# UNIVERSITY OF PADUA

## Department of Land, Environment, Agriculture and Forestry

**Laurea Magistrale Scienze Forestali e ambientali**

**MEDETTERANEAN FORESTRY (MEDFOR)**

# Sustainable Use of Wood for Energy

**Comparison of Energy Support Schemes for Domestic Use of Wood between Germany, Italy, Japan, and UK**

Supervisor
Prof. Davide Mateo Pettenella

Co-Supervisor
Dr. Mauro Masiero

Yu Ishida
no. 1089806

Academic Year
2014 – 2015

## Index

## List of figures

## List of tables

# Abbreviations and acronyms

| | |
|---|---|
| BMEL | *Bundesministerium für Ernährung und Landwirtschaft* (German Federal Ministry for Food and Agriculture) |
| BMU | *Bundesministerium für Umwelt, Naturshutz Und Reaktorsicheheit* (German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety) |
| BMWi | *Bundesministerium für Wirtschaft und Energie* (German Federal Ministry for Economic Affairs and Energy) |
| $CO^2$ | Carbon Dioxide |
| CHP | Combined Heat and Power |
| DECC | Department of Energy and Climate Change |
| DPSIR | Drive-Pressure-State-Impact-Response framework |
| EEA | European Environmental Agency |
| EEG | *Erneuerbare-Energien-Gesetz* (German Renewable Energy Sources Act) |
| EMR | Electricity Market Reform |
| EPC | Energy Performance Certificate |
| EU | European Union |
| FIT | Feed-in Tariff |
| FIP | Feed-in Premium |
| GC | Green Certificate |
| GDA | Green Deal Assessment |
| GHG | Greenhouse Gas |
| GME | *Gestore Mercati Energetici* (Italian Energy Markets Managing Authority) |
| GSE | *Gestore Servizi Energetici* (Italian Energy Services Managing Authority) |
| MAFF | Ministry of Agriculture, Forestry and Fisheries |
| MATTM | *Ministero dell'Ambiente e della Tutela del Territorio e del Mare* (Italian Ministry of the Environment, Land and Sea) |
| MCS | Microgeneration Certification Scheme |
| METI | Ministry of Economy, Trade and Industry |
| MSE | *Ministero dello Sviluppo Economico* (Italian Ministry of Economic Development) |
| NREAP | National Renewable Energy Action Plan |
| OECD | Organization for Economic Co-operation and Development |
| ORC | Organic Rankine Cycle |
| PES | Primary Energy Supply |
| PV | Photovoltaic |
| RE | Renewable Energy |
| RHI | Renewable Heat Incentive |
| ROC | Renewable Obligation Certificate |
| RPS | Renewable Portfolio Standards |
| RSL | Registered Social Landlord |
| SFM | Sustainable Forest Management |
| UN | United Nations |
| UNECE | United Nation Economic Commissions for Europe |

## Acknowledgement

Firstly, I would like to express my gratitude to my supervisor Prof. Davide Pettenella and my co-supervisor Dr. Mauro Masiero for their patient and utmost support for my study. Their professional assistance and technical guidance helped me shaping my unorganized work.

Besides, I would like to thank the Erasmus Mundus program, especially to University of Lleida and University of Padova for hosting me. All the activities and trips they provided enriched my experience.

Also, I would like to thank all of my friends who I met within these 2 years of master study. I have never imagined having such a great relationship with people from all around the world. Sharing culture, learning each language, and cooking traditional food was always fun. I really appreciate the time we shared; all those moments deepened my life. Especially to my colleagues for reviewing my work and encouraging me all the time, thank you very much.

Last but not the least; I would like to thank my parents and grandparents. Without their continuous generous support, I would have not completed my study life here.

This part of my life was one of the best moments.
Thank you everyone and I love you all!

# Summary

This study has investigated the effects of wood products supply chain in relation to national renewable energy support schemes. The research was inspired by the question of whether monetary incentives encourage domestic wood use or induce wood imports.

This research conducted in-depth case studies on four selected countries – Germany, Italy, Japan, and the UK. Its theoretical approach was based from the DPSIR (Driver, Pressure, State, Impact and Response) model created by EEA. The following information were used as indicators of the model: renewable energy support schemes, trend in biomass energy production, trend in wood products, sizes and numbers of plants, and forest resources. Most of the data were collected from documents provided by each national ministry and online databases such as Eurostat and FAOstat.

The findings from the research illustrate the antecedents and consequences of renewable support incentives and biomass energy production together with biomass plants, but further impacts on wood supply remains anecdotal due to the complex interconnections of several disciplines.

The results provided some key aspects for better use of wood biomass in support of renewable energy support incentives, but also limitations were stated for further research in the future.

# 1 Introduction

The aim of study is to define the trend of wood biomass energy production and the further impacts on wood material trades in a relation of renewable energy support schemes. This first chapter provides background information and highlights the problems.

## 1.1 Background

Energy issues have been one of the central topics of discussions among all nations nowadays. The limitation of fossil fuel sources, the skepticism of nuclear energy safety, and the urgency to address greenhouse gas (GHG) emissions have triggered a high demand for a better and more sustainable energy source – the renewable energy. Over the past decade, and particularly in recent years, policy supports have steered most of the advances in renewable energy technologies and helped increasing global production capacity. It specifically attracted more investments in the sector, which in turn has further driven down costs through economies of scale. Renewable energy comprised an estimated 27.7% of the world’s power generating capacity and has provided an estimated 19.1% of global final energy consumption in 2013 (REN21, 2015). In particular, the European Union (EU) declared its own target to have a 20% overall share of energy from renewable sources by 2020. The growth in capacity and energy generation of this sector continued to expand in 2014 with further investments amounting to 270 billion US dollars (REN21, 2015).

The forest sector is unique when it comes to renewable energy policies. It produces both energy and energy intensive products like pulp and paper, and it is therefore closely linked to the energy sector (Solberg, *et al*., 2014). Biomass now has the biggest share among all renewable sources of energy and together with geothermal/solar heat its share accounts to 4.1% of the total final energy consumption in the world in 2013 (REN21, 2015). The forest industry can use the same input, namely wood, both for energy and industrial production (Solberg, *et al*., 2014). Wood material is comparably limited compared to wind and solar energy sources. Thus, energy policies may have multiple impacts on the sector, but the impacts are sometimes not clearly evident.

Policy incentives may help forestry economic performances, while they might not be positively effective from environmental perspectives. Indeed large energy plants relying on wood resources are in construction rush in some parts of the world. This accelerates harvesting wood and creates a larger trade market of the materials, specially wood chips and pellets. The reason wood biomass to be considered as a renewable energy source is because of the carbon neutral theory. Supplying wood far from a plant requires longer transportation of material and it causes discharging more carbon dioxide ($CO_2$) is enough to wipes out an effect of carbon emission. Sustainability is a relevant term to wood biomass for energy due to this reason therefore it is strongly recommended wood energy to adhere to domestic wood supply.
Another aspect to be respected is the *'cascade use'* concept of wood. The *'cascade'* use promotes the multiple use of the wood along its value chain and gives priority to the product with the highest added value (Ciccarese, *et al.*, 2014). As such, this concept puts energy production at the end of the priority list when all possible uses have been exhausted. The concept would help creating synergies between industry and energy sector in accessing wood resources (EFI, 2014).

Consolidation of policy supports for biomass energy production should be elaborated with a consideration also of environmental factors but harmonizig environment operation and policy making for renewable energy is complex. This calls for a review of the existing policy support systems in wood biomass energy production and an evaluation of their implications to wood production and use to seek more suitable way of wood use for energy.

## 1.2 Problem statement

Wood provides almost half of the total renewable energy consumed and is expected to continue to account for the largest share of renewable energy by 2020 (although generation of other types of such as solar or wind power will grow at a faster pace) (UNECE, 2012b). Recent studies state that support schemes have successfully developed and implied to support monetary incentives for biomass energy production but they contain the potential hazard of waving a big stick at forest sector. Meaning, favourable policy support seduce investors to involve in renewable energy sector, especially in larger capacity sized electricity generation plants, and it may overwhelm the absorptive capacity of wood production because they require a huge amount of wood due to its low energy convert efficiency. For instance, a 5 megawatt (MW) capacity sized plant requires about 60 thousand tonnes of chips per year (MAFF, 2012). An intense demand is seen European regions as well that the UNECE/FAO European Forest Sector Outlook Study estimates a 3.5% annual growth rate in the demand for wood energy in close future. As such, it is expected that the wood supply required to satisfy the corresponding renewable energy demand will have to double from 435 million $m^3$ in 2010 to 860 million $m^3$ in 2030 (UN, 2011). A stable procurement of such amount of wood is a big challenge in next decades that may cause unsustainable harvesting and trading of raw material. Also energy production from wood does not always come from its by-products, which against the cascade concept. Forests are often clear-cut and burned for electricity production while others import resources to spare their own domestic resources. In this case, import of wood energy feedstock needs to meet certain sustainability criteria. For instance, trade in wood energy feedstock over long distances can significantly reduce the potential of wood energy to ameliorate GHG emissions. This thus raised questions on the low-efficiency of wood use and energy conversion from wood materials transported over long distances (UNECE, 2012b). In fact the impact has already seen that net wood biomass trade volumes for energy grew sixfold from 56.5 petajoule (PJ) to 300 PJ between 2000 and 2010, but we have to be always aware that to obtain solely bioenergy related production and trade streams it is indispensable to rely on anecdotal evidence (Junginger, *et al*., 2014)

## 1.3 Objectives and research questions

In connection to the above mentioned concerns, this study focuses on the trends of wood biomass energy production and public incentives with a consideration of the cascade and domestic use of wood. It specifically aims to:

1) Understand the main support schemes for wood biomass energy production in 4 different countries: Germany, Italy, Japan, and the UK;
2) Analyze the impacts on wood use by searching conditions of domestic production and wood import, in relation to the size/number of plants;
3) Understand the interconnection between support schemes and wood uses to see if they are eligible enough to support the sustainable use of wood.

In this study a term “domestic“ refers activities inside of the nation but not specifically in a small scale of region.

## 1.4 Structure of the thesis

The thesis consists of five chapters:

- Chapter 1 introduces about the topic about this study which is on politic support schemes for wood biomass energy production and its impact on forestry sector. Following section states the research objectives based on the background information and problem statement.
- Chapter 2 gives background information including definitions and simple explanation of major support schemes to ease the readers to understand the results part. Here also explains theoretical framework that is applied in this study.
- Chapter 3 describes the research methodology. After a brief description of the research approach in the first section, here describes which steps were taken to conduct the study. Most importantly indicators for the

framework for assessment are explained and sources for the data are also mentioned.

- Chapter 4 presents detailed results for each country by following the research approach. As an overall discussion, results from 4 selected countries are compared to extract some general remarks.
- Chapter 5 finally summarizes key findings as a conclusion. This chapter also includes limitations, proposal of a base framework and suggestions which can be applied for future study.

# 2 Theoretical background

In this section technical background information is provided in order to give the basic knowledge on wood biomass, renewable energy incentives, and the original concept for the study framework.

## 2.1 Definitions

<u>Wood biomass</u>

In general the term “biomass” includes material from forestry and agriculture. Within forestry sector there are several types of energy material: fuel wood, chips, pellets, and waste. These can be burnt with incinerators to produce thermal energy, or they are combusted/gasified with boilers to generate electricity. Wood chips production contains simple processing steps with lower costs thus they are economically friendly to the final customer. Pellets production requires more steps and high energy but it is easier to transport and have a high calorific value. Energy conversion efficiency is higher also because of lower moisture contents than chips. When it comes out as a data they are categorized by technology include: solid biomass, biogas, and bioliquid. Wood contributes to all 3 types but mainly to solid biomass.

<u>Renewable Energy Incentives</u>

According to KPMG (2013) the 12 most common policies for renewable energy support can be divided into three main categories: regulatory policies, fiscal incentives and public financing. Table 1 shows the grouping of these policies.

**Table 1. Common Policies for Renewable Energy Support**

| Regulatory policies | Fiscal incentives | Public financing |
|---|---|---|
| – RE targets<br>– feed-in tariff/premium<br>– quota obligation, renewable portofolio standard (RPS)<br>– net metering<br>– biofuels obligation<br>– heat obligation<br>– tradable renewable energy credit (REC) (certification schemes) | – capital subsidy, grant and rebate<br>– investment and production tax credits<br>– reduction in taxes<br>– energy production payment | – public investment, loans and grants<br>– public competitive bidding/tendering |

Source: (KPMG, 2013)

This study will not cover all the above listed policies. It will be specifically focused on 2 fundamental regulatory policies used in a wide range: the feed-in schemes and renewable energy certification schemes. With the traditional feed-in tariff (FIT) scheme (Figure 1), the energy producers are guaranteed a fix amount of money for each unit of electricity they supply to the grid for 15-20 years. The operating capital is collected by charging additional cost on electricity price paid by the end users.

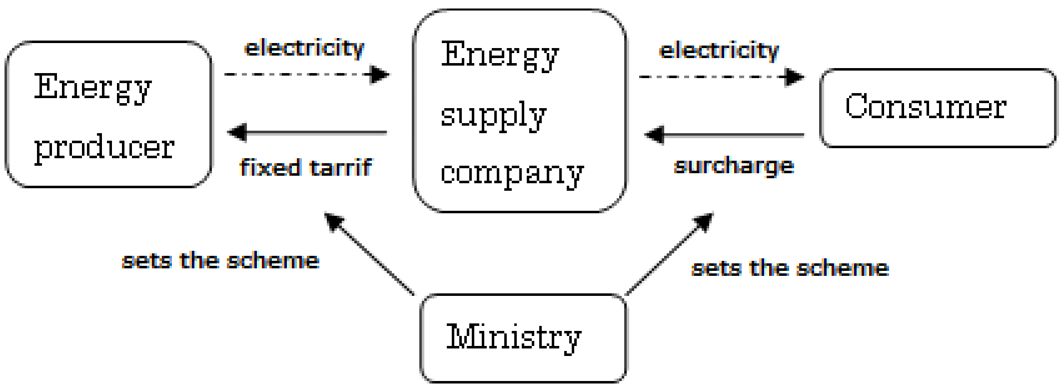



**Figure 1. Basic Framework of FIT Scheme**

Source: created by the author

On the other hand, a renewable energy certification represents attributes of renewable electricity generation. Each nation has its obligation of the amount of electricity which has to be generated from renewable energy. A certificate is issued usually for 1 MWh of renewable energy produced and certificates are used to prove the amount of electricity or can be transferred between different energy suppliers. Here surcharge means the portion of electricity price that the end user must pay to support renewable energy

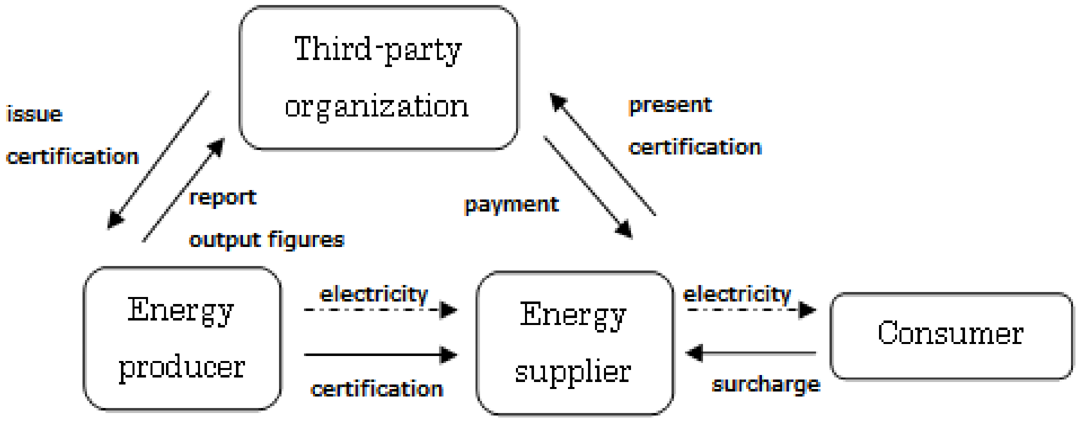



Figure 2).

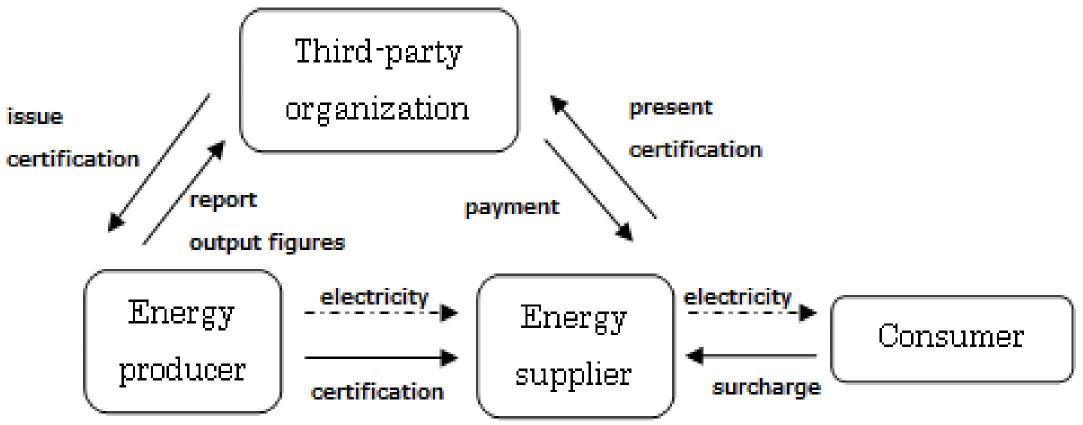



**Figure 2. Basic Framework of Certification Scheme**

Source: created by the author

## 2.2 Theoretical approach

The analytical framework of this research is inspired by the Driver-Pressure-State-Impact-Response (DPSIR) framework developed by the European Environmental Agency (EEA) in 1999. This framework was initially developed by the Organization for Economic Co-operation and Development (OECD) and has been used to assess and analyse the sustainability and impacts on ecosystems, and assist decision-makers in the decision process.

*"According to this systems analysis view, social and economic developments exert pressure on the environment and, as a consequence, the state of the environment changes. This leads to impacts on e.g. human health, ecosystems and materials that may elicit a societal response that feeds back on the driving forces, on the pressures or on the state or impacts directly, through adaptation or curative action. This model describes a dynamic situation, with attention for the various feedbacks in the system. By their nature, indicators take a snapshot picture of a constantly changing system, while the assessments that accompany the indicators can highlight the dynamic relations"* (EEA, 2003, p. 6).

Figure 3 summarises the key components and the rationale of the DPSIR framework. According to the definitions from EEA, **Driver** describes the social, demographic and economic developments in societies and the corresponding changes in lifestyles, and overall levels of consumption and production patterns. **Pressure**, on the other hand describes developments in release of substances, physical and biological agents, as well as use of resources and land in human activities. The **State** gives a description of the quantity and quality of physical, biological, or chemical phenomena while **Impact** describes changes in the conditions. Lastly, **Response** refers to the reactions by groups in society, as well as the government's attempt to prevent, compensate, ameliorate or adapt to changes in the state of environment (EEA, 2003).

