

Cascading of woody biomass: definitions, policies and effects on international trade



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Summary

Cascade use or “cascading” of woody biomass is increasingly being discussed as a key principle upon which to base efficient utilization of wood, especially in the European Union (EU). Cascading does not have one universal definition, although a common theme is that “material use of wood should be prioritized over energy use of wood”, which forms the basis for our analysis herein. This working paper aims to inform the debate on cascading through an analysis of the terminology around cascading, and a review of how the concept is framed and implemented in policies of the EU and selected member states. We also discuss potential implications on international bioenergy markets from implementation of the cascading principle.

In recent years, the cascading concept has been emphasized in EU Bioeconomy Strategy, the EU Circular Economy Package and the EU Forest Strategy. As of September 2015, the cascading principle is also part of EU legislation as part of the so-called “iLUC Directive” that largely governs the role of biofuels in the EU’s climate change mitigation policies up until 2020. However, the terminology surrounding cascading is fragmented in both the research literature and among EU policy documents. There is no clear consensus on a clear and precise definition of what cascading actually entails. Absence of coherent terminology in legislative documents is likely to be a cause for problems and we want to stress the importance of developing a clear definition of cascading if it is to be included in future legislative processes.

We analyze the consequences of potential implementation of the cascading principle by looking at both historical cases of similar policies and current examples from Europe and North America. Conclusions from the cases suggest that there are clear risks that policy implementation of the cascading principle results in complicated legislative processes, especially pertaining to reaching agreement on the set of wood assortments that can be used for material purposes and which therefore should be excluded from energy use. Given the large and growing international trade in both bioenergy and biomaterials, further complications are likely to arise if the cascading principle is enforced only in select EU member states or in the EU but not in North America. Without harmonized rules, the efficiency and efficacy of cascading policies could be compromised as market actors focus more on exploiting regulatory loopholes than on improving their performance.

To support a fruitful debate on the policy structures of a future economy based on renewable resources, and the role of bioenergy therein, it is important to first define the policy goals and from that starting point discuss potential measures to achieve these goals. The measures sorted under the “cascading” banner could be part of the policy portfolio, but before cascading has been properly defined and evaluated, it should not be seen as the silver bullet that resolves all potential problems in the transition to a biobased economy.

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1 Introduction

Cascading use of biomass is an issue that has become increasingly discussed in policy debates especially in the European Union, commonly promoted as an important concept to ensure efficient use of woody biomass resources. In this working paper, we aim to inform the current debate on cascading by discussing the role of the cascading principle in historical, existing and future policy structures on the governance of renewable energy and forest resources.

We discuss biomass cascading policies from several different perspectives with the objective to:

- a) Review the terminology surrounding cascading
- b) Present examples from different contexts of how cascading is currently discussed and – where applicable – implemented in policies
- c) Discuss if, how, and to what extent, EU and national policies should be used to allocate biomass resources according to cascading principles
- d) Analyze how implementation of cascading principles into policy might interact with international trade in woody biomass
- e) Summarize our conclusions on policy implementation of biomass cascading and suggest topics that need to be addressed to further the discussion on allocation of biomass resources

2 Resource cascading – origins and terminology

The term “cascading” has in recent years become used with growing frequency in discussions on policy strategies pertaining to how to allocate biomass resources in order to maximize societal and environmental benefits. This is an issue that has become especially relevant in the context of emerging ambitions striving towards a *bio-based economy* (Asveld et al. 2011; Fritsche and Iriarte 2014). The cascading concept itself has been around for several decades, but has also taken several different forms, as is reviewed below.

2.1 Cascading-in-time

Resource cascading as a concept was introduced in the early 1990's. Sirkin & Ten Houten (1994) explain that the term stems from a metaphor, where the stepwise use and re-use of resources is analogous to “...a river flowing over a sequence of plateaus” (Sirkin and Ten Houten 1994, p.215). The basis for *resource quality* which they define as “...the capacity to perform tasks at various degrees of difficulty” (Sirkin and Ten Houten 1994, p.216), similar to the concept of **exergy** in physics (Odegard et al. 2012).

This original idea of the cascade chain is that resources should be re-used sequentially in the order of the specific resource quality at each stage (see Figure 1). This would enable the resource to stay longer in the system and thereby reduce the need for additional resource extraction and reduce strain on natural resources (Fraanje 1997). If the concept is applied for biomass resources, the potential of long-term carbon storage in wood products has also been highlighted (Sikkema et al. 2013). Following Odegard et al (2012), we refer to this as *cascading-in-time*.

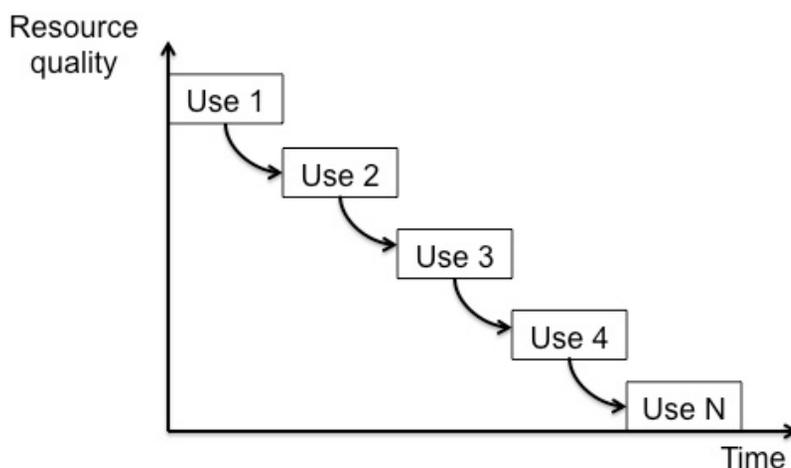


Figure 1. The cascade chain (adapted from Sirkin and Ten Houten 1994)

There are conceptual similarities between cascading-in-time and the *waste hierarchy* (also known as “Lansink’s ladder”). The waste hierarchy as specified by the European Commission (2012a) lists five different waste management methods and the priority in which they should be used:

1. Prevention
2. Preparation for re-use
3. Recycling
4. Other recovery (incl. energy recovery)
5. Disposal (incl. landfilling or incineration without energy recovery)

With origins in the late 1970s, the waste hierarchy has been a key part of waste management strategies in Europe for several decades (Lazarevic et al. 2010). The objective of maximizing the time a resource remains in the system is present both in the waste hierarchy and the cascading-in-time framework. The themes also intermingle in the broader discussions on recycling and the move towards a circular economy (Ellen MacArthur Foundation 2012).

