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Recent energy efficiency trends in Southern and Eastern Mediterranean countries

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ABSTRACT

The Mediterranean Association of National Agencies for Energy Management (MEDENER) has developed in cooperation with the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) an EU project called Mitigation Enabling Energy Transition in the MEDiterranean region (meetMED). Part of this project focuses on the implementation of a database of energy efficiency indicators (so called top-down methodology) aiming at supporting energy efficiency policies evaluation in 3 Maghreb countries (Tunisia, Algeria and Morocco) and Lebanon. This techno-economic database is organized by end-use, fuel and sector. It covers the 2000-2017 period.

This paper compares energy efficiency trends between the four countries and, in some cases with some Mediterranean EU countries, using energy efficiency indicators. After a presentation of the main steps of the study, results of recent energy efficiency trends achieved in the region for the period 2000-2017 are shown. These results illustrate the usefulness of the database to decision-makers and other stakeholders. A focus is made on possible applications for the monitoring and evaluation of NEEAPs of Tunisia and Lebanon. Finally, recommendations for the continuation of the current project as well as its extension to other countries are made.

Introduction

Energy efficiency improvements are generally considered as the best strategy to reduce CO_2 emissions, to limit the energy dependence and to alleviate the effect of oil price increase. For this reason, most countries have implemented energy efficiency programmes. However, these programmes are not always accompanied by a systematic monitoring of the energy performances of buildings, cars, appliances and other systems and of benchmarking with similar countries, although this would allow to better evaluate the policy impacts and to better target new policy measures. Energy efficiency indicators have been developed to monitor trends in energy efficiency; A significant experience has been developed from the 1980's in Europe in this field with the ODYSSEE-MURE project that has progressively covered all the EU Member States (Bosseboeuf et al. 1997 and 2012) and accompanied by similar experiences (Morovic et al. 1987, Morovic 1987, Schipper et al. 1992 and 2001). International cooperation projects have aimed at transferring this experience outside the EU (Bosseboeuf et al. 2015; IEA 2018, IEA 2019; ISO 17742:2015 and ISO/FDIS 50049).

In this framework, MEDENER (Mediterranean Association of National Agencies for Energy Management) has developed in cooperation with the Regional Centre for Renewable Energy and Energy Efficiency (RCREEE) an EU project called Mitigation Enabling Energy Transition in the MEDiterranean region (meetMED). In this framework, MEDENER and its members have set up a regional observatory of energy efficiency trends in the Mediterranean countries. Four Southern and Eastern Mediterranean countries (Algeria, Lebanon, Morocco and Tunisia) have developed evaluation methods through the implementation of detailed data bases on final energy

consumption by sector and end-use (meetMED, 2020a). These four countries had already initiated this process in the framework of a former project (Enerdata et al. 2014).

This paper illustrates how the database can be used to compare energy efficiency trends between countries and to conduct national trend analysis. In the first part, the main steps of the study are presented: data collection, calculation of indicators as well as of an energy efficiency index, and analysis of results. In the second part, recent energy efficiency trends achieved in the region for the period 2000-2017 are discussed in relationship with national energy efficiency policies and macroeconomic drivers. The analyses enriched by comparison with 5 EU Mediterranean countries (France, Spain, Portugal, Greece and Italy). In the third part we show a decomposition analysis in the transport sector of Lebanon. The fourth part presents example of possible applications for the monitoring and evaluation of the NEEAPs of Tunisia and Lebanon. Finally, we issue recommendations of data collection improvements, as well as on the conditions necessary to extend the study to other Mediterranean countries.

Project implementation and ex-post top down methodology

Data sources

The report is based on data and indicators calculated for Southern and Eastern Mediterranean countries under the MEDENER project and for northern countries under the ODYSSEE-MURE project (https://www.odyssee-mure.eu/project.html). The work of data collection is performed by the national energy efficiency agencies partners of each project[1]. Capacity building is an important component of this activity and is done through various training on data collection methodology and interpretation and energy efficiency indicators (see Bosseboeuf et al. (2015). Figure 1 shows an example of the data mapping in Tunisia necessary to collect the scattered data.

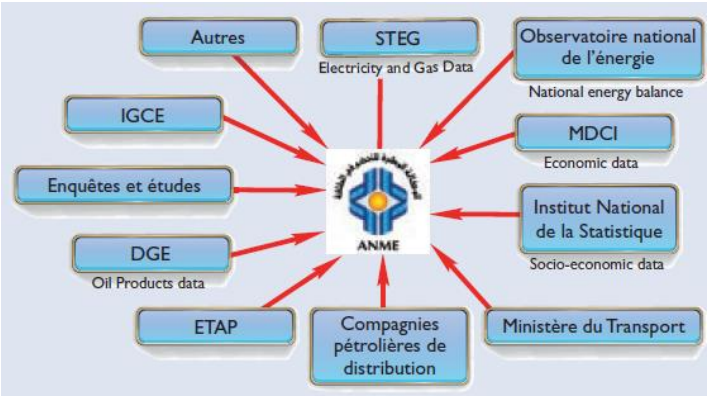

Figure 1. Organization of data collection in Tunisia: the current information system SIM2E. *Source:* Enerdata et al., 2014.