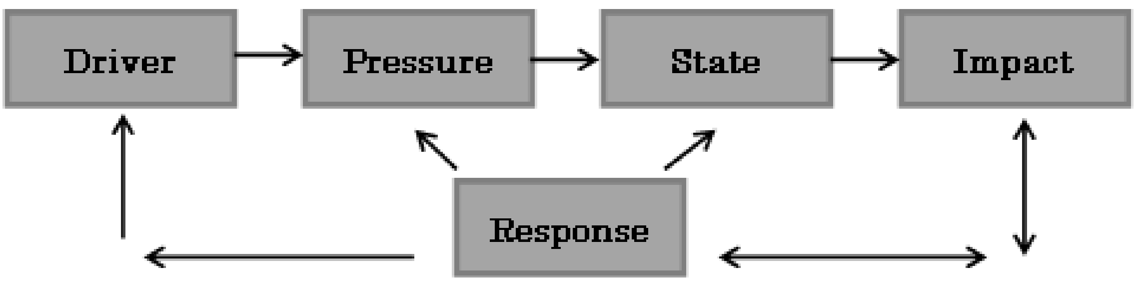



**Figure 3. DPSIR model**

Source: (EEA, 2003)

This study tries to apply a modified version of the DPSIR model as shown in Figure 4. The thought of man's absolute energy needs and less dependence on nuclear energy obviously induce more commitment to renewable energy. To support this shift, a variety of policies have been developed (Driver). These same policy incentives have successfully increased the amount of energy produced from renewable energy sources, including wood biomass, expanded the market and induced the size and number of plants. These developments describe the outcomes after the Driver (Pressure). On the other hand, the increase in biomass energy production influences the amount of production and import of wood materials. This thus gives a qualitative description of the current situation (State) while data on forest resources provide a representation of the state of the environment (Impact). Lastly, continuous policy amendments are expected to further enhance the current situation (Response).

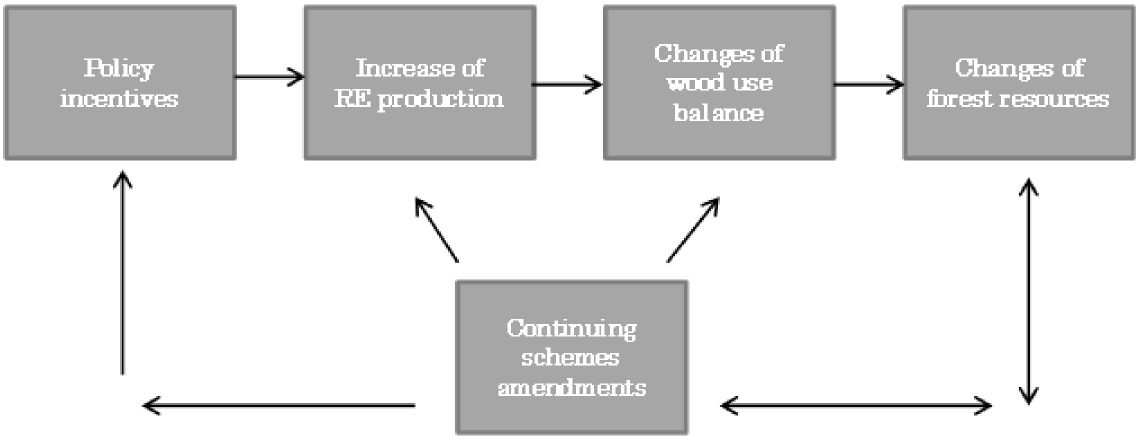



**Figure 4. Modified DPSIR model Applied for Wood Biomass Energy Production**

Source: done by the author

This modified DPSIR model will be applied to four countries, i.e. Germany, Italy, Japan, and UK. Specific indicators for each of the above-described categories will be discussed under methodology, while results of the analysis will be provided for each country, excluding the Response part.

# 3 Research methodology

This chapter explains the methodological framework of the study, study areas, and sources for each data. Then indicators are set following the applied version of DPSIR model.

## 3.1 Research approach

The main approach adopted for this study is a qualitative way of research through literature review with primary and secondary sources of information gathered by following the DPSIR model mentioned previously. In the results part all the information is provided country by country, and in the discussion part deeper observation and a comparison among countries have been done.

## 3.2 Sector and/or study area

For country cases, three EU member states (Germany, Italy and the UK) and one non-EU member (Japan) were selected. Europe remained an important market and a centre for innovation of renewable energy (REN21, 2015) and Germany is one of the most well developed countries in this field. Their experience let other nations to apply empirical assessment for future development. Italy is a top pellets consuming country for household that a study estimates the use of pellets will reach 3.3 mega tonnes in 2015 and 5 mega tonnes in 2020 (Paniz & Bau, 2014). Also Italy remains a main firewood and chips importer. The UK is a big investor in renewables: the average annual investment has more than doubled since 2010 and in 2013 alone almost 11 million euro (original reference was 8 million pounds, see Annex.1 for currency rate) was invested across range of renewable technologies (DECC, 2014a). Japan has a potential of increasing renewable energy having sufficient natural resources but ironically is one of the biggest wood importers like Italy and the UK. Policy schemes have newly implemented just three years ago and they are not highly developed yet.

The diversity in policy instruments and forest situation enhances the variation across cases and makes it interesting to compare.

### 3.3 Data collection

For the policy sector (Driver indicator in the DPSIR model) the information was collected from official documents from each responsible government. There are several policy instruments including subsidies in relation to renewable energy production, but in this study only the main public incentives with much bigger influences were chosen. Table 2 shows a list of entities that are in charge of energy-related and forestry sector policy making.

**Table 2. Government/comapny in Charge of RE Section for Each Country**

| | |
|---|---|
| **Germany** | |
| | Ministry of Economics and Technology<br>Ministry of Food, Agriculture and Consumer Protection<br>Ministry of Environment, Nature Conservation and Nuclear Safety |
| **Italy** | |
| | Ministry of Economic Development<br>Ministry of the Environment<br>Ministry of Agricultural, food, and Forestry Policies<br>GSE (Energy company) |
| **Japan** | |
| | Ministry of Agriculture, Forestry and Fisheries<br>Ministry of Economy, Trade and Industry |
| **UK** | |
| | Department of Energy & Climate Change<br>Ofgem (Government regulator) |

Additional policy information was explored in detail through documents gathered from third party organizations such as energy supply companies.

For the energy production progress and size/number of plants (Pressure indicator in the DPSIR model) data relied on documents from mentioned ministries, Eurostat, and Eurobarometer. It should be addressed that extracting homogeneous energy data specifically for wood biomass is very challenging. For those country who had official data specifically for wood/solid biomass, the data was chosen from its statistical paper rather than worldwide database like Eurostat.

For the wood use sector (State indicator in the DPSIR model) this study used the following indicators of state sustainability: amount of wood used for energy production, amount of wood products imported and wood products production.

The needed pieces of information were mainly collected from available online documents and online databases such as FAOstat, Eurostat, and Eurobarometer. Forest resources data (Impact indicator in the DPSIR model) were mainly taken from the Global Forest Resources Assessment Country Reports produced by FAO. This data specifically give an overall picture of the state of forest resources and activity in each country.

### 3.4 Data analysis

This research focuses on data that are believed to provide valuable information on sustainability issues including wood trade trends and forest stands (State/Impact indicator in the DPSIR model). For a further discussion after the data collection, the study tried to explore interlinkages between policies and domestic use of wood. More specifically, the research analyses the trend of wood use over the last 15 years and discusses the potential reasons behind by looking at its connection to current renewable energy incentives. Yet it should be aware that this data analysis is only indicative because many other factors which will be not mentioned in this study are mutually affected on this topic.

According to the DPSIR model, both qualitative and quantitative data were collected as indicators for each model step/component (Table 3). For the pressure part, energy production is mainly focused on electricity generation due to a complexity of heat data collection and a stronger influence by incentives.

**Table 3. Information Collected for Each Indicator**

| Indicators |
|---|
| **Driver** |
| Renewable energy target |
| Policy incentives / Support schemes |
| |
| **Pressure** |
| Amount of energy produced |
| Size and number of plants |
| |
| **State** |
| Amount of production (chips, pellets, fuel wood) |
| Amount of import (chips, pellets, fuelwood) |
| |
| **Impact** |
| Amount of fellings |
| Net annual increment |
| Amount of biomass stock |
| Amount of wood removal |

*see Annex.2 for specific definitions

# 4 Results and Discussions

Following the methodology described in Chapter 3, results are reported for Germany, Italy, Japan, and the UK. For each country a dedicated section is developed, divided into four sub-parts addressing Driver, Pressure, State, and Impact respectively. At the end of this chapter a comparative overview and general discussion are reported to give a summary.

## 4.1 Germany

Germany is one of the top leading countries implementing policy support schemes for biomass energy production. The Renewable Energy Sources Act (EEG) was enacted in 2000 and has supported renewable energy installations. Biomass for energy plays an important role in backing up renewable energy promotion, using its abundant forest resources. Germany covers a land area of 35.7 million ha and a share of approximately 32% (11.4 million ha) is covered by forests (FAO, 2010a). There is a small increase in the total forest area in recent years but forest figures remain almost the same from 2000 to 2010 (FAO, 2010a). Germany is well on the way to attaining its ambitious goals for the expansion of renewable energy using a wealthy forest resources, but the surcharge the people is bearing is swelling up as the total capacity of renewable sourced electricity grows and now it turns out EEG scheme should be amended to be more flexible to let the renewable energy market independent.

### 4.1.1 Driver

According to EEG energy from renewable sources should cover 18% of gross final energy consumption by 2020 and at least 80% of gross electricity consumption by 2050 (EC, 2013a). The fundamental incentive mechanism consists of feed-in schemes with several types of premium and a market premium system has been introduced more recently. Since 2012 renewable energy source plant operators can choose between receiving a fixed FIT and a sliding market premium on a monthly basis. These policy schemes have been amended several times during the last years (in year 2007, 2009, 2012, 2014) and the use of biomass will be considerably limited, and restricted to installation using waste and residual materials dues to its expenses (BMWi, 2014). Two fundamental schemes so called FIT and market premium system (also known as feed-in premium) are briefly described as below.

### a) Feed-in Tariff

The EEG offers fixed payments for every kilowatt-hour (kWh) of renewable electricity supplied to the grid. Plants bigger than 20 MW are not eligible for compensation under this scheme. And the plants that had applied were 5 MW in size, on average, and they normally treat scrap wood from constructions. Taking this into consideration Germany amended FIT to give more support to smaller plants (Kumazaki, 2013). The most notable change was that they obligate plants to be Combined Heat and Power (CHP) with energy conversion efficiency higher than 60% to get remuneration from 2012 instead of putting a bonus. Current prices are showed in Table 4 and changes of FIT prices for biomass (in Euro cents, €ct) are reported in Figure 5 below. From 2016 prices are going to be adjusted every quarter of a year.

**Table 4. Current FIT Price for Biomass in Germany**

| Capacity | Price (€ct/kWh) | Bonus | |
|---|---|---|---|
| | | **material | Special technology |
| ≦150kW | 13.66 | 6 | 4 |
| ≦500kW | 11.78 | 6 | |
| ≦5MW | 10.55 | 2.5 | |
| ≦20MW | 5.85 | | |

*CHP is obligated
**specifically bark and forest waste

Source: (BMWi, 2014)

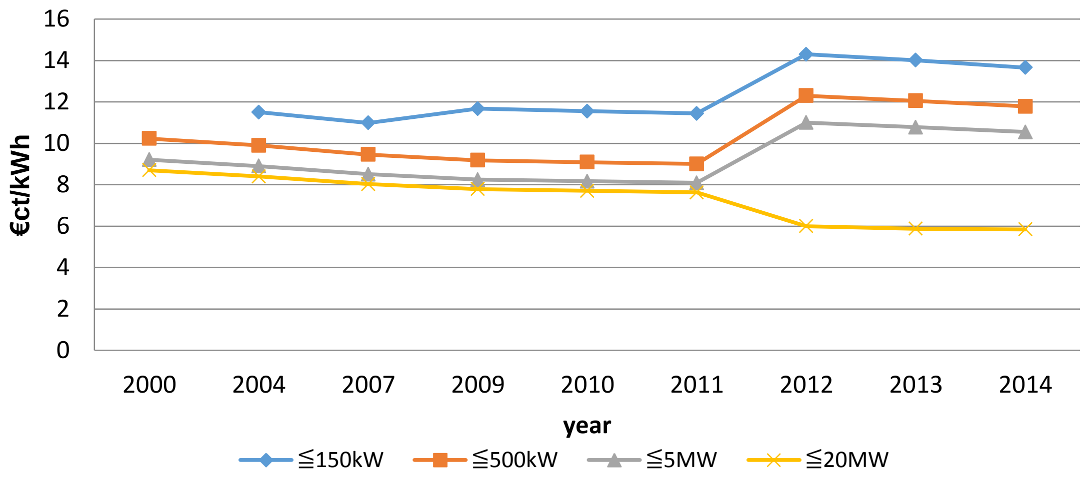



**Figure 5. FIT price changes over years in Germany**

Source: EEG, 2000~2014

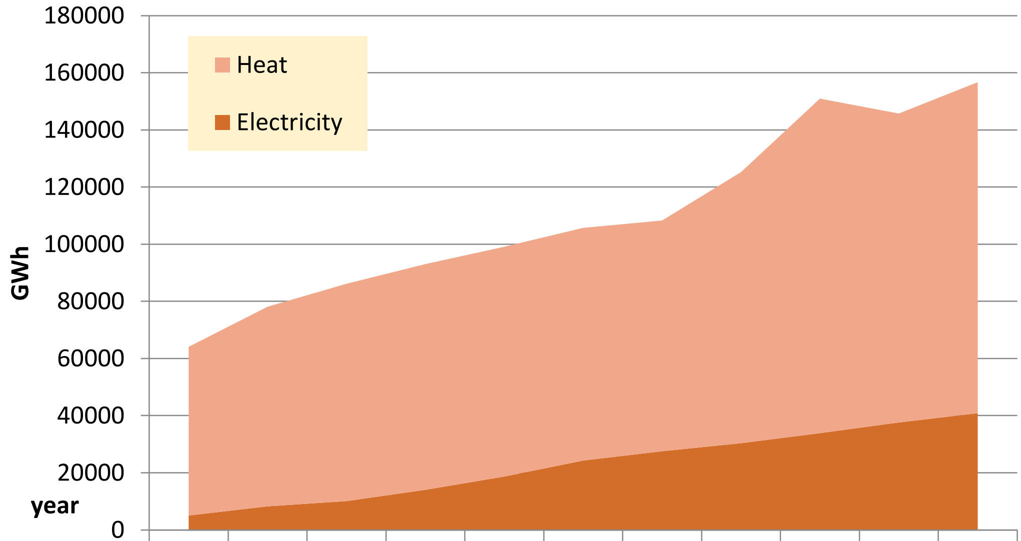
The latest edition of the EEG gives bonus depending on sources of material and technology of plants. In the case of electricity generated from bark or forest waste wood 2.5-6 €ct per kWh is paid, and in the case of using special technology such as organic rankine cycle (ORC) 4 €ct per kWh is paid as a bonus (BMWi, 2014). Higher price is given for small plants using wood waste and this points out that Germany is trying to encourage a wood-cascading approach. One additional note is that the revised EEG does not subsidise biomass co-firing (Tagesfragen, 2012).

**b) Market Premium (feed-in premium)**

Germany is shifting from the traditional FIT system to market premium system. With the FIP plant operators, which are bigger than 500 kW, are supported by a premium for electricity they sell directly. Monthly advance payments of an appropriate amount shall be made for payment of the EEG surcharge. The amount of market premium is calculated on a monthly basis and is equal to the difference between the feed-in tariff and a “reference price”, which is calculated at the end of each month (Gawel & Purkus, 2013). The aim of market premium is to provide market experience to renewable plant operators and incentives for demand-oriented electricity production (Gawel & Purkus, 2013). There is a greater amount of risk under the market premium system than under the fixed FIT because the actual payments received by generators during the course of a month may be different than the average market price that is used to calculate the market premium (Fulton, *et al*., 2012).

### 4.1.2 Pressure

The amount of energy produced from biomass has significantly increased after year 2000, when the EEG was implemented. The total share of renewables in the gross final consumption of energy in Germany was 12.4% in 2013 (BMU, AGEE-Stat, 2013), slightly above the forecast value of 11.4% given in the National Renewable Energy Action Plan (NREAP) (EC, 2010) and biomass contributes to a large proportion of this percentage. The amounts of electricity and heat produced from biomass are showed in Figure 6.




| | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Heat | 59051 | 69875 | 76072 | 79010 | 80416 | 81434 | 80761 | 94888 | 1E+05 | 1E+05 | 1E+05 |
| Electricity | 5038 | 8247 | 10077 | 14025 | 18685 | 24281 | 27531 | 30341 | 33866 | 37603 | 40850 |

**Figure 6. Energy Production from Solid Biomass in Germany**

Source: (BMU, AGEE-Stat, 2013)

Tough heating section is bigger than electricity production, electricity generation has increased dramatically over this 10 years and this could not have occurred without a contribution by support schemes. Large amount of heat production is due to a high number of CHP. EEG aims to increase the share of renewable energy in electricity supply to at least 35% by 2020, rising up to 80% by 2050 (BMWi, 2012). Solid biomass, mainly from wood, contributes to produce heat and the amount is 10 times as much as electricity generation. Gaseous biomass is used more for electricity generation and wood counts as a material also for gaseous plants (Köppen, *et al*., 2013).

Biomass installations also have increased steadily. Figure 7 shows the distribution of the capacity size and number of cogeneration plants in Germany. The system of biomass for energy is equal to thermal power generation and thus the energy production efficiency hugely depends on the size of plants. The policy driver affects the figure of distribution of plants as well.

