The "Energy Efficiency Matrix" An Africa-EU Energy Partnership (AEEP) tool to foster Energy Efficiency in Africa

This paper has been prepared by:

The Energy Efficiency work stream is part of the Africa-EU Energy Partnership (AEEP), a long-term framework for strategic dialogue between Africa and the European Union aimed at sharing knowledge, setting political priorities and developing joint programmes on the key energy issues and challenges in the 21st century.

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Abstract

The Political Target on Energy Efficiency by 2020 of the Africa-EU Energy Partnership (AEEP) consists in taking actions to improve the energy efficiency and the use of renewable energy in all sectors of Africa. To contribute to the progress towards this target, Politecnico di Milano is setting up the Energy Efficiency Workstream (EE WS), composed of relevant actors in the field of energy efficiency. This paper describes the "Energy Efficiency Matrix", a tool developed and disseminated by the EE WS to contribute in fulfilling the AEEP targets.

With the geographical scope of Africa, such Energy Efficiency Matrix is built with the aim of fostering collaboration among members and institutions, enhancing political dialogue and stakeholder engagement for expanding networks and outreaching on the topic of energy efficiency and joint

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cooperation between Africa and the EU. Moreover, the energy efficiency matrix will help to contribute to the involvement and participation in energy sector events and processes of several participants and society segments that are not directly related to energy; to improve on knowledge sharing between European and African countries; to foster the capacity building related to energy efficiency in Africa and to give technical and political advisement to African leaders towards energy efficiency.

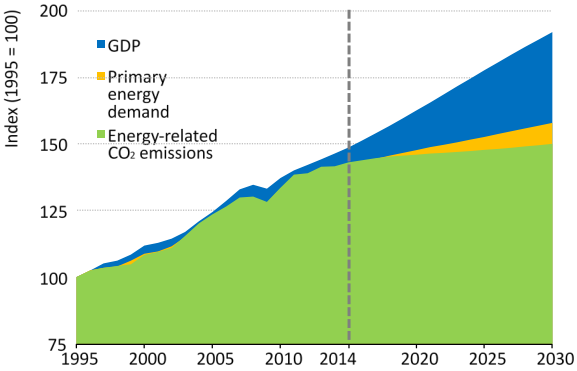
1. Why energy efficiency matters?

This section outlines the topic of energy efficiency as a fundamental dimension for contributing to the transformative path that is needed in the energy sector to match with the complexity of the 2030 Agenda and the associated 17 Sustainable Development Goals[2].

Energy Efficiency: an overview

Human production activities heavily rely on natural resources use. Nowadays, the majority of the resources used by human activities are non-renewables, implying pollutants and greenhouse gases emissions (GHG), and the latter became a global concern in the last decades. Non-renewable energy resources are limited, their misuse affects the environment and their non-equitable management may affect social inclusion. Therefore, the rational use of non-renewable energy resources is fundamental for the achievement of a sustainable future.

From one end, the increasing attention to the environment stresses, the global concern about over-exploitation of limited non-renewable natural resources used for human activities. From the other end, the historical evidence states that no country has substantially reduced poverty without an increased use of energy, in the form of different carriers and without a progressive shift to more efficient systems and high quality energy services.

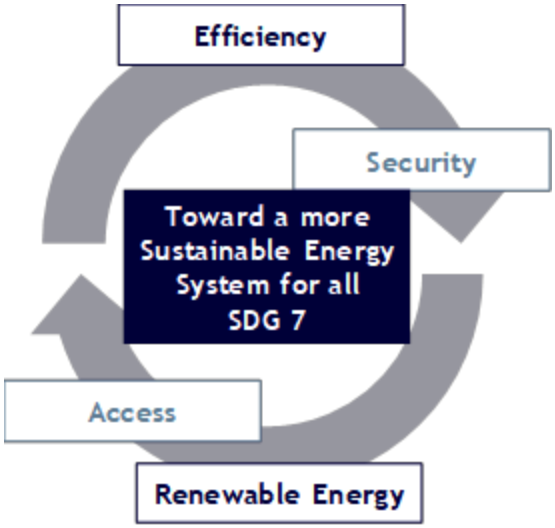


The link between the economic growth, non-renewable energy sources consumption, GHGs and pollutant emissions, has characterized the global economy until recent years. Indeed, the only time where a decrease in the energy consumption and GHGs emissions happened was the period of the economic crisis and the recession. With reference to the figure below, starting from 2014, the seeds of a decoupling came to be more and more evident. To rate of growth for economic prosperity has come again to be positive, assessing around a value that is higher of both the rate of increase for the energy consumption and GHGs emission. For instance, although the international energy prices remained low, the growth of the global Gross Domestic Product (GDP) was around 2.6% in 2015, the global primary energy demand grew by just 0.6% and GHG