Note to Figure 1: The mains stakeholders are : STEG: Société Tunisienne de l'Electricité et du Gaz (Tunisian Company of Electricity and Gas); Observatoire national de l'énergie (National Observatory of Energy); MDCI : Ministère du Développement de l'Investissement et de la Coopération Internationale (Ministry of Development, Investment and International Cooperation); Institut National de la Statistique (National Institute of Statistics); Ministère du Transport (Ministry of transports); Compagnies pétrolières de distribution (oil distribution

[1] In the framework of the MEDENER project, the following agencies are involved: the Algerian National Agency for the Promotion and Rationalization of the Use of Energy (APRUE), the Lebanese Association for Energy Conservation and Environment (ALMEE), the Moroccan National Agency for the Development of Renewable Energy (ADEREE); and the Tunisian National Agency for Energy Management (ANME).

companies); ETAP : Entreprise Tunisienne d'activités pétrolières (Tunisian Company of Petroleum Activities); DGE : Direction des Grandes Entreprises (Large Companies Directorate); Enquêtes et études (surveys and studies); IGCE : Industries Grandes Consommatrices d'Energie (energy-intensive industries); Autres (others).

The Medener database: MedObservEEER

In 2020, the database covers all 4 countries (Algeria, Lebanon, Morocco and Tunisia) for the period 2000-2017. It is based on data collected in 2019 and contains some detailed data necessary to analyze the energy consumption dynamics: energy consumption by sector and end-use, economic and technology drivers (e.g. GDP, value added equipment rates, dwelling sizes...). For Algeria and Lebanon, the databases are filled almost completely. Tunisia's database presents an intermediate state while the coverage of data by Morocco still needs to be improved (Table 1).

Based on these data, about 100 energy efficiency indicators are computed relating energy consumption and activity data, among which specific energy consumption (in physical units) and energy intensities (in monetary units). More advanced indicators are also calculated, such as the energy efficiency index MEDEX which measures the energy efficiency progress by sector; this index is calculated as a weighted average of indices of energy efficiency progress by sub-sector (industrial branches, household end-uses or transport modes), in a similar manner than the ODEX indicator developed for EU countries in the Odyssee Mure project (Bosseboeuf et al., 2005). Finally, the database also includes energy savings by sector and end-use. Energy savings are calculated by sector from the MEDEX indicator, as MEDEX is equal to the ratio between the energy consumption at year and a fictive consumption that would have happened without energy savings. Depending on the data coverage and quality by sector and by country, the database can be used to conduct national trend analysis and to compare energy efficiency trends between countries. Such comparisons are possible because the data collected are based as much as possible on common definitions (e;g. categories of vehicles, buildings, sectors).

Table 1. Qualitative database coverage by sector and country.

	Macro economic	Energy	Industry	Transport	Residential	Services	Agriculture
Morocco							
Tunisia							
Algeria							
Lebanon							

Dark green: good to very good; light green: quite good; orange: intermediate or quality issue
Source: MEDENER (data collected by the authors for the 2000-2017 period).

Comparison of energy efficiency trends between countries

Energy efficiency context

Energy efficiency has gradually developed in Southern and Eastern Mediterranean countries and now represents a major policy issue in most of these countries. Energy efficiency strategies are declined into National Energy Efficiency Action Plans (NEEAPs) (see the References section). Regarding energy efficiency Tunisia is the country with the most ambitious targets, as it seeks to reduce its primary energy consumption by 30% in 2030 compared with a baseline scenario. On the other hand, Algeria and Morocco have set lower targets for 2030: 20% for Morocco and 9% for Algeria compared with a baseline scenario. In Lebanon, the national energy efficiency action plan aims at a level of 5% savings in the total Lebanese electric power demand in 2020 compared with a baseline scenario established in 2010.

General energy efficiency trends

Over the period of 2000-2017, the primary intensity at normal climate has decreased in two southern Mediterranean countries (Tunisia and Lebanon) and in the EU Mediterranean countries. In Tunisia and Lebanon, this decline was 2 to 3 times faster than in EU countries (Figure 1). The economic and financial crisis of 2008 has slowed down the intensity decline in EU countries (not shown; Odyssee Mure 2018, EU sectoral profile). In most countries except Morocco and Lebanon, the primary intensity has been decreasing faster than the final intensity. Thus, the energy sector (that represents the difference between the primary and final intensity) has contributed to the reduction of the primary intensity in all these countries.

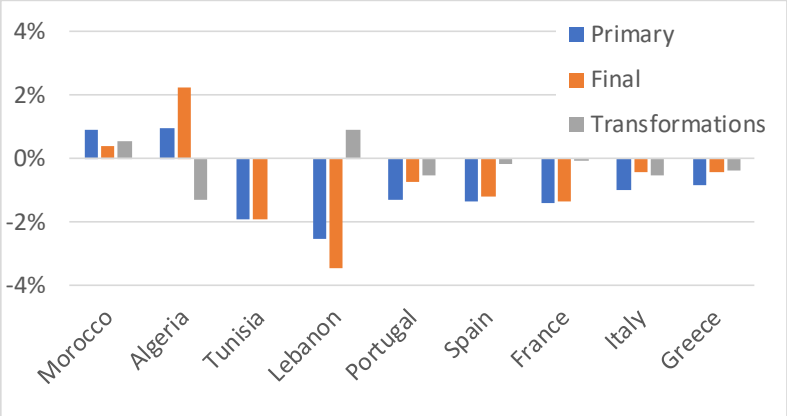

Figure 1. Trends in primary and final energy intensity at normal climate in %/year for 2000 – 2017 (2000-2010 for Morocco and 2005-2010 for Tunisia). *Sources:* Odyssee and MEDENER.