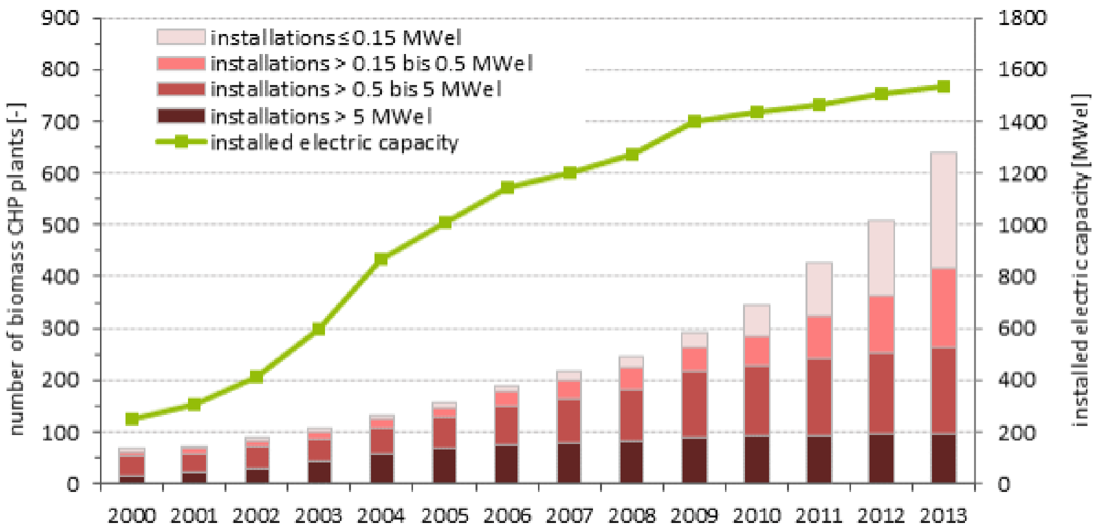



**Figure 7. Capacity sizes and numbers of CHP biomass plants in Germany**

Source: (DBFZ, 2015)

The EEG had excluded from subsidization plants with a capacity larger than 20 MW. Large energy suppliers have sold their plants to foreign suppliers due to the current change of subsidy schemes that makes producing renewable energy less profitable (MarkDöing, *et al*., 2013). In 2011 6 out of 14 new plants had an output lower than 1 MW and the remaining 8 plants were in the 1-10 MW range (DBFZ, 2012). This trend suggests inducements for the construction of small plants and this is because the efficiency of energy production of CHP plants is higher with smaller plants and the amendment of FIT price in 2012 set higher prices for them.

### 4.1.3 State

Figures from 8 to 11 show trends in production and imports for different wood-product categories, together with the trend in primary energy production from biomass between 2002 and 2013. German biomass energy production presupposes using by-products and has a clear vision of wood energy as an end-use within the cascade use. Data also indicate the country does not rely on imports but maintains high production levels. Firstly, Figure 8 shows chips production and import.

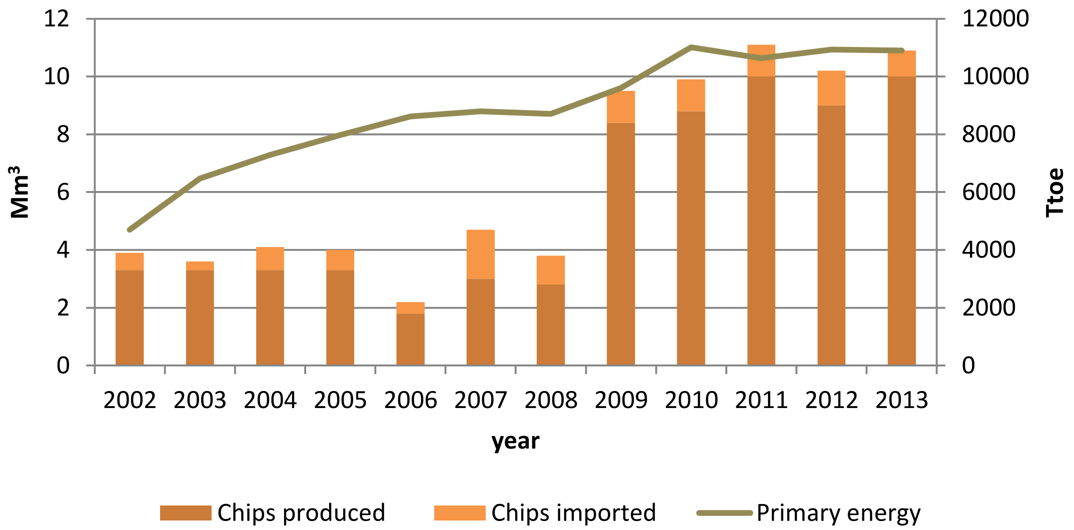



**Figure 8. Chips production and imports, and primary energy production from biomass in Germany**

Source: Eurostat, FAOstat

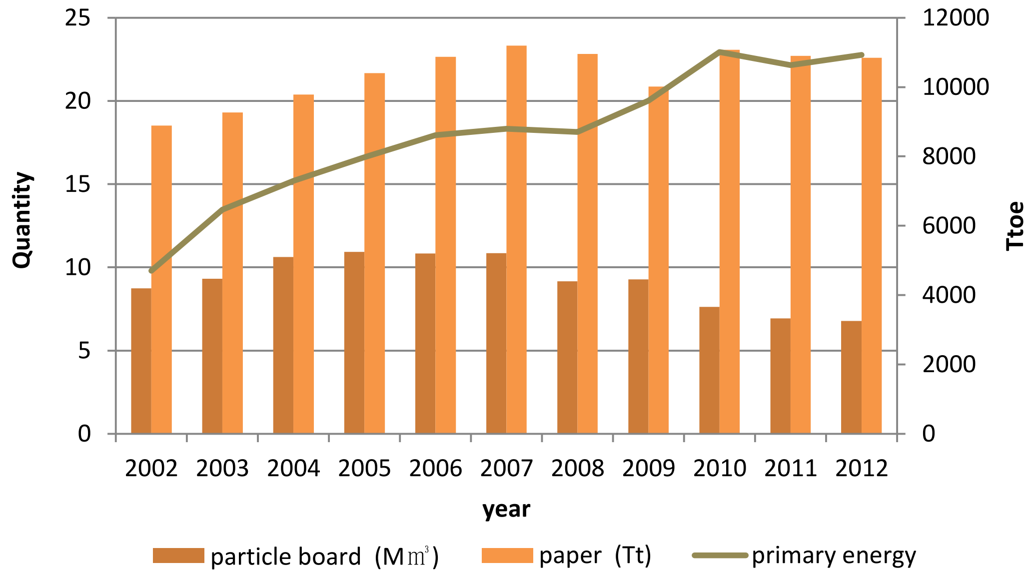



**Figure 9. Particle board and paper production compared to primary energy production from biomass in Germany**

Source: Eurostat, FAOstat

The amount of production showed an intense increase after 2008. The production level exceeds the import but still this consideration should be carefully treated because in principle chips could be produced from imported raw materials.  Figure 9 shows figures of competitor production sectors for wood chips, i.e. particle board and paper sectors, and both remain stable or even particle board production slightly decreases. While electricity generation (see Figure 6) has almost quadrupled within 10 years hence the increase of chips production is likely to be connected with energy generation. In Germany wood chips used in heating sector are still a niche market (DBFZ, 2015).

For the second product, Figure 10 shows a significant increase of both pellet imports and production in Germany.

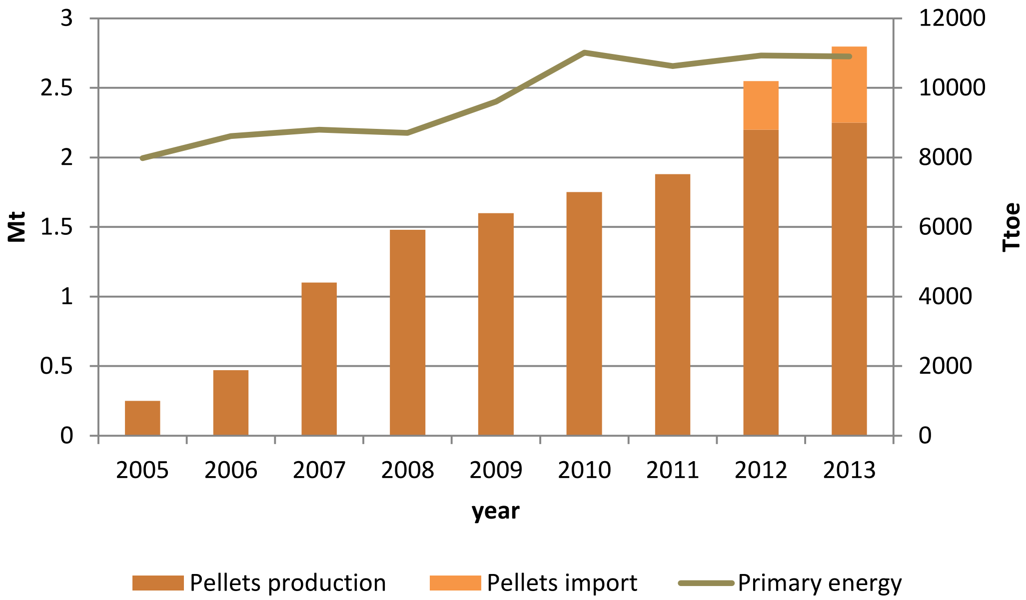



**Figure 10. Pellets production and imports, and primary energy production from biomass in Germany**

*production amount is according to [PellCert, 2012]

Source: Eurostat, FAOstat

Significant level of pellets demand is mainly due to heating operation with small to medium size installations. In Germany 75% of pellets are intended for the heating market and the remaining proportion for electricity power generation (DBFZ, 2012). About 125 thousand pellet heating installations were in operation in 2009 and in 2010 they increased up to 150 thousand (Obernberger & Thek, 2010). It is estimated that almost all of them are intended for the heating market and barely used for electricity production now a days (EPC, 2014). Recently the production level is exceeding the consumption level and Germany is a net exporter of pellets. Majority of the trade is intra-EU (62.5%) (FAOstat, 2015) including Austria and Italy with respect to the trade of certified pellets (DBFZ, 2015). Wood pellets are not used in power stations in terms of co-firing in Germany yet (DBFZ, 2012).

As a third product Figure 11 shows the result for fuel wood.

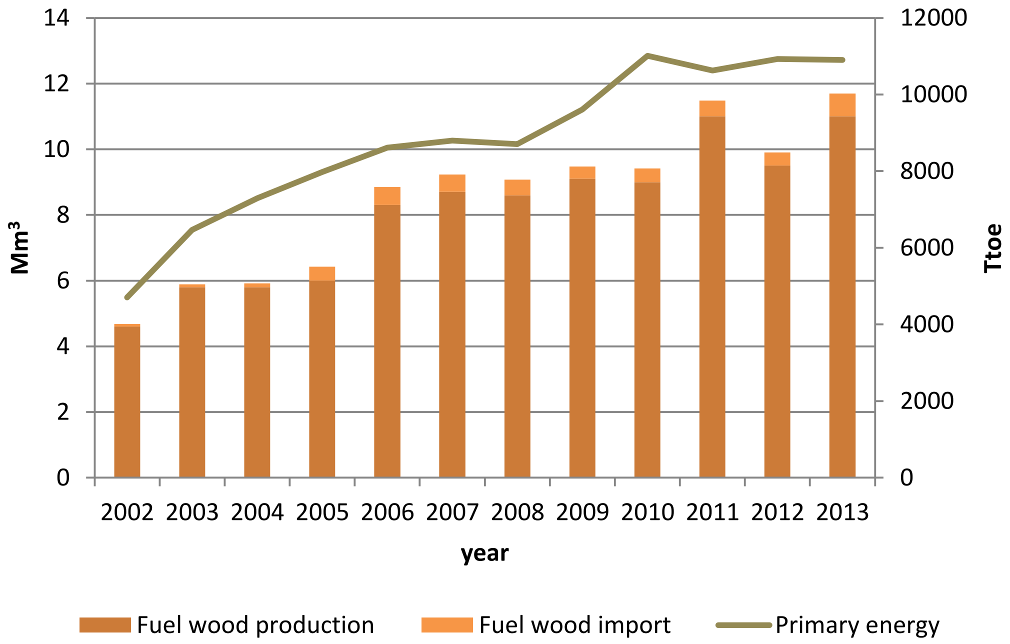



**Figure 11. Fuel Wood production and imports, and primary energy production from biomass in Germany**

Source: Eurostat, FAOstat

Still the amount of production greatly exceeds the amount of import, yet since 2004 the level of import increased. The percentage of the import remains small however the actual amount of import is very high. The average amount from 2000 to 2013 counts around 340 kilo $m^3$ that it places $5^{th}$ in the world after Italy, Bhutan, Austria, and Sweden. Fuel wood is still commonly used for households heating.

One significant note is that Germany is a net importer of waste wood. The total import volume was estimated at 649.878 tonnes in 2012 and more than 50% of volumes come by far from the Netherlands (DBFZ, 2015). The reason for this high demand for waste wood is that energy production from waste wood is promoted within the EEG. Overall the trade of waste wood mainly takes place with bordering countries because otherwise long-distance transportation would make waste wood imports non-convenient from a financial point of view (DBFZ, 2012).

### 4.1.4 Impact

The total growing stock in German forests was 4,330 million $m^3$ in 2010 and it showed a slight increase over time (Table 5). Even energy production has grown a lot Germany manages well balanced forest uses that maintains both domestic harvest and biomass stock stable. This is a result of its well managed forest activity. Fragmentation of forest property becomes a severe issue recently but still public experienced foresters control forest activity using sophisticated machineries and managed loads. The estimated total biomass potential covers the target demand for bioenergy in 2020 and 2050 at the national level, besides waste wood (Martin Gutsch, 2014). A high forest productivity result in making the country to be a main exporter of wood materials that 3.3 million $m^3$ of roundwood was exported in 2013 (Eurostat, 2015). Electricity generation of solid biofuels has grown marginally in the last years, because the potential of waste wood is widely exhausted in Germany (DBFZ, 2012). Due to the fact the country has decided to step back from wood biomass energy production before domestic resources runout and waste wood import shows further increase. Thus it is expected that the forest stands and industry will not be under strain because of renewable energy promotion.

**Table 5. Forest Wood Resource Changes in Germany**

| | 1990 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Annual fellings ($Tm^3$) | 44,689 | 59,762 | 75,336 | 59,610 |
| Net annual increment ($Tm^3$) | 122,000 | 122,000 | 122,000 | 107,000 |
| *Harvest rate (%)* | *36.63* | *48.99* | *61.75* | *55.71* |
| | | | | |
| Biomass stock ($Mm^3$) | 2,169 | 2,600 | 2,815 | 3,661 |
| (million tonnes) | (1,549) | (1,857) | (2,011) | (2,615) |
| Industrial roundwood removals ($Tm^3$) | 37,043 | 47,265 | 58,788 | - |
| Woodfuel removals ($Tm^3$) | 7,646 | 12,497 | 16,548 | - |
| *Removal rate* | *1.4%* | *1.6%* | *1.9%* | - |

*see Annex.1 for units
**see Annex.2 for specific definitions
***biomass stock data was originally in metric tonnes (see Annex.1 for unit conversion)

Source: Eurostat, (FAO, 2010a)

## 4.2 Italy

Italy is one of the most highly populated countries among EU countries, thus requiring large amounts of energy. In 2012 the overall share of renewable energy sources at national level reached 13.53% (EC, 2013b) but energy balance is still strictly relying on imports of fossil fuels, electricity, and natural gas (Cocchi, 2012). Italy has fair amount of wood biomass and has a potential to manage energy production. According to the World Bank online data source approximately 31.19% (9.15 million ha) of Italy was covered by forests in 2011 and the forest cover keeps increasing over years (World Bank, 2015). Especially in the northern regions wood has been used traditionally for heating and the installations still remain nowadays. For electricity production, the NREAP foresees an increasing use of biomass with a contribution of 19% in 2020 compared to 12% in 2008. The majority of electricity should be produced with solid biomass tough a large relative increase in the use of bioliquids and biogas in particularly is expected (Cocchi, 2012).

### 4.2.1 Driver

In a recent ministerial decree the government has increased the 2020 target for electricity from renewable energy sources to 32%, a 17% share of renewable energy in final energy consumption. According to the NREAP published in 2010, in 2020 solid biomass is expected to cover 50% of the renewables share in the heating sector, increasing from 1,875 kilotonne of oil equivalent (ktoe) in 2008 up to over 5,600 ktoe (MSE, 2010) (Cocchi, 2012).

While most European countries use FIT in one form or another, Italy had relied on a quota model to develop their large-scale renewable energy sources (Gipe, 2012). Since 2002, all energy plants fuelled by other types of renewable energy sources qualify to participate in an incentive regime based on Green Certificates (GCs) which are issued by the Gestore Servizi Energetici (GSE) (i.e. in English: Energy Services Managing Authority) a private company managing electricity services. Pursuant to a law passed three years ago (Decree 6 July 2012) the GC regime will be replaced by a dedicated FIT from 2016, which will be calculated on the basis of the average price for the sale of electricity during the relevant year (Arturo, *et al*., 2013). After all 2 main schemes at this moment are so called all-inclusive FIT and GCs.

**a) All-inclusive feed-in tariff**

The all-inclusive feed-in tariff is a national scheme applicable to renewable energy plants**,** excluding solar photovoltaic (PV)**.** The tariff is granted over a period of 15 years, during which its rate remains fixed and based on the amount of electricity fed into the grid. Table 6 summaries the current prices for each capacity and source of material.

**Table 6. Current Prices for All-inclusive FIT in Italy**

| Capacity | Price (€ct/kWh) | |
|---|---|---|
| | Biological origin | By-products |
| ≦300 kW | 22.9 | 25.7 |
| ≦1MW | 18 | 20.9 |
| ≦5MW | 13.3 | 16.1 |
| ≧5MW | 12.2 | 14.5 |

*degression rate 2%

Source: [MATTM, 2012]

The price is differentiated by size of plants and types of wood resources and in general prices are much higher than FIT prices in other countries. By-products of biological origin include sources derived from the processing of forest production, from the management of the forest, pruning, twigs, and debris. On top €30/MWh is paid when plants meet the atmospheric emission requirements, and €10-40/MWh is paid when plants operate in high-efficiency cogeneration mode sometimes with district heating (EC, 2013b).

**b) Green Certificates**

The scheme is based on the legal obligation for producers and importers of electricity from non-renewable energy sources to inject each year into the national electricity system a minimum quota of electricity from renewable energy sources (EC, 2013b). Energy generators and importers can meet their obligations by generating energy from renewable energy source and obtaining the required amount of GCs or by purchasing GCs from another energy producer or the GSE. GCs can be traded between operators on a dedicated market, and surrendered to GSE at a fixed price. Each GC corresponds to 1 MWh of energy. The power produced by the plant is multiplied by a coefficient set out in the law, which is 1.8 for biomass (Law 99 of 23/07/2009). GCs prices are established by the market but are greatly influenced by the value that is set by law for the surrender of GCs from the market by the GSE (Arturo, *et al*., 2013). For 2015 the structure and amount of the fees to be paid by each market participant for the services provided by GME in the GCs market are shown in Table 7 below.