[2] This section is updated with the data from OECD/IEA, World Energy Outlook 2017, by the International Energy Agency (IEA).

emissions decreased by -0.1% (IEA, World Energy Outlook 2017).

This was brought by the joint efforts of two main actions: first, by promoting energy efficiency interventions, and secondly by increasing the penetration of renewable energy within the energy mix. These actions are essential in order to achieve the SDG7, namely the "Sustainable Affordable and Safe Energy for all". Apart from access to energy, the fulfillment of this goal also requires the identification and use of appropriate, sustainable and equitable ways to manage the energy sector along the whole supply chain, including the phases of exploitation, extraction or transformation, use and disposal back to the environment.



In particular, energy efficiency plays a crucial role and provides high impact opportunities, providing the same economic services with a reduced consumption of primary energy, or more services with the same consumption of primary energy. Indeed, the International Energy Agency (IEA) recognizes the two-fold role of energy efficiency: first, it is a key to ensuring a safe, reliable, affordable and sustainable energy system for the future; secondly, energy efficiency can be seen as like as one type energy resource that every country possesses in abundance, and it is the quickest and the least costly way of addressing energy security, environmental and economic challenges (see figure below).

As demonstrated during the past years, when energy efficiency is coupled with deployment of renewable energy sources, it ensures rapid progresses achieved in terms of performance and economic costs. This is reflected by the continuous decrease of the global energy intensity year by year. The continuous decrease of the rate of growth for the global energy demand has been considered the direct result of government policies and measures, such as mandatory energy efficiency (e.g. fuel-economy standards, minimum performance standards, industry targets, building energy codes), public financing and the use of market-based instruments (e.g. tradeable certificates linked to energy saving obligations on utilities). Efficiency improvements are also attributable to price effects, advances in technology and energy management practices in the buildings and industrial sectors.

Improvements in the efficiency of energy generation processes have direct implications on the future costs of the global energy system. Indeed, the largest fraction of the costs associated to energy efficiency improvements lie in the upfront capital expenditures, leading to a more capital-intensive future energy system. This is because energy efficiency improvements require a massive use of technologies with long payback periods. In 2016, investments in energy efficiency reached $231 billion, i.e. more than 10% of global total energy investment, and they are forecasted to grow in the next decades, especially in transport and building sectors. In the industrial sector, investments in energy efficiency will occur

primarily in non-energy-intensive industries, while in the building sector, most of the investments are devoted to improve residential homes insulation and appliances.

Finally, when energy efficiency is combined with the penetration of renewables, such joint-intervention is expected to affect the distribution of global income by reducing the demand on oil, gas, and coal. Importing countries would reduce their import bills, enhancing energy security, while exporting counterpart will need alternative sources of income (or foreign exchange earnings). This can be seen as a virtuous circle supported by energy efficiency interventions and penetration of renewables in national energy mix that ultimately leads to an increased energy security and access.

Role of energy efficiency in future decades

In the next decades, energy efficiency polices are expected to further reduce the energy intensity of national economic production worldwide. Global energy intensity is indeed forecasted to decrease by 1.9 - 3.2% per year by 2040, especially due to energy savings in the transport, electricity and buildings sectors. To achieve about 80% increase in the global GDP by 2040, by projection, energy demand will be required to grow only by 20%. Despite progresses in developed economies, where energy efficiency is expected to reduce by half the energy demand growth by 2040, more demand for new energy services will continue to drive-up energy demand in emerging countries. Nevertheless, access to more energy-efficient technologies and different road maps for the future of the economy will bring lower income countries to follow a more virtuous path from that followed in the past by countries that have higher incomes today. Indeed, closing the gap between advanced and developing economies in the type and number of energy services in 2040 will not necessitate that the developing economies will be characterized by the same level of per-capita energy demand, since new opportunities can arise (e.g. an increase in the electricity load from air conditioning services may be more than counterbalanced by lower space heating demand).

