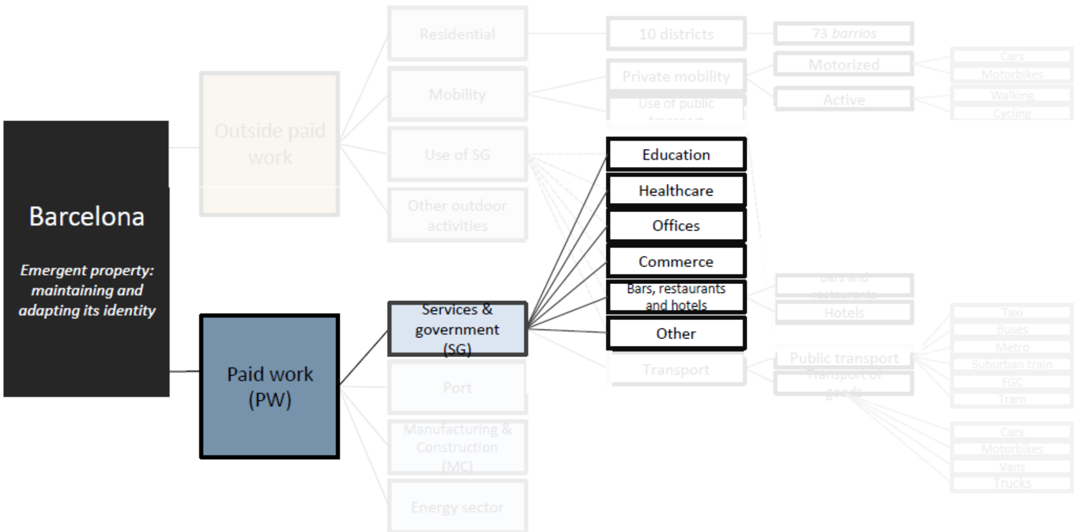

BARCELONA
HA = 15,236 Mh
Constituent Components
outside
Residents
1,542Mh
Residents
12,404 Mh
Commuters
1,758 Mh
Tourists
1,075 Mh
R1: 9,316Mh
R2: 430Mh
C3: 599 Mh
T3: 548 Mh
T4: 393 Mh
R5: 953 Mh
C5: 938 Mh
R6: 394 Mh
C6: 93 Mh
R6: 82 Mh
1. Home
9,316 Mh
2. Mobility
593 Mh
3. LCE
2,472 Mh
4. Hotels
393 Mh
5. Paid work
1,892 Mh
6. Other outdoor activities
570 Mh
Functional elements


6. Other outdoor activities
570 Mh
5. Paid work
1,892 Mh
4. Hotels
393 Mh
3. LCE
2,472 Mh
Other outdoor activities
PW
Hotels
LCE
Offices
Healthcare
Study
Sports, arts
Bars&rest.
Commerce
0
500
1.000
HA [Mh]
Tourists
Commuters
Residents

Functions of the system Barcelona



Results – services and government

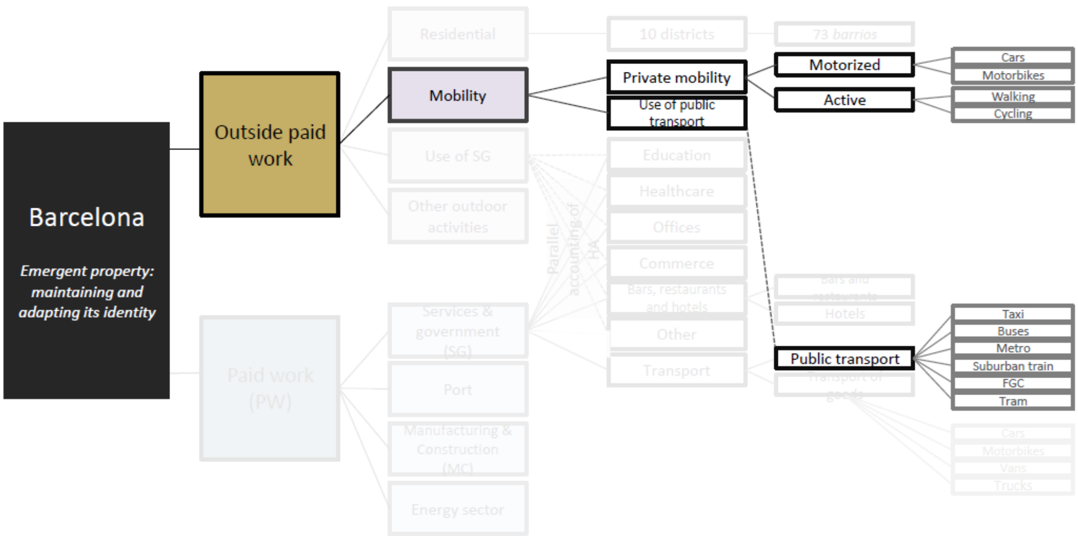


Results – services and government

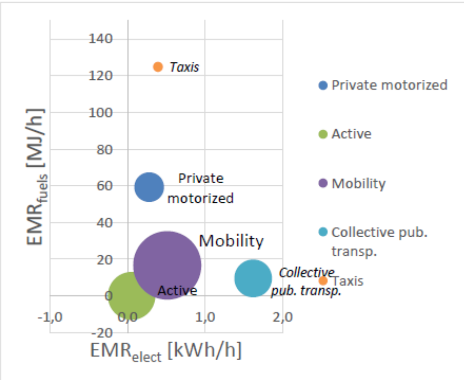
	HA	US	EMR		EJP	EMD		EUSP	ET		VA
			Elect.	Heat		Elect.	Heat		Elect.	Heat	
	Mh	km^2	kWh/h	MJ/h	€/h	kWh/m^2	MJ/m^2	€/m^2	GWh	TJ	M€
SERVICES & GOV.	**1,539**	**31.8**	**2.7**	**2.6**	**39**	**132**	**125**	**1,884**	**4,200**	**3,990**	**60,000**
Education	101	3.6	1.3	6.3	35	38	177	986	135	637	3,542
Healthcare	157	1.9	1.4	1.3	22	116	104	1,805	223	201	3,477
Offices	641	7.0	1.9	1.2	45	177	112	4,075	1,246	792	28,697
Commerce	321	8.3	4.1	5.4	35	156	208	1,337	1,300	1,730	11,114
Hotels, bars & restaurants	135	2.0	2.2	2.0	37	149	133	2,467	304	270	5,031
Other	119	3.7	5.9	3.0	33	190	99	1,063	696	360	3,881

Closure

Results– mobility – user side



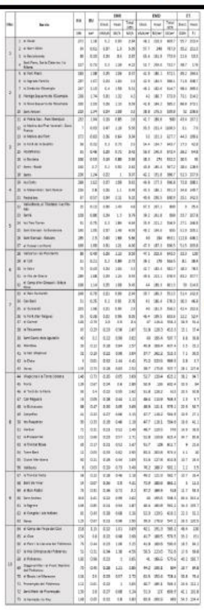
Results– mobility – user side

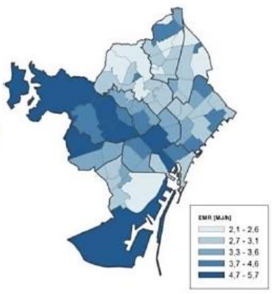


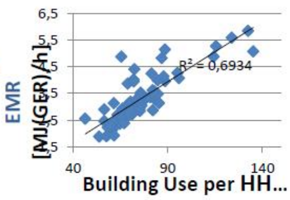
	HA	EMR		ET		Distance
		Elect.	Fuels	Elect.	Fuels	
	Mh	kWh/h	MJ/h	GWh	TJ	Gm
MOBILITY	**593**	**0.5**	**16**	**303**	**9,853**	**8,990**
PRIVATE MOBILITY	401	0.1	17	46	6,620	4,884
Active	289	0.1	0	15	0	1,588
Private motorized	112	0.3	59	31	6,620	3,296
PUB. TRANSPORT	192	1.3	17	257	3,233	4,105
Collective pub. transp.	180	1.6	9	291	1,712	3,598
Taxis	12.2	0.4	124.8	5	1,521	507

Distance vs HA

Results– residential





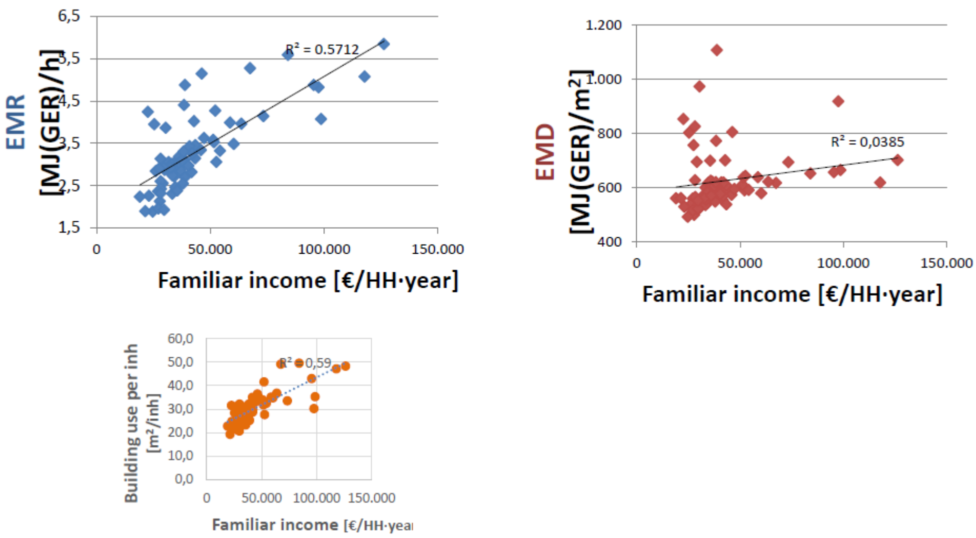


73 barrios ➡ tables no longer useful for visualization

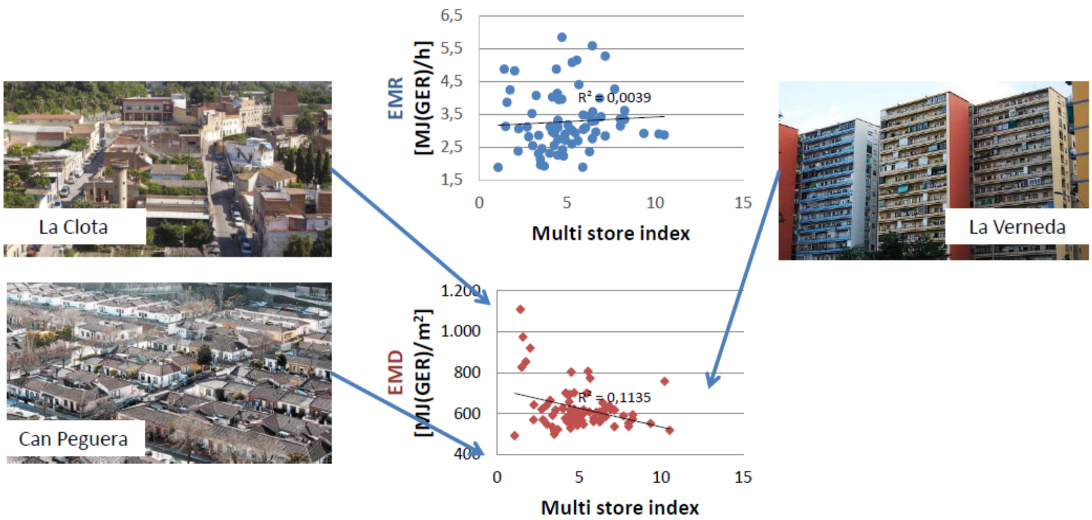
Variables to study:

- Area of HH [m² BU/HH]
- Available space per inh [m²/inh]
- Familiar income [€/year·HH]
- Year of construction
- Multi-storey index

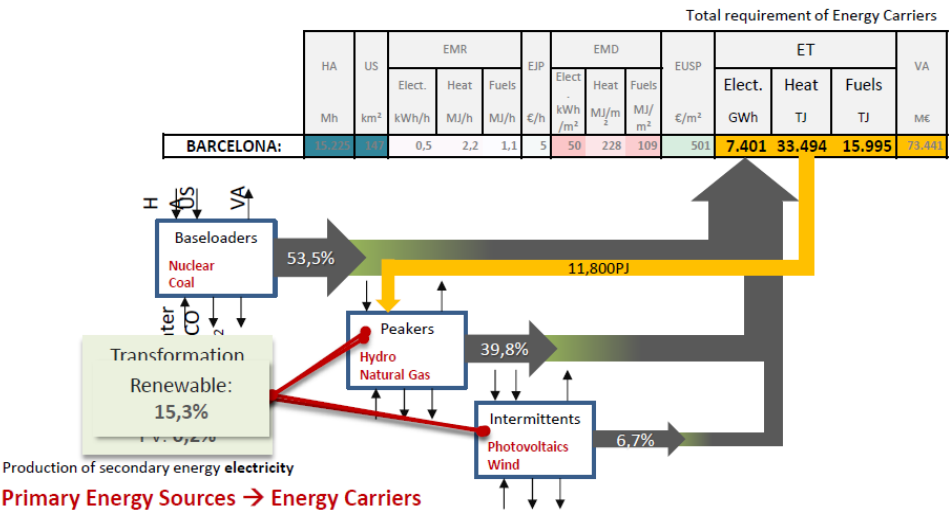
End-use matrix – residential



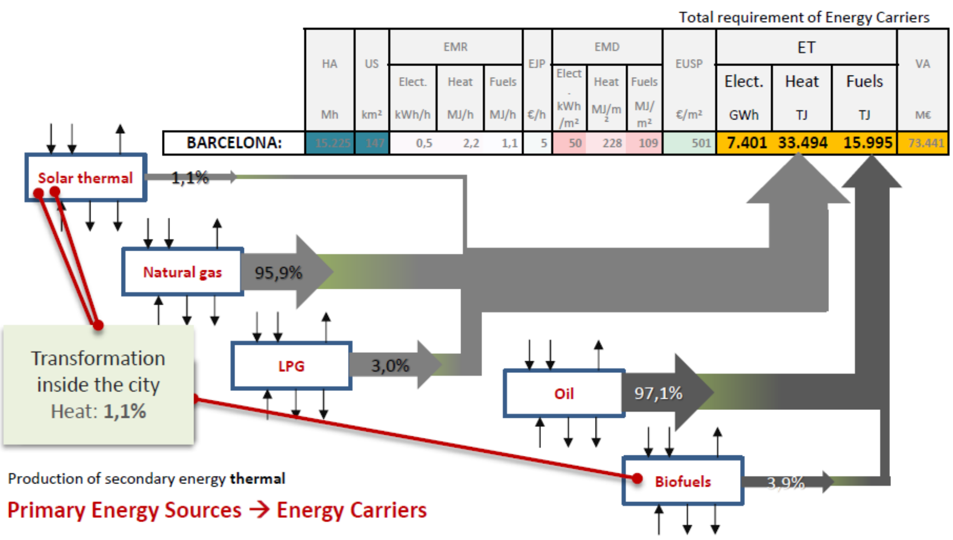
End-use matrix – residential



Primary Energy Sources required by the city: electricity



Primary Energy Sources required by the city: fuels and thermal



4. The multi-level End-use Matrix used to compare the metabolism of EU and China

How to compare two economies that are very different?

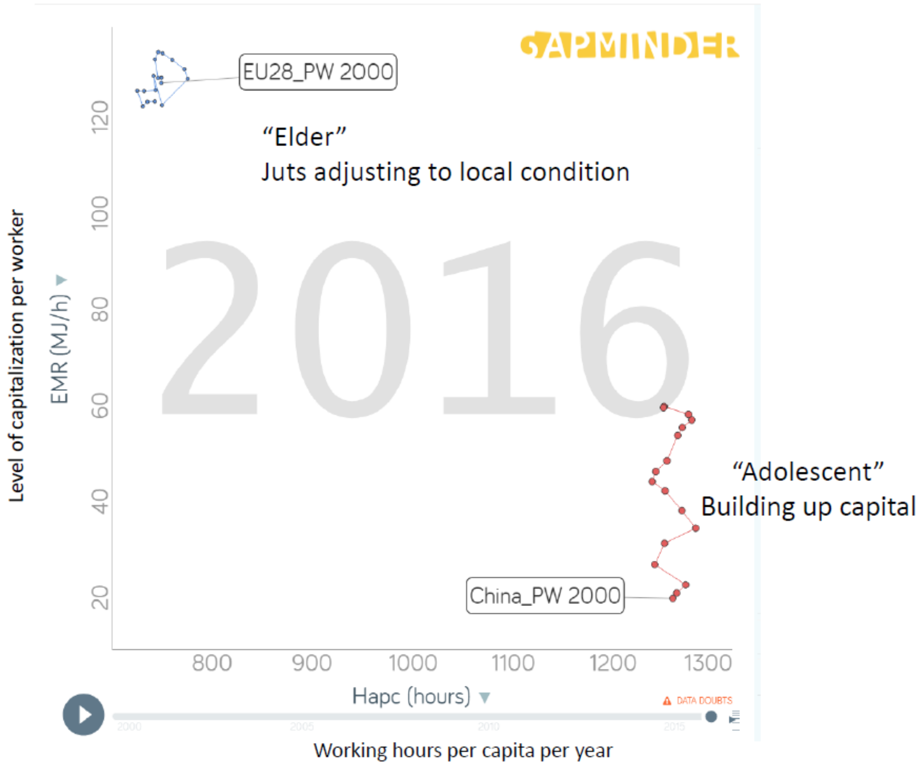
What are the factors to be considered in the comparison?