The number of stages in the cascade chain has been used as to classify different models for cycling resources through the system (Essel et al. 2014; Wern et al. 2014):

- **Solitary energetic use** is given when the resource is directly used for electricity and / or heat provisioning.
- In a **single stage cascade** a first product use phase has to be followed by a second energetic or material use stage such as energetic recovery for electricity and/or heat generation or compost production for sellable fertilizer and soil amendment products.
- A **multi-stage cascade** requires by definition a second material use stage after first product phase and has to be used in the following end-of-life treatment step either energetically or has to be processed for further material use.

There is some debate as to whether the objective here should be to maximize the *time* spent in the system or the *number of cascade stages*. In some cases, as in the use of wood for construction, the number of cascade phases is less relevant than the actual lifetime of the building (Vis et al. 2014)¹. For the case of carbon this is seen as especially relevant as longer retention times of (especially fossil) carbon delays (and in some cases ultimately reduces) greenhouse gas emissions, and thereby contributes to climate change mitigation.

2.2 Cascading-in-value

In recent years, there have been attempts at developing the cascading concept further, especially pertaining to the actual basis for prioritization between uses. In addition to the original concept presented by Sirkin & Ten Houten (1994) - the purpose of which is to maximize the timespan during which the resource stays in the system - a more recent concept is what Odegard et al (2012) labels *cascading-in-value*.

In this framework, the resource shall be used with the purpose of maximizing *value* throughout the cascade chain although the definition of *value* is not consistent in the available literature (Vis et al. 2014). Some sources refer to *added value* primarily in the economic sense (Carus et al. 2014) whereas other discuss both *environmental added value* and *economic added value* (Keegan et al. 2013; Vis et al. 2014).

The cascading-in-value concept is often illustrated by use of the “bio-based pyramid” (Vis et al. 2014) shown in Figure 2.

¹ An important characteristic of wood-based products in this context is that quality will deteriorate significantly with each re-use.

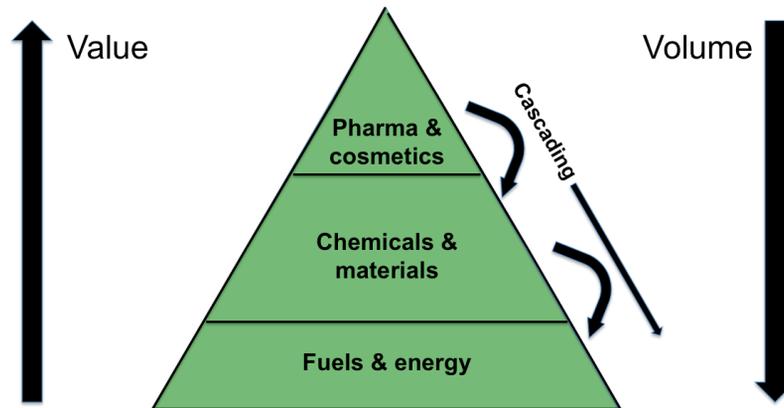


Figure 2. An illustration of the “cascading in value” concept. Adapted from Vis et al (2014).

Vis et al (2014) argue that cascading-in-value is primarily to be used **within** a cascading-in-time framework, as a means of finding the cascade-in-time chain that maximizes value, otherwise, “...cascading in value becomes a (simple) selection process of what application is preferred with a given type of biomass” (Vis et al. 2014, p.17).

2.3 Cascading-in-function

Cascading-in-time and cascading-in-value are arguably the most prominently used definitions of cascading, but Odegard et al (2012) also mention a third definition called *cascading-in-function*. This puts focus on the importance of optimal use of each subcomponent of e.g., a tree, with the objective of ensuring that each part of the tree is used for an optimal purpose. This bears close resemblance to the function of a biorefinery, which as defined by Cherubini (2010) is “a facility (or network of facilities) that integrates biomass conversion processes and equipment to produce transportation biofuels, power and chemicals from biomass” (Cherubini 2010, p.1414). Based upon the conceptual setup of a crude oil refinery, biorefineries process biomass into several different products in a way that maximizes value. A key difference between cascading-in-time and cascading-in-value on the one hand and biorefineries/cascading-in-function on the other is that the latter more strongly emphasizes simultaneous production of several different bioproducts (Keegan et al. 2013; Sokka et al. 2015).

3 The role of biomass cascading in EU policy

Thus far, implementation of the cascading concept into policy frameworks connected to the utilization of biomass has primarily been a European issue. The cascading concept has been a topic in EU policy discussions for several years now and in several different policy areas. Below we review and compare how the cascading concept has been framed and defined in different EU policy documents, in chronological order of publication.

3.1 Biomass cascading in EU policy documents

3.1.1 EU Bioeconomy Strategy (2012)

One of the points in the Bioeconomy Action Plan, as presented in the 2012 EU Bioeconomy Strategy, is to “*Promote the setting up of networks with the required logistics for integrated and diversified biorefineries, demonstration and pilot plants across Europe, including the necessary logistics and supply chains for a cascading use of biomass and waste streams*” (European Commission 2012b, p.9)

A Staff Working Document accompanying the Bioeconomy Strategy states that “*biorefineries should adopt a cascading approach to the use of their inputs, favouring highest value added and resource efficient products, such as bio-based products and industrial materials, over bioenergy. The principle of cascading use is based on single or multiple material uses followed by energy use through burning at the end of life of the material, including taking into account the greenhouse gas emissions (GHG) mitigation potential*” (European Commission 2012c, p.44, emphasis added)

3.1.2 EU Forest Strategy (2013)

The 2013 EU Forest Strategy emphasizes the potential of the cascade principle to prioritize “*...forest outputs that have higher added-value, create more jobs and contribute to a better carbon balance*” (European Commission 2013, p.5). Worth noting is also that the Forest Strategy includes an explicit definition of cascade use: “***Under the cascade principle, wood is used in the following order of priorities: wood-based products, extending their service life, re-use, recycling, bio-energy and disposal***” (European Commission 2013, p.6, emphasis added).

3.1.3 Circular Economy Package (2014-2015)

In a 2014 communication from the Commission on strategies towards a circular economy, one of the strategies mentioned to support the process is to “*...encourage the cascading principle in the sustainable use of biomass, taking into account all biomass using sectors so that biomass can be utilised in a most resource efficient way*” (European Commission 2014, p.6).

Similarly, a fact sheet released with the 2015 Circular Economy package states that “*a cascading use of renewable resources should be encouraged*” (European Commission 2015, p.6) and that the Commission will “*promote an efficient use of bio-based resources through a series of measures, such as guidance and dissemination of best practices of the cascading use of biomass and support to innovation in the bioeconomy*” (ib.)