The key role of energy efficiency in global industry, transport and residential sectors is detailed below:

- *Industry.* Approximately half of the avoided energy demand that would be attributable to energy efficiency by 2040. Energy efficiency measures will limit the growth in industrial demand for coal. Electricity for industrial applications will rise, mainly due to the electrification of the expanding industrial production, and the replacement of fossil fuels with electricity driven technologies (e.g. heat pumps) for producing industrial heat. Increasing the energy efficiency of electric motor systems can represent an important opportunity to offset this rise.
- *Transport.* Efficiency interventions are focused on the internal combustion engines. Contributions in reduction of primary non-renewable energy consumption will also be driven by fuels switching, from oil-based to electricity, and natural gas and biofuels will contribute to reduce oil consumption and increase fuel-economy mainly by hybridization of traditional engines, variable valve actuation, direct injection, friction reduction and light-weighting.
- *Residential*. Energy efficiency measures are forecasted to largely contribute to decrease the global electricity demand. Electricity and gas demand in buildings in developing economies is expected to increase more

than double. In Africa and Asia, key opportunities for energy efficiency are expected in the rapidly expanding air conditioning market and the rapid deployment of light-emitting diode (LED) based lighting. Finally, improving energy efficiency in the building sector of emerging economies would represent an important driver to decrease the urban air pollution from cooking and heating.

Energy efficiency and renewables

Governments generally support energy efficiency measures and penetration of renewables by adopting different policy instruments. Nevertheless, an integrated promotion of both energy efficiency and renewable systems is becoming progressively more compelling. Indeed, without an integrated approach, investments may be allocated sub-optimally. For instance, distributed generation systems can be more appropriately managed through a well-balanced combination of efficiency and renewable energy measures, avoiding to rely on further investments for addressing technical imbalances, such as electricity storage.

Coupling energy efficiencies with renewables can also provide more effective opportunities, and deep electrification represents among others an important cross-cutting trend. Indeed, achieving a higher share of renewables is facilitated by the electrification of heat and transport sector, and also the overall energy efficiency can be improved by electrification where new technologies, such as heat pumps and electric vehicles, have better energy performance. This represents a huge opportunity for appropriately electrifying remote areas in developing economies, where highly efficient appliances and renewable-based systems can provide efficient energy services and represent affordable and available solutions for households. Furthermore, increasing energy efficiency and renewables' use, and reducing fossil-fuels use would contribute to alleviating the problem of premature deaths from household air pollution, leading to 1.5-2 two million fewer deaths in 2040 than today.

Energy efficiency measures and renewables can provide more effective results, if they are implemented by following three general guidelines suggested by the IEA: (1) focus on the end goal, overtaking the short- and long-term obstacles to the adoption of energy efficiency and renewable energy; (2) maximize the synergies between energy efficiency and renewables in order to reduce the risk of implementing contradictory policies; (3) ensure a flexible policy framework, which can support the existing markets and regulations to adapt to the dynamic changes in the global energy sector – e.g. the digitalization of energy systems –, and to facilitate the development of new business models and solutions.

2. Energy Efficiency Work Stream

The Africa-EU Energy Partnership (AEEP) Political Target on Energy Efficiency by 2020 consists in *improving energy efficiency in Africa in all sectors, starting with the electricity sector, in support of Africa's continental, regional and sectoral targets*. In order to contribute to the progress towards meeting the AEEP 2020 Target on Energy Efficiency, Politecnico di Milano is setting up the AEEP Energy Efficiency Workstream (EE WS), composed of a group of relevant actors in the field of energy efficiency, with the objective of developing and disseminating an Energy Efficiency Matrix, generally outlined in this paper. The AEEP EE WS is composed by diverse members belonging to different institutions:

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With the geographical scope of Africa, such Energy Efficiency Matrix is designed with the aim of fostering collaboration among members and institutions, enhance political dialogue and stakeholder engagement for expanding networks and outreach on the topic of energy efficiency and joint cooperation between Africa and the EU.