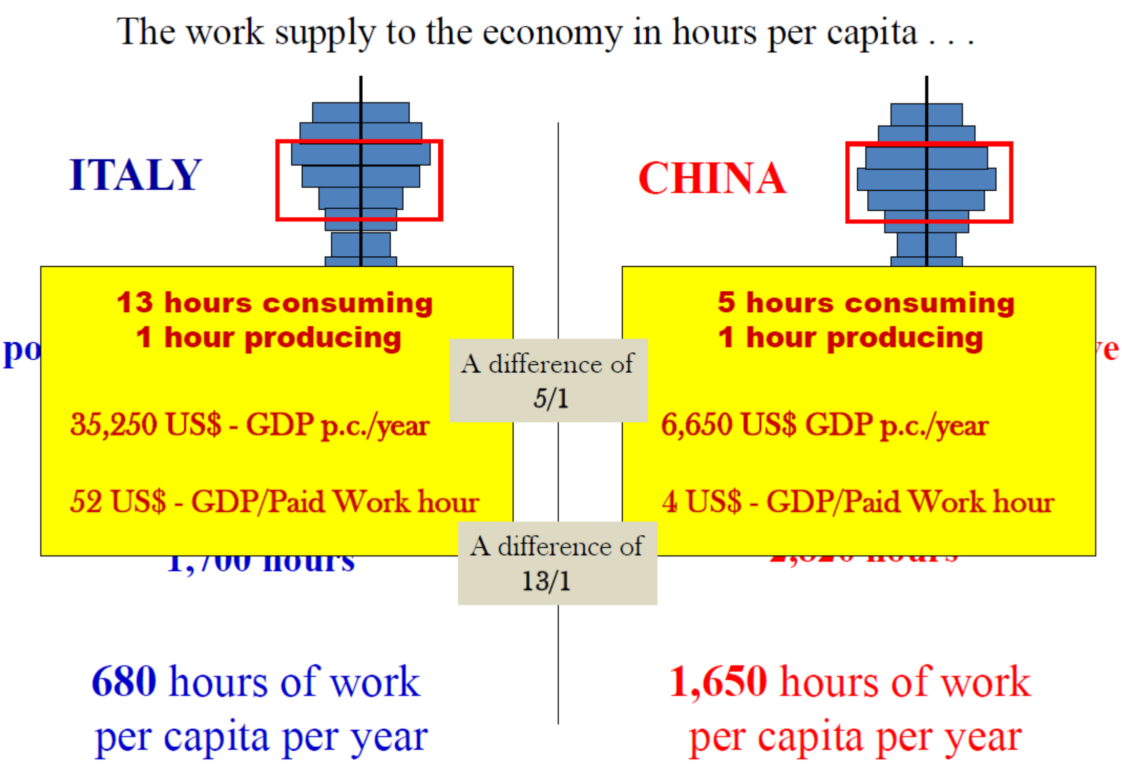
How to compare “Apples” with “Oranges”?

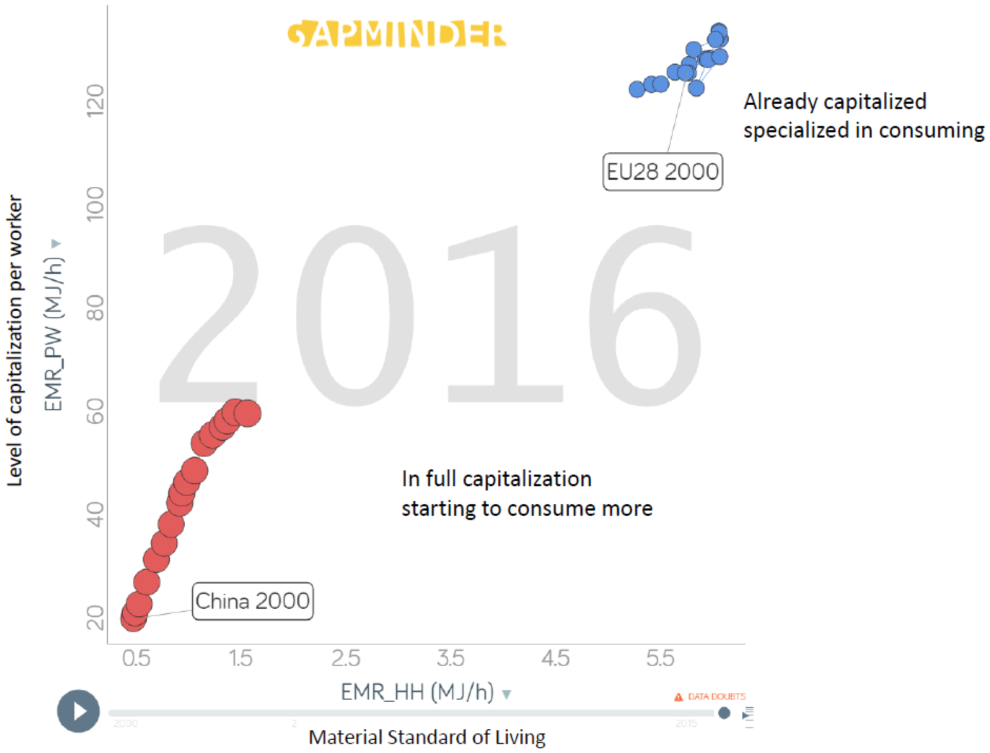
Who is more efficient?

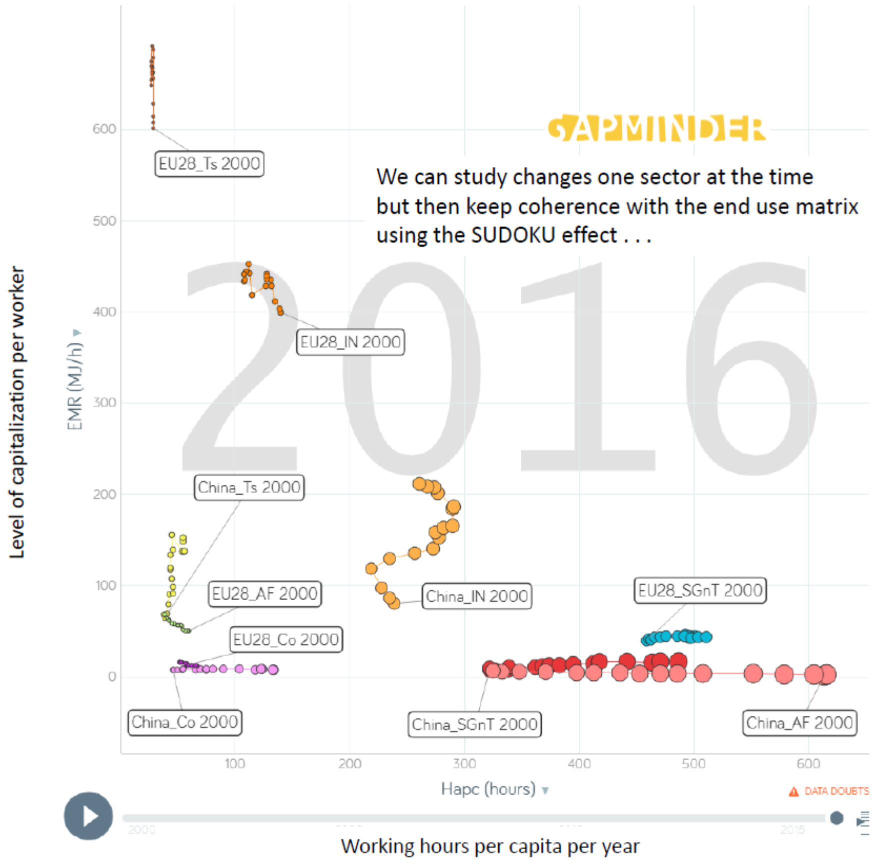
The metabolism
of an aged economy
(post-industrial)

The metabolism of an
adolescent economy
(still industrial)


GAPMINDER
EU28_PW 2000
"Elder"
Juts adjusting to local condition
2016
"Adolescent"
Building up capital
China_PW 2000
Level of capitalization per worker
EMR (MJ/h)
120
100
80
60
40
20
800
900
1000
1100
1200
1300
Hapc (hours)
Working hours per capita per year


The work supply to the economy in hours per capita . . .
ITALY
CHINA
13 hours consuming
1 hour producing
35,250 US$ - GDP p.c./year
52 US$ - GDP/Paid Work hour
5 hours consuming
1 hour producing
6,650 US$ GDP p.c./year
4 US$ - GDP/Paid Work hour
A difference of
5/1
A difference of
13/1
680 hours of work
per capita per year
1,650 hours of work
per capita per year

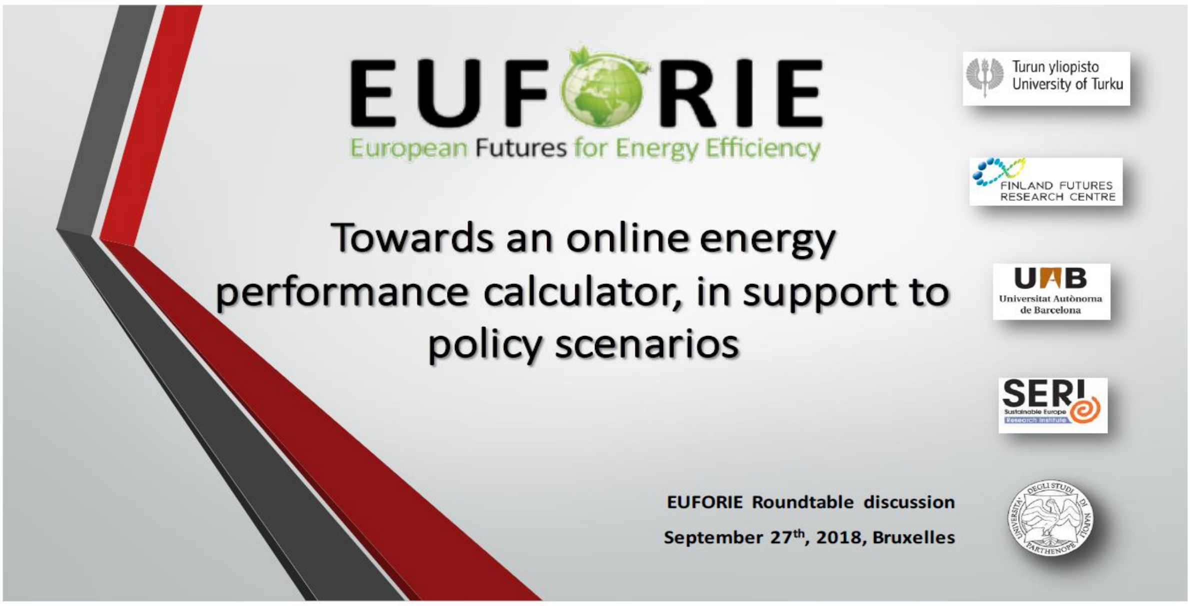

GAPMINDER
2016
Already capitalized
specialized in consuming
EU28 2000
In full capitalization
starting to consume more
China 2000
Level of capitalization per worker
EMR_PW (MJ/h)
EMR_HH (MJ/h)
Material Standard of Living

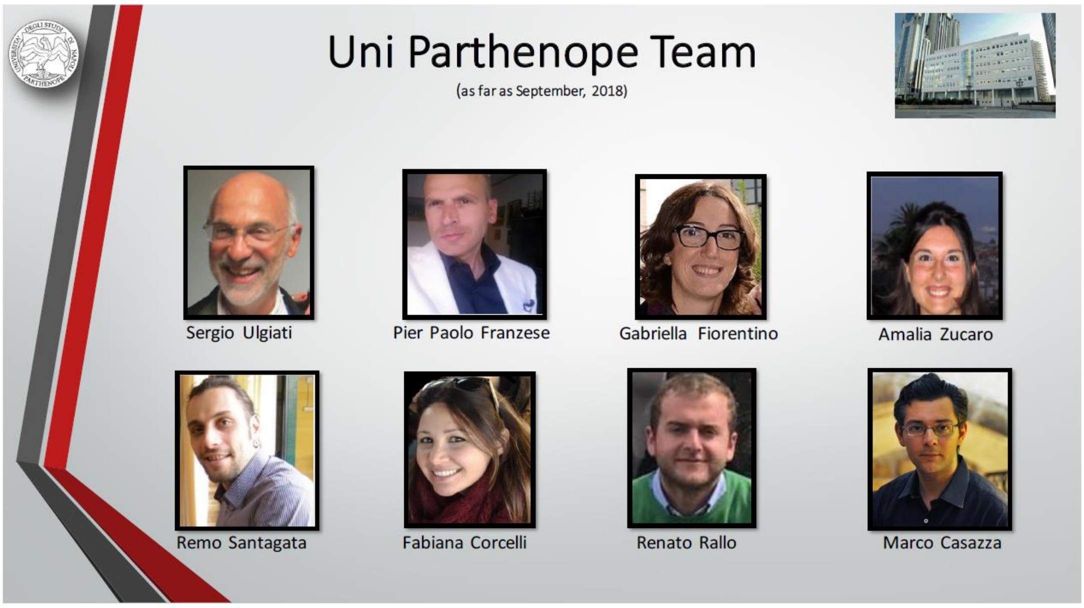

GAPMINDER
2016
We can study changes one sector at the time
but then keep coherence with the end use matrix
using the SUDOKU effect . . .
EU28_Ts 2000
EU28_IN 2000
China_Ts 2000
EU28_AF 2000
EU28_Co 2000
China_IN 2000
EU28_SGnT 2000
China_Co 2000
China_SGnT 2000
China_AF 2000
Level of capitalization per worker
EMR (MJ/h)
Hapc (hours)
Working hours per capita per year

Levels	2015 China	HA (10^9 h/year)	HA per Capita (h)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (¥/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 ¥)	EEI (MJ/€)
n	Average Society	11.103	8760	1,6	4,3	1,1	6,1	4.515	19.490	4.907	10.028	3,6
n-1	Household	9.506	7517	0,26	0,61	0,15	-	523	2.971	205	-	
n-1	Paid Work	1.597	1243	10	27	7,1	43	3.992	16.519	4.702	10.028	3,1
n-2	Agriculture & Forestry	779	333	5,3	1,6	1,6	13,7	192	312	337	1.494	0,8
n-2	Industrial sector	306	263	213	111	3,0	63	3.266	14.623	1.158	4.002	6,1
n-2	Construction	58	124	7,8	1,6	2,5	27	58	141	141	553	0,8
n-2	Services & Government (without Transport)	50	55	148	26,3	108	40	101	633	2.305	816	3,9
n-2	Transport Services	405	468	16	4,0	2,7	49	375	811	761	3.163	0,8
n-3	Energy & Mining	53	36,3	49	94	6	69	876	3.055	451	1.016	5,7
n-3	Food and Tabacco	12	4	64	54	22	111	127	663	67	450	2,4
n-3	Textile and Leather	22	20	14	41	1,9	95	161	465	52	351	2,7
n-3	Wood and Wood Products	38	28,5	18	18	0,7	46	12	66	4,5	25	4,0
n-3	Paper, Pulp and Print	2,3	1,9	35	60	3,1	136	97	380	26	99	6,7
n-3	Chemical and Petrochemical	9,5	5,9	33	71	2	64	518	2.680	116	376	11
n-3	Non-Metallic Minerals	28	21,0	68	269	5	74	275	2.333	156	181	18
n-3	Basic Metals	18	11,4	72	402	8,7	84	655	4.919	75	291	23
n-3	Machinery	23	16	176	774	2,5	70	250	510	115	851	1,5
n-3	Transport Equipment	62	84	13	6	1,0	48	73	173	34	212	1,9
n-3	Non-Specified Industry (Rubber, Plastic products, Forniture & others)	18	21	12	9	2	61	169	272	61	150	5,1

Levels	2015 EU28	HA (10^9 h/year)	HA per Capita (h)	EMR_elec (MJ/h)	EMR_heat (MJ/h)	EMR_fuel (MJ/h)	EJP (€/h)	ET_elec (PJ/year)	ET_heat (PJ/year)	ET_fuel (PJ/year)	GVA (10^9 €)	EEI (MJ/€)
n	Average Society	4.455	8760	2,6	4,7	3,8	2,6	11.557	21.103	17.126	11.581	5,9
n-1	Household	4.082	8028	0,70	1,8	1,8	-	2.864	7.485	7.200	-	-
n-1	Paid Work	372	732	23	37	27	31	8.693	13.618	9.926	11.581	4,0
n-2	Agriculture & Forestry	21	41	8,6	15	27	9,3	178	307	552	192	6,9
n-2	Industrial sector	55	109	94	185	6,1	38	5.209	10.199	338	2.106	11
n-2	Construction	27	52	2,6	3,1	4,9	21	69	83	129	561	0,70
n-2	Services & Government (without Transport)	256	504	12	10,2	2,1	33	3.010	2.601	550	8.425	1,3
n-2	Transport Services	14	27	16	31	601	22	228	428	8.357	306	31
n-3	Energy & Mining	3,7	7,2	470	765	19	76	1.727	2.812	69	281	26
n-3	Food and Tabacco	8,4	17	49	91	3,8	30	416	769	32	249	7,6
n-3	Textile and Leather	4,1	8	19	25	1,5	14	76	101	6	58	5,3
n-3	Wood and Wood Products	1,9	3,7	46	134	4,5	17	87	249	8,4	33	15
n-3	Paper, Pulp and Print	2,4	4,8	172	402	3,1	36	421	982	8	88	24
n-3	Chemical and Petrochemical	3,0	5,8	220	497	6	79	650	1.472	19	233	14
n-3	Non-Metallic Minerals	2,2	4,3	111	528	13	30	241	1.152	29	65	28
n-3	Basic Metals	1,8	3,5	356	1.040	5,7	44	636	1.857	10	79	45
n-3	Machinery	16	31	27	21	1,5	37	422	330	23	588	2,5
n-3	Transport Equipment	5,4	11	36	27	2,6	50	192	145	14	266	2,5
n-3	Non-Specified Industry (Rubber, Plastic products, Forniture & others)	6,6	13	51	50	18	25	340	329	119	168	8