These overall trends are further discussed below by sector.

Energy efficiency in the power sector

The efficiency of the power sector is linked to the electricity mix (share of renewable) and the efficiency of thermal power generation.

In Morocco, Algeria, Tunisia and Lebanon, the efficiency of the power sector is lower than in European countries (Figure 2) because of lower performance in thermal production (Figure 3) and, for all countries except Morocco, still a low share of renewables (around 2%) (Figure 3). In these countries the efficiency of the power sector is therefore mainly linked to the performance of thermal power plants. In Morocco, the efficiency of the power sector increased between 2000 and 2010 thanks to the increase of power production from renewable (from 13% to 16%).

The highest performances of the power sector in the Mediterranean region can be found in Portugal, Spain and Italy with an efficiency around 50% (Figure 2). This good result is explained by:

- the sharp increase in the share of renewables in the power mix. This share was around 30% in Spain, 35% in Italy and 40% in Portugal in 2017 (Figure 4).
- the rapid diffusion of gas combined cycles, thanks to which the efficiency of thermal power production exceeds 40% (Figure 3).

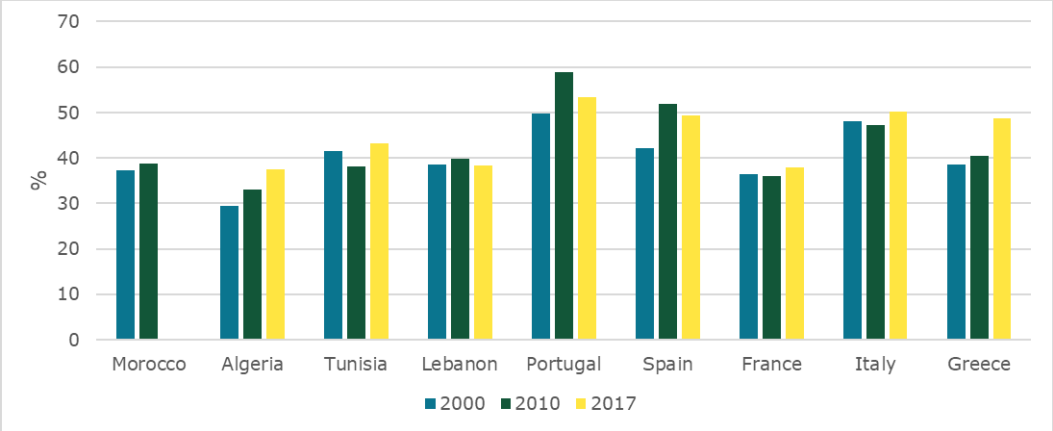

Figure 2. Efficiency of the power sector of the countries in 2000, 2010 and 2017. *Sources:* Odyssee and MEDENER.

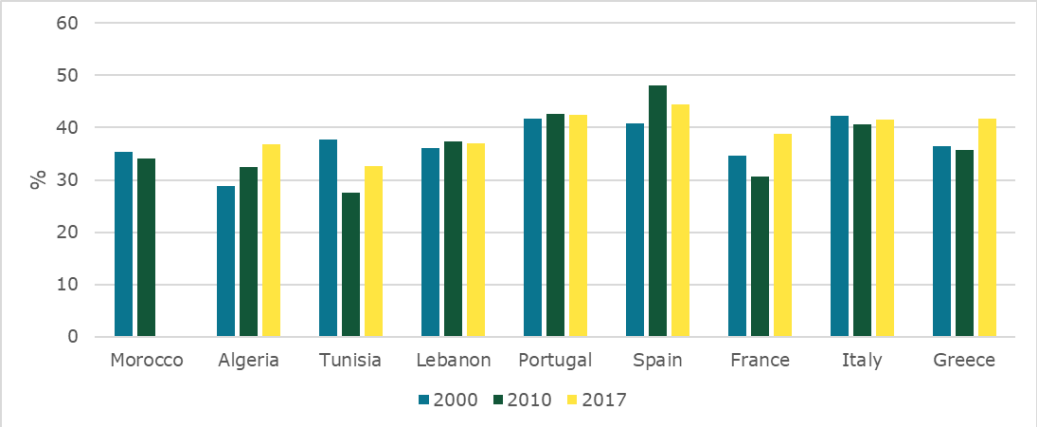

Figure 3. Efficiency of thermal power plants in 2000, 2010 and 2017. *Sources:* Odyssee and MEDENER.