3.1.4 iLUC Directive (2015)

As of September 2015, cascading is formally included as a component in EU energy policy, through the adoption of the so-called “iLUC directive” (EU 2015/1513), which amends the Renewable Energy Directive (European Parliament and Council of the European Union 2009b) and the Fuel Quality Directive (European Parliament and Council of the European Union 2009a). The directive emphasizes the importance of “...*taking due account of the principles of the waste hierarchy established in Directive 2008/98/EC and the biomass cascading principle, taking into consideration the regional and local economic and technological circumstances*” (European Parliament and Council of the European Union 2015, p.239/20, emphasis added).

Note that the text in bold was added rather late in the process of formulating the directive, thereby making the wording more cautious than otherwise would have been the case. Also, the cascading principle was not included as a component of sustainability criteria as it had been in earlier draft versions of the directive (CEPF 2015).

3.1.5 Biomass cascading in EU policy documents: discussion

As is clear from the above overview, the cascading principle is seen as an important component in at least four key EU policy areas, although the 2015 iLUC directive is the first and only instance thus far where cascading is actually included as part of a legislative document.

It is interesting to note that the cascading principle is explicitly explained in only two of the reviewed policy documents (the Bioeconomy Strategy and the Forest Strategy). In the remaining two documents, the cascading principle is alluded to without definition or reference to an external source. This is unfortunate, given that a reoccurring characterisation in the research literature of cascading as a concept is the absence of a solid definition.

Regardless, examining the two definitions that are formulated in the Bioeconomy Strategy and the Forest Strategy is useful in order to discern the views of EU policy makers on the cascading principle.

- The Bioeconomy Strategy emphasizes that it is important that biorefineries should prioritize “*highest value added*” and “*resource efficient products [...] over bioenergy*”. Using the terminology presented in section 2, the framing here seems to be a mix of cascading-in-time (resource efficiency) and cascading-in-value (maximize value added).
- The Forest Strategy defines the cascading principle as an order of priority for how woody biomass should be utilized, although the cascading principle is also alluded to as a vehicle to ensure higher value-added, job creation and carbon storage. Notable here is that resource efficiency is not mentioned but there again is a mix of cascading-in-time (carbon storage) and cascading-in-value (value-added, job creation).
- The Circular Economy strategy includes no explicit definition of cascading, but the concept is mentioned as a means of ensuring that biomass is used in a resource efficient way.

Table 1 below gives an overview of the ways in which biomass cascading is framed in key EU policy documents.

Policy document	Bioeconomy Strategy	Forest Strategy	Circular Economy Package	iLUC Directive
Key terms associated with cascading	<ul style="list-style-type: none"> Value added Resource Efficiency Re-use GHG emission reduction 	<ul style="list-style-type: none"> Value added Job creation Carbon storage 	<ul style="list-style-type: none"> Resource Efficiency 	-
Role of bioenergy	<ul style="list-style-type: none"> Other uses of biomass than bioenergy should be prioritized 	<ul style="list-style-type: none"> Bioenergy second lowest priority 	-	Other uses of biomass than bioenergy should be prioritized

Table 1. Framing of cascading in different EU policy documents

There is not complete coherence across the different policy areas as to what is meant by “cascading”, nor which policy goals cascading is supposed to serve. An important question is if the different potential benefits associated with cascading be achieved at the same time, or if there are conflicts between e.g. a cascade chain designed to maximize value added and one that is aimed at maximizing carbon storage.

3.2 Implementation of the cascading principle in national policies in EU countries: examples from Germany and Flanders

As was noted above, cascading is formally included as a component in EU energy policy with the adoption of the “iLUC directive” (EU 2015/1513). But, exactly if/how this is to be enforced at the member state level is as of yet uncertain. However, even before the adoption of the iLUC directive, the cascading principle has been introduced as a component in policies of several individual member states, especially pertaining to strategies for progress towards bio-based economies. Below we review two examples of this, one from Germany and one from the province of Flanders in Belgium.

3.2.1 Cascading in national policy: Germany²

The bioeconomy concept with cascading use (and use of by-products) as one favourable component is widely promoted in Germany for example within the national research roadmap bioeconomy “BioÖkonomie 2030” (BMBF 2010; BMEL 2014b) and biorefineries (BMELV 2012), the National action plan for industrial use of renewable resources (BMELV 2009); R&D e.g. within the Leading-Edge Cluster Bioeconomy (Thrän et al. 2014). This bioeconomy sector today, compared to other established wood uses, is relatively small.

The most relevant biomass material flows with respect to cascading use in Germany are wood, waste wood and biowaste. The policies with the most wide-ranging impacts on cascade use currently adopted are the policies on End-of-Life management of waste wood (AltholzV/KrWG) and the policies on treatment of organic waste (BioAbfV/KrWG). Both waste treatment ordinances introduce regulations on collection quotas and recycling targets. In parallel, the

² Section 3.3.1 is a summary of a longer case study written by Jens Ponitka, Daniel Hildebrand & Daniela Thrän. The full case study is attached as Appendix A.

Renewable Energy Sources Act (EEG) supports the energetic use of energy crops, forest wood biogenic residues and waste.

Under the current regimes both ordinances are promoting energetic recovery in biomass-fired power plants and waste digestion plants/composting plants respectively. This supports waste recovery. However, the goal of extending of the value chain is not directly supported.

When it comes to the impact of these policy structures on international trade, the impact has been rather minor. This is due to a low transport worthiness and/or a low energy density of the major fractions of heterogenic organic residues, as well as high emission control standards in combustion of chemically modified waste wood and no incentives for carbon reduction from fuel substitution in large scale power plants. It is however important to emphasize that despite this, recent years have seen increases in intra-EU trade in both waste wood and municipal solid waste.

3.2.2 Cascading in national policy: Flanders³

According to Flemish legislation on the use of biomass for energy⁴, wood-fueled electricity generation is eligible for green electricity certificates only if the wood stream in question is not used as an industrial resource. An important rationale behind excluding industrial resources for green electricity certificates is to maintain a cascading hierarchy of material over energy applications and avoid an uneven playing field between energy and material applications.

The legal procedure on this topic has been amended over the past years (see Appendix B). Currently it is the public Waste Agency⁵ and the wood and paper industry sector federations who are consulted for their advice on the question whether a specific wood resource **is** used (and not potentially **can be** used) as an industrial resource.

The Waste Agency, to formulate and underpin their advice, is in need of an assessment framework of practical criteria and indicators. A recent VITO study, commissioned by the Waste Agency, concludes on the basic principles for an assessment framework based on which the optimal use of woody resources for material and energy should be balanced in order to be in accordance with the principles of cascading and resource efficiency (see Annex B). A main conclusion was:

*Next to the discussion about what 'cascading' in practice actually means, even more complex is to define what is meant by an 'optimal or desired cascade'. A major difficulty is that the concept of 'optimal or desired cascade' is a political concept, as it can be given meaning, **depending on the set priorities and policy objectives**. Also, the optimal cascade can differ from one region to another. ... A solely scientific approach will have difficulties to provide a conclusive objective answer that is universally applicable.'*

In a next step these basic principles need to be translated into a concrete assessment framework with indicators, which are currently still missing.