Annex 4. Presentation slides of "Towards an online energy performance calculator in support to policy scenarios"





Deliverables completed and ongoing

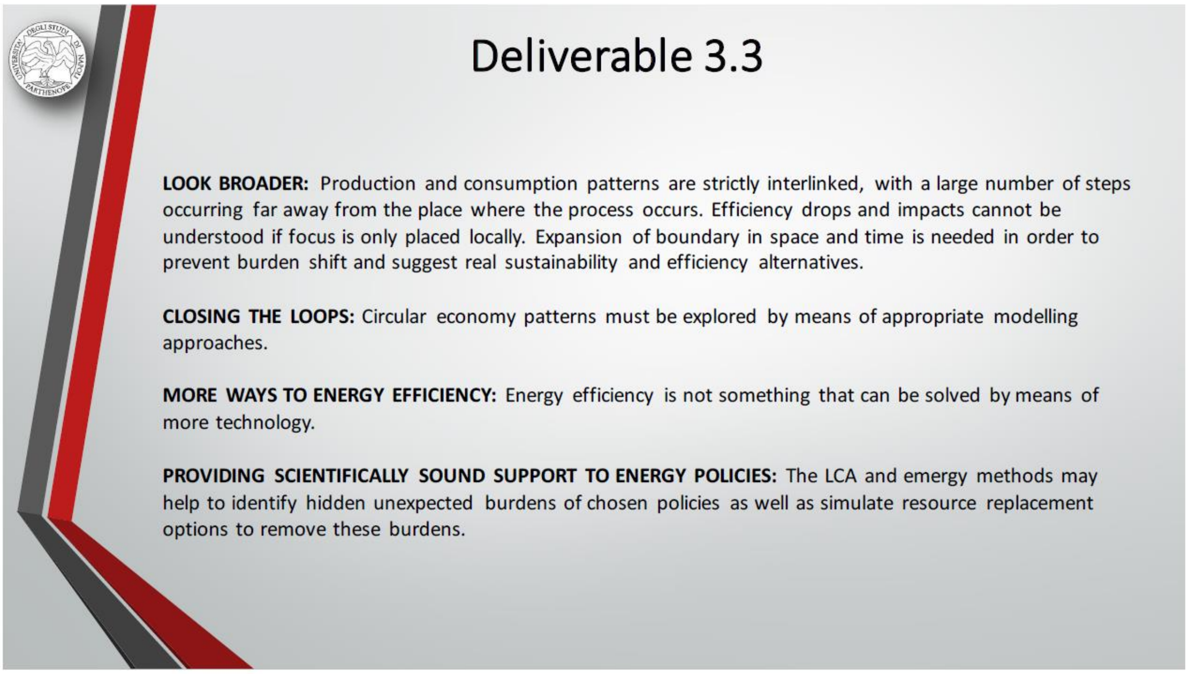
December 2016 — **D3.1:** "Regional case studies of energy efficiency in Europe. Analysis of energy efficiency barriers at the regional levels"

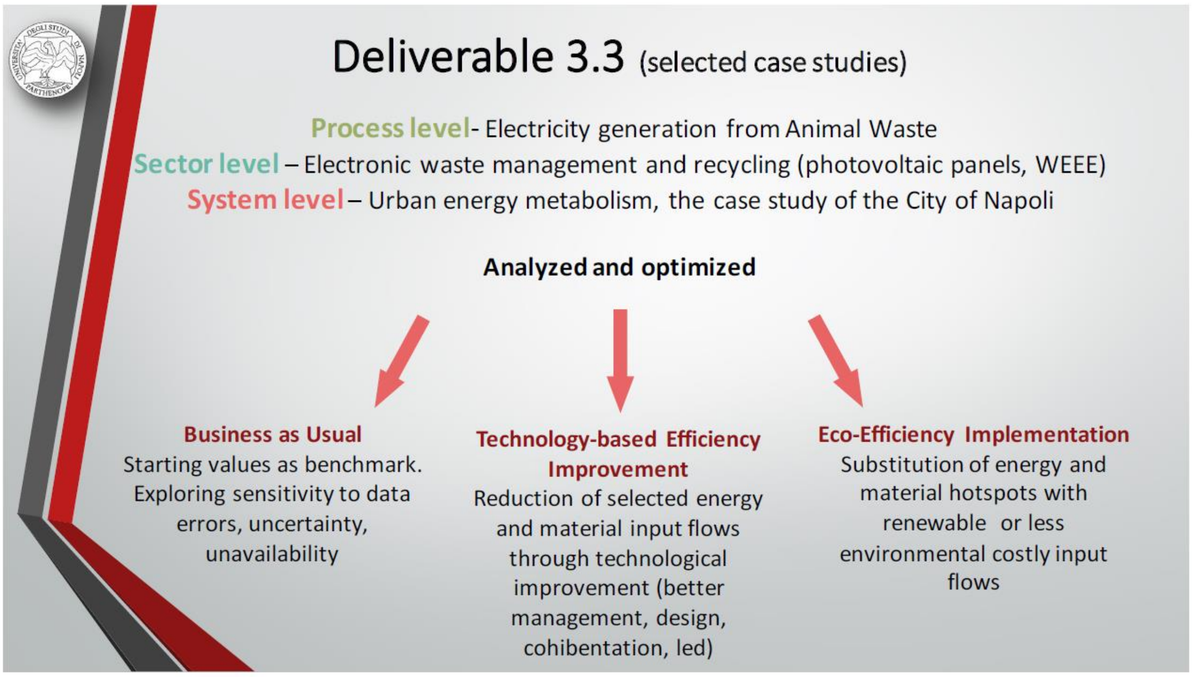
September 2017 — **D3.2: "**Report on costs of solutions, initial findings and work in progress"

June 2018 — **D3.3:** "Report. Assessment of costs and benefits of energy efficiency solutions"

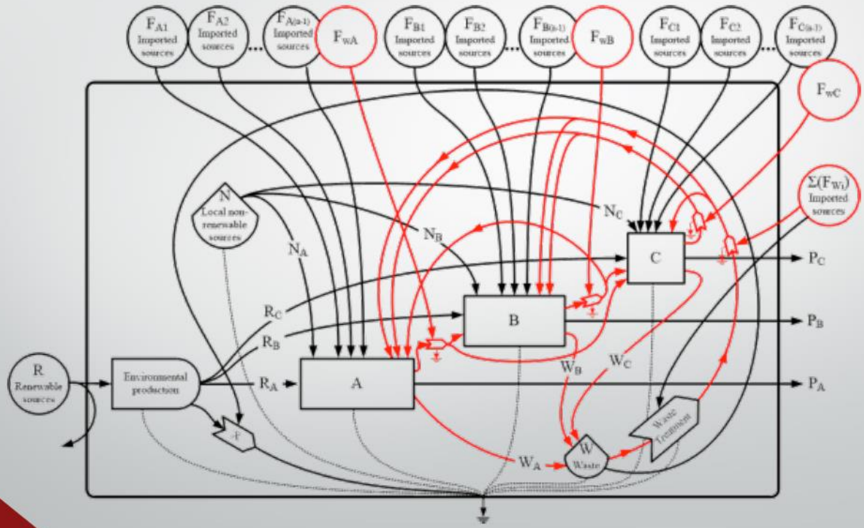
November 2018 — **D3.4:** "Report. Standardization and integration of assessment methods focused on energy efficiency"

Deliverables 3.3 and 3.4

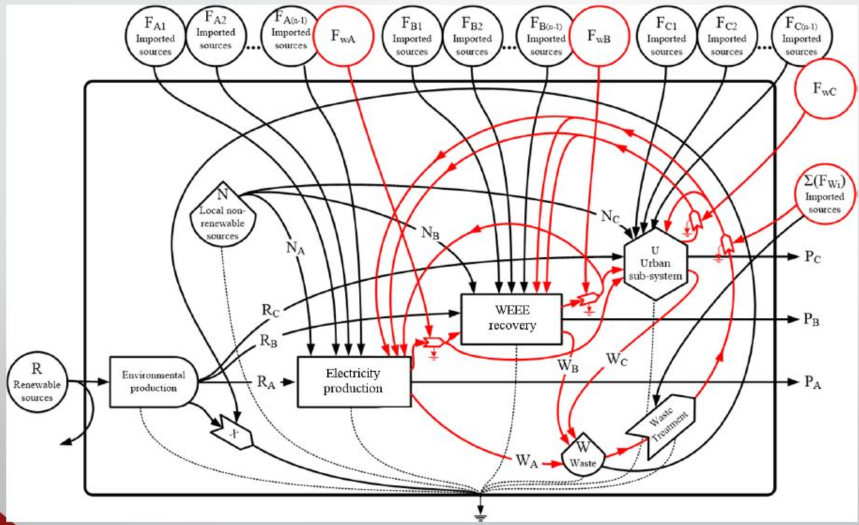

Deliverable 3.3
LOOK BROADER: Production and consumption patterns are strictly interlinked, with a large number of steps occurring far away from the place where the process occurs. Efficiency drops and impacts cannot be understood if focus is only placed locally. Expansion of boundary in space and time is needed in order to prevent burden shift and suggest real sustainability and efficiency alternatives.
CLOSING THE LOOPS: Circular economy patterns must be explored by means of appropriate modelling approaches.
MORE WAYS TO ENERGY EFFICIENCY: Energy efficiency is not something that can be solved by means of more technology.
PROVIDING SCIENTIFICALLY SOUND SUPPORT TO ENERGY POLICIES: The LCA and emergy methods may help to identify hidden unexpected burdens of chosen policies as well as simulate resource replacement options to remove these burdens.

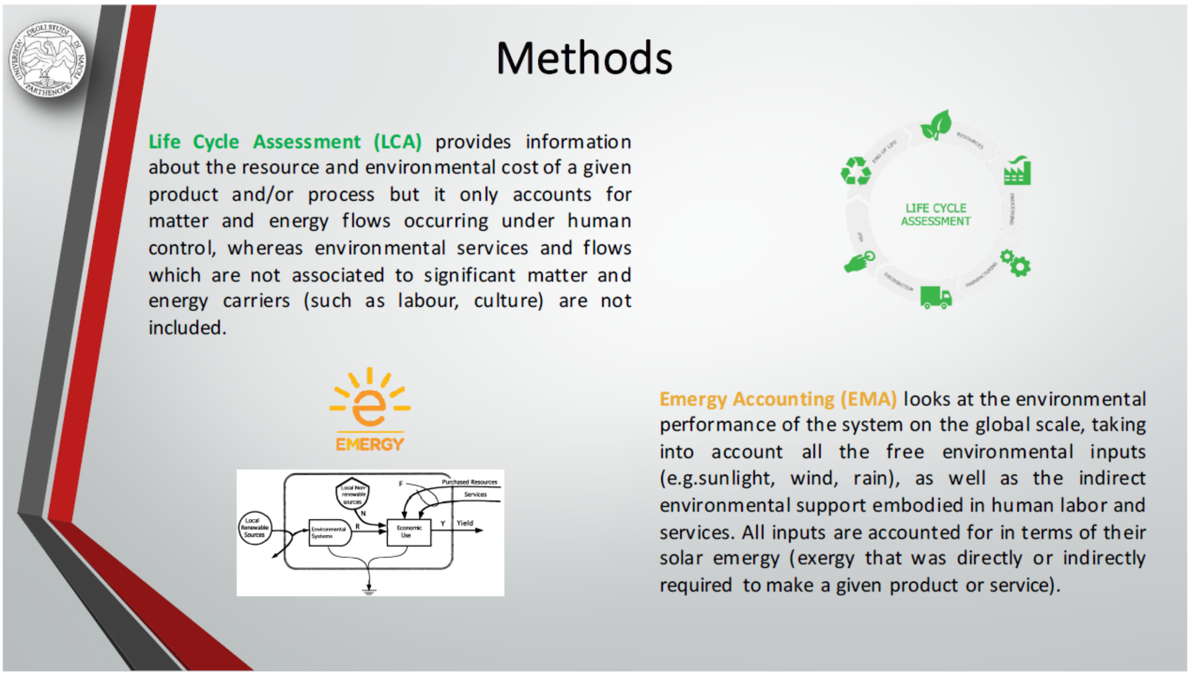

Deliverable 3.3 (selected case studies)
Process level- Electricity generation from Animal Waste
Sector level – Electronic waste management and recycling (photovoltaic panels, WEEE)
System level – Urban energy metabolism, the case study of the City of Napoli
Analyzed and optimized
Business as Usual
Starting values as benchmark. Exploring sensitivity to data errors, uncertainty, unavailability
Technology-based Efficiency Improvement
Reduction of selected energy and material input flows through technological improvement (better management, design, cohibentation, led)
Eco-Efficiency Implementation
Substitution of energy and material hotspots with renewable or less environmental costly input flows