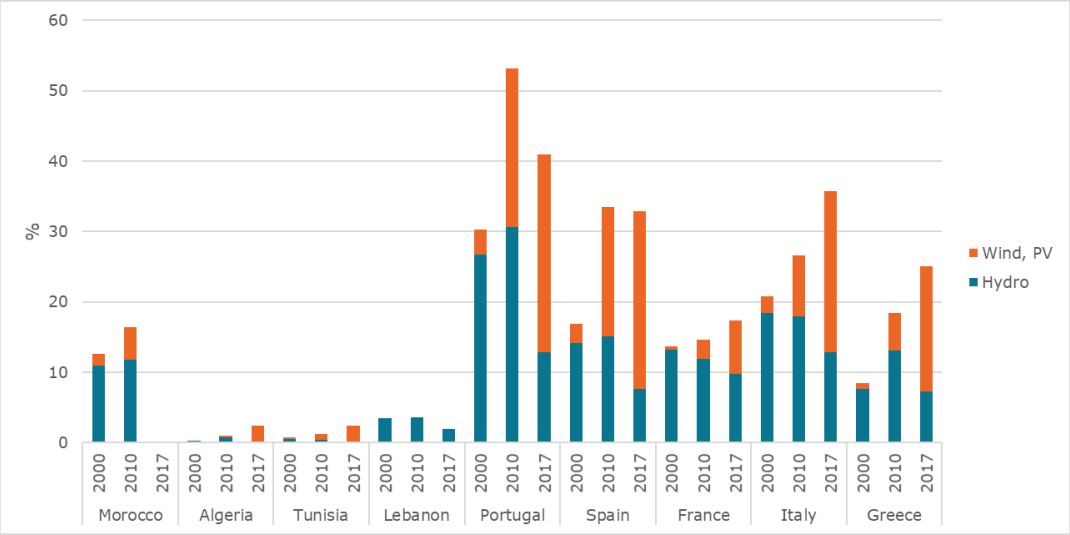

Figure 4. Share of renewable in electricity production in 2000, 2010 and 2017. *Sources:* Odyssee and MEDENER.

Energy efficiency trends for households

Because of demographic growth and increasing urbanisation, the building sector presents one of the highest levels of energy consumption in the Southern Mediterranean countries. It is also one of the main targets of energy efficiency measures, such as the implementation of building codes for envelopes and systems (thermal insulation standards, implementation of minimum energy performance standards (MEPS), labelling systems for appliances) (MeetMED 2019). The following results focuses on the residential sector.

Households consume on average 26% of final energy consumption in Mediterranean countries (2017). There are significant differences among countries, with shares reaching 16%-29% in Portugal and Spain on the one hand, and 27-34% for France, Italy, Lebanon and Algeria on the other hand. These differences reflect contrasting energy uses and rates of equipment ownership which are themselves linked to differences in energy prices and income level. Trends of final energy consumption of households also differ significantly according to countries and periods (Figure 5).

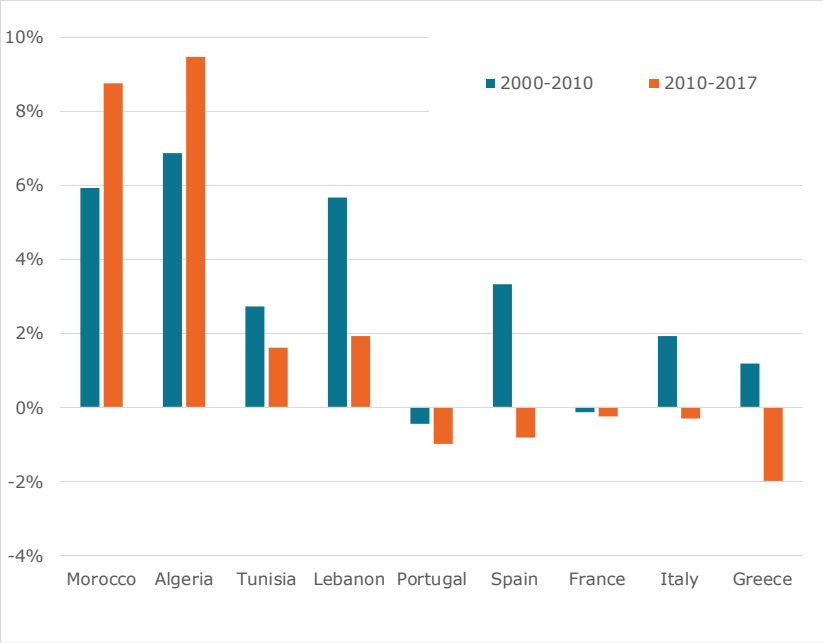

Figure 5. Annual growth rate of energy consumption of households in %/year. *Sources:* Odyssee, MEDENER and GED (Global Energy Data from Enerdata used for Tunisia in 2000 and Morocco in 2017)

In 2000-2010, all countries display growing trends of final energy consumption of households except France and Portugal, for which the trends are stable or slightly negative (-0.1 and -0.5%/year respectively). For countries with increasing energy consumption, the faster trends (ranging between 5.5 and 7%/year) are observed for Morocco, Algeria and Lebanon, whereas trends for Tunisia, Spain, Italy and Greece are about 1-3%/year. In 2010-2017 (post-economic crisis period), the energy consumption of households decreases in all European countries, down to -2%/year in Greece, whereas it increases in the other countries, sometimes at a very fast pace (+9.5%/year in Algeria) (Figure 5).

The above trends can be explained by several factors, mainly the change in the number and size of households, the progression in the equipment ownership (and electrification rate for Morocco), and change in the specific energy consumption of dwelling.