The overall goal of the EE WS consists in the establishment and management of an energy efficiency action group with the objective to contribute to the AEEP 2020 political target on energy efficiency. This is achieved by means of the development and dissemination of an Energy Efficiency Matrix, in which the African, European and international players on energy efficiency are identified, and their strategies, policies and actions directed towards the promotion of the efficient use of energy in Africa are extensively analyzed based on specialized literature research.

3. AEEP EE WS Energy Efficiency Matrix

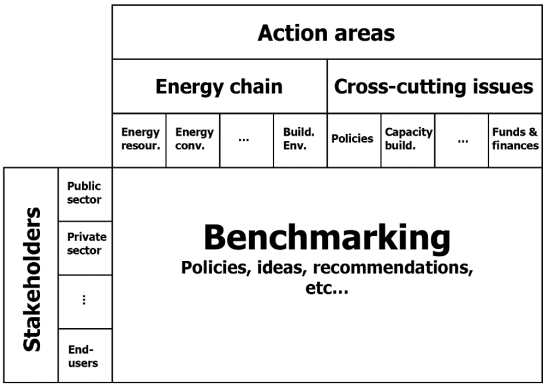
The Energy Efficiency matrix is built with the aim of fostering collaboration among members and institutions, enhancing political dialogue and stakeholder engagement for expanding networks and outreaching on energy efficiency and joint cooperation between Africa and the EU. This matrix will promote cooperation and communication between the main players on energy efficiency field, and will help to analyze strategies, policies and actions for each identified stakeholder, suggesting possible ways to promote an efficient use of energy resources based on previous findings and ideas successfully applied or recommended. Moreover, it will contribute to the involvement and participation in energy sector events and processes of several participants and society segments that are not directly related to energy; to increase the knowledge share between European and African countries; to foster the capacity building related to energy efficiency in Africa and to give technical and political advisement to African leaders towards energy efficiency. The Matrix has been developed by through the following phases:

1. Identification and assessment of the *Stakeholders* and *Action Areas* in the African context.
2. *Literature research* and collection of relevant quotations related to energy efficiency in the African context. Scientific papers, as well as reports produced by public or private organizations, institutional declarations and other kind

of documents have been collected throughout a comprehensive literature review.

3. Derivation of *policy recommendations* and compilation of the Energy Efficiency Matrix.
4. External review made by international experts and dissemination of the Matrix.

As can be inferred from the figure, the columns of the matrix represent the different Action areas, while the rows contain the Stakeholders. In this way, each stakeholder is related to each action area by one cell of the matrix. Each cell is filled with recommendations based on the analyzed literature, including ideas, actions or possible policies and interventions that may be implemented in each couple Stakeholder-Action area.



The major identified stakeholders related to the energy sector are following listed:

- *Public sector*. Public institutions, governments and agencies, which manage the legislative framework and the public budget, and thus have the power to introduce new policies or change the existing ones. This sector includes local, regional, national and international authorities.
- *Private sector*. Private companies and organizations pursuing private interests. They are not under direct control of governments, however it is possible to condition their behaviors through laws and regulations. It also includes Small and Medium Sized Enterprises (SMEs) or Large Enterprises.
- *Civil society*. Organizations and individual actors whose actions can have a great influence or relevance on the society, in particular Non-Profit and Profit organizations.
- *Academia*. It refers to educational institutions which main objective is the capacity building and spreading information.
- *Research*. This refers to every activity of investigation, surveys, think tanks and Research & Development (R&D) related to energy. They can be further classified into a public or a private research organizations.
- *Individuals*. It refers to individual citizens as end consumers and users of energy, and the actions that they can take, marginally, in order to follow the path towards a sustainable model of economy.

For the action areas, a major classification is used, distinguishing between action areas belonging to the energy sector and those belonging to cross cutting issues. Energy sector action area includes:

- *Energy Resources*. It refers to the phase of resource extraction and also to the kind of resource used to provide energy.
- *Energy Conversion*. It refers to all the processes and machinery involved on energy transformation into more useful forms or to goods, services and utilities.
- *Transmission and Distribution*. It considers all the infrastructures and methodologies

used for taking or delivering energy or energy resources from suppliers to consumers in different phases of the energy chain.

- *End-User devices*. They involve all the domestic or commercial machines and devices that consume energy providing to provide a direct service or good to the final users.