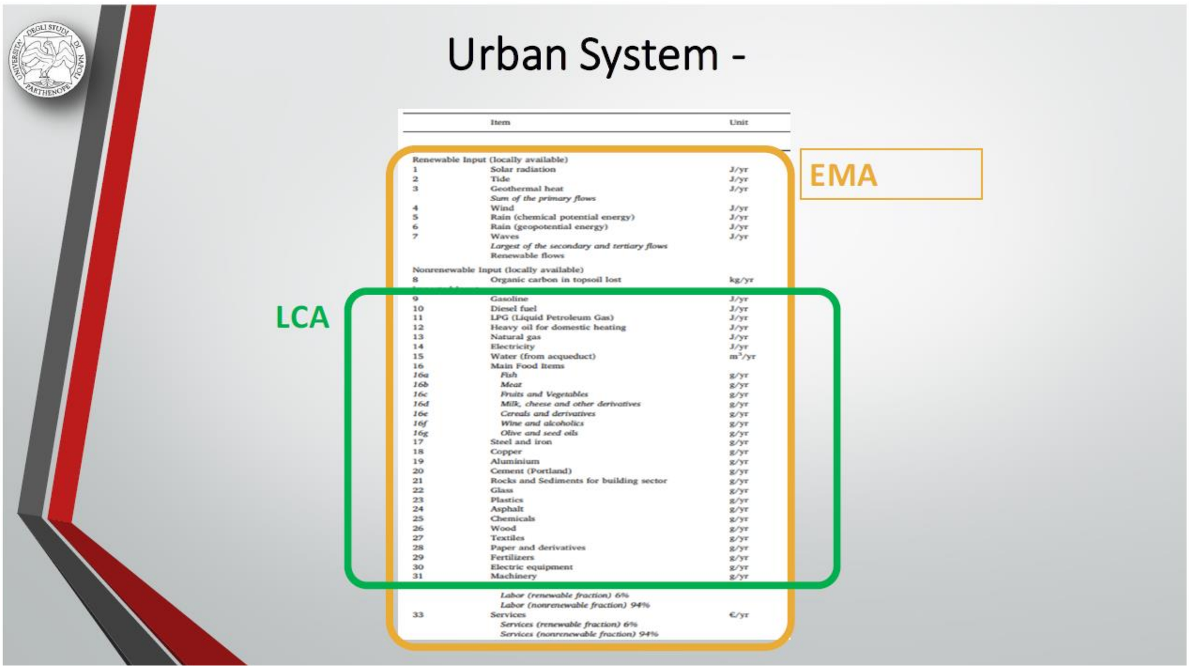
System Model



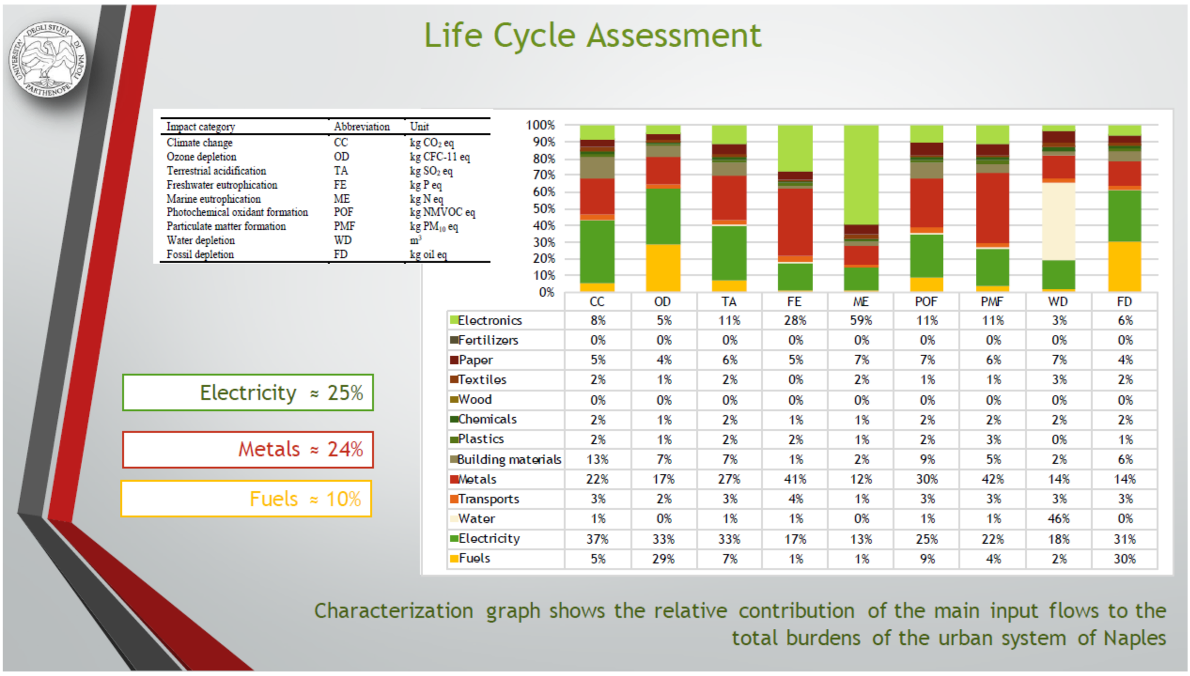
Urban System- City of Napoli

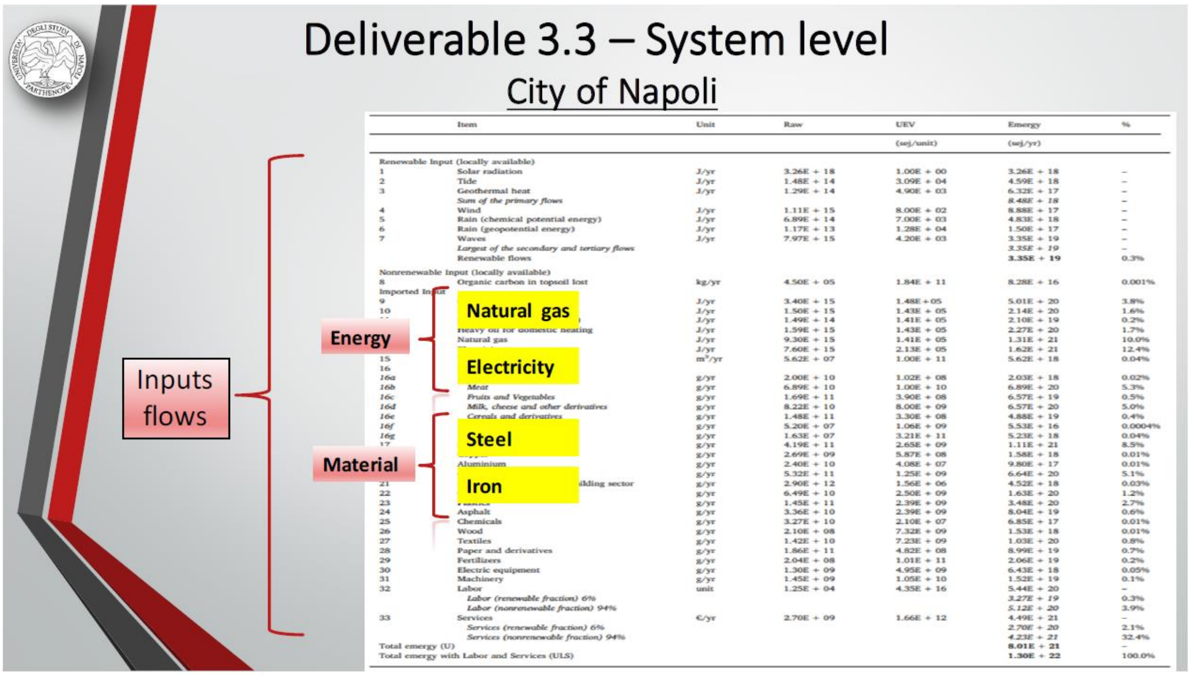


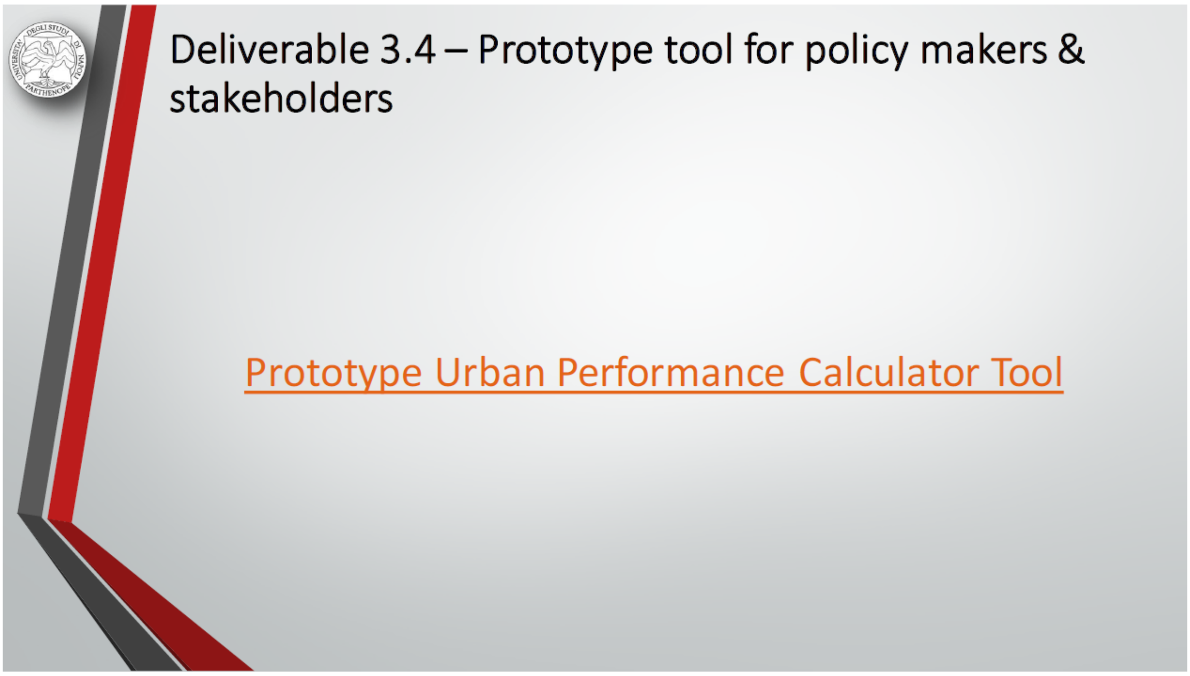




	Item	Unit
Renewable Input (locally available)		
1	Solar radiation	J/yr
2	Tide	J/yr
3	Geothermal heat	J/yr
	Sum of the primary flows	
4	Wind	J/yr
5	Rain (chemical potential energy)	J/yr
6	Rain (geopotential energy)	J/yr
7	Waves	J/yr
	Largest of the secondary and tertiary flows	
	Renewable flows	
Nonrenewable Input (locally available)		
8	Organic carbon in topsoil lost	kg/yr
9	Gasoline	J/yr
10	Diesel fuel	J/yr
11	LPG (Liquid Petroleum Gas)	J/yr
12	Heavy oil for domestic heating	J/yr
13	Natural gas	J/yr
14	Electricity	J/yr
15	Water (from acqueduct)	m^3/yr
16	Main Food Items	
16a	*Fish*	g/yr
16b	*Meat*	g/yr
16c	*Fruits and Vegetables*	g/yr
16d	*Milk, cheese and other derivatives*	g/yr
16e	*Cereals and derivatives*	g/yr
16f	*Wine and alcoholics*	g/yr
16g	*Olive and seed oils*	g/yr
17	Steel and iron	g/yr
18	Copper	g/yr
19	Aluminium	g/yr
20	Cement (Portland)	g/yr
21	Rocks and Sediments for building sector	g/yr
22	Glass	g/yr
23	Plastics	g/yr
24	Asphalt	g/yr
25	Chemicals	g/yr
26	Wood	g/yr
27	Textiles	g/yr
28	Paper and derivatives	g/yr
29	Fertilizers	g/yr
30	Electric equipment	g/yr
31	Machinery	g/yr
	Labor (renewable fraction) 6%	
	Labor (nonrenewable fraction) 94%	
33	Services	€/yr
	Services (renewable fraction) 6%	
	Services (nonrenewable fraction) 94%	


Life Cycle Assessment
Impact category | Abbreviation | Unit
Climate change | CC | kg CO2 eq
Ozone depletion | OD | kg CFC-11 eq
Terrestrial acidification | TA | kg SO2 eq
Freshwater eutrophication | FE | kg P eq
Marine eutrophication | ME | kg N eq
Photochemical oxidant formation | POF | kg NMVOC eq
Particulate matter formation | PMF | kg PM10 eq
Water depletion | WD | m3
Fossil depletion | FD | kg oil eq
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
CC OD TA FE ME POF PMF WD FD
Electronics 8% 5% 11% 28% 59% 11% 11% 3% 6%
Fertilizers 0% 0% 0% 0% 0% 0% 0% 0% 0%
Paper 5% 4% 6% 5% 7% 7% 6% 7% 4%
Textiles 2% 1% 2% 0% 2% 1% 1% 3% 2%
Wood 0% 0% 0% 0% 0% 0% 0% 0% 0%
Chemicals 2% 1% 2% 1% 1% 2% 2% 2% 2%
Plastics 2% 1% 2% 2% 1% 2% 3% 0% 1%
Building materials 13% 7% 7% 1% 2% 9% 5% 2% 6%
Metals 22% 17% 27% 41% 12% 30% 42% 14% 14%
Transports 3% 2% 3% 4% 1% 3% 3% 3% 3%
Water 1% 0% 1% 1% 0% 1% 1% 46% 0%
Electricity 37% 33% 33% 17% 13% 25% 22% 18% 31%
Fuels 5% 29% 7% 1% 1% 9% 4% 2% 30%
Electricity ≈ 25%
Metals ≈ 24%
Fuels ≈ 10%
Characterization graph shows the relative contribution of the main input flows to the total burdens of the urban system of Naples


Deliverable 3.3 – System level
City of Napoli
Inputs flows
Energy
Material
Natural gas
Electricity
Steel
Iron


Deliverable 3.4 – Prototype tool for policy makers & stakeholders
Prototype Urban Performance Calculator Tool

Urban Performance Calculator

Naples case study

The Urban Performance Calculator Prototype Tool is based on the integration of LCA (Life Cycle Assessment) and EMA (EMergy Accounting) methods suggested as a useful support to the stakeholders and policy makers discussion and decision processes

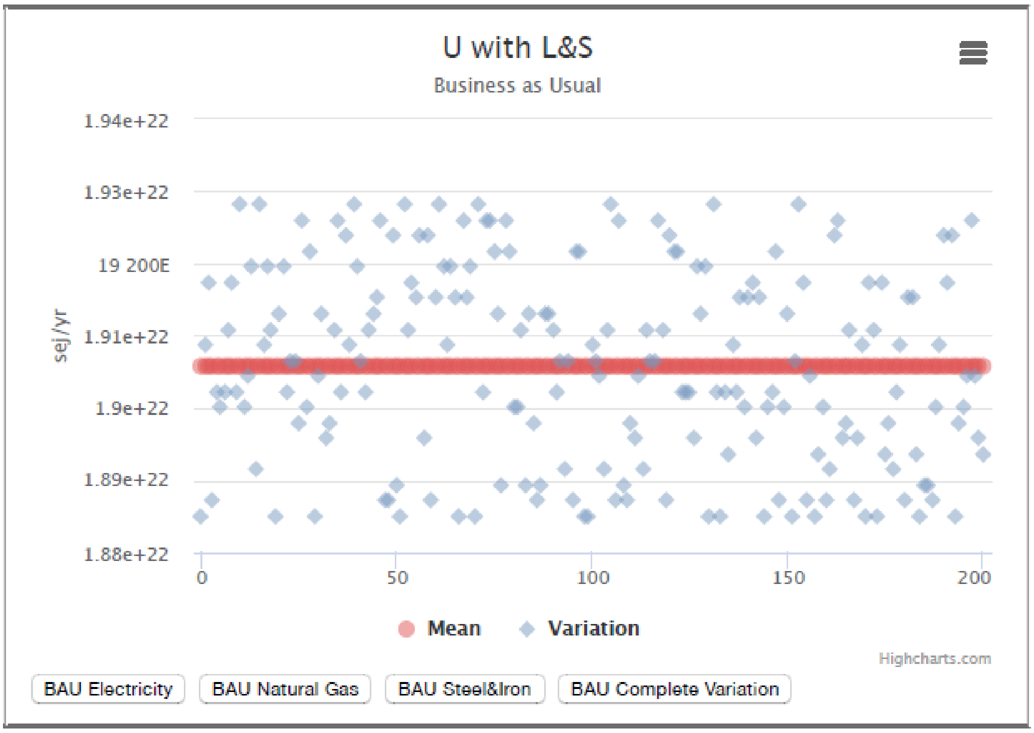
The hot-spot inputs identified by means of LCA method within the Naples case study are:

1) Electricity; 2) Natural Gas; 3) Steel & Iron.

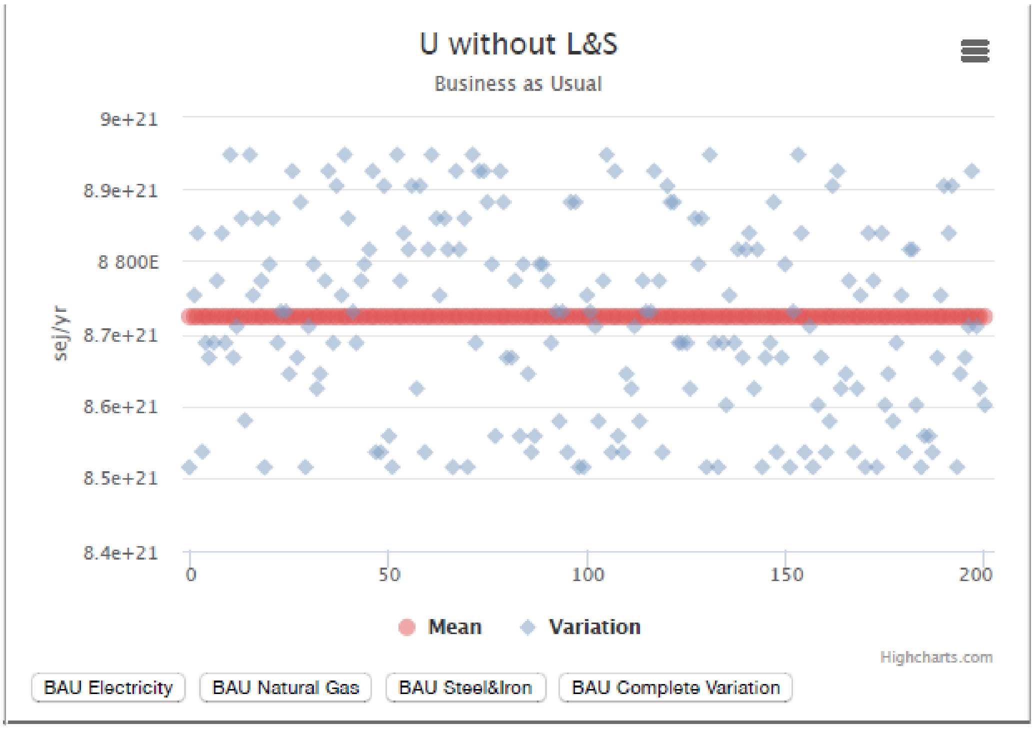
Total Emergy (U) values for i) Business As Usual, ii) EcoEfficiency Implementation, iii) Technology-based Efficiency Improvement scenarios are shown, with and without Labor and Services (L&S)

Business as Usual

Variation between -10% and +10% of selected hot-spots



Urban Performance Calculator 10/4/18, 14:03

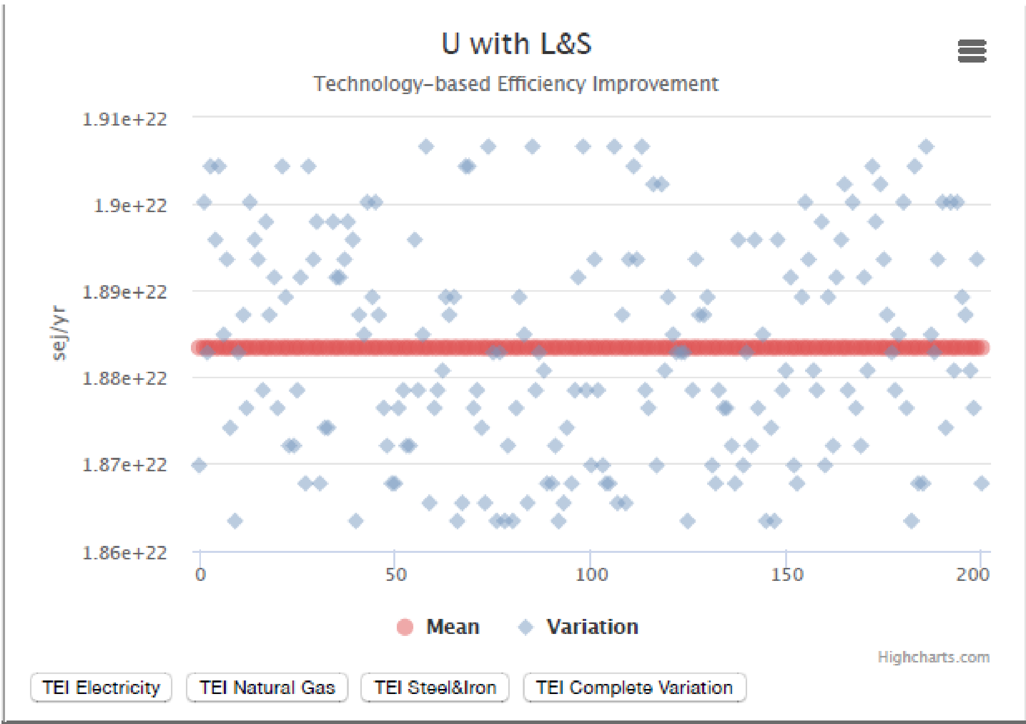


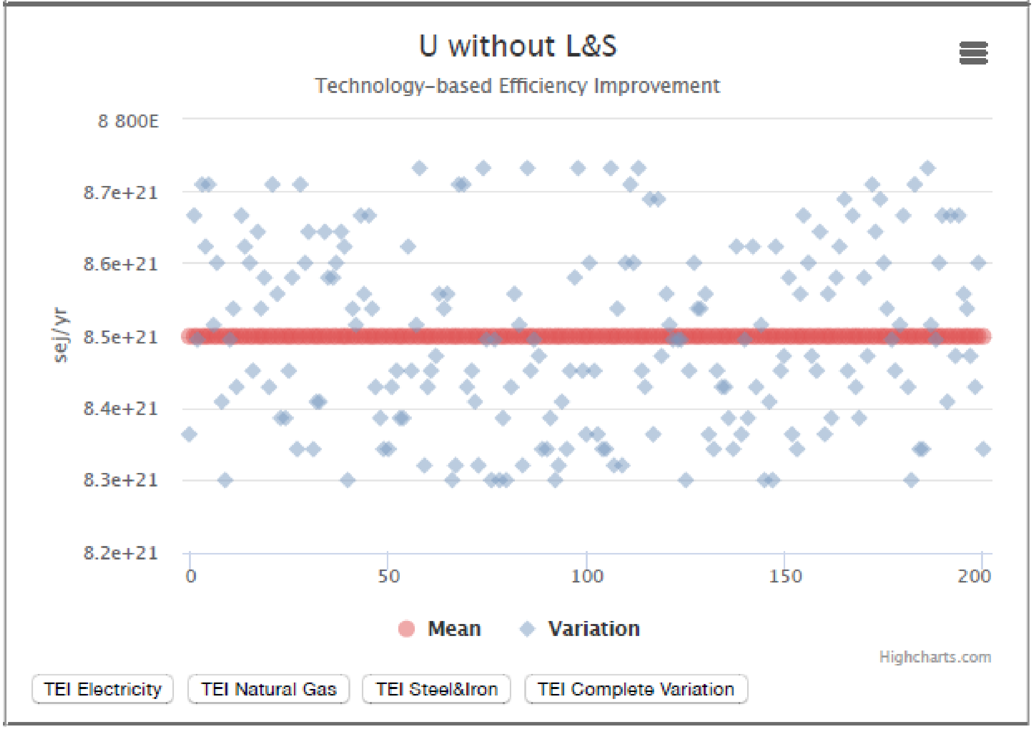
- **BAU Electricity**: Variation of U resulting from variation of Electricity input
- **BAU Natural Gas**: Variation of U resulting from variation of Natural Gas input
- **BAU Steel&Iron**: Variation of U resulting from variation of Steel and Iron input
- **BAU Complete Variation**: Variation of U resulting from variation of all hot-spots