3.2.3 Cascading policies in Germany and Flanders: summary

The examples from Germany and Flanders paint two somewhat different pictures of how far the implementation of the cascading principles into policy has come. In the German setting, the

³ Section 3.3.2 is a summary of a longer case study written by Ruben Guisson. The full case study is attached as Appendix B.

⁴ Flemish Energy Decree and its Decisions

⁵ OVAM – English pages: <http://toep.ovam.be/jahia/Jahia/pid/973?lang=en>

cascading principle is primarily framed within its original structure with focus on repeated re-use and recycling of products to support resource efficiency.

The Flanders case gives an example of more direct implementation of the cascading principle and its interaction with bioenergy policies. An important theme of discussions is how to strike a balance between on the one hand enforcing the cascading principle and on the other hand supporting biomass for energy. The debate in Flanders on the opportunities and dilemmas of cascading policies touch upon many of the issues that we discuss later in this working paper. For this reason, we will return to the Flanders case in section 4.2.2 where we discuss some of the complications that can arise in the interaction between the cascading principle and policies to support renewable energy.

4 Biomass cascading and resource allocation

As has been reviewed in the previous chapter, there is still no consensus about the definition of biomass cascading. However, a common theme of all definitions of cascading – in both the research literature and in the EU policy documents (see Table 1) – is the designation of bioenergy as the lowest priority utilization of biomass other than disposal. In fact, a somewhat crude but rather accurate definition of cascading is:

“Material use of wood should be prioritized over energy use of wood”

Although this may seem fairly straightforward in principle, transforming this idea into policy and practice is another question. In this chapter we begin by a review of two historical examples of policy processes where the above interpretation of cascading has been implemented. The second part of the chapter places focus on the heterogeneity of woody biomass as a resource. This has important consequences for the process of defining what constitutes industrial raw materials and which therefore should be excluded from energy use according to the cascading principle.

4.1 *Administrative resource allocation: two historical cases*

4.1.1 The Swedish “Wood Fiber Law”⁶

In the mid 1970s concerns emerged in Sweden that demand for woody biomass from the forest industry and bioenergy sectors would soon exceed Swedish supply capacity. The wood energy sector began to grow after the 1973 oil crisis, an expansion that prompted a debate whether wood energy use would compromise reliable supply of wood to the forest industry.

A regulation – later named the “The Wood Fiber Law” - was introduced in 1976 with the purpose of controlling the building of new capacity for wood processing and utilization. The pulp and paper industries supported the wood fiber law since it moderated competition for raw material from the energy sector, whereas the bioenergy sector and independent sawmills criticized the wood fiber law.

The practical implementation of the Wood Fiber Law took the form of a regulation that stipulated a permit process before new processing capacity (e.g. a pulp & paper mill or a biomass-fuelled district heating plant) could be built. Licenses to build new capacity could involve different types of conditions, e.g. that a percentage should be in the form of import wood.

The main result of the law was that instead of securing a sufficient raw material supply to the forest industries, the law hampered the further development, especially of the bioenergy sector. An evaluation of the law in 1991 found that the state and forest sector could use other means for reaching the same goals, e.g. an increased import and measures to stimulate wood supply. It also highlighted the difficulties in defining the amount of increased bioenergy use that would be on the expense of the wood supply to the forest industry.

Later studies identified additional problems with the regulation, most prominently that the Wood Fiber Law failed to consider the diversity of wood assortments, and that it nurtured opportunistic behavior and biased incentives among market actors.

⁶ Section 4.1.1 is a summary of a longer case study written by Anders Roos. The full case study is attached as Appendix C.

4.1.2 European Ban on the Use of Natural Gas for Electricity Generation: Directive 75/404/EEC⁷

This case highlights the effects of attempting to address notions of resource scarcity by regulations that restrict resource use only to specifically designated sectors. In focus here is the EEC (European Economic Community, forerunner of the European Union) ban on the use of natural gas for electricity generation that was introduced in the mid-1970s and remained until the early 1990s.

As a response to the 1973 oil crisis and ensuing widespread perceptions of acute resource scarcity, legislation was in 1975 passed in the European Economic Community that effectively banned expansion of the use of natural gas for electricity generation. According to EEC directive 75/404/EEC, electricity production from natural gas was only allowed “...if the natural gas cannot be put to a more profitable use”. Before the directive was put in place, the share of natural gas in the combined electricity mix of the EEC countries had expanded rapidly, from 1% in 1968 to 13% in 1975.

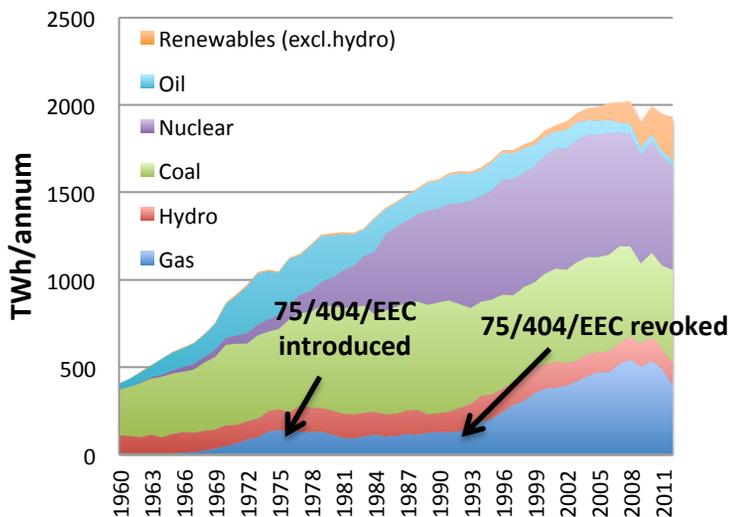


Figure 3. Electricity mix in the 1973 EEC countries (Belgium, Denmark, France, Germany, Ireland, Italy, Luxembourg, Netherlands & UK) 1960-2012. Data source: IEA & World Bank

As can be seen in Figure 3, the implementation of the directive clearly broke this trend and by 1980, the share had fallen to 9%. Instead, coal & nuclear increased their shares in the electricity mix.