Cross cutting issues area includes:

- *Policies*. Governmental or corporative actions, laws, regulations, etc.
- *Capacity Building*. It focuses on enhancing the abilities fundamental to achieve measurable results.
- *Behavioral Change*. It refers to changes in consumption habits, not only for individuals, but also for companies and institutions.
- *Entrepreneurial Attitude*. It considers all the initiatives, innovation and fresh ideas that have been proved to have a positive benefit when progress enhancement is sought.
- *Integration and Coordination of Policies*.
- *Finance, Funding and Risk Management*.

Action areas vs Stakeholders	**Civil Society**	**Individuals**	**Private sector**	**Public sector**
Behavioral Change	1		1,2,4,7	6
Capacity Building			3	
End use – Device & Building Environment			6	4
Energy Conversion		6	2,1	
Energy Resources				2,7
Entrepreneurial attitude			3	
Finance, Fund & Risk Management			5	
Integration/Coordination of Policies			1,3	1
Policies	7		4	1,5
Transmission & Distribution				3

Energy Efficiency matrix: highlights

The Energy Efficiency matrix, not extensively reported in this paper, has resulted from an in-depth literature review, covering about 30 scientific publications and more than 40 documents, including grey papers and reports from authoritative public and private institutions (a complete document list is reported in section 5).

In order to foster the increase in the energy efficiency of the supply chains for Developing Countries, the most promising, feasible and affordable ways to be followed emerged as the following ones: first, the implementation of environmental regulation and standards, and the use of tools and techniques to assess and to monitor environmental performance of products that have been successfully adopted in developed economies, may represent a great opportunity. Secondly, a shift in technology adopted in DCs towards the state of the art systems for energy use in the residential and transport sectors appears to have the largest benefits from multiple viewpoints: beside the rationalization of energy end uses, great improvements are expected in local pollution and health conditions. Moreover, it is worth mentioning that since a high increase of the electrification rate is forecasted in the next decades, it will be crucial to implement appropriate and affordable funding policies in order to promote a renewable-based access to electricity combined with the penetration of efficient end-use appliances and industrial devices.

The most relevant recommendations among the about 350 recommendations derived as outcomes of the literature review have been collected in this section. From the table on the left, it can be directly inferred that most of the recommendations are mainly applicable to the

private and the public sectors, while only few recommendations concern the civil society and the individuals. All the recommendations can be grouped in the following general categories:

1. *Development of environmental regulations and Environmental Labelling systems*.
   This recommendation appears to be relevant for Behavioral change and Integration/coordination of policies in the Private sector, focusing in particular on the integration of a law system for eco-design and labeling practices in activities of private enterprises.
2. *Improvement of domestic cooking systems.*
   Dissemination of clean and safe cooking devices should be a fundamental target for public institutions, and a potential business for private companies. The positive implications of this action on human health, local pollution levels and negative impact on deforestation make the implementation of this recommendation urgent.
3. *Development and application of tools for energy auditing and Life Cycle Assessment.*
   Dissemination of knowledge and competences about methods and models to account for the environmental impact of products and to perform energy auditing seems to be crucial for private companies.
4. *Set a system of Minimum Energy Performance Standards (MEPS) and efficiency standards.*
   This practical action can be implemented by the joint intervention of public and private sector, and it is particularly relevant for the end-use devices and for buildings.
5. *Improve and increase funding and investments on energy efficiency.*
   This recommendation is related to the private and the public sectors, and it would provide the necessary financial support for applying several other actions identified.
6. *Reduce energy use in transport sector.*
   This recommendation seems to be very crucial for individuals and for private companies respectively in energy conversion and end-use processes. It includes a variety of practical actions, ranging from the use of alternative fuels, to the development of the supply chain of alternative power trains for road and water transport.
7. *Improve energy access through a combined use of energy efficiency and renewables.*
   This recommendation can be pursued in several ways by several actors: private companies may play a crucial role in fostering the behavioral change in energy end users, while public sector and civil society should provide the necessary political framework to facilitate the dissemination of renewables and the implementation of energy efficiency policies.

5. Fundamental literature

The above list collects the most relevant scientific and grey documents analyzed to derive the recommendations included in the matrix.

Scientific literature

Stefano Mandelli, Jacopo Barbieri, Lorenzo Mattarolo and Emanuela Colombo. 2014. Sustainable energy in Africa: A comprehensive data and policies review.