**Table 7. Prices for GCs from 2015 in Italy**

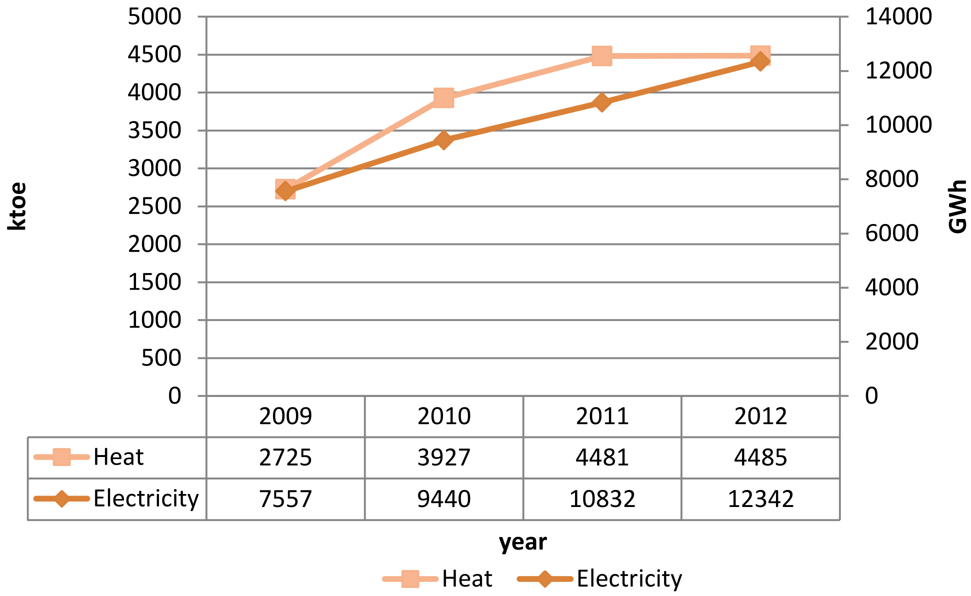
| | €ct/certificate |
|---|---|
| First 2,500 GCs traded (each of 1MWh) | 6 |
| Over 2,500 GCs traded (each of 1MWh) | 3 |

*€3.00 used to be paid for each 5 MWh certificate traded before

Source: (GME, 2015)

### 4.2.2 Pressure

With the support of incentives Italy steadily progresses on increasing a share of renewable energy. 30% of total electricity generation counts for renewable energy sources: 3% of this derives from biomass (MarkDöing, *et al*., 2013). Figure 12 provides an overview of energy production from biomass in Italy. The new set of FIT was approved just 3 years ago with relatively high prices hence further ascent of electricity production will be possibly expected from biomass in case some investors build big plants.




| | 2009 | 2010 | 2011 | 2012 |
|---|---|---|---|---|
| Heat | 2725 | 3927 | 4481 | 4485 |
| Electricity | 7557 | 9440 | 10832 | 12342 |

**Figure 12. Energy Production From *Biomass in Italy**

*includes waste, solid biomass, biogas, and bioliquids

Source: (EC, 2013b)

Due to the favourable incentive conditions for small scale plants most of the plants have a capacity of 1MW (MarkDöing, *et al*., 2013). A lot of new small biogas plants were installed (GSE, 2012) but at the present there are no plants burning pellet to produce electricity in Italy. Figure 13 shows a distribution of size and number of plants for each type of renewable energy in Italy.

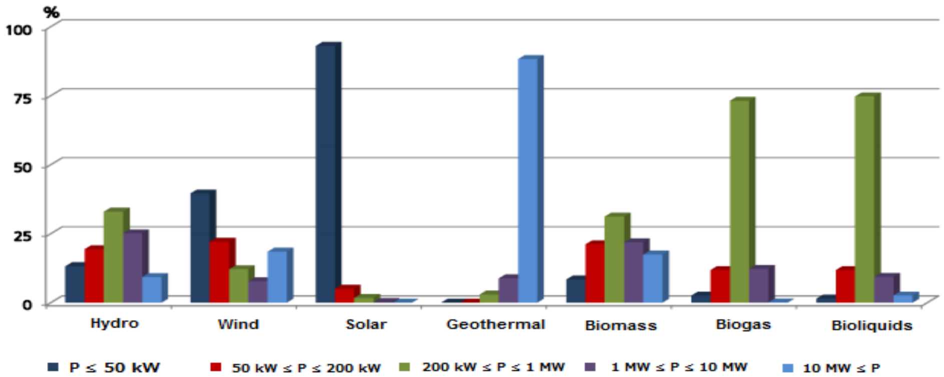



**Figure 13. Capacity sizes and numbers of RE plants in Italy**

Source: [GSE, 2015]

Plants bigger than 200 kW and smaller than 1 MW dominate in a biomass sector. In Italy there are nearly a hundred biomass plants with a rated capacity greater than 1 MW (BASIS, 2014) but in fact it is difficult to concretely assess the plant asset in Italy as many small facilities are operational in the country.

This is aggravated by the fact that a macroeconomic overview of the asset is impossible due to inconsistent statistical declarations (MarkDöing, *et al*., 2013).

### 4.2.3 State

Figures from 14 to 17 show trends in production and imports for different wood-product categories, together with the trend in primary energy production from biomass between 2002 and 2013.

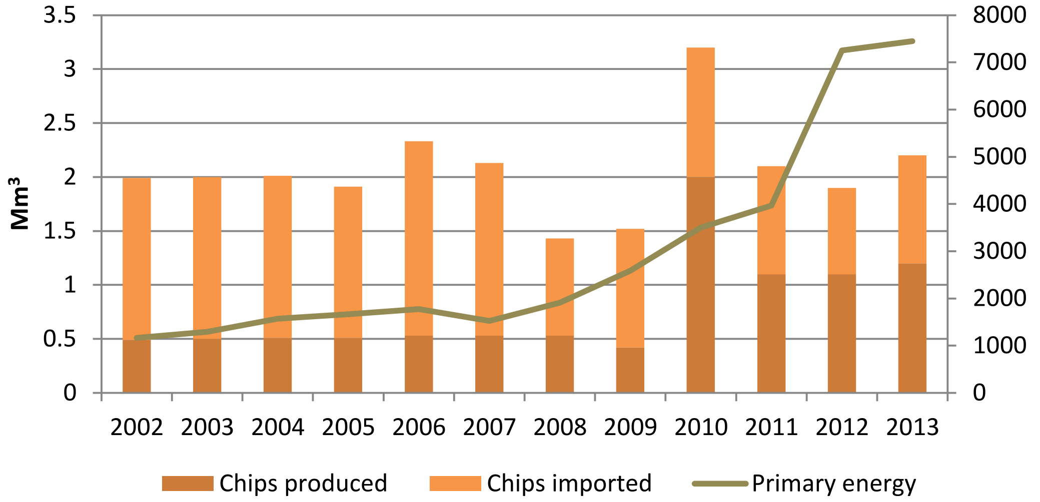



**Figure 14. Chips production and imports, and primary energy production from biomass in Italy**

Source: Eurostat, FAOstat

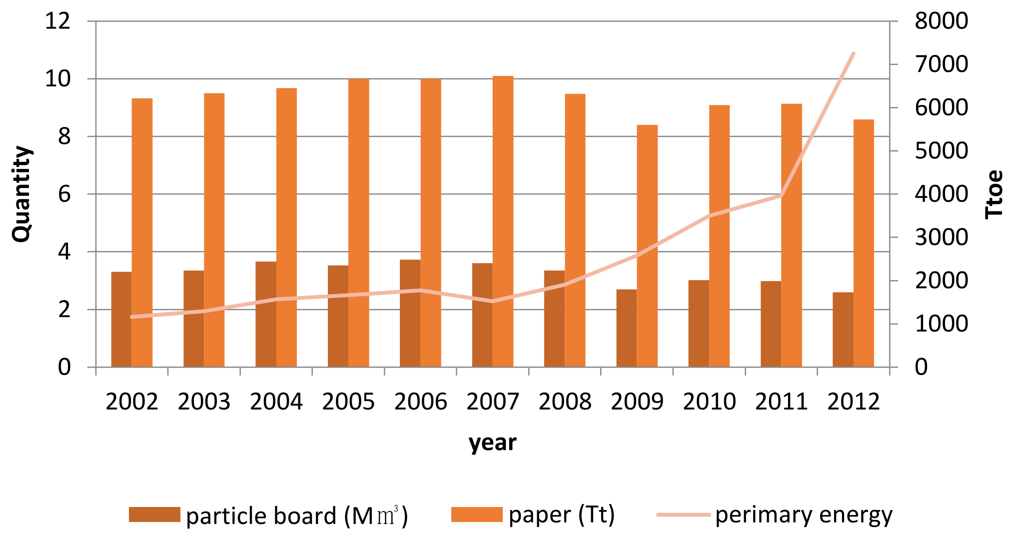



**Figure 15. Particleboard and paper production compared to primary energy production from biomass in Italy**

Source: Eurostat, FAOstat

Imported chips are mainly used to supply big power plants. Chips are burnt in electricity producing plants and also co-incinerating biomass in coal power plants plays a role (MarkDöing, *et al*., 2013). Electric plants are mainly located in the nearby of harbours or in areas where imported wood chips can easily supply the plants (BASIS, 2014). Import growth was parallel to the progressive achievement of thermal power plants after 1990 and it assumes 1 million tonnes of chips are imported annually (Ciccarese, *et al*., n.d.). Competitive productions, i.e. particleboard and paper, have not changed (particle-board) or they have decreased (paper) in the last 10 years, while electricity production increased by almost twice (see Figure 12).

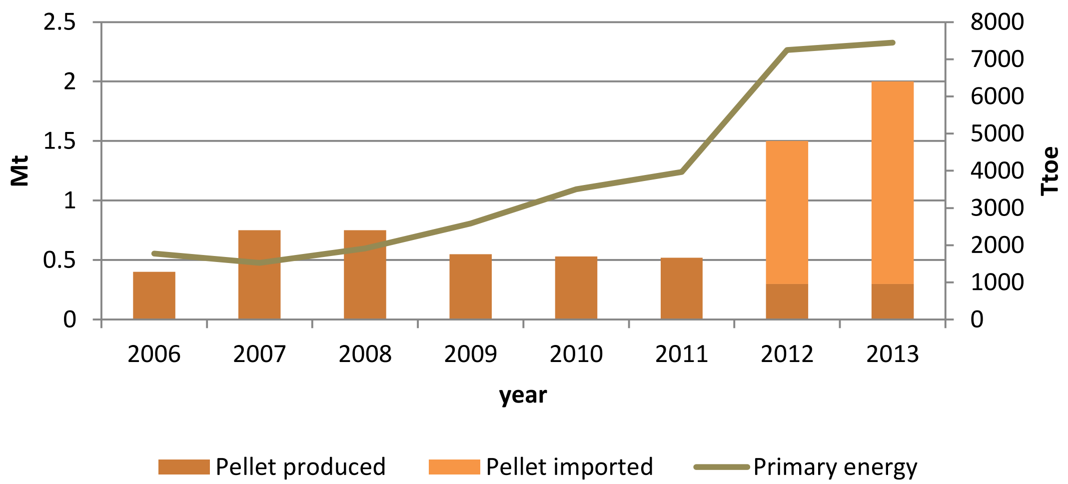



**Figure 16. Pellets production and imports, and primary energy production from biomass in Italy**

*production amount is according to “European Pellet Report” (2012) and AIEL

Source: FAOstat

The Italian domestic pellet market grows rapidly that 15% increase in demand for pellets has seen in last 3 years (Prokhorov, 2015). It has been estimated that 60% of nationally consumed pellets were produced internally in 2009 (SFI, PROFORBIOMED, 2012) but within this recent years imports exceeded production. Unlike other EU countries, there are no electric plants using pellets in Italy and pellets are used for the heating sector, mostly at household scale. In the last 5 years many district heating plants were built, most of them under 1 MW and some studies suggest this is due to support incentives for heating, like

*Conto Termico* and others (BASIS, 2014). Under specific conditions operators may get a huge amount of tax reduction on construction work by the incentive *Conto Termico* and this stimulate the demand for pellets for heating. It can be concluded that a huge amount of pellets import is due to the high demand and it does not mean the domestic production is vulnerable.

Figure 17 shows a trend of fuel wood production and import. Italy actually is the top fuel wood importing country in the world that the average amount of import from 2000 to 2013 records more than 800 km$^3$ annually.

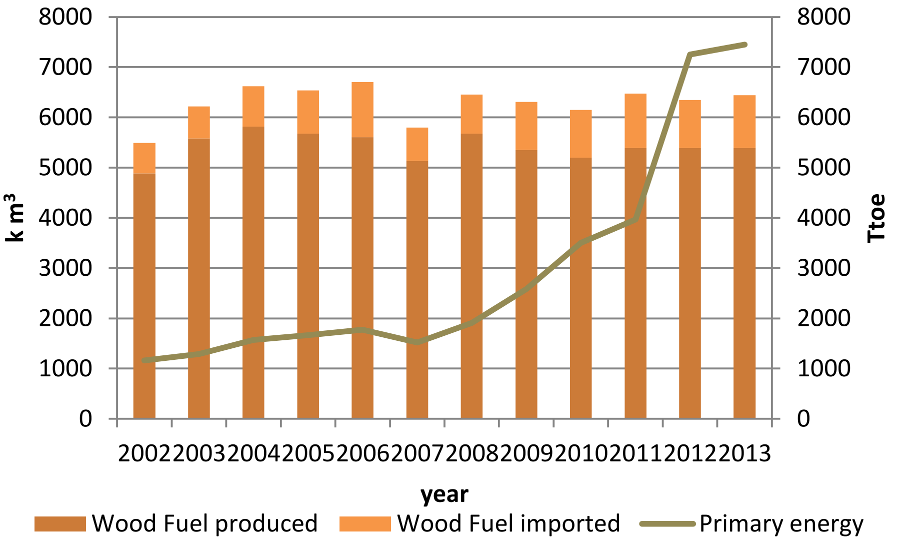



**Figure 17. Fuel Wood production and imports, and primary energy production from biomass in Italy**

Source: Eurostat, FAOstat

Over 90% of logwood is burnt in low-efficiency domestic heating systems and the amount of consumption is equivalent to almost 2 billion euros *(Ciccarese, et al*., n.d.). Very small amount of wood fuel is processed to make chips or pellets for domestic and district heating. Due to shortage of raw material the Italian producers are forced to get the raw material from foreign countries like the Balkans, Romania and Bulgaria (Alfano & Pignatelli, 2010).

### 4.2.4 Impact

Table 8 summaries some features about Italian forest stands. One of the forest resources characteristics of the country is that harvest rate is very low compare to other EU countries. Also the annual rate of removal is very low even the extent of forest characterized by a productive primary function is conspicuous in Italy. This negative trend could be due to the policies and measures of conservation and protection of existing forests, plantation forestry programs, and the natural expansion of forests on abandoned croplands and graze lands, especially in marginal hilly and mountainous areas (SFI, PROFORBIOMED, 2012). In addition issues can be addressed on fragmentation of forest ownership causing forest management inefficient, or on low technology capacity for local forest companies on average. In fact forests are not bound to increase their productivity or carbon sequestration in the absence of harvesting. The study reveals that forests might become a source of carbon instead of being a sink if they are let evolving without any managing intervention (Fiorese & Guariso, 2010). Renewable energy incentives may give an opportunity for domestic harvesting then it helps building anticipation on both forest management and domestic economics.

Apart from those considerations, for the case of Italy it is believed that official forest statistics underestimate the wood removal, especially in the case of firewood.

**Table 8. Forest Wood Resource Changes in Italy**

| | 1990 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Annual fellings ($Tm^3$) | 13,336 | 14,362 | 13,298 | 12,754 |
| Net annual increment ($Tm^3$) | 27,779 | 30,161 | 31,352 | 32,543 |
| *Harvest rate (%)* | *48.01* | *47.5* | *42.42* | *39.19* |
| | | | | |
| Growing stock ($Mm^3$) | 0.926 | 1,155 | 1,269 | 1,384 |
| Industrial roundwood removals ($Tm^3$) | 4,982 | 4,031 | 3,499 | - |
| Woodfuel removals ($Tm^3$) | 4,895 | 6,000 | 6,542 | - |
| *Removal rate* | *1.0%* | *0.9%* | *0.8%* | - |

*see Annex.1 for units
**see Annex.2 for specific definitions

Source:Eurostat, [FAO, 2010b]

## 4.3 Japan

Japanese energy policy has changed completely after the Fukushima nuclear power plant disaster on March 11th 2011. The national energy plan requests to increase the share of primary energy supply from renewable energy up to 10% by 2020 but according to recent figures the current share of biomass in electricity generation counts only 1.1% in 2012 (ISEP, 2014) and further development is strongly needed. Although solar and wind power generation show strong growth after FIT support scheme has been implemented in 2012, biomass section is in a chaotic situation because of a lack of knowledge and development in the forestry sector. Still Japan has huge potential forest resources that the total forest area at national scale was 25.1 million ha in 2010, corresponding to approximately 68% of the total national area (MAFF, 2014). Because of the historical background the country used to import cheap wood materials and the volume of domestic wood production bottomed out at roughly 15 million $m^3$ in 2002 (MAFF, 2013). Wood collected from thinning and other forest operations is normally left unused in the forests then wood for energy could be a breakthrough to put values on domestic materials.

### 4.3.1 Driver

After Fukushima disaster the national energy plan is facing to re-establish with a consideration of nuclear power. Unlike European countries, the Ministry of Economy, Trade and Industry (METI) proposes renewable energy scenarios but does not set clear targets for renewable energy promotion. The issue of becoming less dependent from nuclear energy and move towards a more dispersed energy system was addressed in 2012. At this time feed-in scheme was finally introduced 10 years after Germany. The final purchase prices and periods were subsequently decided by METI. Prices has newly amended in 2015 and wood from forest thinning gains higher prices than before. Table 9 shows the current FIT prices for each type of wood resource. Co-firing plants are also considered and offered the same price. Forest thinning includes thinned wood and timber. Wood includes imported wood and waste material from sawmill. Waste includes pruned wood and wood dust.

**Table 9. Current FIT Price for Biomass in Japan**

| | Forest thinning | | Wood | Construction Waste | Waste |
|---|---|---|---|---|---|
| | ≦2000kW | 2000kW≦ | | | |
| €ct/kWh | 30 | 24 | 18 | 14 | 13 |

*see Annex.1 for currency rate

Source: (METI, 2015d)

Prices used to be differentiated only by type of material, but from 2015 also the size of plants is took into consideration for one category. Historically thinned wood was not efficiently used before and for this reason the price was set very high to put some values on it. Yet the prices is too high compared to other renewable sources and forest thinning categories ridiculously include industrial logs, which indicates an approach that is not in support of the cascade wood use. FIT for biomass in Japan still has many concerns, including the stable supply of raw materials, technical facilities harvesting and conveyance system of wood products, and the establishment of supply chain. At the end of March 2014, certified capacity of woody biomass reached over 1.5 gigawatt (GW), that corresponds to 77% of total capacity of certified facilities using biomass as a fuel (ISEP, 2014). FIT is the main and only incentive for supporting renewable energy sources at this point besides small amount of subsidies from local prefectures.