Technology-based Efficiency Improvement

Variation between -20% and 0% of selected hot-spots, resulting from a more efficient use of resources

file:///Sergio/European%20Union%20e%20altri%20progetti/2014%20...20Bruxelles%20Calculator/Urban%20Performance%20Calculator.html Page 2 of 5



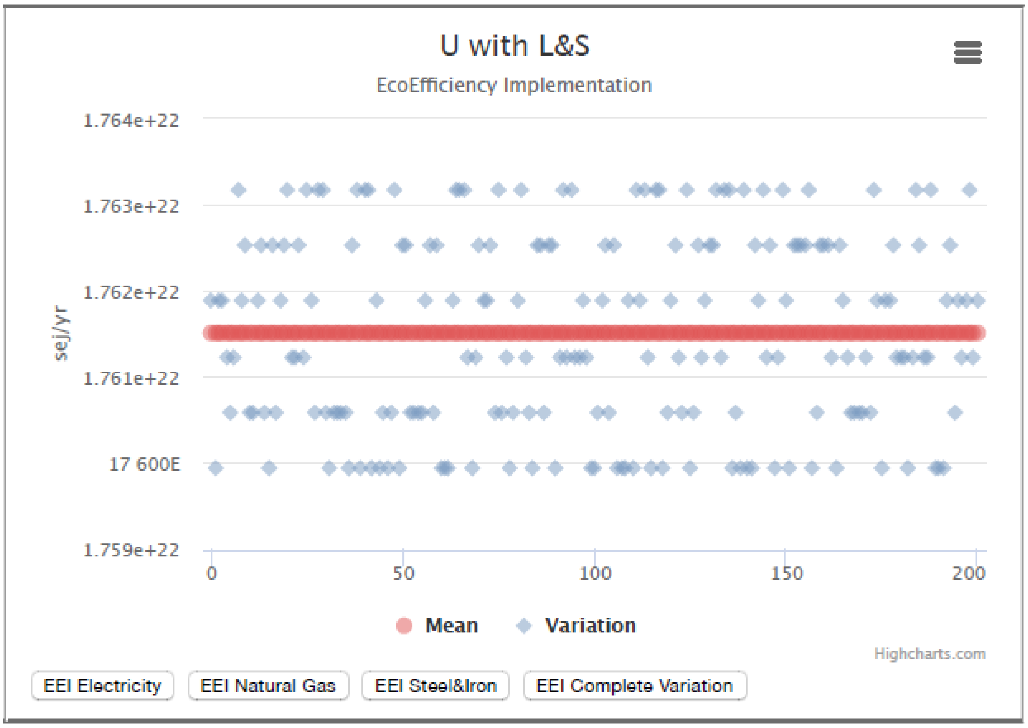


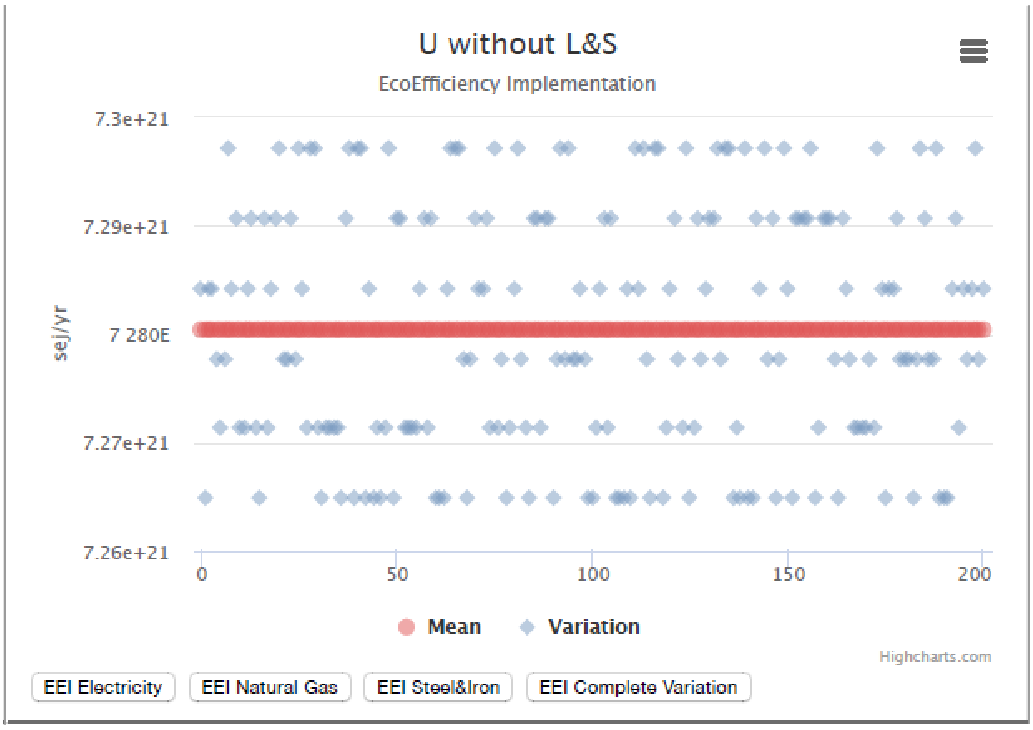
- **TEI Electricity**: Variation of U resulting from variation of Electricity input
- **TEI Natural Gas**: Variation of U resulting from variation of Natural Gas input
- **TEI Steel&Iron**: Variation of U resulting from variation of Steel and Iron input

- **TEI Complete Variation**: Variation of U resulting from variation of all hot-spots

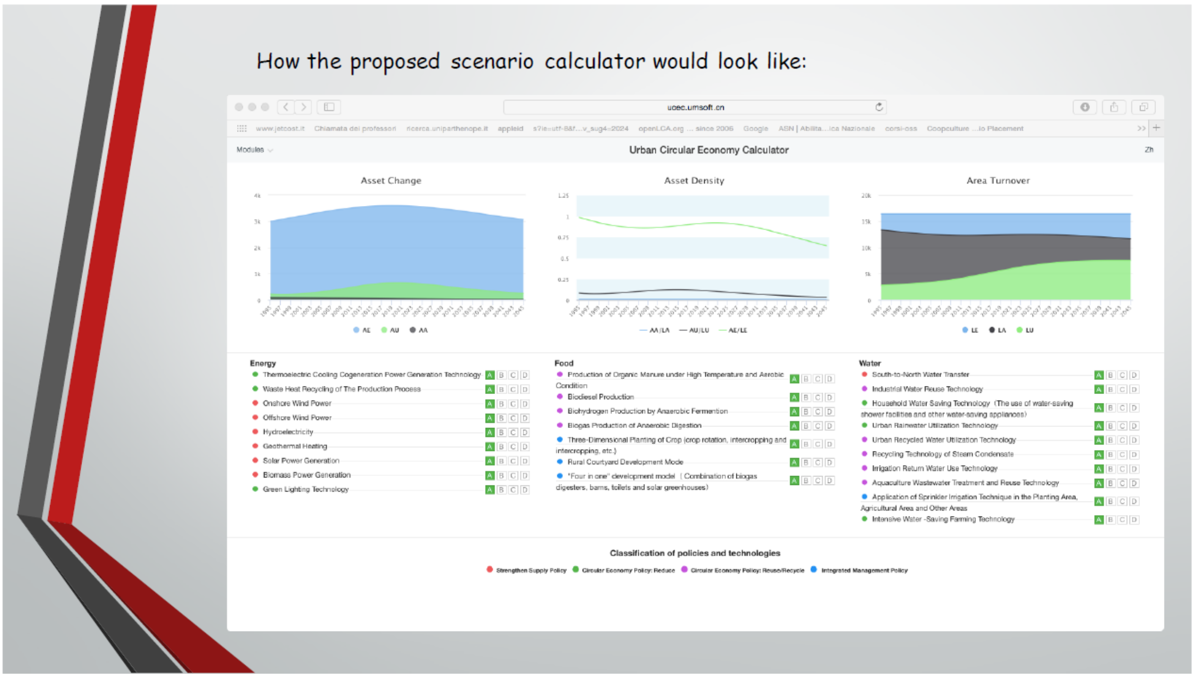
EcoEfficiency Implementation

Variation between -10% and -5% of selected hot-spots





- **EEI Electricity**: Variation of U resulting from variation of Electricity input
- **EEI Natural Gas**: Variation of U resulting from variation of Natural Gas input
- **EEI Steel&Iron**: Variation of U resulting from variation of Steel and Iron input
- **EEI Complete Variation**: Variation of U resulting from variation of all hot-spots


How the proposed scenario calculator would look like:
uoec.umsoft.cn
Urban Circular Economy Calculator
Asset Change
AE AU AA
Asset Density
AA/LA AU/LU AE/LE
Area Turnover
LE LA LU
Energy
Thermoelectric Cooling Cogeneration Power Generation Technology
Waste Heat Recycling of The Production Process
Onshore Wind Power
Offshore Wind Power
Hydroelectricity
Geothermal Heating
Solar Power Generation
Biomass Power Generation
Green Lighting Technology
Food
Production of Organic Manure under High Temperature and Aerobic Condition
Biodiesel Production
Biohydrogen Production by Anaerobic Fermention
Biogas Production of Anaerobic Digestion
Three-Dimensional Planting of Crop (crop rotation, intercropping and intercropping, etc.)
Rural Courtyard Development Mode
"Four in one" development model (Combination of biogas digesters, barns, toilets and solar greenhouses)
Water
South-to-North Water Transfer
Industrial Water Reuse Technology
Household Water Saving Technology (The use of water-saving shower facilities and other water-saving appliances)
Urban Rainwater Utilization Technology
Urban Recycled Water Utilization Technology
Recycling Technology of Steam Condensate
Irrigation Return Water Use Technology
Aquaculture Wastewater Treatment and Reuse Technology
Application of Sprinkler Irrigation Technique in the Planting Area, Agricultural Area and Other Areas
Intensive Water -Saving Farming Technology
Classification of policies and technologies
Strengthen Supply Policy
Circular Economy Policy: Reduce
Circular Economy Policy: Reuse/Recycle
Integrated Management Policy


Dissemination activities

Conferences & Workshops

"Global Cleaner Production & Sustainable Consumption Conference", 1-4 November 2015, Sitges (Spain)

"World Environmental Accounting Summit", 4-6 July 2016, Beijing (China)

9th Biennal Emergy Research Conference, 7-9 January 2016, Gainesville (Florida)

10th Biennal Emergy Research Conference, 24-27 January 2018, Gainesville (Florida)

9th Biennal International Workshop "Advances in Energy Studies", 4-7 May 2015, Stockholm (Sweden)

12th Conference of the European Society for Ecological Economics, 20-23 June 2017, Budapest (Hungary)

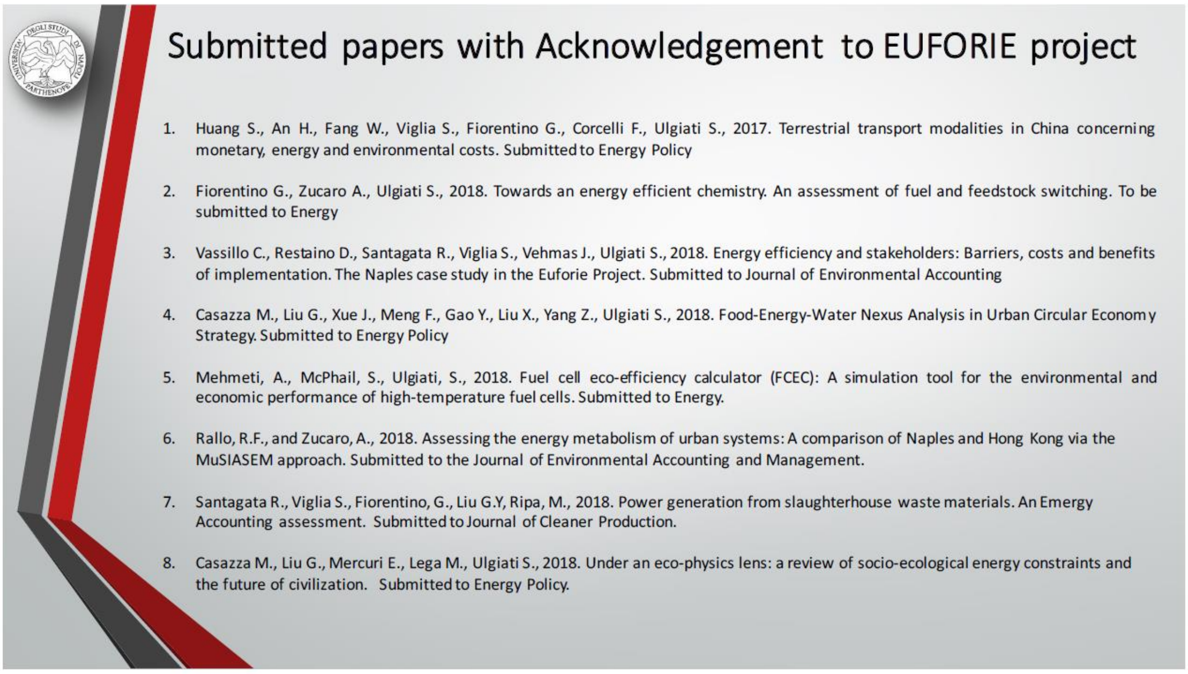
15th Toruń Ecological Seminar, Ecosystems – Structure and Functions, 29-30 June 2017, Toruń (Poland)

10th Biennial International Workshop "Advances in Energy Study". Energy futures, environment and well-being. 25-28 September 2017 Naples (Italy), organized by UNIPARTH team

Energizing Futures Sustainable development and energy in transition – 13-14 June 2018, Tampere (Finland)