Kazunori kojima and Lisa Ryan. 2010. Transport Energy Efficiency. Implementation of IEA recommendations since 2009 and next steps.

Michael Bräuninger. 2012. Achieving sustainability in urban transport in developing and transition countries.

Kahn Ribeiro, S., S. Kobayashi, M. Beuthe, J. Gasca, D. Greene, D. S. Lee, Y. Muromachi, P. J. Newton, S. Plotkin, D. Sperling, R. Wit, P. J. Zhou. 2007. Transport and its infrastructure.

Anumita Roychowdhury et al. 2016. Urban air quality management in Ethiopia: A guidance framework.

Mantas Felneris. 2016. Algal Biodiesel in Lithuania: From Promise to Reality. Procedia Engineering Volume 134.

P. Janulis. 2004. Reduction of energy consumption in biodiesel fuel life cycle. Renewable Energy, Volume 29.

Dalia Streimikiene. 2011. Comparative assessment of future motor vehicles under various climate change mitigation scenarios. Renewable and Sustainable Energy Reviews Volume 15.

R.N Colvile. 2001. The transport sector as a source of air pollution. Atmospheric Environment Volume 35.

Kandasamy Muralidharan. 2011. The Effect of Bio-Fuel Blends and Fuel Injection Pressure on Diesel Engine Emission for Sustainable Environment. American Journal of Environmental Sciences.

Grey Literature

Katrina Pielli, U.S. Department of Energy; Himesh Dhungel, Doug Mason, Dan Tobin, Millennium Challenge Corporation; and David Gottfried, U.S. Department of Treasury. 2014. Examining Energy Efficiency Issues in Sub-Saharan Africa.

International Renewable Energy Agency (IRENA). 2013. Africa's renewable future, The Path to sustainable growth.

International Institute for Applied System Analysis (IIASA). 2014. Research, Research Projects, Energy Access - Analyzing the Energy Dimensions of Poverty.

Sustainable Energy For All. 2015. Global Energy Efficiency Accelerator Platform, Lighting.

World Bank. 2008. Financing Energy Efficiency: Lessons from Brazil, China, India, and Beyond.

European Commission. 2014. Energy Efficiency and its contribution to energy security and the 2030 Framework for climate and energy policy.

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The Worldwatch Institute (Christopher Flavin, Molly Hull Aeck). 2005. The Potential Role of Renewable Energy in Meeting the Millennium Development Goals.

Sustainable Energy For All. 2012. A Global Action Agenda (Pathways for Concerted Action toward Sustainable Energy for All).

European Commission. 2012. Energy Efficiency Directive.

International Partnership for Energy Efficiency Cooperation (IPEEC). 2015. Delivering Energy Savings in Buildings.

G20. 2014. G20 Energy Efficiency Action Plan.

International Council on Clean Transportation (ICCT). 2016. Reducing CO2 emissions from road transport in the European Union: An evaluation of policy options.

International Partnership for Energy Efficiency Cooperation (IPEEC). 2016. G20 Energy Efficiency Finance Task Group (EEFTG) Activity Report.

International Council on Clean Transportation (ICCT). 2016. Policies to reduce fuel consumption, air pollution, and carbon emissions from vehicles in G20 Nations.

International Partnership for Energy Efficiency Cooperation (IPEEC). 2014. LDV fuel economy and the G20.

International Energy Agency (IEA). 2016. IEA Energy Efficiency Market Report 2016.

International Energy Agency (IEA). 2007. World Energy Outlook 2007.

EPA Climate Change Report. 2010. Transportation's role in reducing US Greenhouse Gas Emission.

European Commission. 2014. Reducing CO2 emissions from passenger cars.

Ilka N. Buss. 2010. Recommendations for the Design of a Long -Term Capacity Building Strategy for the Wind and Solar Sectors by the MEF Working Group.

Department of Minerals and Energy (of) Pretoria. 2004. Energy Efficiency Strategy of the Republic of South Africa.

UNESCO. 2013. Good Practices for Energy-Efficient housing in the UNECE Region.

European Commission. 2015. Energy Efficiency Trends and Policies in the Household and Tertiary Sectors an Analysis Based on the ODYSSEE and MURE Databases.

Climate Change Committee. 2016. Home energy efficiency and demand reduction.