### 4.3.2 Pressure

National energy supply from biomass has increased from 4,729 thousand tonne of oil equivalent (Ttoe) in 1990 to 8,169 Ttoe in 2013 (METI, 2015c). Figure 18 shows the trends of electricity production from different types of renewable energy sources in Japan from 1990 to 2012.

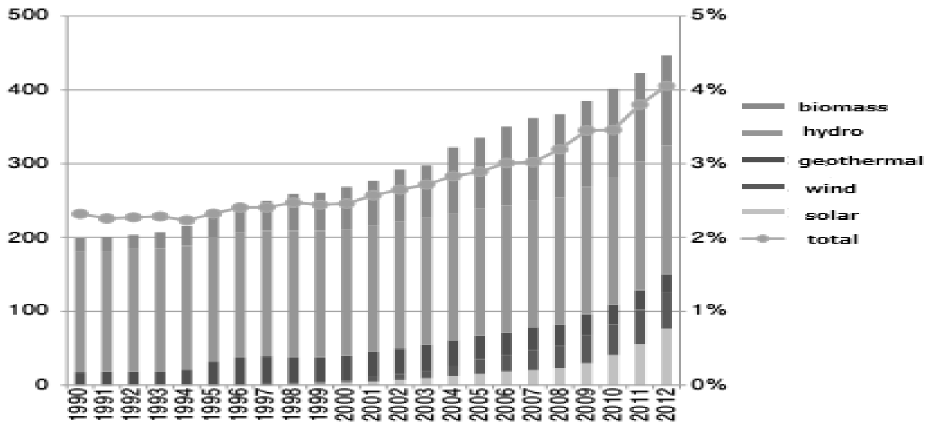



**Figure 18. Renewable Electricity generation by types in Japan**

Source: (ISEP, 2014)

It is assumed that electricity generation excesses heat generation however any official data for biomass heat generation does not exist. Facilities for heating from biomass, such as pellet boilers or stoves, are not commonly installed at buildings or houses and district heating system either exists. CHP is not compulsorily subsidized and because the FIT prices for biomass are considerably high, energy production from biomass mainly focused on electricity. After the introduction of FIT the amount of new introduced electricity from biomass has doubled in 2 years (METI, 2015b). The generation constantly increases and growth rate is expected to be much higher after 2012 due to its support scheme.

FIT surely affecting sizes and numbers of biomass plants recently. Figure 19 shows the number of plants according to different capacity classes.

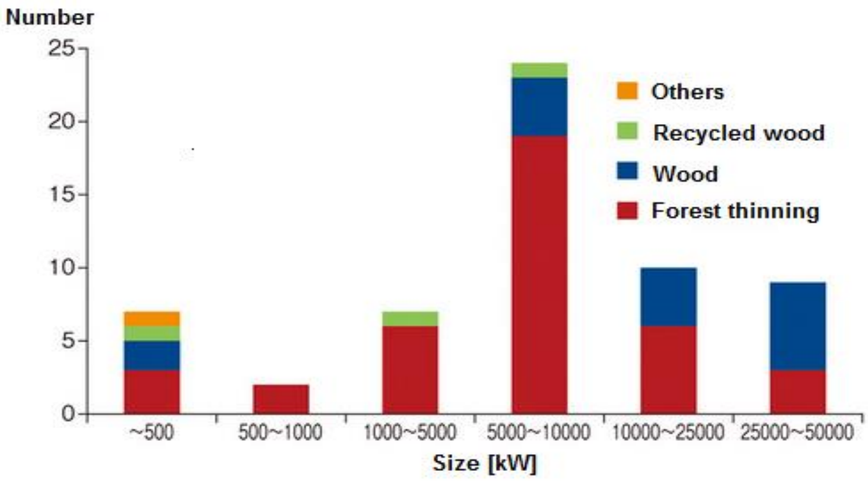



**Figure 19. Biomass plants per capacity classes in Japan**

Source: (BIN, 2013)

This indicates that 5 to 10 MW capacity class is the dominant size for plants operating wood materials. Yet Japanese FIT scheme does not differentiate the prices for size of plant, except forest thinning category, and according to Biomass Industrial Society Network (BIN), huge electricity biomass plants will be continuously constructed in next few years (BIN, 2013). Co-firing projects are also increasing and due to this fact imports of pellets are likely to increase in close future. As of January 2014, 37 woody biomass power plants are taking advantage of the FIT to sell power. Amid expectations that woody biomass will contribute to regional economies, there is a need to engage in preliminary study concerning the efficient and stable supply of woody biomass resources (ISEP, 2014). At this point forest thinnings are the dominant source of biomass energy production and this includes wood resources that could be suitable for industrial processing.

Figure 20 is a distribution map shows electricity producing plants using wood biomass activated after the enforcement of FIT scheme in 2012.

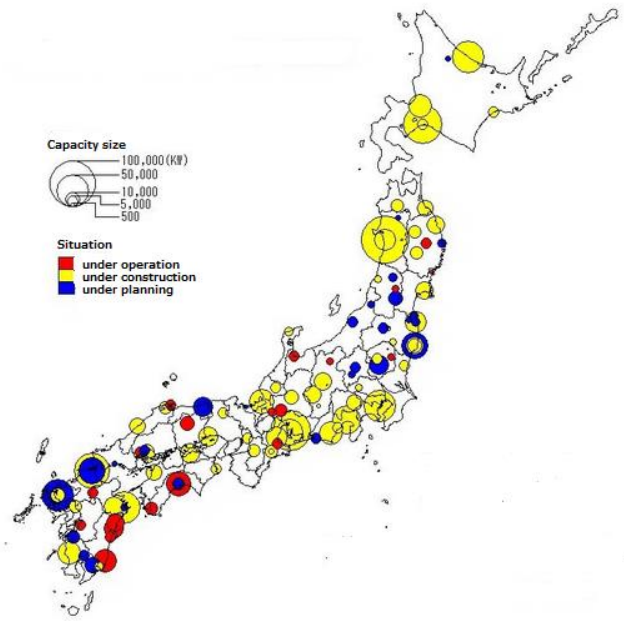



**Figure 20. Distribution of biomass electricity plants under operation/construction/planning after 2012 in Japan**

Souorce: (Japan Wood Energy, 2015)

Red circles refers plants already operating, yellows refers plants under the construction and will be operated soon, and blue refers plants now are in the planning stage. As it clearly reveals many plants will be in operation and some of them are bigger than 50 MW capacity sized. FIT scheme strongly accelerates this intense construction boom as a driver.

### 4.3.3 State

Figures from 21 to 23 show trends in production and imports for different wood-product categories, together with the trend in primary energy production from biomass between 2002 and 2013.

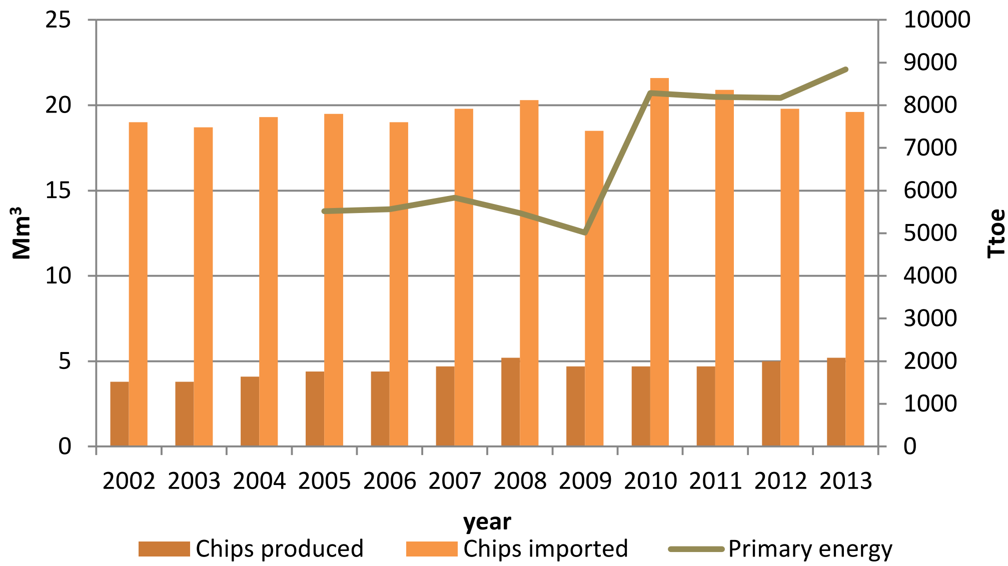



**Figure 21. Chips production and imports, and primary energy production from biomass in Japan**

Source: FAOstat, (METI, 2015c)

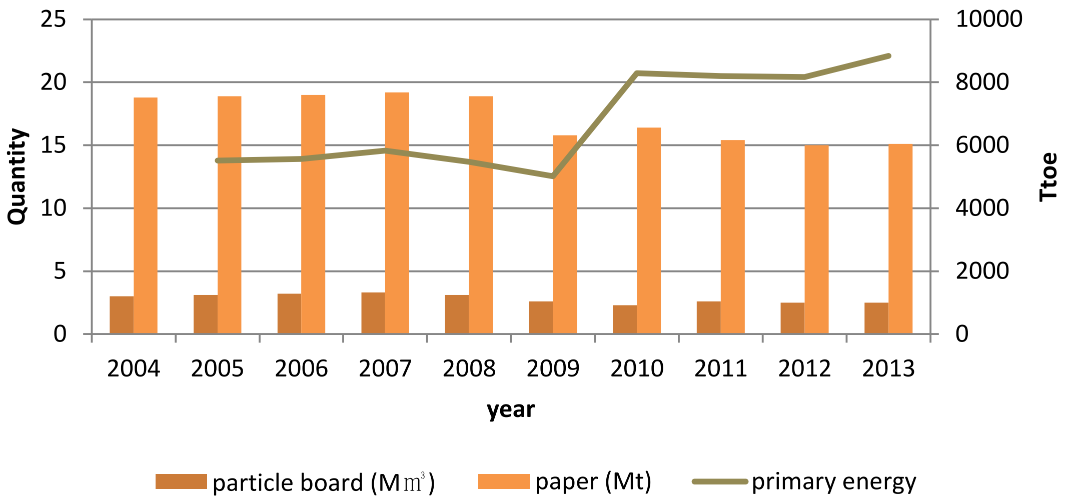



**Figure 22. Particleboard and paper production compared to primary energy production from biomass in Japan**

Source: FAOstat, (METI, 2015c)

The amount of imported chips is extremely high compared to other countries, for instance Germany. Japan is a leading pulp producing country and historically chips are used to produce paper-related products: Japanese paper industry strongly depends on imports (JPA, 2015). Besides pulp industry the government expects 6 million $m^3$ chipped-wood will be used for particle boards and energy production by 2020 (MAFF, 2014), and usually those chips burnt for energy production are high qualitied. If the number of large electricity plants will continue to increase, imports of chips will grow accordingly, unless the domestic market is able to supply cheap material in appropriate quantities.

Pellets production grew slightly over few recent years as Figure 23 represents.

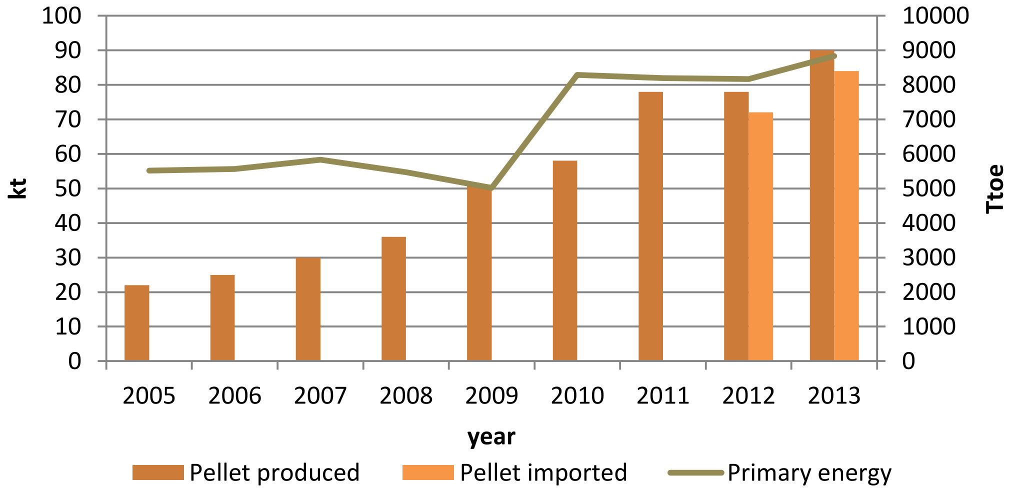



**Figure 23. Pellet production and imports, and primary energy production from biomass in Japan**

Source: FAOstat, (METI, 2015c)

Wood pellet boilers are increasingly being introduced into public facilities and private houses, and therefore wood pellets gradually get more attention. Despite its positive recognition, technical issues are under prepared to fully support its growth. Almost all pellet boilers and stoves are imported, mainly from Germany and Austria, therefore prices are very high and maintenance difficulties exist. Supply chain system of pellets is undeveloped either and generally speaking it is challenging to keep ideal moisture contents due to geographical futures. Also disposal management of ash after burning is strictly regulated because of recent concerns of radiations. In recent years a bad practice prevails in burning high qualitied wood pellets together with coal for electricity production in big plants. In a case of co-firing at a 1 GW capacity sized plant requires around 70 thousand tonnes of pellets annually without CHP facility but at the same time contributes to 11 million tonnes of $CO_2$ emission (ABO, 2015).

Japan, known as a net importer of wood material, yet imports very little amount of fuel wood as Figure 24 shows.

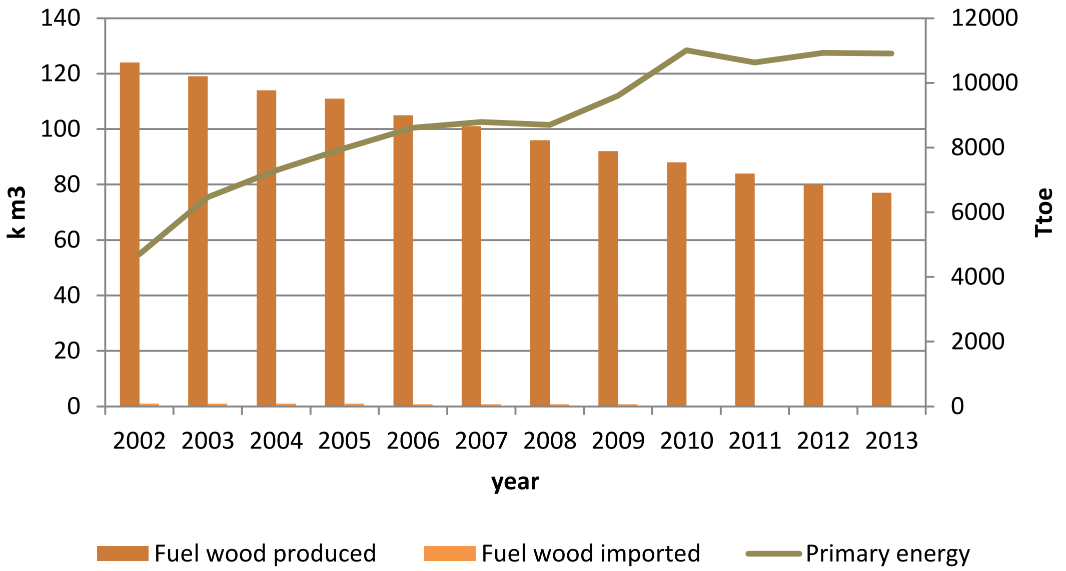



**Figure 24. Fuel Wood production and imports, and primary energy production from biomass in Japan**

Source: FAOstat, (METI, 2015c)

After 2010 the import amount is already less than 500 $m^3$. Unlike many countries there is no habit to use fuel wood for domestic heating purposes. On the other hand roundwood import level is very high that the country was historically top importer around the world but the amount significantly decreases over this 20 years in a relation to a decrease of home construction.

As for other woody biomass, most of the “mill residue wood” and “construction refuse wood” is already almost fully utilized. Thus, use of “unused thinned wood” (produced at an estimated rate of 20 million $m^3$ annually) is indispensable for the promotion of energy production using woody biomass (ISEP, 2014).

#### 4.3.4 Impact

One of the severe considerations that Japan faces is a corruption of wood cascade use that materials having higher values are used for energy. It was epoch-making that FIT scheme puts value on unused wood as a source of energy but this causes a change of valence for the uses of thinned wood. Table 10 shows the amount of production for each category which is delivered from thinned wood. Proper cascade use should put higher priorities on log and sawn wood however production of raw material, which can be chips/pellets for energy, has unfortunately increased.

**Table 10. Uses of Thinned Wood in Japan**

| | Total | Sawn wood | Log | Raw material |
|---|---|---|---|---|
| 2007 | 3,440 | 2,140 | 470 | 830 |
| 2008 | 3,680 | 2,260 | 390 | 1,030 |
| 2009 | 4,230 | 2,570 | 480 | 1,180 |
| 2010 | 4,430 | 2,700 | 420 | 1,310 |
| 2011 | 4,860 | 2,880 | 400 | 1,580 |
| 2012 | 5,210 | 3,000 | 360 | 1,860 |

*unit: $Tm^3$

Source: (MAFF, 2014)

Table 11 gives a general idea of forest stands. After the Second World War Japan planted huge amount of trees and now they are mature. While trees were growing after the plantation the country used to depend on import then gradually domestic wood market has shrinked. Now the Ministry of Forestry seeks to raise the self-sufficiency of wood supplies (see Annex.2 for the definition) up to 50% by 2020 (MAFF, 2011). The ministry plans to harvest more trees and suppress net annual increment to make forest more close to even aged stands (MAFF, 2011). The ministry does not clearly restrict the harvest activity including a cutting area threshold and some experts point out this could invoke clear cutting.

**Table 11. Forest Resource Changes in Japan**

| | 1990 | 2000 | 2005 | 2010 | 2012 |
|---|---|---|---|---|---|
| Net annual increment (Tm$^3$) | - | - | 7,400 | 7,400 | - |
| Domestic production (Mm$^3$) | 29.4 | 18.0 | 17.2 | 18.2 | 21.1 |
| Total Consumption (Mm$^3$) | 81.8 | 81.2 | 68.7 | 52.0 | 73.9 |
| *Self-efficiency (%)* | *26.4* | *18.2* | *20.0* | *26.0* | *28.6* |
| | | | | | |
| Biomass stock (Mm$^3$) | 2,587 | 3,083 | 3,406 | - | - |
| (million tonnes) | (1,848) | (2,202) | (2,433) | | |
| Industrial roundwood removals (Tm$^3$) | 30,765 | 18,601 | 17,803 | - | - |
| Woodfuel removals (Tm$^3$) | 365 | 242 | 160 | - | - |
| *Removal rate (%)* | *0.8%* | *0.4%* | *0.4%* | - | - |

*see Annex.1 for units
**see Annex.2 for specific definitions
***biomass stock data was originally in metric tonnes (see Annex.1 for unit conversion)
Source: Eurostat, [FAO, 2010c], (MAFF, 2014)

By double checking the data from FAO and the nation's ministry, lots of categories came out with different numbers for instance the amount of biomass stock. Classifications are different at many times and it is hard to make a decision which data to rely on.