Published paper with acknowledgement to EUFORIE project

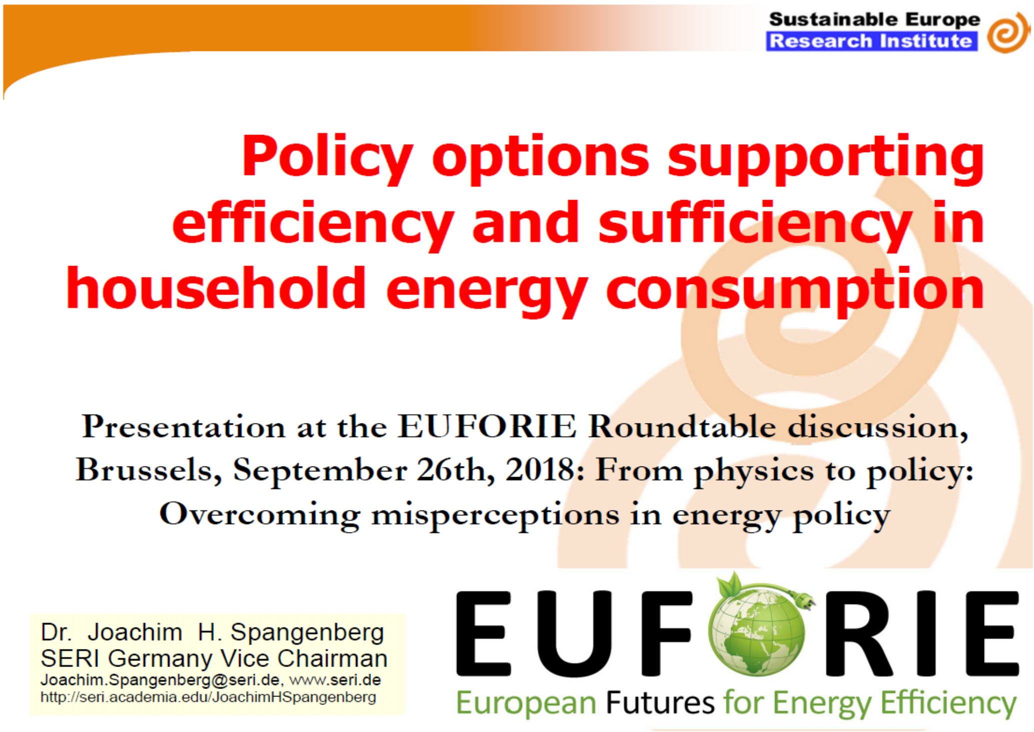
1. Fiorentino G., Ripa M. and Ulgiati S., 2016. Chemicals from biomass: technological versus environmental feasibility. A review. Biofuels, Bioproducts and Biorefining, 11: 195-214.
2. Buonocore E., Mellino S., De Angelis G., Liu G., and Ulgiati S., 2016. Life cycle assessment indicators of urban wastewater and sewage sludge treatment. Ecological Indicators, in press.
3. Santagata R. , Ripa M. , Ulgiati S. , 2017. An environmental assessment of electricity production from slaughterhouse residues. Linking urban, industrial and waste management systems". Applied Energy, 186(2): 175-188.
4. Ripa M. , Fiorentino G. , Vacca V. , Ulgiati S. , 2017. The relevance of site-specific data in Life Cycle Assessment (LCA). The case of the municipal solid waste management in the metropolitan city of Naples (Italy). Journal of Cleaner Production, 142(1): 445-460.
5. Puca A., Carrano M., Liu G., Musella D., Ripa M., Viglia S., Ulgiati S., 2017. Energy and eMergy assessment of the production and operation of a personal computer. Resources, Conservation and Recycling, 116: 124-136.
6. Corcelli F., Ripa M., Leccisi E., Cigolotti V., Fiandra V., Graditi G., Sannino L., Tammaro M., Ulgiati S., 2016. Sustainable urban electricity supply chain – Indicators of material recovery and energy savings from crystalline silicon photovoltaic panels end-of-life. Ecological Indicators, in press.
7. Ghisellini P. and Casazza M., 2016. Evaluating the energy sustainability of urban agriculture towards more resilient urban systems. Journal of Environmental Accounting and Management, 2016, 4(2): 175-193.
8. Casazza M., Liu G., Ulgiati S., 2016. The Tenth Planetary Boundary: To What Extent Energy Constraints Matter. Journal of Environmental Accounting and Management 4(4): 399-411.
9. Tian X., Geng Y., Ulgiati S., 2017. An emergy and decomposition assessment of China-Japan trade: Driving forces and environmental imbalance. Journal of Cleaner Production 141: 359-369.
10. Geng Y., Tian X., Sarkis J., Ulgiati S., 2017. China-USA Trade: Indicators for Equitable and Environmentally Balanced Resource Exchange. Ecological Economics 132: 245–254
11. Viglia S., Civitillo D.F., Cacciapuoti G., Ulgiati S., 2017. Indicators of environmental loading and sustainability of urban systems. An emergy-based environmental footprint. Ecol. Indic., in press.
12. Corcelli F. , Ripa M. , Ulgiati S., 2017. End-of-life treatment of crystalline silicon photovoltaic panels. An emergy-based case study. Journal of Cleaner Production, 161: 1129-1142.
13. Corcelli F., Ripa M., Ulgiati S., 2018. Efficiency and sustainability indicators for papermaking from virgin pulp – An emergy-based case study. Resour. Conserv. Recycl. 131, 313–328.
14. Ghisellini P., Ripa M., Ulgiati S., 2017. Exploring environmental and economic costs and benefits of a circular economy approach to the construction and demolition sector. A review. Journal Cleaner Production, 178:618-643.
15. Corcelli, F., Fiorentino, G., Vehmas, J., Ulgiati, S., 2018. Energy efficiency and environmental assessment of papermaking from chemical pulp - A Finland case study. J. Clean. Prod. 198, 96–111. doi:10.1016/j.jclepro.2018.07.018
16. Xue, J.Y., Liu, G.Y., Casazza, M., Ulgiati, S., 2018. Development of an Urban FEW nexus online analyzer to support urban circular economy strategy planning. Energy 164, 475-495
17. Huang S., An H., Fang W., Viglia S., Fiorentino G., Corcelli F., Ulgiati S., 2018. Terrestrial transport modalities in China concerning monetary, energy and environmental costs. Energy Policy, 122, 129-141.

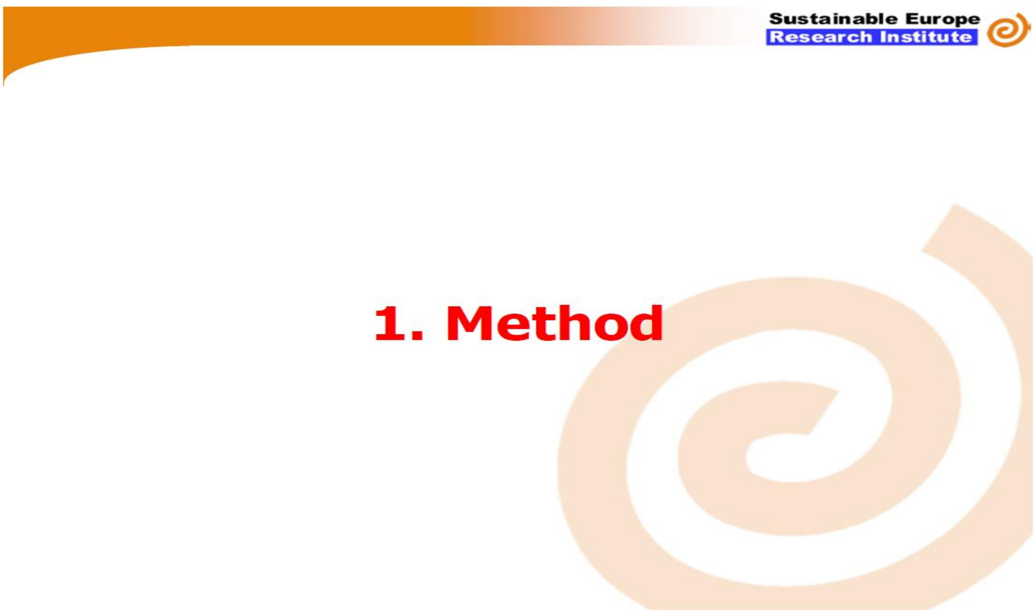


Submitted papers with Acknowledgement to EUFORIE project

1. Huang S., An H., Fang W., Viglia S., Fiorentino G., Corcelli F., Ulgiati S., 2017. Terrestrial transport modalities in China concerning monetary, energy and environmental costs. Submitted to Energy Policy
2. Fiorentino G., Zucaro A., Ulgiati S., 2018. Towards an energy efficient chemistry. An assessment of fuel and feedstock switching. To be submitted to Energy
3. Vassillo C., Restaino D., Santagata R., Viglia S., Vehmas J., Ulgiati S., 2018. Energy efficiency and stakeholders: Barriers, costs and benefits of implementation. The Naples case study in the Euforie Project. Submitted to Journal of Environmental Accounting
4. Casazza M., Liu G., Xue J., Meng F., Gao Y., Liu X., Yang Z., Ulgiati S., 2018. Food-Energy-Water Nexus Analysis in Urban Circular Economy Strategy. Submitted to Energy Policy
5. Mehmeti, A., McPhail, S., Ulgiati, S., 2018. Fuel cell eco-efficiency calculator (FCEC): A simulation tool for the environmental and economic performance of high-temperature fuel cells. Submitted to Energy.
6. Rallo, R.F., and Zucaro, A., 2018. Assessing the energy metabolism of urban systems: A comparison of Naples and Hong Kong via the MuSIASEM approach. Submitted to the Journal of Environmental Accounting and Management.
7. Santagata R., Viglia S., Fiorentino, G., Liu G.Y, Ripa, M., 2018. Power generation from slaughterhouse waste materials. An Emergy Accounting assessment. Submitted to Journal of Cleaner Production.
8. Casazza M., Liu G., Mercuri E., Lega M., Ulgiati S., 2018. Under an eco-physics lens: a review of socio-ecological energy constraints and the future of civilization. Submitted to Energy Policy.

Annex 5. Presentation slides of “Policy options for supporting efficiency and sufficiency of household energy consumption”





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Data sources and method

This presentation draws on five case studies from Finland, Italy, Hungary, Spain, UK, and identifies some policies stimulating investments in energy efficiency in the residential sector.

The core method of analysis consists of screening them for policy instruments addressing six criteria, considering those which do as promising instruments and, in combination, as promising instrument mixes.

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The six criteria

To minimise energy consumption while maintaining a good supply of energy services, a building must be

1. built in a heat conservation and appropriation supporting way, based on local or regional planning (governance);
2. capable of keeping heat within the building envelope, by means of isolated walls and roofs, adequate windows, doors and shutters;
3. equipped with service providing installations requiring only low inputs;
4. offering energy security; as standard heat storage tanks offer supply for about 2 hours per m^3 of storage, external supply or in-house fuel storage must be available;
5. used accordingly, which required adequate behaviour based on relevant knowledge, motivation and skills (management);
6. part of an efficiency enhancing energy supply system.

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About the six criteria

- The first three criteria primarily address the physical characteristics of the building in question, and since based on physics, they are the same throughout the European Union.
- The fourth criterion, although formulated for reasons of service reliability, is similarly phrased in physical terms.
- Criterion five refers to the adequate use of the physical structures, and in our analysis on the information provision for this behalf.
- Finally, the sixth criterion addresses the overall energy supply system in which the households are embedded.

The criteria are formulated on a level general enough to be applicable across the board in Europe.

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2. Why households? Status quo


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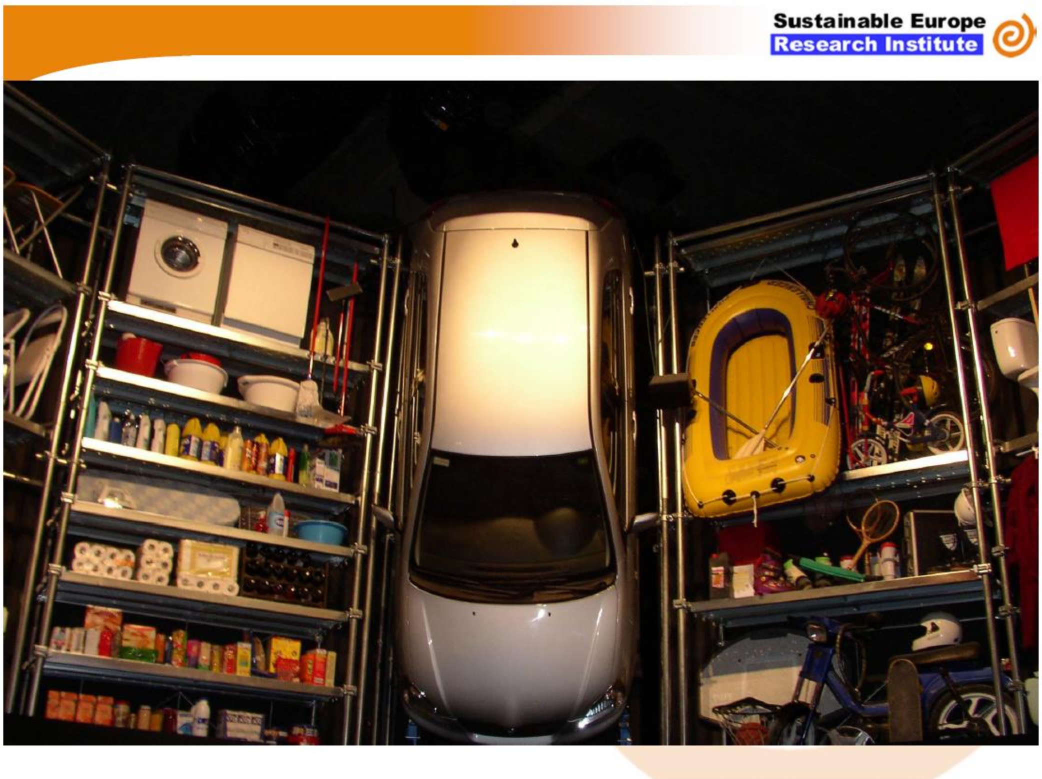
que la família consumeix, cotxe inclòs, feta
How much energy
do we consume?
Lots, lots, lots...
About 37,000 kW per year,
the equivalent of 4,500 W
of permanently illuminated
light bulbs. We would get
the same amount of light with
just 900 W of high-performance
light bulbs, which consume
just 7,400 kW per year.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Why households

The residential sector dominates the demand for low-temperature heat and is significant in electricity demand. It offers the highest cost-efficient potential for mitigation, and is thus vital to meeting the EU objectives for a low-carbon economy and energy system.

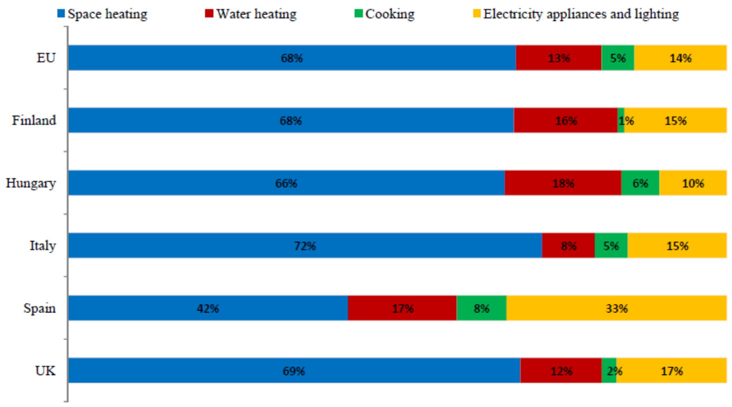
Trends per m² are too slow but positive, trends per dwelling less so.

Country differences are significant.

Status quo

The EU residential energy sector

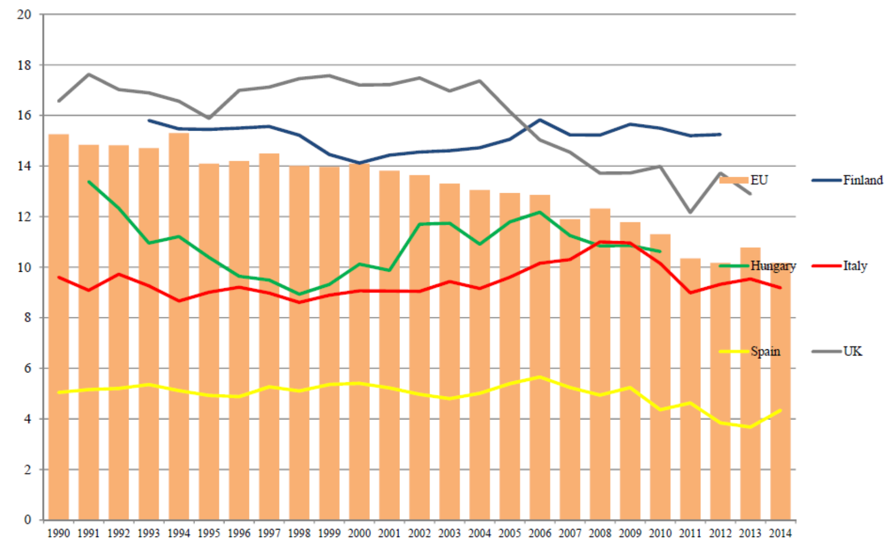
The residential sector accounted for about a quarter of the total final energy consumption in Europe in 2013.