In 1991, the ban was lifted as a result of a) a general trend of liberalization of energy markets, b) realization that the fears of resource scarcity had been exaggerated and c) that the environmental benefits of natural gas vis-à-vis coal (regarding both CO₂ and sulphur oxide emissions) were too important to be ignored. The latter point was strengthened by notable technological advances in the development of high-efficiency Combined Cycle Gas Turbine (CCGT) power stations. After the ban was lifted, natural gas-fuelled power production expanded rapidly, especially in the UK.

⁷ Section 4.1.1 is a summary of a longer case study written by Olle Olsson. The full case study is attached as Appendix D.

In later analyses of this policy, the legislation have been framed as a) supporting established industrial structures (coal & nuclear) in their struggle against an innovative and disruptive technology (CCGT) and b) a means to maintain established structures of the natural gas market under a trend of increasing market liberalization.

4.2 How to define what is industrial raw material?

4.2.1 The heterogeneity of woody biomass

Wood comes in many forms. Tree biomass can be differentiated into stem wood (core wood and sap wood), branch wood, stump wood, bark, and leaves/needles. In addition, there are great differences between tree species, and actual conditions of the tree in question, i.e. whether it is healthy or damaged from insects or storms.

When harvested, all or part of the tree biomass can be utilized in the form of whole trees, un-debarked or debarked stems or cut-to-length assortments as veneer logs, saw logs, pulpwood and sticks. Rejects, branches, tops and stumps tend only to be used for energy purposes. From the processing of industrial roundwood, significant portions end up as by-products. In sawmills and woodworking industries these materials consist of bark, chips, sawdust or logs of lesser quality (due to e.g., root or fungal attacks creating color disfiguration). In the pulp & paper industry they consist of bark, rejects due to quality, and in a chemical pulp mill dissolved lignin, hemicellulose and tall oil. In practice, most of the biomass residue streams are suitable for energy utilization, but some are also usable as industrial raw material. Thus, wood chips, shaving, and sawdust from sawmills can be used either for energy, as raw material in pulp & paper mills or in particleboard manufacturing.

The diverse and varying characters of woody biomass presents significant challenges when it comes to determining whether a certain biomass stream actually **can** be used for another purpose than energy. As was noted above, some woody biomass assortments – notably forestry by-products like tops and branches – can today only be used for energy purposes. At the other end of the spectrum, some woody biomass assortments, like high quality stemwood, command far too high prices as industrial raw material for them to be used for energy purposes. In between these two extremes lie assortments such as small diameter roundwood and sawmill by-products that are used either as industrial raw material or for energy, depending on location and current market conditions. Close to a large pulp & paper mill most or all small diameter round wood and sawmill chips will likely be used as input in the pulp & paper processes. Contrastingly, in an area with no industrial user of sawmill by-products, these could be used for energy purposes. In situations where there simultaneously is high demand for energy and a slump in pulp & paper markets, there might be shifts in some streams with larger shares of roundwood from thinnings being used for energy purposes.

Ongoing technological progress may very well change the situation sketched above. For example, advanced biochemical or thermo-chemical conversion routes may be able to convert hemicellulose or even lignin into valuable chemicals (albeit at often significantly higher production costs than their fossil counterparts).

4.2.2 Policy challenges in defining what is industrial raw material: an example from Flanders

As was discussed above, for many woody biomass assortments, it is not possible to make general and distinct categorizations of the assortments that can or cannot be used for another purpose than energy. This is an issue that tends to be lost in many of the discussions on

biomass cascading, but one that is important to be aware of when the debate proceeds into if/how the cascading principle can be implemented in policy frameworks.

An important case in point here is the development in Flanders in recent years, which was broadly presented in section 3.3.2. Flanders is also illustrative as an example of the dilemma of politically defining whether or not a specific biomass assortment should be classified as an industrial raw material and thus excluded from energy use. According to Flemish legislation on the use of biomass for energy⁸, wood-fueled electricity generation is eligible for green electricity certificates only if the wood stream in question is not used as industrial resource.

In the period 2008-2013 the practical implementation of the 'industrial resource' issue was regulated by a communication⁹, which stipulated that the wood¹⁰ and paper¹¹ industry sector federations needed to declare that the wood resource in question did not serve as an industrial resource. The result of the declaration was binding and issued on plant level, giving the federations a virtual veto right on the matter.

The sector federations provided a positive declaration and hence their consent for a large converted coal power plant, Max Green, until the end of 2013. As the feedstock for this plant concerned for the larger part imported wood pellets, e.g. from North America, this was considered by the wood and paper sector federations to not conflict with the wood supply for Flemish processing industry, which tends to source raw material more locally.

However, around 2012 another Flemish coal power plant announced its conversion plans to a dedicated biomass power plant. First announcements indicated that this time the envisioned sourcing area for wood pellets would be more locally which was then perceived by wood processing industries as a potential risk as it could interfere with their own local sourcing area, and lead to price increases.

As a reaction to this announcement, the industrial federations opted not to renew nor provide consent for any power plant. First in line for renewal was the Max Green power plant starting 2014. Regardless of the fact that the plant was not sourcing locally, the consent was not prolonged. As a consequence the plant was not issued green certificates from January 2014 onwards. According to plant management, this meant that operation became uneconomical and electricity production was put on-hold from March 2014.

Needing a quick solution, the Flemish government responded to this problem early 2014 by altering the role of the industry federations, turning the binding character of their advice (adopted in a communication) into an **advisory** character (adopted in law¹²). Since May 2014 it is the public Waste Agency of Flanders¹³ and the wood and paper industry sector federations who are consulted for their advice by the Flemish Energy Agency to determine whether a specific wood resource can be used as industrial resource. Invoking proximity or geography of the sourcing area as an argument in the advisory process was ruled as illegitimate. Moreover, in case of a negative advice, federations needed to show that the envisioned wood resource **is** effectively used (and not **potentially to be** used) as a resource in industrial processes. If the advice of the consulted parties is unanimous it is binding¹⁴. In case no unanimous advice is

⁸ Flemish Energy Decree and its Decisions

⁹ From the Flemish regulator for electricity and gas (VREG) <http://www.vreg.be/sites/default/files/mededelingen/mede-2008-2.pdf>

¹⁰ Fedustria: Belgian federation of the textile, wood and furniture industries

¹¹ Cobelpa: Belgian Association of Pulp, Paper and Board Manufacturers

¹² Flemish energy decree

¹³ OVAM – English pages: <http://toep.ovam.be/jahia/Jahia/pid/973?lang=en>

¹⁴ Note: if thoroughly motivated the Flemish ministers of Energy and Environment jointly (on behalf of the Flemish government) can overrule the binding advice

obtained the Flemish government will make a final decision based on advice from the Flemish Energy Agency¹⁵.

Within this new legislative framework, Max Green obtained a positive advice from the sector federations as well as the Waste agency leading to a renewal of the consent, a reissuing of certificates and a resume of plant operation in September 2014.