## 4.4 The UK

One of the problems the UK is facing is the presence of limited energy sources to support a high population. Many of coal plants are going to be closed by 2015 and as a consequence alternative sources of energy – including renewables - will be required. The shifting towards a higher rate of energy from renewable sources, however, progresses at a very slow pace: only 5.2% of total energy production in the UK in 2013 proceeded from renewable energy sources (DECC, DUKES, 2014). About 12.9% (3.14 million ha) of the UK national area is covered by forests (Forestry Commission, 2014) and the woodland area keeps increasing over years. Also total wood removals have increased over time, reaching 10 million $m^3$ (FAO, 2014). An increase of renewable energy installation contributes to a reduction in discharging carbon dioxide but on the other hand a high target of GHG emission reductions can cause an increase in wood chip/pellets imports, because more plants burn coal and wood chips together. Besides, a new nuclear plant will be installed in 2023 and citizens are obligated to pay additionally for the initial cost on top.

### 4.4.1 Driver

The UK targets the amount of share of renewable energy to 15% by 2020 (DECC, 2013) and on top the government sets the aim of a reduction of GHG emission by 60% by 2050 (Mark Maslin, 2007) Renewable Energy Roadmap documents do not set a target for electricity share produced from renewable sources (DECC, 2011). Compare to public incentives from other countries the UK shows its uniqueness. While feed-in schemes dominate in many countries to support renewable energy production, the UK had eliminated it for biomass section from the beginning after a careful observation of foreign countries which already have applied it. Besides, the country focuses on heat section much more than electricity section. The study has been focused on electricity but here one scheme for heat is also mentioned because it is the main incentive for biomass in the UK.

## a) Renewable Obligation

Electricity suppliers are obliged to prove that a certain percentage of electricity was generated from renewable sources. Since 2002 the Renewable Obligation (RO) mechanism obligates electricity suppliers to supply a fixed amount of renewable energy and Ofgem, the third party intermediary, issues 1 Renewable Obligation Certificate (ROC) per 1 MWh. If a company has not been issued with a sufficient number of ROCs to cover its obligation from its own production, it may either buy more ROCs from companies that have a surplus, or pay a buy out price (around 500 euro per MWh in 2008; original reference was 35.76 pounds, see Annex.1 for currency rate). The buy-out price suppliers pay a fixed price per MWh shortfall. The price is adjusted in line with the Retail Prices Index each year (Yamaguchi, 2014) . Proposed ROC allowances from 2015 are showed in Table 12. As FIT has applied for smaller plants RO is applied mainly for plants bigger than 5 MW. Unlike FIT, the price of ROCs depends on demand and supply (market) thus it is less stable for energy producer or investors.

**Table 12. The banding levels for the banding review period 2015-2016 in the UK**

| ROCs per MWh | 2015/2016 |
|---|---|
| Co Firing Standard <50% | 0.5 |
| Co Firing Mid-range, 50-85% | 0.6 |
| Co Firing High-range >85% | 0.6 |
| Biomass conversion | 1 |
| Dedicated Biomass (up to 400 MW) | 1.5 |
| Dedicated Biomass with CHP | 2 |

Source: (EC, 2013c)(GOV.UK, 2015)

Under the RO mechanism, operators of 50 kW stations must provide information about performances with regard to given sustainability requirements. Specific requirements are defined for solid and gaseous biomass: 1) land criteria and 2) GHG emissions criteria. From 2013 solid and gaseous biomass will need to meet the sustainability criteria to be eligible to receive ROCs. Operators should provide an annual report with information about the biomass material, including form, mass or volume, and country of origin, and should report the land and GHG criteria on a monthly basis. To comply with the land criteria, the biomass cannot be obtained from primary forests, protected areas, wetlands, and so on. Interestingly in 2014 the documents newly state that a fuel which classifies as a waste or a processing residue is exempt from

the land criteria (Ofgem, 2014). For GHG Criteria, the emissions associated with the biomass should be less than or equal to 79.2g $CO_2$eq/MJ electricity. (Ofgem, 2011). The source of biomass should be determined clearly through a chain of custody (traceability) system and a mass balance checking is mandatory in relation to solid biomass by 2013 (Ofgem, 2011).
Finally in 2017 the forecasted Electricity Market Reform (EMR) will replace the RO mechanism with new schemes. Companies will get a fixed and secure price at which they can sell their electricity to consumers (DECC, DUKES, 2014).

### b) Renewable Heat Incentive

Introduces in 2011, the Renewable Heat Incentive (RHI) is similar to a FIT and represents the main incentive for biomass energy production. The amendments of prices are shown in Figure 25 below. The UK is building new markets and seeking a step change in consumer and industry behaviour in a renewable heat deployment, and there has been a 7% increase in energy from renewable heat sources in 2012 (DECC, 2013). RHI supports both biomass and cogeneration plants for domestic use from 2011 and non-domestic use from 2014, and the government defrays the cost and guarantees the technology cost for 7-20 years as an installation support. The RHI has supported the production of some 627 GWh of heat from biomass, mostly wood, between November 2011 and December 2013. This is equivalent to some 148 thousand tonnes of commercial wood pellets (DECC, DUKES, 2014).

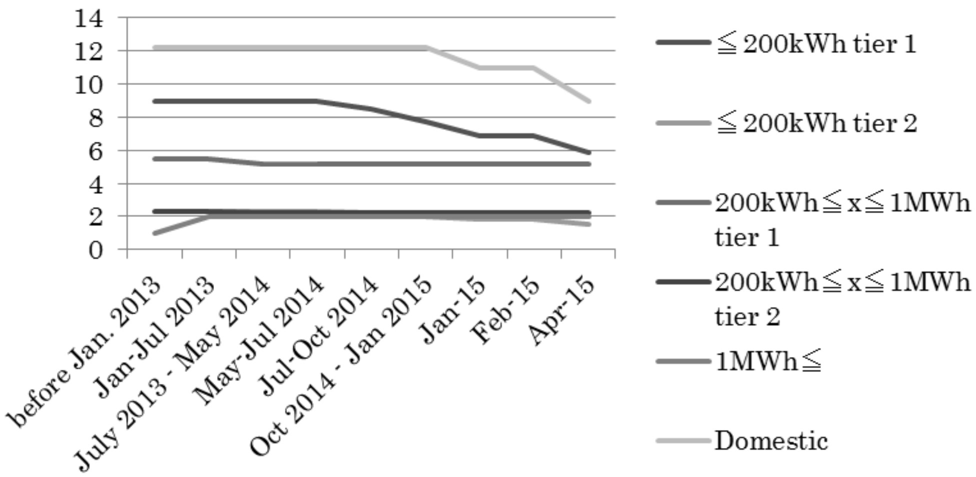



**Figure 25. RHI price changes over years in the UK**

*Tier break= limitation (up to kWh×1.31 is tier1 and upper is tier2), paid for 20 years

Source: Ofgem 2011-2015

The RHI fits well mall and middle size plants, while it does not perfectly fit large plants, thus in 2013 the price had increased to support RHI application to the latters. As of 2013, 1,238 plants benefit from RHI and 92% of them are solid biomass boilers. The budget for RHI was estimated about 78 million euro in 2011 and 589 million euro in 2014 (Tokio Marine & Risk Consulting Co, Ltd, 2014). RHI contains 2 components, i.e. the one for domestic plants and the one for non-domestic ones. Domestic RHI broadly speaking is for heating systems for single homes. People will receive quarterly payments for seven years. Heating system types include: biomass only boilers and biomass pellet stoves, air source heat pumps, ground source heat pumps, or solar thermal panels (Ofgem, 2015b). Non-Domestic RHI is open to industrial, commercial, public sector and not-for-profit organizations (Ofgem, 2015b). A plant generating heat from solid biomass using 100% biomass fuels is required to keep records of fuel/feedstock purchase and use, including invoices.

**c) FIT**

FIT in the UK has started since 2010 and is applied only for PV, wind, hydro, and aerobic power generators but still supports CHP plants for biomass section. These will include the newer biomass boilers that generate electricity from the heat of the boiler, as well as boilers that burn biogas. Prices are: about 16.4 €ct /kWh (April 2010 to March 2013; original reference was 11.84 p/kWh, see Anne.1 for currency rate) and about 18.7 €ct/kWh (March 2013 to March 2016; original reference was 13.45p/kWh) [Ofgem, 2015c].

### 4.4.2 Pressure

The electricity market from biomass has slightly grown within these years with institutional supports. A ROC review came into effect in October 2011 which could have a significant impact particularly on co-firing. Coal-fired plus biomass generation currently provides security of supply benefits in terms of availability, reliability and flexibility (CEP, 2011). Figure 26 and Table 13 show percentage shares and absolute values for electricity production from biomass.

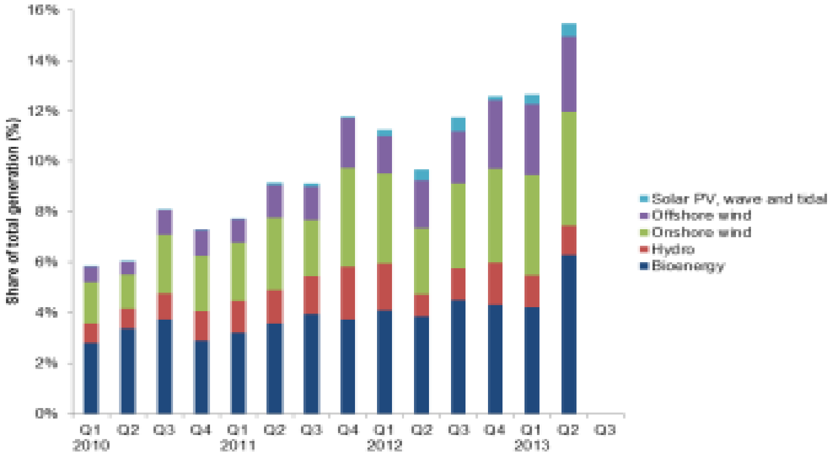



**Figure 26. Share of Electricity Generation from Renewables in the UK**

Source: (DECC, 2013)

**Table 13. Gross Electricity Production from Solid Biomass in the UK**

| | 2008 | 2009 | 2010 | 2011 | 2012 | 2013 |
|---|---|---|---|---|---|---|
| Electricity (TWh) | 2,768 | 3,535 | 4,677 | 5,606 | 7,008 | 10,577 |

Source: Eurobarometer

The UK progress report on renewable energy production says 2,016 MW of electricity and 922 ktoe of heat had produced specifically by solid biomass in 2012 (EC, 2013c). (DECC, 2011). According to available data, 62% of electricity generation is from waste (mainly landfill gas), 21% from co-firing and 17% from dedicated biomass plants (CEP, 2011). A recent study (ARUP, 2011) has considered a range of different options for biomass usage, including dedicated biomass plants as well as existing coal plants in a variety of regimes. The report recognizes that small biomass plants smaller than 50 megawatts of electrical output (MWe) tend to use locally sourced biomass fuel delivered by road. The

Arup study estimated that the UK could host 50 to 60 dedicated biomass plants distributed around the country. In addition, large plants, up to 350 MWe, could be located near ports specifically to access a wide range of imported fuels. The study indicates that up to 1.8 GWe of high capacity factor, low planning risk of conversion capacity could be feasible (ARUP, 2011). UK possesses largest electricity plants in the world that several plants have a capacity size of 500 to 750 MWe and they require 1.5 to 2 million tonnes of biomass mainly chips or pellets (Hogan, 2013). Besides support schemes Large Combustion Plant Directive (LCPD) is effective on big plants to operate co-firing. LCPD is an EU directive that came into effect from 2008 controlling hazard gas emissions. Thermal fuel plants bigger than 50 MW capacity sized should follow this directive for the operation. Plants whether have to observe new lower emissions limit value for $SO_2$, $NO_x$ and dust or plants are obliged to cease operations permanently after a further 20 thousand hours of operation no later than 2016 (Perry & Rosillo-Calle, 2006).

### 4.4.3 State

Bioenergy task report edited by International Energy Agency (IEA) states that about 25% of the feedstock purchased in the UK was from domestic sources, including small round wood and woodchips, biogas and waste (CEP, 2011) while the remaining feedstock has been imported from EU countries. Figures from 27 to 29 show trends in production and imports for different wood-product categories, together with the trend in primary energy production from biomass between 2002 and 2013.

Data for chips demonstrated in Figure 27, however, shows that the production remains much higher than the amount of import.


**Figure 27. Chips production and imports, and primary energy production from biomass in the UK**

Source: Eurostat, FAOstat

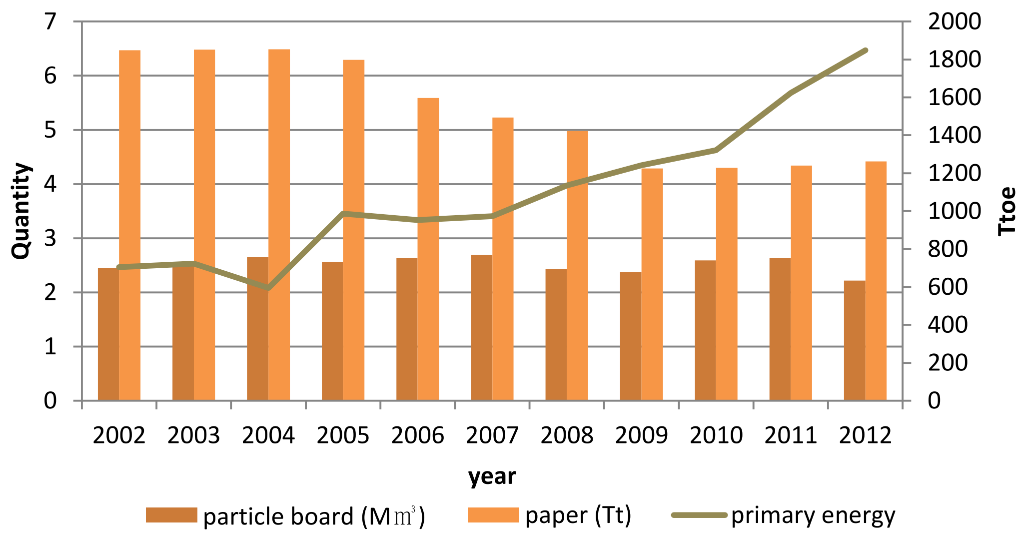



**Figure 28. Particleboard and paper production compared to primary energy production from biomass in the UK**

Source: Eurostat, FAOstat

Import share remains stable over 10 years while production level slightly increased. At the same time the export amount has increased (around 30 thousand $m^3$ in 2002 to 200 thousand $m^3$ in 2012) meaning the total consumption level stays the same (FAOstat, 2015). Figure 28 shows paper production declined recently and it gives an insight that energy production may replace the use of some amount of chips for energy. In any case it seems energy production does not affect chips industry directly while primary energy production almost doubled.

Figure 29 shows that the UK uses a significant amount of wood pellets, mostly imported from North America, Russia, South Africa and New Zealand (FAOstat, 2015).

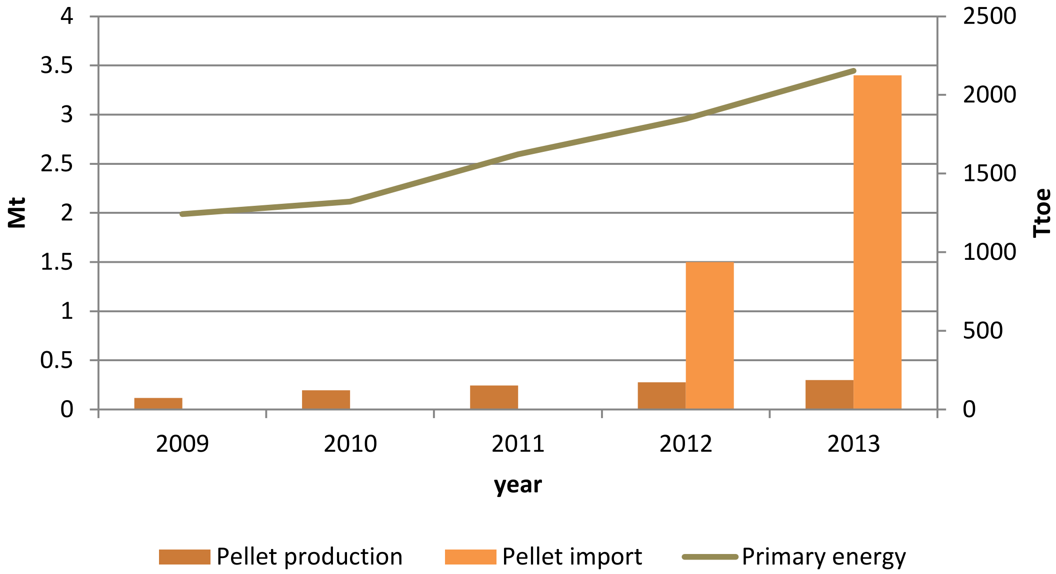



**Figure 29. Pellets production and imports, and primary energy production from biomass in the UK**

*production data is according to Forestry Commission

Source: Eurostat, FAOstat

It is estimated that the majority of pellets manufactured and imported in the UK are co-fired for electricity generation but there are also increasing numbers of individuals, and organizations who are using pellets as their main source of heating (CEP, 2011). Pellet imports for electricity generation are predicted to rise to about 10 million tonnes per year by 2015 and perhaps 15 to 20 million tonnes per year by 2020 (Hogan, 2013). As mentioned above there is a specific support scheme for heating, and unlike other countries like Germany or Italy, in the UK pellets are not generally used in CHP or for heat in district heating.

Figure 30 shows a steady increase of fuel wood production. Fuel wood is predominantly imported from the EU, with the vast majority ostensibly coming from Latvia or the Netherland (Hogan, 2013).