Source: Authors' elaboration based on Odyssee database (2017)
*Data for Hungary are of 2010

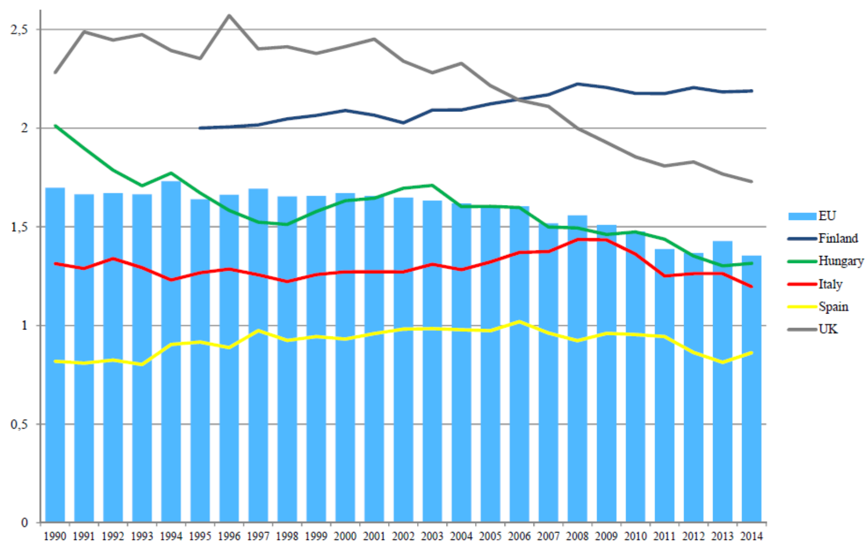
Residential energy consumption by end-use in 2013 for the EU

Status quo



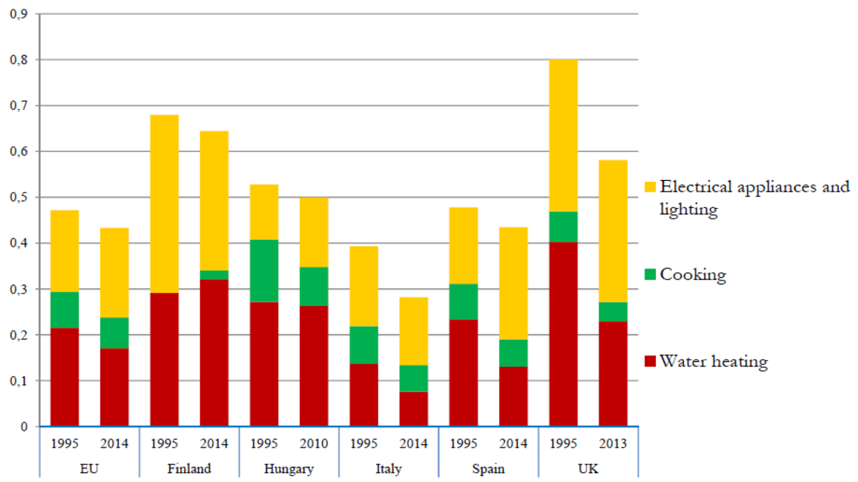
Final residential space heating consumption per floor area 1990-2014 (at normal climate) for the European Union and selected countries [kgoe/m²]

Status quo

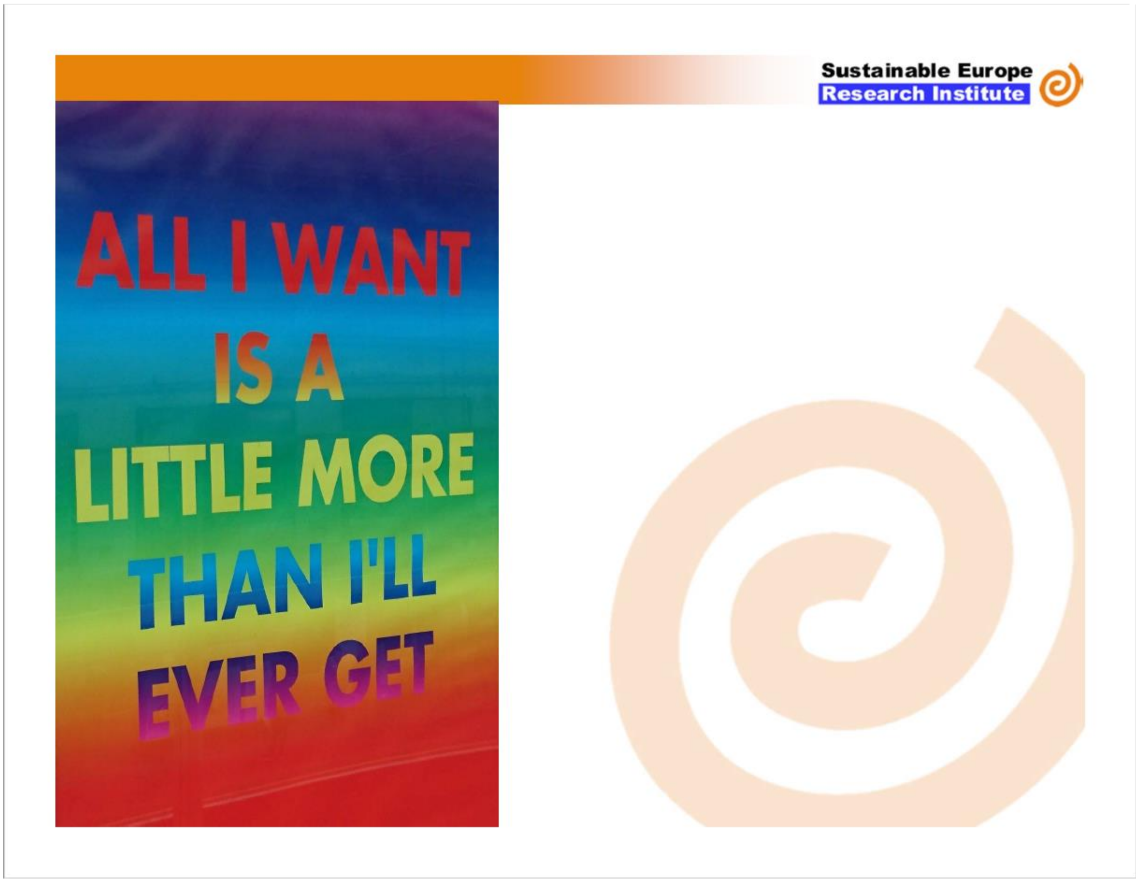


Final residential energy consumption per stock of dwelling permanently occupied 1990-2014 (at normal climate) for the European Union and selected countries [toe/dwellings]

Status quo



Final water heating, cooking, electrical appliances and lighting consumption per stock of dwelling permanently occupied in 1995 and 2014 for the European Union and selected countries [toe/dwellings]



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3. Policy Instruments
a. National Examples

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Caveat

The achievable effect of energy efficiency policies depends *not only on the local or national circumstances and the policy instruments chosen*, but also on the design of the instrument and the process of developing, implementing and adapting it, to degrees varying with the situation.

Policy instruments

	Finland	Hungary	Italy	Spain	UK
Improving the energy performance standards of new and existing buildings	✓ EPBD	✓ EPBD	✓ EPBD	✓ EPBD	✓ EPBD
Financial facilities to encourage private capital investments	✗	The Warmth of the Home Programme	✗	①State Housing Plan ②PAREER-CRECE Programme	✗
Fiscal incentives that indirectly reduce the cost of investments	A general tax reduction for any household services	✗	Tax deductions for the energy upgrading of buildings	✗	✗
Promotion of small-scale renewable energy production systems	✗	✗	①Thermal Account ②Thermal Account 2.0	✗	Domestic Renewable Heat Incentive

Policy instruments

	Finland	Hungary	Italy	Spain	UK
Measures addressing vulnerable consumers and fuel poverty	✗	✗	Social bonus	Social bonus	①Energy Companies Obligation (ECO1, ECO2, ECO3) ②Warm Home Discount
Measures addressing the landlord-tenant problem	✗	✗	Regional Law 13/12/2013	✗	①Landlord's Energy Saving Allowance ②Green Deal Home Improvement Fund ③New Minimum energy efficiency standards
Increasing consumer information and promoting behavioural change	✓ Motiva Completed roll out of Smart meters	✓ NEPECN and Energy and Climate Awareness-Raising Action Plan No Smart meters	✓ Enea Completed roll out of Smart meters	✓ IDEA Roll out of Smart meters by 2018	✓ EST Completed roll out of Smart meters

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Examples of national energy policy

- Motivated by a residential energy sector that appears to be more problematic than other countries (high energy poverty occurrence), the **UK** government has implemented a more balanced set of residential sector energy efficiency policies, with the participation of diverse private actors, compared to what has been done in the last years in Finland, Spain, Italy, and Hungary,
- Improvements of energy efficiency in the residential sector seem to be not a priority for the government of **Finland**. Considering that Finland has the highest energy consumption per capita and the highest space heating demand in Europe, this result is quite surprising. Finland is the only country that didn't decrease its residential energy consumption per stock of dwelling permanently occupied within the period 1995-2014.

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- In **Spain**, where the residential energy sector is one of the most efficient in Europe, major attention has been given to the transport sector that represents about the 40% of the energy consumption while the residential energy sector seems not to be at the top of the political agenda.
- With the Warmth of the Home Programme, the **Hungarian** government provided financial incentives to households ranging from the replacement of inefficient appliances or obsolete facade doors and windows, to complex energetic refurbishment of blocks of flats. When demand significantly surpassed supply, however, the government declared the insufficient funding a sign of success of this policy measure.
- In **Italy**, fiscal incentives and promotion of small-scale renewable energy sources have kept the energy demand per dwelling stable. The tax deduction scheme and the Thermal Account provided effective incentives for renewable energy and energy efficiency investments.

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3. Policy Instruments
b. European Synthesis

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1. **EU policies matter;** they are a **driving force for national policies** in most countries (implementing «the directive, the whole directive and nothing but the directive»)

2. **A longer term policy horizon is needed to create confidence in the private sector that there is money to be made through efficiency**. In fact, getting private investments in energy efficiency in the residential sector is a challenge**. That the cleanest energy is the energy that is not used at all actually points the greatest weakness of efficiency: there appears to be nothing to sell, and thus no profit**. Energy providers cannot easily decouple utility profits from energy volumes and ESCOs cannot benefit from economies of scale by selling energy efficiency solutions to households.

➢ **New business models take time to emerge.**

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Promising Policy Instruments 1

Using an instrument mix, based on effectiveness considerations without ideological bias against specific instruments, with special emphasis on building energy codes has significant effects on the improvement of residential space heating energy efficiency.

Effective instruments include e.g. energy performance standards, minimum thermal insulation standards including glazing and airtightness, and standards for the efficiency of fixed building services such as heating, lighting and controls.

Such regulatory policies have been found to have more impact than financial or informative instruments.

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Energy savings campaigns:
Often focus on irrelevant factors.
Always rational individual decisions.

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Promising Policy Instruments 2

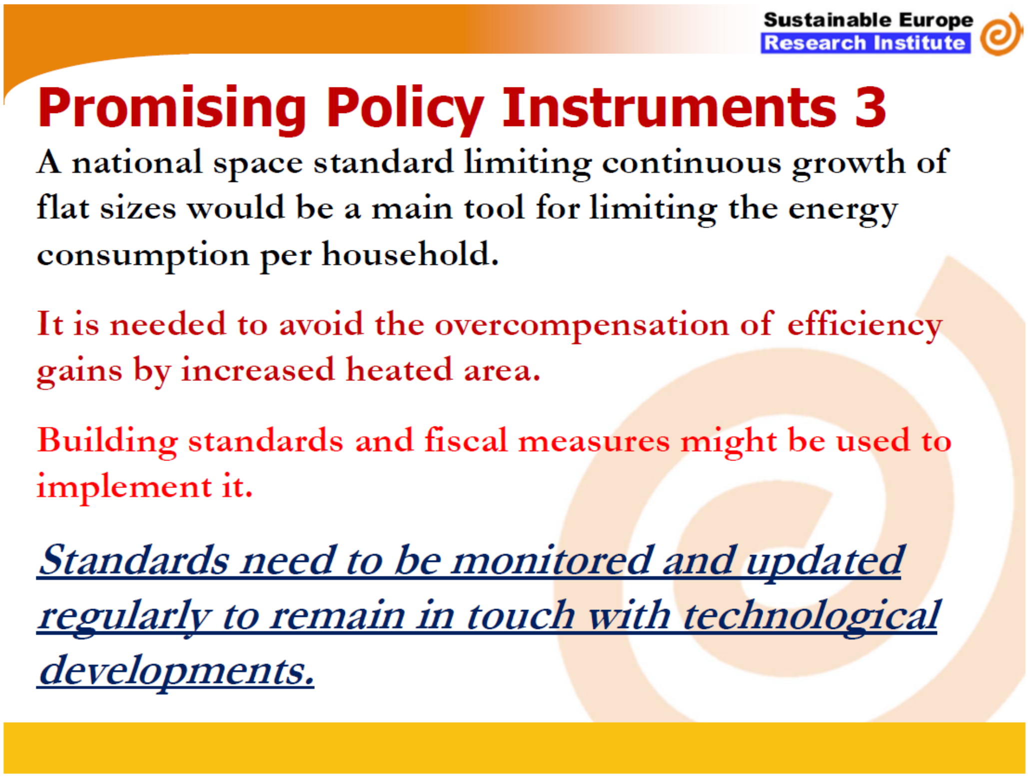
Sufficiently high energy prices - by government or EU intervention in case of too low world market prices - allow for a decent return on energy efficiency investment.

Social vulnerabilities need to be taken into account.

Using energy efficiency to enable lower energy prices for households and industry (Romania), pursuing the reduction of energy cost (Finland) and considering energy price a matter of competitiveness (Hungary) generates incentives for more energy consumption and is counterproductive.

Economic incentives can be effective, but carry the risk of regressive effects.

Promising savings is programming rebounds. Sufficiency is making efficiency effective.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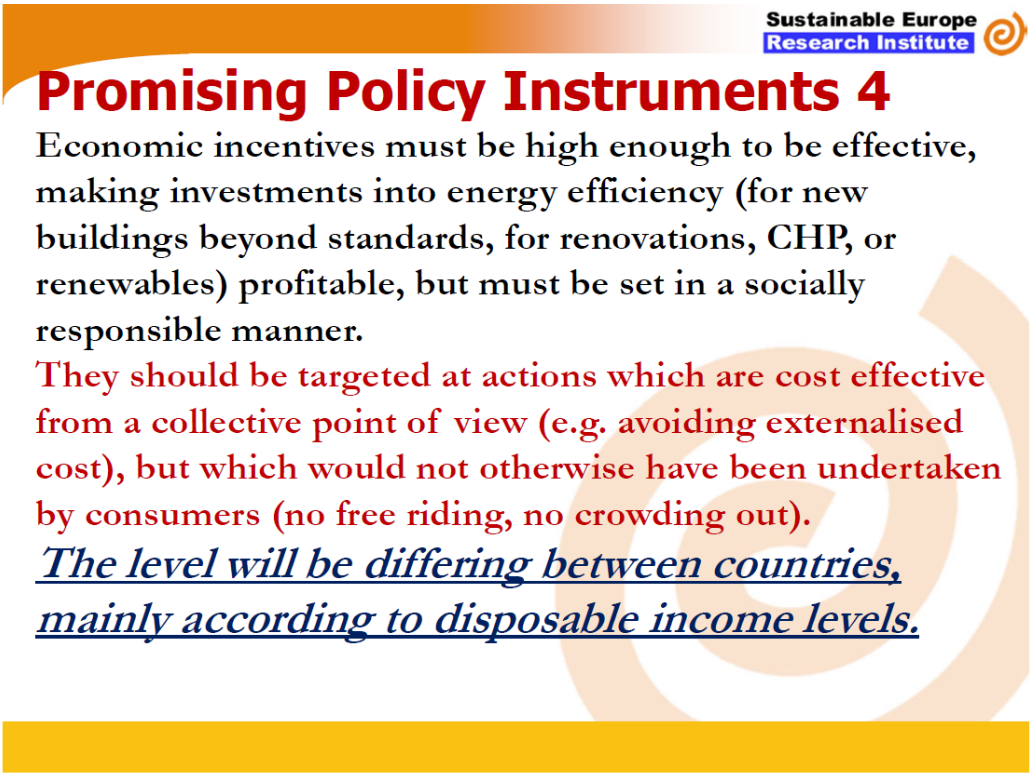
Research Institute
Promising Policy Instruments 3
A national space standard limiting continuous growth of flat sizes would be a main tool for limiting the energy consumption per household.
It is needed to avoid the overcompensation of efficiency gains by increased heated area.
Building standards and fiscal measures might be used to implement it.
Standards need to be monitored and updated regularly to remain in touch with technological developments.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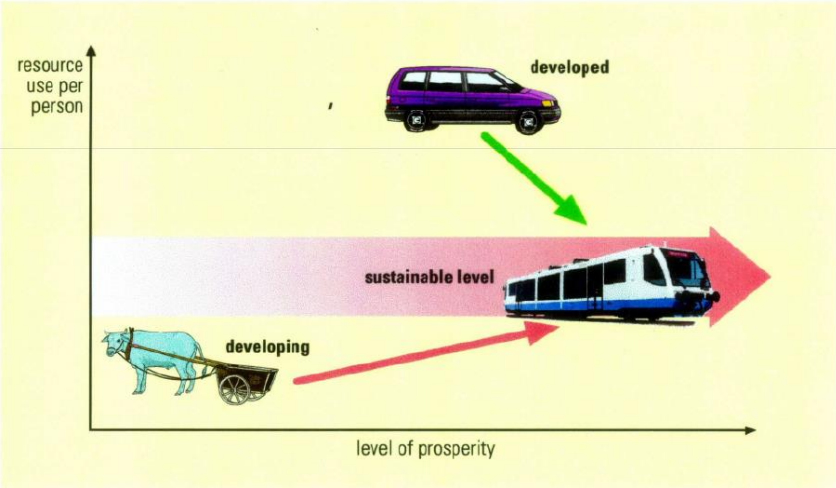
Research Institute
Promising Policy Instruments 4
Economic incentives must be high enough to be effective, making investments into energy efficiency (for new buildings beyond standards, for renovations, CHP, or renewables) profitable, but must be set in a socially responsible manner.
They should be targeted at actions which are cost effective from a collective point of view (e.g. avoiding externalised cost), but which would not otherwise have been undertaken by consumers (no free riding, no crowding out).
The level will be differing between countries, mainly according to disposable income levels.

The challenge to affluent consumers is to reduce consumption *Levels*, not to "green" consumption *Patterns*



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Promising Policy Instruments 5

Profitability can often not be achieved efficiently with one policy instrument but requires a combination of several tools such as grants, reduced interest (soft) loans and tariff reductions, providing effective incentives beyond compliance.

In order not to lose effectivity, fiscal incentives should be dynamic.

If energy efficiency gains lead to decreasing energy expenditure and thus to increasing rebounds, they should be coupled with sufficiency policies, e.g. energy taxation which makes sure that the average energy cost is at least not sinking, and increasing for the laggards not making use of energy efficiency improvement opportunities.

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4. Conclusions

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Limits to policy instruments

Regarding energy efficiency in residential buildings, a number of physical, social and behavioural conditions determine the outcome. Political frameworks mainly address the physical parameters of buildings, as these are accessible to legal norms, standards, regulations and economic incentives.

Social factors are hard to influence by climate and energy related policies, and are thus hardly addressed in the context of energy efficient dwellings. Behavioural factors are mainly addressed by means of information campaigns (push information) and online information provision (pull information).

The effectiveness of information campaigns is limited.

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Some very rational proposals appear not to immediately resonate with consumers…

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The way forward

The EU Directives have proven in almost all member states investigated as the key policy tools for enhancing energy efficiency in buildings.