From the perspective of biomass cascading, an important drawback in this procedure is the fact that the advices are only a momentary evaluation of possible competition with material uses, but that the advices are valid for the approved project duration (10 – 15 years). Evolution of the uses of wood in that period cannot be taken into account any more. From the perspective of the biomass power producer on the other hand, the validity period of the advices assures the sourcing of biomass and the financial support for the installation.

4.3 Discussion: the risks of administrative resource allocation

The cases reviewed above give clear indications about the sensitivities and complexity of maintaining a cascading hierarchy while at the same time supporting renewable energy production. As market conditions, sourcing areas and exclusion criteria can change, the relevant policy frameworks need to be adapted accordingly. This can lead to difficult positions as policy frameworks need to be stable and predictable to provide long-term security, at the same time as technological developments and market conditions can shift swiftly. For several markets for biomass, both in cascading chains and for direct use for energy, the market conditions and prices shift often on a day-to-day basis. Formulas for success in those types of businesses are based on flexibility and quick decisions. Strict regulations regarding cascading could reduce efficiency with the effect that biomass would be less competitive against fossil materials and fuels. Regulations might also hamper the capacity for innovation and could lead to missed opportunities for technological breakthroughs, as research and development efforts will take policy developments into account.

The cases also highlight some of the problems associated with allocation of resources based on regulations rather than market mechanisms. A key issue to be aware of here is that prices in a market are not only a mechanism for exchange, they also contain relevant information for market actors in their decision making. When markets are regulated the administrator takes over some of these information processing and planning duties and must consequently be able to consider all contingencies (cf. Coase 1960). This changes the conditions for the function of the resource allocation process as well as the behavior of market actors within the system.

While regulations in different forms can obviously be motivated to account for external cost issues in the form of environmental degradation or threats to human health, regulations have a tendency to change over time, which creates substantial business risks. Furthermore, increasing the role of regulations in resource allocation tends to make it more important for market actors to adapt to, or influence, regulatory structures than to focus on running operations efficiently.

Another problem of using non-market means of allocating resources is that the dynamism of the price mechanism is blunted. For instance, high bioenergy prices normally create incentives for a higher biomass production (and increased carbon sequestration) as well as improvements in the biomass sector that eventually lead to increased efficiency and cost reductions. Conversely, artificial restrictions on demand for biomass incentivize forest owners and farmers to convert forests into other land uses.

¹⁵ VEA

Our examples on implemented regulations on the use of resources feature different goals and regulatory mechanisms, depending on differences between the countries with regard to the perceived challenges. However, the differences also reflect path dependencies and local power relations that have influenced policy processes in the different countries. Policies are partly formed by actual needs, and partly influenced by specific policy processes and national interest groups. Policies and policy processes are highly context-specific, a fact which is crucial to take into account.

5 Cascading and international trade

There is a large and growing trade in woody biomass between the EU and external partners in lumber, engineered wood and woody biomass for energy. For this reason, it is important to take into account how international trade affects and is affected by potential implementation of the cascading principle into EU policy. Furthermore, as the cascading debate has primarily been a European topic, it is important to widen the scope. Herein, we review to which extent cascading of woody biomass and similar concepts are discussed in North America. This is important not least for the impacts of potential EU cascading legislation on the wood bioenergy trade flows from Canada and the South-Eastern United States to the UK, the Netherlands and Belgium.

5.1 *Cascading in North American forest policies?*

5.1.1 USA¹⁶

The USA currently does not have a cascading policy in place that regulates wood use in the forest products sector. EU aspirations for a hierarchical use of wood however could potentially affect respective US exports, especially the US South due to its current dominance in US wood pellet exports.

The number of forest product establishments has declined nationally since 2002 with an increased rate of decline after 2007. However, by 2015, the number of US South mills consuming pulpwood and residual chip fiber is the same as in 2000; as there has been a sector shift from pulp and paper to wood pellet production. Wood pellet mills typically use residual chip fiber and pulpwood; the same feedstock as panelboard, OSB or pulp and paper mills. During the decline of the US housing market and following recession, available pulpwood and sawmill residual chip supply declined significantly in the US South for both soft- and hardwood. This decline has increased demand (and stumpage prices) for pulpwood and residuals.

Unless forests are owned by companies and grown for a specific assortment, forest management and harvest timing are usually driven to maximize the most valuable fractions. For softwoods, managed forests in the US South are geared to maximize their sawtimber quantities. Chip-n-saw as well as pulpwood fractions are secondary products. Woody feedstock for energy production is traditionally derived from harvesting and processing residues, which are often not part of traditional forest management objectives, although they can provide economic revenue streams. As such, these low-value harvest fractions¹⁷, require a high-revenue companion market to provide sufficient financial incentives for harvest operations in the first place. In other words, without a companion market such as sawtimber, less pulpwood and residual quantities are available to the market, including energy production.

5.1.2 Canada¹⁸

Cascading as it is debated in the EU is not currently implemented into policy in Canada. However, there are elements of the cascading principle implicitly present in the judicial and institutional arrangements of the Canadian forest sector. Canada has about 400 million hectares of forests and other wooded land, nearly 92% of which is publicly owned, of which 90% by 10

¹⁶ Section 5.1.1 is a summary of a longer case study written by Patrick Lamers and Damon Hartley. The full case study is attached as Appendix E.

¹⁷ E.g., tops and branches or residual sawtimber or pulpwood rendered non-merchantable due to quality issues related to shape (crooked) or pest damages (e.g., beetle or fungi infestation)

¹⁸ Section 5.1.2 is a summary of a longer case study written by Bo Hektor of Svebio/First Bioenergy AB. The full case study is attached as Appendix F.

provinces and 3 territories. Forest-related laws are not completely homogenous across the country, but the goal is the same across the country: sustainable forest management (SFM). This approach to forest management is based on historical legislation in which the various interests would have their “fair share” of a common resource. The allocation rules consider not just timber, but many other forest-related values, including wildlife, biodiversity, soils, water, scenery, and aboriginal interests (e.g. First Nations). Here, it is important to note that “energy” is not mentioned among the forest-related values, which has come to have negative implications for the development of bioenergy.

Also the processing of wood resources (harvesting, manufacturing, transport, etc.) is subject to strict regulations. In addition to the allocation rules mentioned above, the decades-long trade dispute between Canada and the US regarding pricing of standing timber has led to the development of rules on the matter (the Softwood Lumber Agreement, SLA). The heart of the dispute is the claim by the USA that the Canadian sawn timber industry is unfairly subsidized, as most prices charged to harvest the timber (stumpage fees) are set administratively, rather than through competitive bidding, which is the norm in the US. To meet SLA requirements, detailed “Stumpage Assessment Manuals” are applied. They consist of standard values for all relevant cost items in the production chain from the point of export back to the timber harvest. The balance constitutes the charge for “stumpage”.