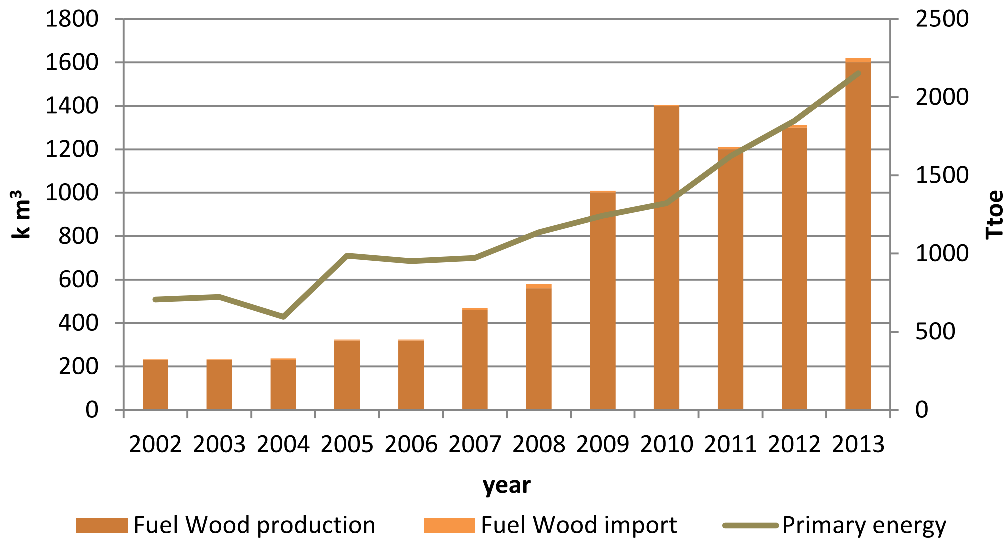



**Figure 30. Fuel Wood production and imports, and primary energy production from biomass in the UK**

Source: Eurostat, FAOstat

Together with RHI the Forestry Commission had provided a grant for wood fuel production with a total fund of about 14 million pounds. The grant offers 60% towards the coast of work including roads, machinery and other infrastructure to assist the extraction of timber from woodland (Forestry Commission, 2015). This may be a reason of positive increase of domestic fuel wood production. There is probably much more firewood imported than the statistics show as there are lots of small companies who simply bring in just one or two lorry loads a year from Eastern Europe (Hogan, 2013).

### 4.4.4 Impact

Table 14 gives a short description about the UK's forest resources. The latest FAO Forest Resource Assessment reports the woodland area keeps increasing slightly and reached 3,127 million ha in 2013 (FAO, 2014). Harvest rate increased by about 6% within the last 20 years and energy production could increase this trend by stimulating further harvesting in close future. Yet it is true the biomass stock is very small compare to the countries like Germany or Japan however the UK is also high populated. In a result around 85% of domestic demand for wood products comes from imports mainly from Sweden, Latvia, and Finland (Forestry Commission, 2004). The Forestry Commission states that given the availability of timber resources, current levels of round wood supply depend on decisions about when to harvest. These decisions are influenced by issues that include: levels of market demand, expectations regarding present and perceived future prices for round wood and harvesting costs, as well as a diversity of forest management objectives (Forestry Commission, 2004).

**Table 14. Forest Resource Changes in the UK**

| | 1990 | 2000 | 2005 | 2010 |
|---|---|---|---|---|
| Annual fellings ($Tm^3$) | 7,950 | 9,680 | 10,560 | 10,500 |
| Net annual increment ($Tm^3$) | 18,000 | 20,700 | 20,700 | 20,700 |
| *Harvest rate (%)* | *44.17* | *46.76* | *51.01* | *50.72* |
| | | | | |
| Growing stock ($Mm^3$) | 282 | 309 | 340 | 379 |
| Industrial roundwood removals ($Tm^3$) | 6,901 | 8,452 | 9,149 | - |
| Woodfuel removals ($Tm^3$) | 256 | 259 | 352 | - |
| *Removal rate (%)* | *2.5* | *2.9* | *2.8* | - |

*see Annex.1 for units
**see Annex.2 for specific definitions

Source: Eurostat [FAO, 2010c]

### 4.5 Comparison between Four Countries

Table 15 summarizes the results of the comparative analysis discussed above. It gives a comparison of the different categories and indicators for each country. This section will give a general overview of each country with respect to the modified DPSIR model, followed by a discussion part which will highlights the significance of the results in answer the objectives of this study.

Driver, as already has been discussed, explains the national energy targets and monetary incentives. In this case, incentives are positively valued if they consider the sources of material, size of plant, and co-generation as measures of sustainability and efficiency of energy production. Pressure, on the other hand, indicates the amount of energy produced from biomass while State describes how much percentage of material is imported over the total supply. Lastly, impact refers to the biomass stock/harvest ratio.

The symbols for the support scheme indicators in the chart below refer to the degree by which the policies are considered in each country. The detailed description of the current situation will be explained in further paragraphs.

**Table 15. Comparison of Results Between the four selected Countries**

| | Germany | Italy | Japan | UK |
|---|---|---|---|---|
| **Driver** | | | | |
| RE target share of gross final energy consumption by 2020 (%) | 18 | 17 | 10 | 15 |
| Renewable electricity production target by 2020 (%) | 32 | 26 | - | - |
| Support scheme | | | | |
| Wood resource discrimination | ◎ | ○ | △ | ○ |
| Plant capacity size discrimination | ◎ | ◎ | △ | △ |
| Promotion of CHP | ◎ | ○ | × | ○ |
| Restriction of co-firing | ◎ | × | × | △ |
| **Pressure** | | | | |
| RE share in gross final energy consumption in 2013 (%) (*biomass) | 12.4 (9.9) | 16.7 (4.2) | 4.0(5.4) | 5.1 (3.9) |
| Electricity generated from renewable sources in 2013 (%) (biomass) | 25.6 (5.7) | 31.3(-) | 1.6 (0.5) | 13.9 (-) |
| Energy from biomass in 2013 (Ttoe) | 10,902 | 7,448 | 8,169 | 2,153 |
| Share of wood biomass for Primary Energy Supply (PES) | 4.7 | 3.1 | 1.3 | 2.8 |
| Increase point of wood energy from 2002-2013 | 2.32 | 6.4 | 1.5 | 3.1 |
| **State** | | | | |
| Import ratio in 2013 ***(%) | | | | |
| Chips | 8.3 | 45.5 | 79.0 | 5.3 |
| Pellet | 19.6 | 85.0 | 48.3 | 91.9 |
| Fuelwood | 6.0 | 16.3 | 0.4 | 1.2 |
| **Impact** | | | | |
| Biomass stock in 2005 (Mm3) | 2,815 | 1,384 | 3,406 | 340 |
| Harvest rate (%) | 55.71 | 39.19 | - | 50.72 |

*share of total renewable consumption from geothermal, biomass and other (BP, 2015)
**see Annex.2 for word definitions
*** calculated by the amount of import divided by the amount of production (does not consider the amount of export)
Legends: ◎, well addressed; ○, partially addressed; △, addressed, but not well constructed; ×, not mentioned at all

Source: Eurostat, FAOstat, NREAP, Statistics from each Ministry

### 4.5.1 Country Summary

Germany sets the highest energy share targets from renewables and achieves the highest share of biomass in energy production. The energy (mainly electricity) provision is supported by FIT support schemes and they are classified in detail by source of material and plant size. Incentives successfully back up national energy production, which maintains an upward trend since 2002, together with an increase of CHP plants. Support schemes following the cascade use of wood and energy production efficiency, results to wood biomass use with smaller plants and less co-firing. The country relies on a large amount of biomass stock and wood production exceeds imports in the chips, pellets, and fuel wood sectors. However, the current sawmill industry crisis caused a decrease in raw material availability (DBFZ, 2015) hence some wood material production sectors, like pellets, will possibly be negatively affected. Another thing is that that the country imports a lot of wood waste for energy because of its favourable FIT price. Still in general German FIT is well structured to maintain its own wood resources.

Italy sets the second highest energy targets after Germany and actually marks the highest rate of renewable energy consumption among the four selected countries. Incentive prices within the so-called FIT scheme for electricity are the highest in Europe with respect to the use of by-products, smaller sized and CHP plants. After the new FIT set was activated 3 years ago both electricity and heat generation have increased. The status of wood trade reveals that Italy is a great importer of wood materials. In Italy, chips are for electricity generation and pellets and fuel wood are for domestic heating. In this study heat incentives were not mentioned in detail but they may largely influence biomass heating with tax reduction. Like Germany, the support schemes in Italy are also well structured. However, these support schemes seem not to be very helpful in stimulating the supply of domestic/local wood resources due to the considerably low harvest rate. It is assumed that the low harvest activity might be influenced by unorganized forest management as well as forest protection policies. Relatively high FIT prices for electricity possibly will affect both domestic and imported wood use but conservative wood use for heating will, however, remain very strong.

The Japanese situation concerning both renewable energy promotion and forest industry is way behind the European countries compared in this study. Especially that undeliberate support schemes give negative impacts on wood material supply chain within the country. FIT puts higher price on thinning wood that can be used as timber while wood waste deserves lower price. This price setting mainly aims at giving high value on unused thinned wood in the forests. The scheme does not promote CHP plants and does not restrict co-firing. Consequently, operators are mesmerized by “green” revenue and now many large electricity wood biomass plants are being constructed. Even though the country is composed with highly forested area, domestic production of wood material is very low and the country heavily depends on imports. Low harvest rate can be traced historically as a way to combat cheap imported materials, sagged house constructions, and a shortage of human resources in the forests. On top of it, the lack of technology causes hesitation in heat generation since imported biomass boilers are thought to be expensive and difficult to handle. Policy revamp is needed so that FIT could stimulate and promote domestic harvesting. However, setting unfair price levels can negatively affect the implementation of the cascade approach since it drives wood use to energy purposes rather than industrial processing.

Unlike to other countries like Germany or Japan, the UK does not apply feed-in schemes for electricity, but rather, for heat. Prices from support scheme do not differentiate material sources. CHP plants were originally promoted by FIT scheme but not by the main incentive, RO. Instead, RO obliges operators to follow specific criteria considering sustainability. Wood is consumed for electricity more than heat in contrast to Germany and Italy, in spite of an enforcement of heat incentive (RHI). The UK has the largest co-firing electricity plants in the world, burning high amount of wood material. It is mainly due to this fact that the UK is the top importer of wood pellets. It has been calculated that the UK could end up burning as much as 82 million tonnes of biomass each year and this is more than 8 times the annual wood production (Doward, 2013).

Apart from politic energy promotion the UK policies mostly concentrate on GHG emissions. To achieve national goals, co-firing energy production will likely to continue unless energy policy schemes will restrict it. Huge wood import is also attributed to poor forest resources. A careful scheme structure is needed; otherwise it is very possible to cut domestic wood, and import wood chips and pellets for energy –going against the cascade use of wood.

### 4.5.2 Overall Discussion

Some findings are summarised below following the study objectives.

National bioenergy support schemes vary greatly following each nation's perspective of forest management and target of energy supply. To achieve the share target of biomass energy production monetary incentives are applied in most of the developed countries. Comparison of Drivers from the selected four countries let few key aspects to be selected to measure its effectiveness.

The first aspect considers if incentives differentiate among sources of wood materials used for energy production. This can be done by giving different prices for each resource or by paying bonus on top of the basic price within FIT or renewable energy certificate scheme. In some European countries, policies for the promotion of wood biomass build on the principle that wood wastes from sawmills or forest management operations should be collected and used. This is in accordance to the more general "cascade use approach" that is promoted by the EU Forest Strategy.

The second aspect refers to the possibility to define incentives depending on the number and size of plants. European countries included in this study set different prices for each plant size category while Japan is now moving in the same direction. Obviously, bigger plants require more biomass resources. Promoting large plants can therefore put pressure on domestic and non-domestic supply of wood. The average size of plants is around 1 MW in most countries, but smaller capacity sized plants are more ideal to maintain the amount of wood stock thus higher incentive prices are distributed to smaller plants.

The third aspect is about CHP plants. Cogeneration technique greatly contributes to energy efficiency and in Europe it is already largely adopted. Yet in other regions/countries, like Japan, this technology is not well known and used. Heat that is produced in the process of electricity production can be used for drying wood materials to reduce moisture contents for high efficiency burning. For example, in Germany, plant managers are obliged to establish cogeneration systems to be active within feed-in schemes.

As for the fourth aspect, co-firing should be considered. Burning wood together with coal could contribute to less GHG emission targets by releasing less $CO_2$. Thermal power stations, however, usually have huge capacity and consequently they require big amounts of wood. The mixed fuel-burning ratio (usually 2-5%) should be carefully instituted. In addition, co-firing has a positive impact unless plants consume waste wood. In some cases, high quality pellets are burnt together with coal for the high efficiency of energy production and this induces higher imports of pellets and sawdust.

Finally, another additional aspect to consider is promoting controls of the amount of imported wood. All support schemes from the four analysed countries mention imported wood as a potential input. Germany manages its domestic forest supply chain well but at the same time, they import waste wood for energy production. Even if categorized as waste, transporting wood over long distances may raise questions about the real sustainability of this operation. In another aspect in many situation imported roundwood is operated in the imported country to produce chips or pellets and those second wood products are classified as domestic products. Matter of categorize hugely influences the outcomes of data.

Regardless of the outcomes, the analysis of the State shows that every country relies on imports in some way. What to import depends on policy, plants' facilities, and knowledge of energy production efficiency. Uses of imported material are also different for the same reasons. Countries that possess developed heating boilers or stoves tend to use chips/pellets for heating and countries that do not possess those facilities tend to burn chips/pellets for electricity. To give an example, in Japan, such high-technology heating boilers are not well-equipped and normally household use electricity-based air conditioning units to generate heat. In addition, biomass electricity plants are not able to treat inhomogeneous figures and moisture contents of biomass. Due to those facts, Japan tends to import chips/pellets for electricity generation. Besides, for every case the total amount of biomass needed is obviously affected by the number and size of plants. Indeed both biomass energy production and material import are increasing. However, concluding wood biomass for energy to be a reason of this active biomass trade is very short sighted.

Incentives (Driver), energy production (Pressure) and wood material production or trades (State) are interconnected but are only indicative. The main reason is that the issue is straddling multiple areas such as economic, environmental, and social. Energy targets are under the jurisdiction of the ministry of economy, while the ministry of forestry controls wood supply and use of sources depend on human traditions and habits. In reality, respective directives, decrees, and subsidy schemes are inextricably intertwining in promoting renewable energy production besides the mentioned support schemes. Later prices of logwood, chips, and more importantly oil affect the import ratio of wood resources. It tends to consume more biomass when oil price escalate. In addition, trends of traditional wood products are indirectly important. A decline of the demand of paper due to further break-through in the information technology may let proponents to invest chips more on energy than paper. Upstream of the supply chain, harvest ration and production get influence from historical issues and forest management procedures. Wood biomass for electricity is a new issue thus huge impacts on forest stands are not yet seen but some experts warn that clear cutting of forest for energy may have impacts on biodiversity. After all, it can be noted that energy support incentives surely affect domestic production and trade market although to decide if it is positive or negative requires more in depth research.

Considering these aspects, an assessment framework has been developed based on the DPSIR model applied to biomass energy production. Table 16 list some indicators as well as their descriptions and possible sources. It is difficult to cover all the related factors but these indicators could be a basis to think over wood biomass energy related issues.

## Table 16. Assessment Indicators for Wood Biomass Energy Production based on DPSIR model

| Indicator | Description | Source |
|---|---|---|
| **Driver** | | |
| RE target (%) | Desirable percent share of RE over the total energy production/consumption | Ministry of Economy/Environment |
| GHG emission target (%) | Desirable percent of $CO_2$ emission | |
| Support schemes | Monetary support to promote RE from the government | Ministry of Economy |
| **Pressure** | | |
| Electricity production (watt) | Amount of electricity produced | Eurostat/Eurobarometer |
| Heat production (toe) | Amount of heat produced | EC National Renewable Energy Action Plan |
| Share of Biomass energy (%) | Percentage share of energy produced from biomass over the total energy produced/consumed | EC Progress Report<br>IEA reports<br>Ministry of Economy/Environment |
| Size and number of plants | Capacity sizes and their numbers of biomass plants | Ministry of Environment<br>Research papers |
| **State** | | |
| Wood material production (m3, t) | Amount of material produced within a country | Eurostat/FAOstat |
| Wood material import (m3, t) | Amount of material imported | Ministry of Forestry |
| **Impact** | | |
| Biomass stock (m3) | All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage | Eurostat<br>Ministry of Forestry |
| Net annual increment (m3) | The average annual volume over the reference period of gross increment less natural losses | FAO Forest Resource Assessment Country Report |
| Harvest rate (%) | Percentage of amount of fellings over net annual increment | |
| **Response** | | |
| Policy amendments | Continuous revision of policy | Ministry of Economy |

# 5 Conclusions

In conclusion, comprehending the phenomena of wood biomass for energy in relation to policy support incentives is very complicated. While monetary incentives give opportunity to local economic development, tackling wood biomass is a sensitive issue due to its resource limitation. Further impacts on wood products supply and forest stands partially get effects from energy production, however other economic situations or conventional aspects may affect more.

Unfortunately, there are many limitations on this study. Wood biomass energy topic interacts with several sectors of study such as energy sector, environmental sector, and social sector. Consequently, more policies should be searched and covered. The study only focused on the support schemes for monetary incentives. However, in reality, other policies such as GHG emission policies, forest policies, construction policies etc., are affecting wood biomass energy production as well. These policies might directly or indirectly promote the use of renewable energy and provide additional contributions in better understanding the trend and dynamics in the biomass for energy sector. Another limitation of this study is data collection. One main limitation here is the lack of reliable data for the heating section. The study mainly extracted electricity generation data while wood biomass consumption is heavily connected to heat production. An additional critical aspect is that data sources that have been used are not homogeneous. For wood import and production, FAOstat provides valuable and quite complete information, but there is no such online database for wood renewable energy production. Each country provides statistical reports but it comes in different units and classifications, especially for wood resources. Moreover, the data of biomass usually include biomass from agriculture and there are only a few data set specifically intended for wood biomass.

For the recommendation, monitoring and organizing energy data specifically for wood biomass with a detailed categorization would help a future analysis. And furthermore improvement on energy use efficiency, within human activities, is expected to grow more than energy promotion in a consideration of sustainability. Renewable energy will certainly grow more and wood biomass is not an exception. Indeed, promoting wood biomass could decrease the use of fossil energy and consequently reduce GHG emissions. If the whole cycle works in an ideally way – i.e. local sawmills collect by-products and wastes to produce both electricity and heat with CHP generators, use their own energy they sell the surplus by applying incentive schemes - wood biomass has a potential to change the  “waste” to “treasure”. All operators must understand that energy production should come at the end of the cascade flow and consider applying adequate facilities to obtain higher energy production efficiency.

# References

ABO, 2015. *Asia Biomass Office.* [Online]
Available at: http://www.asiabiomass.jp/topics/1102_01.html
[Accessed 30 6 2015].

AEBIOM, 2014. *European Pellet Quality Certification: Creating a uniform system for Europe,* s.l.: PellCert.

Alfano, V. & Pignatelli, V., 2010. *Study on Biomass Trade in Italy,* s.l.: ENEA.

Annalisa Paniz, L. B., 2014. *Italy, the most important European pellet market,* s.l.: AIEL.

Arturo Sferruzza, G. M. M. L. S. M. Z., 2013. *European Renewable Energy Incentive guide-Italy,* s.l.: s.n.

Arturo, S., Gennaro, M., Mario, L. & Maria, Z. S., 2013. *European Renewable Energy Incentive guide-Italy,* s.l.: s.n.

ARUP, 2011. *Review of the Generation Costs and Deployment Potential of Renewable Electricity Technologies in the UK,* s.l.: DECC.