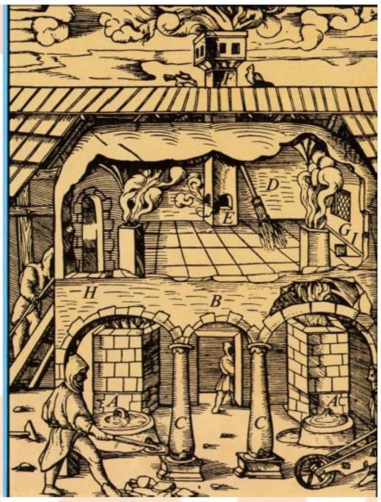
Only few make use of the possibility to set a number of more ambitious targets (Hungary, Italy, Spain, Denmark).

As the directives lag behind what is technically possible and environmentally desirable (in particular after the Paris agreements), sharpening the standards in the coming revision is advisable.

Progressively increasing the standards, with early warning to the economic agents, has been identified as the most effective way of achieving progress.

Specific measures should be taken to improve compliance.

Of course efficiency, circular economy, and renewable resources offer a potential reduction:



Maybe by a factor 4 to 5, i.e. exactly what 3% growth will eliminate within 50 years…

Graph: Metal dust recovery system, enforced by regional kings „to avoid damage to neighbouring fields and grazing grounds". Source: Agricola, G. (1556). De re metallica

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We cannot afford further delays in changing consumption levels of energy and other resources


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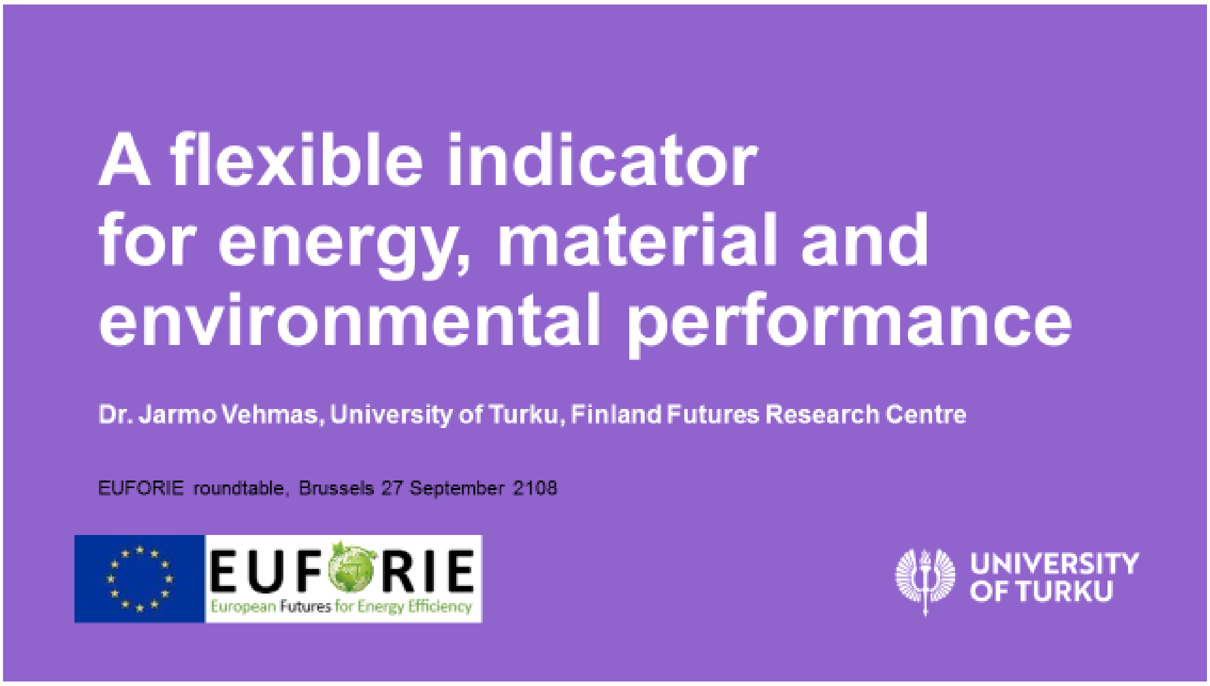
Annex 6. Presentation slides of "A flexible indicator for energy, material and environmental performance"



Companies and performance indicators

Information of company's environmental performance

- environmental reports
- sustainability reports
- corporate social responsibility reports
- websites and data management tools

Indicators reported by companies:

- specific energy consumption (by fuel); specific electricity consumption
- specific material consumption (by raw material fraction)
- specific emissions (by type of emissions into air, water and soil); specific waste fractions

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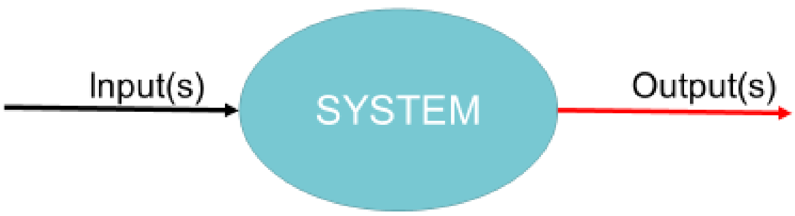
Energy, material and environmental efficiency – more from less?

Efficiency = Output / Input



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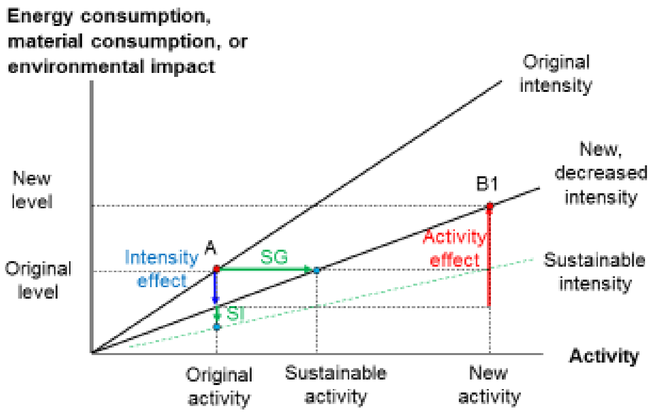
Performance indicators



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Equations for SG and SI

$$SG = -\frac{\text{Intensity effect}}{\text{Activity effect}} \times 100\%$$

$$SI = -\frac{\text{Activity effect}}{\text{Intensity effect}} \times \frac{\text{Original level}}{\text{New level}}$$

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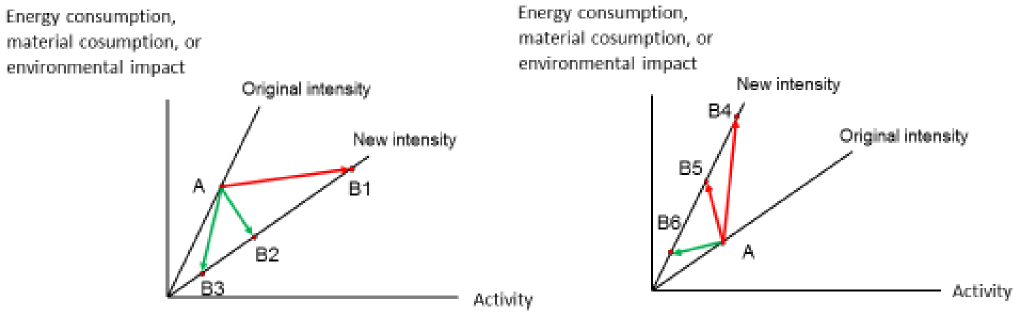
Six cases of performance



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	A-B1	A-B2	A-B3	A-B4	A-B5	A-B6
V explained	$V_0 < V_1$	$V_0 > V_1$	$V_0 > V_1$	$V_0 < V_1$	$V_0 < V_1$	$V_0 > V_1$
Activity X	$X_0 < X_1$	$X_0 < X_1$	$X_0 > X_1$	$X_0 < X_1$	$X_0 > X_1$	$X_0 > X_1$
Intensity Y=V/X	$Y_0 > Y_1$	$Y_0 > Y_1$	$Y_0 > Y_1$	$Y_0 < Y_1$	$Y_0 < Y_1$	$Y_0 < Y_1$
Intensity effect	decreasing	decreasing	decreasing	increasing	increasing	increasing
Activity effect	increasing	increasing	decreasing	increasing	decreasing	decreasing
Size of effects	$\|X_{eff}\|>\|Y_{eff}\|$	$\|X_{eff}\|<\|Y_{eff}\|$	-	-	$\|X_{eff}\|<\|Y_{eff}\|$	$\|X_{eff}\|>\|Y_{eff}\|$
SG (%)	0< SG <100	SG > 100	SG < 0	SG < 0	SG > 100	0< SG < 100
SI (coeff.)	SI > 1	0 < SI < 1	SI < 0	SI < 0	0 < SI < 1	SI > 1
Performance	unsustainable	sustainable	sustainable	unsustainable	unsustainable	quasi-sustainable
Corrective action 1	Intensity decrease	(Activity increase)	(Activity increase)	Intensity decrease	Intensity decrease	(Intensity increase)
Corrective action 2	Activity decrease	(Intensity increase)	(Intensity increase)	Activity decrease	Activity decrease	(Activity increase)

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What to choose?

Calculation of the performance indicators SG and SI requires two input variables based on a pairwise choice from the following: (1) amount of production, (2) energy used, (3) raw material used, or (4) environmental impacts.

Causal relationship between the chosen variables is assumed, such as:
- ✓ production explains energy use
- ✓ production explains material use
- ✓ production explains environmental impact
- ✓ energy use explains environmental impact
- ✓ material use explains environmental impact

The choice is a challenge, especially if the activity includes several products, energy sources, raw materials and environmental impacts. Aggregated variables are therefore an alternative to a large set of disaggregated variables

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Empirical analysis of case companies

- Stora Enso – Finnish forest company (paper, cardboard, mechanical and chemical pulp, wood products, data 2010-2016
- ENEL – Italian energy company (electricity and gas), data 2010-2015
- RWE – German energy company (electricity and gas), data 2010-2016
- Celsa Barcelona – Catalan metal company (metal products), part of Celsa Group, data 2010-2015
- CNPC – Chinese petroleum company (oil production and refinery), data 2010-2014

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Empirical analysis of case companies

Company	Production	Energy use	Material use	Environmental impact
Stora Enso	Paper and cardboard	Total fuel use	Total wood use	Total CO_2 emissions
ENEL	Total electricity, electricity produced by coal, oil and gas, renewables, geothermal and biomass		Total fuel use, use of coal, oil and gas, renewables, geothermal and biomass	Total CO_2 emissions
RWE	Total electricity, electricity production by lignite, hard coal, and oil & gas		Total primary energy use, use of lignite, hard coal, and oil & gas	Total CO_2 emissions, SO_2 and NO_x emissions from lignite, hard coal, and oil & gas
Celsa Barcelona	Production amount of 4 product groups	Total energy consumption, energy consumption of 4 product groups	Total use of scrap and steel alloys	Total CO_2 emissions
CNPC	Total refined oil products		Total and domestic crude oil production	Total oil pollutants in wastewater

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Empirical analysis of case companies

	Energy performance, number of incremental analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	-	-	-	**7**	-	7
B2	1	-	-	-	-	1
B3	**4**	-	-	**7**	-	**11**
B4	-	-	-	2	-	2
B5	**4**	-	-	2	-	6
B6	3	-	-	**7**	-	10
Total	12	-	-	25	-	37

	Energy performance, number of cumulative analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	-	-	-	-	-	-
B2	-	-	-	-	-	-
B3	3	-	-	10	-	13
B4	-	-	-	1	-	1
B5	-	-	-	2	-	2
B6	**9**	-	-	**12**	-	**21**
Total	12	-	-	25	-	37

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Empirical analysis of case companies

	Material performance, number of incremental analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	-	4	3	-	**6**	13
B2	-	8	**5**	1	-	14
B3	1	6	3	1	-	11
B4	-	**9**	**5**	-	2	**16**
B5	1	2	3	**2**	-	8
B6	**4**	4	**5**	1	-	14
Total	6	33	24	5	8	76

	Material performance, number of cumulative analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	-	**9**	4	-	**8**	**21**
B2	-	4	2	-	-	6
B3	-	3	4	1	-	8
B4	-	3	3	-	-	6
B5	-	8	**9**	-	-	17
B6	**6**	6	2	**4**	-	18
Total	6	33	24	5	8	76

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Empirical analysis of case companies

	Environmental performance, number of incremental analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	1	2	7	-	-	10
B2	1	1	6	1	**8**	17
B3	**9**	2	**16**	**3**	-	**30**
B4	1	**4**	7	1	-	13
B5	**4**	-	4	-	-	8
B6	2	1	6	-	-	9
Total	18	10	46	5	8	87

	Environmental performance, number of cumulative analyses					
Case	Stora Enso	ENEL	RWE	Celsa Barcelona	CNPC	Total
B1	-	**3**	1	-	-	4
B2	-	2	5	-	**8**	15
B3	**18**	-	10	**5**	-	**33**
B4	-	2	**16**	-	-	18
B5	-	1	3	-	-	4
B6	-	2	11	-	-	13
Total	18	10	46	5	8	87

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Conclusions

Benefits of the suggested indicators:

- Flexibility: can be calculated (i) for any productive system, (ii) for any time period, (iii) for any combination of two variables with a causal relationship, (iv) at all levels of aggregation (product, process, company)
- Minimum data requirement is small: data of two variables with a causal relationship for two time slots, describing (i) the amount of production, (ii) energy use, (iii) material use, (iv) environmental impact

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Conclusions

Problems and challenges of the suggested indicators:

- Interpretation and clarity of the results: in cases B1 and B6, B2 and B5, and B3 and B4, the indicator values are in the same range
- Proper coverage of activities may require a large number of two-factor decompositions – or aggregated variables
- The results may be sensitive to choices of (1) variables in the analysis, and (2) time period
- Sustainability not absolute, only relative to a reference level
- Applicability to non-procuctive systems (such as households) is difficult

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Thank you for your attention!
Dr. Jarmo Vehmas, University of Turku, Finland Futures Research Centre
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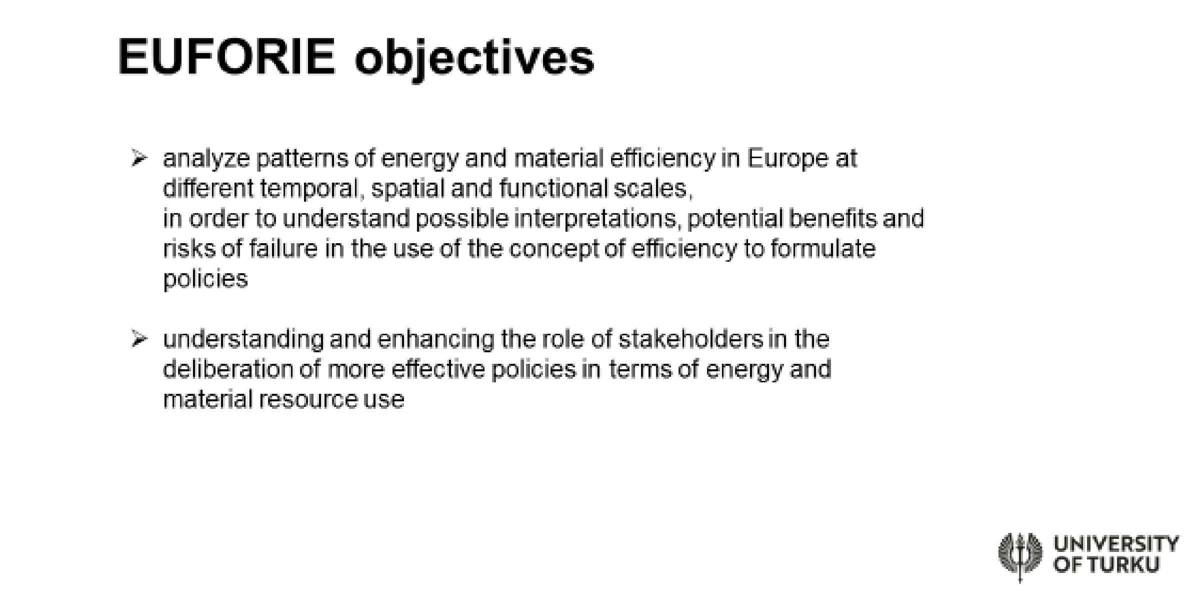
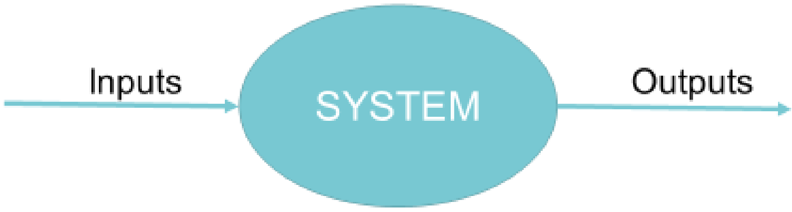
Annex 7. EUFORIE presentation slides "European Futures for Energy Efficiency" in the EMP-E conference



Efficiency – more from less?

Efficiency = Output / Input



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From Physics to Policy: Overcoming Misperceptions in Energy Policy - Agenda

9:00	Opening and introduction of participants
9:15	From energy efficiency to energy performance: The end-use matrix *Mario Giampietro*, Autonomous University of Barcelona
10:00	Towards an online energy performance calculator, in support to policy scenarios *Sergio Ulgiati*, Parthenope University of Naples
10:45	Break and refreshments
11:00	Policy options supporting efficiency and sufficiency in household energy consumption *Joachim Spangenberg*, SERI Germany
11:45	A Flexible indicator for energy, material and environmental performance *Jarmo Vehmas*, University of Turku
12:30	Conclusions and follow-up
13:00	End of the event / Lunch

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Location of the venue

Turku-Southwest Finland
European Office
Avenue Palmerston 26
B-1000 Brussels

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Thank you for your attention!

Further information:

Dr. Jarmo Vehmas
University of Turku
Finland Futures Research Centre

jarmo.vehmas@utu.fi
Tel. +358 50 342 3912

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