However, the SLA models seem to bring unforeseen conserving effects on the Canadian forest industry sector. Technical and methodological innovations are rare and few new or niche business ideas have been implemented. An explanation might be that any major cost reduction will result in higher stumpage fees, and applications of new methods will mean tedious negotiations with other stakeholders, politicians and administrators.

The Canadian history of bioenergy had an early and successful start with production of wood pellets and burning of residues in the forest industry sector. The resource base consisted of inexpensive sawmill residues, which were not regulated. However, as demand for bioenergy grew and there was interest from the bioenergy sector in using standing trees and logging residues, the legal and administrative systems were challenged. Decision processes took long time, typically several years, based on negotiations with stakeholders and lawyers. Some bioenergy companies finally were allowed to compete for timber licenses that were idle or abandoned. Only a few new projects started as conditions were less suitable, both with regard to the geographic location and the wood quality.

5.1.3 North American cases: analysis

The discussions on cascading in the EU in recent years seem so far not to have been echoed in North America. However, there are important elements in both cases that can inform the debate on if and how cascading is to be implemented into EU legislation. The Canadian case highlights the difficulties of adjusting an established regulatory framework in the face of changing market conditions, in this case the emergence and expansion of demand for wood-based bioenergy. The US case study on the other hand shows that although the word “cascading” seems not to be used to any significant extent, there are certain arrangements and processes in practice that touch upon the cascading discussions. The US case especially stresses the importance of companion markets, wherein different parts of a tree are used for different purposes depending on market conditions and where revenue streams from the different products combine to ensure economic viability. This approach is similar to cascading-in-function as discussed in section 2.3.

An important aspect to highlight from these two cases is the problems that can result from lack of regulatory cohesion between trading partners. The two cases reviewed above represent two rather different structures of forest management and institutional arrangements. On the one

hand, the US Southeast with forest ownership dominated by profit-seeking private forest owners and on the other hand Canada with an overwhelming share of public (primarily provincial) ownership and a substantial accompanying regulatory framework. The significant differences between the Canadian and US forest sectors when it comes to mechanisms for allocation of forest resources (administrative in Canada, market-based in the US) have resulted in a trade conflict that now spans several decades.

5.2 International trade and cascading policy

The distribution pattern of forests in Europe means that there will be regions of biomass surplus and regions with a deficit, with trade being used to balance the two. In a foreseen expansion of the use of biomass for energy and generally in the development towards a biobased economy, external supply will be required both to fill the volumes needed and to keep biomass prices on reasonable competitive levels. For this reason, it is informative to analyze the effects of cascading regulation from a perspective of international trade.

It is imperative that EU policies pertaining to cascading are designed so as not to become another example of a re-occurring issue in bioenergy markets, namely that biomass and biofuels are internationally traded whereas policies governing support for bioenergy tend to be national. This is a rationale for many of the international bioenergy trade flows but also not seldom a point of contention and a topic for trade disputes (Oosterveer and Mol 2010; Stattman and Gupta 2014). Countries that export biofuels to the European Union have previously argued that the EU RED sustainability criteria for biofuels act as trade barriers that violate international trade agreements. More recently, there have been similar debates related to EU policies to discourage the use of biofuels that risk leading to indirect land use change (UNCTAD 2016). Implementation of the cascading principle would likely also have an impact on EU international trade in bioenergy, especially imports, but exactly how remains to be investigated. A key objective must be to avoid situations such as those leading up to the US-Canada softwood trade dispute.

Another important issue to take note of is that the effectiveness of cascading policy could be weakened by international trade, if the implementation only takes place in either some EU countries and not others, or in the European Union but not in its trading partners. Implementation of the cascading principle through e.g. a ban on combustion of certain biomass assortments, could result in these materials being exported for combustion elsewhere rather than used for materials locally (cf. Vis et al. 2014).

6 Discussion

In this working paper, we have raised several issues related to the prospect of policy implementation of cascading of woody biomass. Several different perspectives have been highlighted, albeit with particular focus on potential EU regulations of cascading. This discussion section includes our key conclusions and suggests ways to further the discussion on cascading and biomass utilization in general.

6.1 Proper definition of cascading is imperative

The key theme of Chapters 2 and 3 in this working paper was to investigate the terminology surrounding cascading and how cascading is framed in policy documents. Our conclusion from this is that there is still a substantial degree of uncertainty as to what cascading actually entails. This is an issue of importance beyond an academic discussion. The formal inclusion of cascading in the iLUC directive without an accompanying definition could become a source of future problems. Sokka et al (2015) also raise this point and question whether it is at all possible to come to a uniform definition of cascading, which is arguably a key issue for policy makers to be aware of in future policy design on a more general note as well. As it happens, the lack of terminological clarity is not unique to cascading but to neighboring concepts such “resource efficiency” as well.

6.2 First focus on the ends, then the means

A noteworthy characteristic of the current discussion on cascading is its focus on a means or a method to achieve certain policy goals, before the actual goals have defined. At present, it is not really possible to be supportive nor dismissive of cascading because *a)* there is no proper definition of what cascading is, and *b)* the policy goals that cascading could potentially support have not been defined. A productive path forward in discussions on biomass use efficiency and the role of bioenergy in the future bioeconomy would be to **first define the policy goals** that need to be reached, and **then evaluate different options** for how these goals can be realized. The approaches grouped under the “cascading” banner could be among the appropriate policy tools, but for a vital debate, it is important not to assume that cascading is the silver bullet that will resolve all contentious issues in the transition to economies based on sustainable resource use. As other policy options, cascading should be carefully evaluated before implementation, in terms of its relative effectiveness in achieving set goals as well as its effects on existing systems and markets.

6.3 Different pathways to efficient resource use in the biobased economy

The rationale for this IEA Bioenergy Task 40 working paper on cascading is the implications for bioenergy markets of potential EU regulations on cascading, but the cascading discussion raises issues that are of importance well beyond its connection to bioenergy markets.

Legally binding implementation of the cascading principle could create a problematic precedence for future policies towards the bio-based economy. Innovation, flexibility and market principles are likely to be of key importance for a successful expansion of the European biobased economy. *Ex-ante* decisions on areas of biomass utilization that are preferable and those that are not run the risk of creating rigid structures that inhibit innovation and market function. For example, bio-based pyramids such as the one in Figure 2, present only a static view of relative value among different possible uses of biomass. A bio-based pyramid from 1997

would likely have newsprint and other forms of graphic paper fairly high in the hierarchy, whereas the situation in 2016 is different. In other words, what is a by-product today can be a high value product tomorrow. A classic example from the fossil fuel industry is that petrol/gasoline, now a main product from oil refineries, was initially merely an arduous waste product from the extraction of kerosene from crude oil (Yergin 2009).