The average size of household ranges from 3.5-6 persons per households in the southern countries against 2.5 in the EU countries. There is a larger growth of the households' number in the southern than in the

EU countries due to the combined effect of population growth and significant decline in the number of persons per household. The impact of this growth on the consumption was reinforced by the progress of rural electrification in Morocco, where the share of households with access to electricity increased by 31 points from 68% in 2000 to 99% in 2013. This effect was less important in the other southern countries, as the share of households with access to electricity was already above 95% in 2000 (99% in Lebanon).

The average unit consumption per household at normal climate (ratio between the energy consumption of households corrected from climate and the number of households) (Figure 6), varies quite a lot among Mediterranean countries. In 2017, it ranged from about 0.6-0.8 toe/household in Tunisia, Portugal and Spain to around 1 toe in Greece and Lebanon, 1.4 toe in France and Italy and 1.6 toe in Algeria.

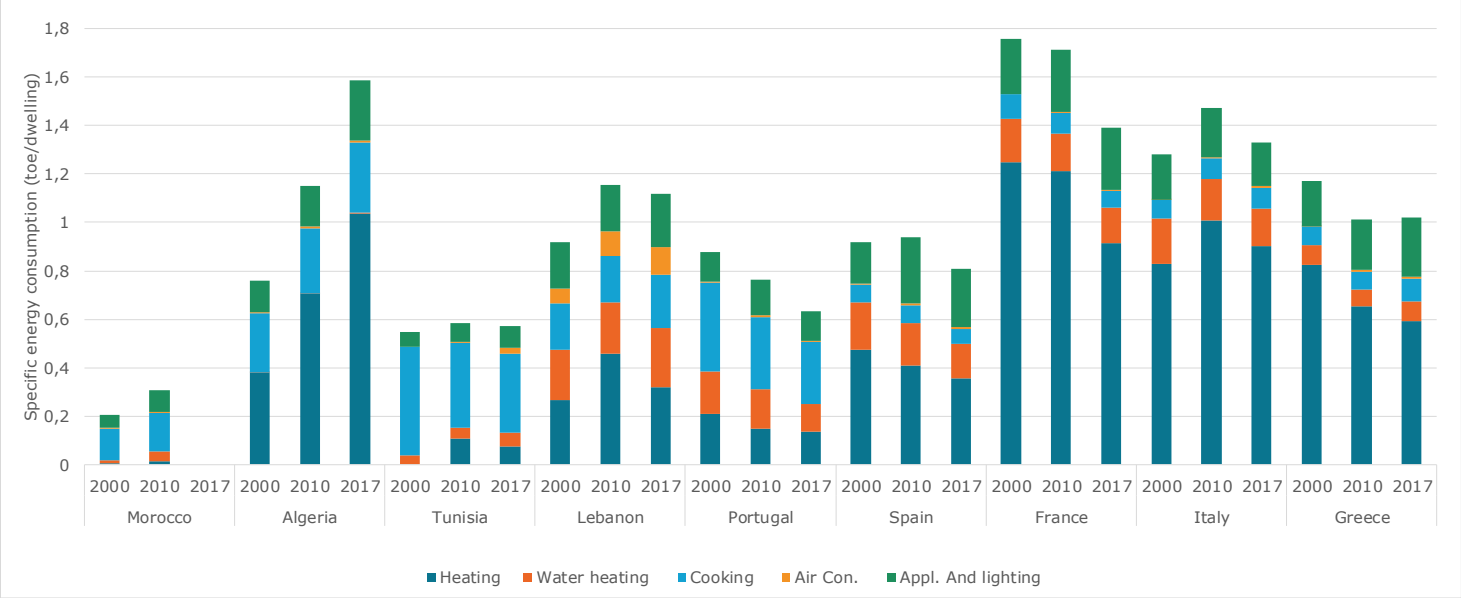

Figure 6. Specific consumption per dwellings by end use in 2000, 2010 and 2017 (normal climate). *Sources:* Odyssee and MEDENER.

In EU countries, except in Italy, the specific consumption of households decreased between 2000-2017 with -1,9%/year for Portugal, -1,4%/year for France and -0,8% in Greece and Spain, mainly because of more efficient electrical equipment and better home insulation (Odyssee 2015). In Greece, Portugal and Spain the economic recession also contributed to lower the consumption. In Italy, the trend is almost stable.

Common characteristics between southern countries are more difficult to identify, due to the lack of data for Morocco (no detailed data on end-uses after 2010) and Tunisia (no exhaustive coverage of all end uses in 2000). Lebanon and Algeria show an increase in specific consumption of households (+1%/year and 4%/year respectively), a common trend for all end-uses.

Figure 6 provides interesting results on captive electrical end-uses[2]. In 2017, Lebanon reaches the largest share of air conditioning in the household energy consumption (10%, against 1% in the other countries). However, the consumption for air conditioning is growing rapidly in Italy (+9%/year), Greece (+7,6%/year), Spain (+6,9%/year) and Algeria (+5,7%/year). This is mainly due to increasing equipment rates in all countries, and for Greece and Algeria, to an increase in the size of dwellings. Concerning energy consumption for appliances and lighting, growth rates are also positive for Lebanon (+3,7%/an), Algeria (+2%/year) and Spain (+1,2%/year) as a result of increasing equipment rate of appliances. Other effects that may operate on the evolution of the captive

[2] Captive electrical uses refer to uses where presently only electricity is used, e.g. air conditioning, refrigerators, TV, washing machines and lighting

electrical consumption capacity and size of the equipment, intensity of use…) are difficult to analyse because of a lack of fine technical data in our database.