BASIS, 2014. *European Wood chips plants Country analysis,* s.l.: Biomass Availability and Sustainability Information System.

BIN, 2013. *Biomass White Paper 2013,* s.l.: Biomass Industrial Society Network.

Biomass Energy Centre, 2015. *Glossary.* [Online]
Available at:
http://www.biomassenergycentre.org.uk/portal/page?_pageid=74,18700&_dad=portal&_schema=PORTAL
[Accessed 10 07 2015].

BMU, AGEE-Stat, 2013. *Renewable Energy Sources 2010 Data on trends in renewable energy in Germany in 2012, 2013,* s.l.: Federal Ministry for the Environmental, Nature conservation and Nuclear Safety.

BMU, 2012. *Renewable Energy Sources in Figures National and International Develpment,* s.l.: s.n.

BMWi, 2000. *Erneuerbare-Energien-Gesetz - EEG 2000,* s.l.: s.n.

BMWi, 2007. *Erneuerbare-Energien-Gesetz - EEG 2007,* s.l.: s.n.

BMWi, 2012. *Erneuerbare-Energien-Gesetz - EEG 2012,* s.l.: s.n.

BMWi, 2014. *Erneuerbare-Energien-Gesetz - EEG 2014,* s.l.: German Federal Ministry for Economic Affairs and Energy.

BP, 2015. *Statistical Review of World Energy.* [Online]
Available at: http://www.bp.com/en/global/corporate/about-bp/energy-

economics/statistical-review-of-world-energy.html
[Accessed 7 7 2015].

CBER, 2015. *Definition of Moisture Content of Wood Fuels.* [Online]
Available at:
http://www.biomassenergyresearch.ca/linked/definition_moisture_content_of_wood_fuels.pdf
[Accessed 10 7 2015].

CEP, 2011. *IEA Bioenergy Task 40 Country Report for United Kingdom 2011,* s.l.: International Energy Agency.

Christoph Böhringer, A. C. D. H. E. A. O., 2014. *The impact of Feed-in Tariffs on Innovation: Empirical Evidence from Germany,* s.l.: s.n.

Ciccarese, L. *et al*., n.d. *Promotion of residual forestry biomass in the Mediterranean basin, Situation Report on Forest Biomass Use Country Italy,* s.l.: Slovenian Forestry Institute.

Ciccarese, L., Pellegrino, P. & Pettenella, D., 2014. A ne principle of the European Union policy: The cascading use of wood products. *L'Italia Forestale e Montana,* 69(5), pp. 285-29.

Cocchi, M., 2012. *IEA Bioenergy Task 40: Country Profile Italy 2011,* s.l.: International Energy Agency.

DB, 2012. *Ther German Feed-in Tariff Recent Policy Changes,* s.l.: Desutsche Bank Group.

DBFZ, 2012. *IEA Bioenergy Task 40: Country Report Germany 2011,* s.l.: International Energy Agency.

DBFZ, 2015. *IEA Bioenergy Task 40 Country Report Germany 2014,* s.l.: International Energy Agency.

DBFZ, n.d. *Stromerzeugung aus Biomasse 03MAP250,* s.l.: German Biomass Research Center.

DECC, DUKES, 2014. *Renewable sources of energy: Chapter 6,* s.l.: Department of Energy & Climate Change, Digest of United Kingdom Energy Statistics.

DECC, 2011. *UK Renewable Energy Roadmap,* s.l.: s.n.

DECC, 2013. *UK Renewable Energy Roadmap,* s.l.: Department of Energy & Climate Change.

DECC, 2014a. *Delivering UK Energy Investment,* s.l.: HM Government.

DECC, 2014b. *Domestic Renewable Heat Incentive: Changes to Eligibility,* s.l.: Department of Energy & Climate Change.

Doward, J., 2013. *the guardian.* [Online]
Available at: http://www.theguardian.com/environment/2013/nov/09/biomass-power-stations-wood-forests-report
[Accessed 30 6 2015].

Dr. Matthians Lang, A. L., n.d. *German Energy Blog.* [Online]
Available at: http://www.germanenergyblog.de/
[Accessed 10 6 2015].

EC, 2009. *Directive 2009/28/EC, the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 2003/30/EC,* s.l.: European Parliament and of the Council.

EC, 2010. *National Renewable Energy Action Plan in Accordance with Directive 2009/28/EC on the promotion of the use of energy from renewable sources,* s.l.: Federal Republic of Germany.

EC, 2013a. *Progress report pursuant to Article 22 of Directive 2009/28/EC on the promotion of the use of energy from renewable sources,* s.l.: Federal Republic of Germay.

EC, 2013b. *Italy's Second Progress Report under Directive 2009/28/EC,* s.l.: s.n.

EC, 2013c. *Second Progress Report on the Promotion and Use of Energy from Renewable Sources for the United Kingdom,* s.l.: s.n.

Ecoprog GmbH, 2013. *Market Study Biomass to Energy 2013/2014.* s.l.:s.n.

EEA, 2003. *Environmental Indicators: Typology and Use in Reporting,* s.l.: European Environment Agency (EEA).

EFI, 2014. *Forest Bioenergy for Europe,* s.l.: European Forest Institute.

EPC, 2014. *Overview of the European pellet market,* s.l.: European Pellet Council.

Erik Gawel, A. P., 2013. *Promotion the market and system integration of renewable energies through premium schemes-Acase study of the German market premium,* s.l.: s.n.

FAO, 2010a. *Global Forest Resource Assessment Country Report Germany,* s.l.: Food and Agriculture Organization of the United Nations.

FAO, 2010b. *Global Forest Resources Assessment Country Report Italy,* s.l.: s.n.

FAO, 2010c. *Global Forest Resource Assessment 2010,* s.l.: s.n.

FAO, 2010c. *Global Forest Resource Assessment Country Report Japan,* s.l.: Food and Agriculture Organization of the United Nations.

FAO, 2014. *Global Forest Resources Assessment 2015 Country Report U.K. of Great Britain and Northern Ireland,* s.l.: Food and Agriculture Organization of the United Nation.

Federal Republic of Germany , 2010. *National Renewable Energy Action Plan in accordance with Directive 2009/28/EC on the promotion of the use of energy from renewable sources,* s.l.: s.n.

Fiorese, G. & Guariso, G., 2010. *Sustainable forest management for bioenergy,* s.l.: Politecnico di Milano.

Forestry Commission, 2004. *International Markets in Wood Products,* s.l.: Forestry Commission.

Forestry Commission, 2014. *Forestry Statistics 2014.* [Online]
Available at:
http://www.forestry.gov.uk/website/forstats2014.nsf/TopContents?Open&ctx=48C3C4BD2348F18A8025731B00537232
[Accessed 25 5 2015].

Forestry Commission, 2015. *Forestry Commission England.* [Online]
Available at: http://www.forestry.gov.uk/england-woodfuel
[Accessed 09 7 2015].

Fulton, M., Capalino, R. & Auer, J., 2012. *The German Feed-in Tariff: Recent Policy,* s.l.: Deutsche Bank.

Gawel, E. & Purkus, A., 2013. *Promoting the market and system integration of renewable energies through premium schemes-A case study of the German market premium,* s.l.: Energy Policy, ELSEVIER.

Gianluca Grilli, G. C. I. D. M. G. G. F. M. A. P. D. V. A. P., 2015. *Experts' Perceptions of the Effects of Forest Biomass Harvesting on Sustainability in the Alpine Region,* s.l.: South-East European Forestry.

Gipe, P., 2012. *Wind-works.* [Online]
Available at: http://www.wind-works.org/cms/index.php?id=199&tx_ttnews%5Btt_news%5D=2071&cHash=e89c4c7348b9f9e2040552448af1839f
[Accessed 6 6 2015].

GME, 2015. *Green Certificates.* [Online]
Available at: https://www.mercatoelettrico.org/En/Mercati/CV/CorrispettiviCV.aspx
[Accessed 23 6 2015].

GOV.UK, 2015. *GOV.UK.* [Online]
Available at:
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/211292/ro_banding_levels_2013_17.pdf
[Accessed 20 6 2015].

GSE, 2012. *Statistical Report 2011 Renewable Energy Power Plants in Italy,* s.l.: s.n.

GSE, 2013. *Incentives as per MD of 6 Jul. 2012,,* s.l.: s.n.

GSE, 2015. *Rapporto Statistico Energia da fonti rinnovabili Anno 2013,* s.l.: s.n.

Hogan, G., 2013. *UK trade in woodfuel - an overview, FR Report to FC Plant Health,* s.l.: Biomass Energy Centre.

Honert, A., 2014. *Financial Incentives for Renewable Energy in Italy,* s.l.: s.n.

ISEP, 2014. *Renewables Japan Status Report 2014 Executive Summary,* s.l.: Institute for Sustainable Energy Policies.

Japan Wood Energy, 2015. *Japan wood energy Co.,Ltd.* [Online]
Available at: http://www.mori-energy.jp/
[Accessed 10 7 2015].

JORA, 2006. *Biomass Nippon,* s.l.: Japan Organics Recycling Association, MAFF.

JPA, 2015. *Japan Paper Association.* [Online]
Available at: http://www.jpa.gr.jp/
[Accessed 10 7 2015].

Junginger, M., Goh, C. S. & Faaij, A., 2014. *International Bioenergy Trade: History, status & outlook on securing sustainable bioenergy supply, demand and markets.* ISBN 978-94-007-6982-3 ed. s.l.:Springer.

Köppen, S. *et al*., 2013. *Implementing the GBEP Indicators for Sustainable Bioenergy in Germany,* s.l.: IINAS, ifeu.

KPMG, 2013. *Taxes and incentives for renewable energy,* s.l.: s.n.

Kumazaki, M., 2013. *Japan Biomass Energy Association.* [Online]
Available at: http://www.jwba.or.jp/
[Accessed 13 5 2015].

Lorenzo Ciccarese, P. P. D. P., 2014. *A new principle of the european union forest policy: The cascading use of wood products,* s.l.: L'Italia Forestale e Montana/Italian Journal of Forest and Mountain Environments, Accademia Italiana di Scienze Forestali.

MAFF, 2011. *Forestry White Paper,* s.l.: Ministry of Agriculture, Forestry, and Fisheries.

MAFF, 2012. *Action Plan for Bioenergy.* s.l., Ministry of Agriculture, Forestry and Fishieries.

MAFF, 2013. *Annual Report on Forest and Forestry in Japan,* s.l.: Ministry of Agriculture, Forestry and Fishieries.

MAFF, 2014. *Forestry White Paper,* s.l.: Ministry of Agriculture, Forestry, and Fisheries.

Mark Maslin, P. A. A. D. J. M. M. O. V. P., 2007. *Audit of UK Greenhouse Gas emissions to 2020: will current Government policies achieve significant reductions?,* s.l.: UCL Environmental Institute, University College London.

Martin Gutsch, P. L.-B. A. B. L. F. S. A. M. T. P., 2014. *Uncertainty of biomass contributions from agriculture and forestry to renewable energy resources under climate change,* s.l.: Meteorologische Zeitschrift.

MATTM, 2012. *Il Ministro dello Sviluppo Economico (Ministerial Decree of 6 Jul. 2012,* s.l.: Il Ministro dell'Ambiente e della Tutela del Territorio e del Mare.

METI, 2014. *Recent condition and challenges about renewable energy.* [Online]
Available at:
http://www.meti.go.jp/committee/sougouenergy/shoene_shinene/shin_ene/pdf/001_03_00.pdf
[Accessed 10 7 2015].

METI, 2015a. *About a promotion of small wood biomass plants,* s.l.: s.n.

METI, 2015b. *Data and Trends of Renewable Energy Electricity Production,* s.l.: Ministry of Economy, Trade, and Industry.

METI, 2015c. *Statistics on Energy,* s.l.: s.n.

METI, 2015d. *Renewable Energy.* [Online]
Available at: http://www.enecho.meti.go.jp/category/saving_and_new/saiene/
[Accessed 23 4 2015].

MSE, 2010. *Italian National Renewable Energy Action Plan,* s.l.: Italian Ministry of Economic Development.

Obernberger, I. & Thek, G., 2010. *The Pellet Handbook, The production and thermal utilisation of biomass pellets.* UK, USA: Earthcan.

Ofgem, 2011. *Renewables Obligation: Sustainability Criteria for Solid and Gaseous Biomass (greater than 50 kilowatts),* s.l.: Ofgem.

Ofgem, 2014. *Renewables Obligation: Sustainability Criteria,* s.l.: Ofgem.

Ofgem, 2015a. *Domestic Renewable Heat Incentive, an introduction to the Domestic Renewable Heat Incentive scheme,* s.l.: Ofgem.

Ofgem, 2015b. *Non-Domestic Renewable Heat Incentive, Guidance Volume Two: Ongoing Obligations and Payments (version 4),* s.l.: Ofgem.

Ofgem, 2015c. *Feed-in Tariff (FIT) scheme.* [Online]
Available at: https://www.ofgem.gov.uk/environmental-programmes/feed-tariff-fit-scheme
[Accessed 21 5 2015].

Paniz, A. & Bau, L., 2014. *Italy, The most important European pellet market. Pellet Day 15th January 2014,* s.l.: Associazione Italiana Energie Agroforestali (AIEL).

PellCert, 2012. *European Pellet Report,* s.l.: s.n.

Perry, M. & Rosillo-Calle, F., 2006. *Co-firing Report- United Kingdom,* s.l.: Imperial College London.

Prokhorov, I., 2015. *Ukranian Biofuel Portal, Italian pellet production broke the 200000 mark in 2014.* [Online]
Available at: http://pellets-wood.com/italian-pellet-production-broke-the-200-000-mark-i-o12829.html
[Accessed 10 7 2015].

REN21, 2015. *Renewables 2015 Global Status Report,* Paris: Renewable Energy Policy Network for the 21st Century (REN21 Secretariat).

SFI, PROFORBIOMED, 2012. *Situation report on forest biomass use in Mediterranean region,* s.l.: Slovenian Forestry Institute.

Solberg, B. *et al*., 2014. *Impacts of forest bioenergy and policies on the forest sector markets in Europe - what do we know?,* s.l.: European Forestry Institute.

Tagesfragen, E., 2012. *Co-firing solid biomass: the underrated option.* [Online]
Available at: http://www.paconsulting.com/introducing-pas-media-site/highlighting-pas-expertise-in-the-media/opinion-pieces-by-pas-experts/energiewirtschaftliche-tagesfragen-co-firing-solid-biomass-the-underrated-option-july-2012-greening-business/
[Accessed 09 7 2015].

Tokio Marine & Risk Consulting Co, Ltd, 2014. *Report on Renewable Energy Progress in several countries,* s.l.: Ministry of Environment.

UN, 2011. *European Forest Sector Outlook Study II, 2010-2030,* s.l.: UNECE/FAO ISSN 1020-2269, ISBN 978-92-1-117051-1.

UNECE/FAO, 2012. *Green Economy Policy Brief,* s.l.: s.n.

UNECE, 2012a. *European Forest Sector Outlook Study Ⅱ, 2010-2030,* s.l.: United Nations publication.

UNECE, 2012b. *Green Economy Policy Brief,* s.l.: United Nations publiation.

World Bank, 2015. *THE WORLD BANK.* [Online]
Available at: http://data.worldbank.org/
[Accessed 10 6 2015].

Yamaguchi, T., 2014. *Electricity Market Reform in UK and and its implication on Japan's renewable policy,* s.l.: Tokyo University.

# Annexes

## Annex 1 – Units and Currency Rates

| Symbol | Unit/Definition |
|---|---|
| GW | gigawatt |
| ha | hectare |
| kW | kilowatt |
| kWh | kilowatt per hour/<br>a unit of energy equivalent to one kilowatt of power generated for one hour of time |
| $m^3$ | cubic metre |
| $Mm^3$ | million cubic metre |
| Mt | million tonne |
| MW | megawatt |
| MWe | megawatt of electrical output/<br>equivalent to MW |
| MWh | megawatt per hour |
| **PJ** | petajoule/equivalent to about 23,885 toe |
| **$Tm^3$** | thousand cubic metre |
| **toe** | tonne of oil equivalent/<br>a measure of energy used to relate different fuels to the equivalent oil requirement based on an energy value for oil of 42 MJ/kg (Biomass Energy Centre, 2015) |
| Ttoe | thousand toe |
| TWh | telawatt per hour |

| Currency rate (10/07/2015) | |
|---|---|
| **1 euro** | 132 Japanese yen |
| **1 euro** | 0.72 UK pounds |

# Annex 2 – Special Term Definitions

| Term | Definition |
| --- | --- |
| **Biomass stock** | All living biomass above the soil including stem, stump, branches, bark, seeds, and foliage (in this study it only considers above-ground biomass) (FAO) |
| **Co-firing** | the process of replacing part of the fossil fuel supplied to a power station or boiler with a 'carbon lean', renewable alternative (Biomass Energy Centre, 2015) |
| **Co-generation (CHP)** | a system in which the heat associated with electricity generation is also used for space heating or process heat. In this way the overall efficiency of the process in terms of the proportion of the energy in the biomass fuel that is made use of is increased considerably (Biomass Energy Centre, 2015) |
| **Felling** | the volume of all trees, living or dead, which are felled during a given period, whether or not removed from the forest or other felling sites. Removals (the term is synonymous with roundwood production) are equal to fellings less unrecovered fellings (Eurostat) |
| **Growing stock** | the volume over bark of all living trees more than X cm in diameter at breast height (or above buttress if these are higher). Includes the stem from ground level or stump height up to a top diameter of Y cm, and may also include branches to a minimum diameter of W cm (FAO) |
| **Harvest ratio** | the percentage ration calculated by annual fellings divided by net annual increment |
| **Industrial roundwood removals** | the wood removed (volume of roundwood over bark) for production of goods and services other than energy production (FAO) |
| **Moisture content** | the proportion of water in a sample of biomass, defined as the weight of water as a percentage of the weight of biomass. This can be defined on either a wet basis, as a percentage of the total (wet) weight of the sample, or a dry basis, as a percentage of the oven dry weight of biomass. Wet basis is usually used for fuel purposes (Biomass Energy Centre, 2015) |
| **Net Annual Increment** | gross increment less natural losses over a given period. Gross increment is the average volume of increment of all trees (all diameters, down to a stated minimum diameter) over a given period. It is reported in cubic metres overbark (Eurostat) |
| **Primary energy supply** | energy production plus energy imports, minus energy exports, minus international bunkers, then plus or minus stock changes (OECD iLibrary) |
| **Removal ratio** | the percentage ratio calculated by the amount of total wood removal divided by the biomass/growing stock |
| **Self-sufficiency of wood materials** | the percentage ration calculated by the amount of domestic production divided by the amount of total supply minus the amount of export. Only Japanese ministry applies the concept within official documents |
| **Woodfuel removals** | the wood removed for energy production purposes, regardless whether for industrial, commercial or domestic use (FAO) |