Energy efficiency in industry

The energy intensity of the manufacturing industry, defined as the ratio between final energy consumption and value added, is declining in all countries except Morocco and Algeria (Figure 7). Trends in the energy intensity of the manufacturing industry are influenced by two main factors:

- Changes of the intensities at branch level (chemicals, non metallic minerals, food and beverages, textile, etc.) which corresponds to a good proxy of energy efficiency (Figure 8).
- Changes in the structure of value added by branch ("structural effect") (Figure 8). In countries with an increasing share of energy intensive branches in the value added, the energy intensity should, all things being equal, increase. On the opposite, a greater specialization towards less intensive branches such as textile or electrical equipment or transport equipment (automotive assembly) will reduce the energy intensity.

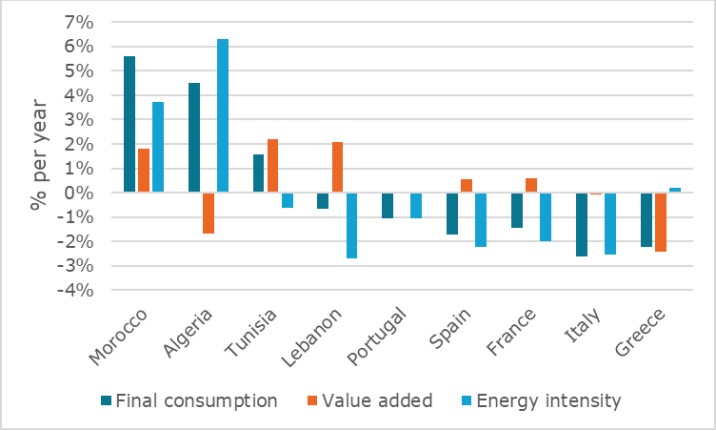

Figure 7. Specific Trends in final energy consumption, value added and intensity of manufacturing industry between 2000 and 2017 (2000-2010 for Morocco). *Sources:* Odyssee and MEDENER.

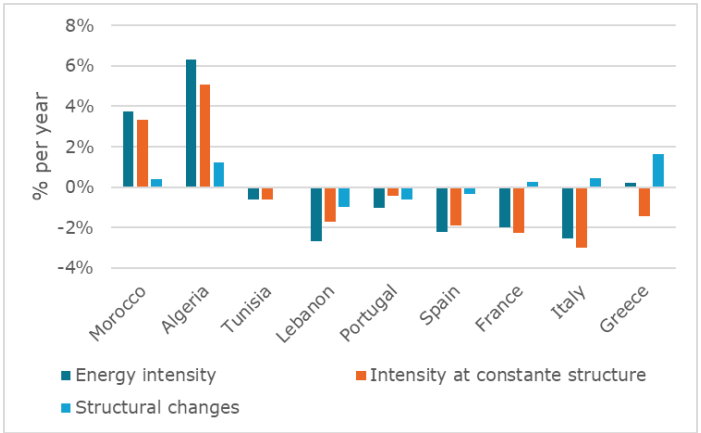

Figure 8: Structural effect in manufacturing industry between 2000 and 2017 (2000-2010 for Morocco). *Sources:* Odyssee and MEDENER.

In Morocco (over 2000-2010) and Algeria (over 2000-2017), the effect of the increasing sectoral intensities has been reinforced by structural effects (Figure 8). In these countries, the growing share of non-metallic minerals in the value added of industry led to an increase on the overall energy intensity of industry.

In Lebanon, the decrease of sectoral intensities is the main factor explaining the energy intensity reduction. This effect was reinforced by the change of the economic structure towards less intensive branches.

In European countries, progress in energy efficiency has been observed in all branches. In addition, there is now almost no structural effect except in Greece[3] where this effect canceled out energy efficiency gains in the branches.

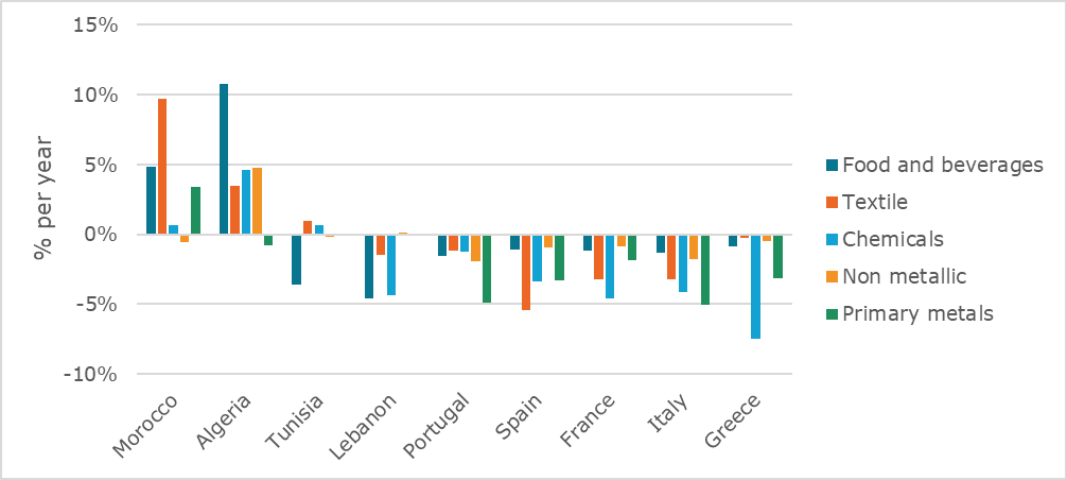

Figure 9: Trends in energy intensities by branch between 2000 and 2017 (2000-2010 for Morocco). *Sources:* Odyssee and MEDENER.

Energy intensive industries (steel, cement, phosphates, paper, etc.) represent a significant share of the overall energy consumption of industry. In Morocco, Algeria, Tunisia and Lebanon, the most important energy intensive industry is cement which accounts for between 30 and 50% of the energy consumption of the manufacturing industry (against 5 to 15% in the European countries considered here). This is clearly one of the sectors where policies have been the most targeted (audits, standards etc.)

The specific energy consumption of cement is defined as the amount of energy consumed to produce one ton of cement. Most countries are in a range of 0.05 to 0.08 toe per ton (Figure 10). The comparison also shows a significant potential for energy savings in some countries (Algeria, Portugal).

[3] Because of the growing share of primary metals in the value added of industry.

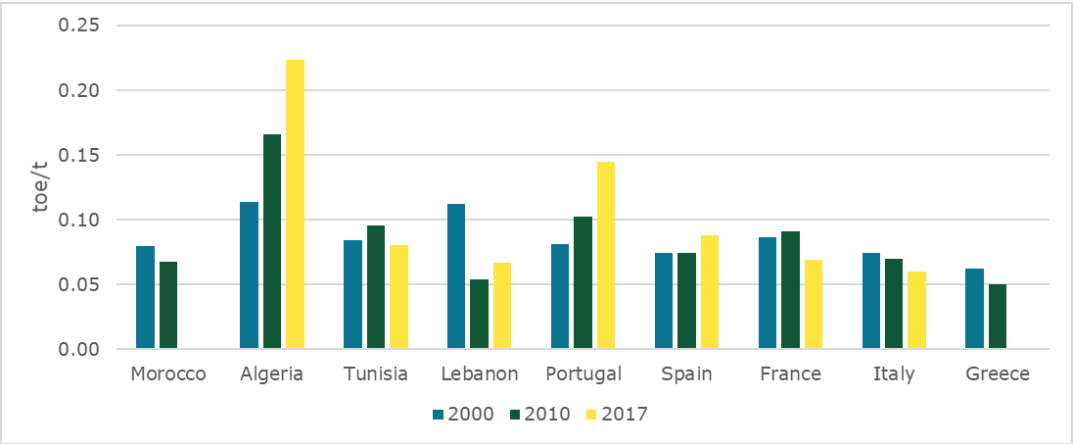

Figure 10: Specific energy consumption of cement. *Sources:* Odyssee and MEDENER.

Illustration of a decomposition analysis: the case of transport in Lebanon[4]

The purpose of decomposing the variation of the final energy consumption between two years is to assess the contribution of the various factors explaining demand (see e.g. ISO/FDIS 50049; ODYSSEE-MURE 2020). An example of a decomposition analysis of the transport sector in Lebanon is shown in Figure 11. This sector has the highest level of consumption (48% of the final energy consumption in 2017). Road transport dominates the energy consumption of the sector, with 91% against 9% for air traffic (there is no railway in Lebanon).

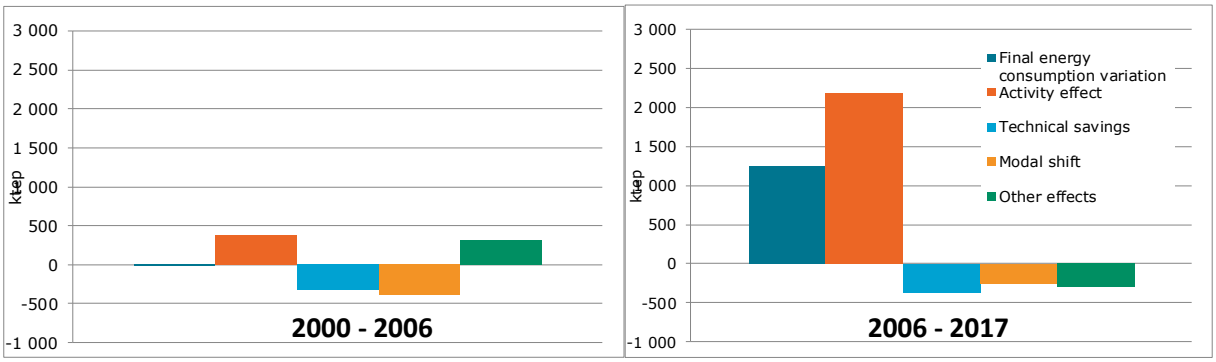

Figure 11: Decomposition of energy demand of the transport sector in Lebanon for two periods (2000-2006 and 2006-2017). *Source:* MEDENER.

During the 2000-2006 period, there has been a relative stagnation of the energy consumption of the sector, where the energy savings due to a better efficiency of cars, trucks and airplanes (technical savings) and modal shift have been compensated by an increase of activity (increase in passenger and goods traffic) and other effects, i.e. behavioral effects and "negative savings" in freight transport due to low capacity utilization (Figure 11 left). The subsequent 2006-2017 period displays contrasting features, with a large increase of the energy consumption of the sector (+1258 ktoe) mainly due to an increase in traffic (activity) (+2192 ktoe), which has been only partly compensated by technical energy savings (-375 ktoe; the energy efficiency index MEDEX improved by 30%), modal shift (-255 ktoe) and other effects (such as behavioral effects or “negative savings” in freight transport due to low capacity utilization) (-304 ktoe).

[4] See also decomposition analysis of transport in Tunisia by e.g. Mraihi et al. (2013) and Achour and Belloumi (2016).

MedObservEEER: a useful tool for monitoring and evaluating policies and measures

The detailed data and the calculated indicators of the database are used to assess progress in energy efficiency and the development of renewable energy. These indicators can also be used in a preliminary step to monitor and evaluate the implemented Policies and Measures (PaMs).

A preliminary work has been carried out for Tunisia and Lebanon. First, the main PaMs included in the NEEAPs were selected. Secondly, the PAMs were classified by targeted sector, sub sector or end use and their type (e.g. regulation, financial or fiscal). Then one or more indicators was associated with each PaM. Depending on the measure to be evaluated, the indicator can be an energy intensity, an indicator of unit consumption (for example energy consumed in toe per dwelling), energy savings (measured in ktoe), a diffusion indicator (number of compact fluorescent lamps installed or surface area of solar water heater in m^2). Finally, we checked the indicators availability in the database. Table 2 illustrates this work with an example of measures targeting the residential sector in Tunisia (taken from the country's strategy for energy management) and the corresponding indicators. Note that for a complete evaluation of the PAMs, the results derived from this preliminary work should be compared with a baseline scenario. Moreover, effects such as interaction effects should be considered in particular for the evaluation of measure packages.

Table 2: Example of PaMs and evaluation indicators for the residential sector in Tunisia. The color code refers to the indicator availability in the database (green: available; red: unavailable).

End-use	Measure	Impact indicator	Diffusion indicator
Lighting	Compact Fluorescent lamp distribution program and ban on incandescent lamps	Unit consumption per household for lighting	Share of efficient lamps Sales of efficient lamps
Appliances	Replacement of refrigerators over 10 years old with class 1 refrigerators	Unit consumption of refrigerators	Stock / sales of class 1 refrigerators
Hot water	Development of solar water heaters	Unit consumption for hot water	Total solar water heating surface Solar water heating surface installed per year Solar water heating surface for 1000 inhabitants

Source: MEDENER, ANME (2014)

Conclusion and discussions

Along this article we have shown that our methodology of energy efficiency indicators implemented so far in four south Mediterranean countries is relevant, workable and provides a solid basis to policy evaluation. The data gathered in the MedObervEER database are crucial to:

- evaluate and compare progress in energy efficiency by sector and end-use and relate it to the observed trends in energy consumption.
- report on energy efficiency and energy savings.
- support for monitoring national targets on energy efficiency.

The project also showed that the quality of data collection could vary between countries or between sectors. Efforts to collect data on energy demand and its determinants need to be strengthened to improve the quality of PaMs assessments. Several axes can be mentioned. First, the data collection carried out within the framework of this project showed that some topics were poorly covered (for example, passenger and goods traffic (per mode), floor area of tertiary buildings, etc...). In addition, some existing surveys should be extended to consider new energy end-uses or new technologies such as LEDs. Finally, it is important to launch regular surveys (at least every 3 or 4 years) to be able measure trends.

The energy efficiency agencies of the 4 countries involved in this work have been responsible for the data collection and involved in the publication of analysis on national energy efficiency trends (meetMED, 2020b). Thus, this project has been a unique opportunity for them to build capacity on data collection and energy efficiency indicator analysis, as well as to exchange good practices.

This paper is the outcome of a first pilot operation on 4 countries of the South which aims to be extended in a second phase to other Mediterranean countries, namely Jordan, Palestine and Egypt. The challenge is not obvious because the economic, social and energy contexts of these countries are very contrasted and differs from the Maghreb countries. However, they all have in common the following feature:

- This is a good timing for these countries to implement a monitoring system because energy efficiency becomes a priority in their energy transition. NEEAPS reviews indicate an ongoing implementation of energy efficiency policies at large scale.
- There is a satisfying data availability.
- The countries already have an experience in Energy Efficiency Indicators and database management (in particular in energy efficiency projects.)

Based on the results of about 40 stakeholders' interviews in Jordania, Palestine and Egypt and a literature review (meetMED, 2020b), we consider that the conditions for an effective participation of these new countries rely on the following criteria of eligibility:

- A sufficient level of energy efficiency policies implementation to justify the need of setting up a monitoring system and to ensure that their impacts can be observed or visible on the energy end-use balance.
- A willingness to monitor and evaluate the energy efficiency situation at detailed levels.
- A data availability of the basic end use data and the sustainability of the data collection
- A practice in monitoring and more generally in managing data base,
- A practice on EEIs
- A capacity to organize a data collection which is scattered through a good governance and expertise (a focal point from an energy efficiency agency for instance),
- A willingness to participate to a regional benchmark,
- A capacity to use and disseminate their results.

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