As was noted in section 2.3, some definitions of woody biomass cascading, especially “cascading in function”, have clear similarities with the concept of wood-based biorefineries. In these, different parts of a tree are used for different purposes and several different revenue streams combine to maximize total income from the process as a whole. An important component of the biorefinery and cascading-in-function concept compared to cascading-by-time or cascading-by-value is the emphasis on capability to shift between outlets depending on market conditions. This is already implemented in e.g. how Brazilian sugar/ethanol mills produce ethanol and sugar in different proportions depending on relative prices in the two markets. This allows for a substantial level of flexibility in resource utilization that is likely to be an important precondition for bio-businesses to thrive. Strict implementation of cascading is likely to significantly reduce this flexibility.

6.4 The role of bioenergy in mobilization of resources for the bioeconomy

In Europe, annually harvested wood volumes in 2010¹⁹ represent less than 65% of annual increment in forests (Eurostat, 2010) and the present trend is that yields increase. In addition, there are substantial amounts of un- or underutilized biomass resources in residues from branches, stumps etc. Obviously, several factors restrict the utilization of these excess quantities. Some forests are explicitly set aside for other main uses than wood production (biodiversity protection, recreation etc.), but there are also several other reasons. Forest owners or managers may choose to keep mature stands or trees longer than optimum age with regard to yield. This could be problematic as over-aged forests run increased risks of storm felling, attacks from insects and fungi, and reduced growth. Plenty of thinning operations need to be carried out to improve stand quality and ensure high yield and high quality of final products. However, for thinning operations to be economically viable it is imperative to have an outlet for extracted wood. In the present situation with reduced demand of pulpwood, forest managers look for other outlets, in particular from urgent necessary thinning operations. Here, bioenergy has an important part to play in providing economic incentives to carry out thinning operations that are necessary to enable subsequent extraction of high quality timber. As was noted in section 5.1.1, companion markets and different revenue streams are essential to make commercial forestry economically viable and ensure that wood is a competitive alternative to other more carbon-intensive materials. In order to maintain - and preferably increase - wood supply from European forests, functioning markets are imperative. Artificial restrictions on certain forms of wood utilization would be an obstacle for the expansion of European wood supply, and as such an obstacle for the development of a sustainable resource base for an economy with an increasing demand for renewable materials and fuels.

6.5 Cascading of fossil resources – a possible test case?

The case study in section 4.1.2 - on the history of the EEC ban on the use of natural gas for electricity purposes - stands out from the rest of the material in this working paper in its focus on a fossil fuel, not biomass. This case was included to highlight the practical implications of an artificial restriction on a specific use of a resource, but it can also be used as a starting point for

¹⁹ Most recent EU-wide data available from Eurostat.

another discussion: cascade use of fossil resources. Given the extensive discussion on cascading in recent years, it is surprising that the focus has primarily been on cascade use of biomass resources, without little or no discussion on the cascade use of fossil resources.

In principle, the potential benefits from cascade use of biomass should be even more beneficial with cascade use of crude oil, given that the latter is a non-renewable resource. Application of the “material use should be prioritized over energy use” principle to crude oil could open up for many innovative ideas on how to utilize petroleum. Given that currently only about 16% of traded crude oil volumes are used for non-energy purposes (IEA, 2015), there is plenty of room for expansion. Shifting crude oil consumption from fuels to materials could have important gains in terms of carbon storage with carbon locked in e.g. plastics instead of combusted as petrol. Regulating cascade use of fossil resources would also be beneficial in that any downsides of the regulation – e.g. hindering innovation and market function – would carry lower risk in the light of the fact that the long-term goal of policy strategies, in the EU as well as globally, is to phase out fossil fuels altogether.

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8 Appendices: Full-text versions of case studies

APPENDIX A

POLICIES TO INFLUENCE CASCADING USE OF BIOMASS AND THEIR EFFECT ON BIOMASS TRADE

-case study Germany-

by

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Introduction and data on resource base & use

The bioeconomy concept with cascading use and use of by-products as one favourable component is widely promoted²⁰ in Germany although this sector today, compared to other established wood uses, is relatively small²¹.

The product groups and their affecting policies which are primarily discussed or are already important within the German context of cascading use are wood, wood based products, bioplastics and bioenergy (biowaste²², waste wood). Current policies tend to influence also the use of other feedstocks such as agricultural crops and agricultural residues for direct energetic use.

Despite the different principles and definitions of cascading²³, there is still a research demand (e.g. development of indicators) to be able to model the quality of cascades for the complex processes involved in cascading biomass uses (Adler et al. 2015).

Wood is the main source of both bioenergy and bio-based material or industrial use with a total annual wood use of around 135 million m³ [2012, 50% energetic, 50% material use] (see (Mantau 2012a)), of which about 80 million m³ is forest wood (see Table 2). On the other hand national (statistically recorded²⁴) wood supply (logging) is relatively stable at 55 million m³. Standing volume in total is about 3.7 billion m³ [on 11.4 million hectare] and 1.1 million people (BMEL 2014a) work in the forest and wood sector. The overall timber growth still exceeds the wood removal (BMEL 2014a).

²⁰ For example: National research roadmap bioeconomy "BioÖkonomie 2030" (BMBF 2010; BMEL 2014b) and biorefineries (BMELV 2012); National action plan for industrial use of renewable resources (BMELV 2009); R&D e.g. Leading-Edge Cluster Bioeconomy (Thrän et al. 2014)

²¹ For specific data on EU member states see the new bioeconomy observatory: <https://biobs.jrc.ec.europa.eu/country/>

²² The supply of biowaste has stabilized between 8 to 9 million tons per year in Germany. (Kern and Sprick 2011)

²³ For further discussion and information about general aspects of cascading use of biomass and bio-based products within the German and EU context see (Carus et al. 2015; Dammer et al. 2013; Essel et al. 2014; Raschka and Carus 2012; UBA 2014; Wern et al. 2014)

²⁴ For methodology see (Weimar 2015)

The main material use of wood is sawn wood, wood materials and wood pulp (Mantau 2012a). Within for example the bio-based chemical cluster with next generation polyesters there is an ongoing, increasing interest in sophisticated material use of biomass²⁵.

The forest and wood sector and also the agricultural sector and the processing industries are important for the economy in Germany. There is an almost equal split of material and energetic use of wood with and without pronounced cascading use depending on the sector.

The use of residues and wastes is favorable. A recent study (Brosowski et al. 2015) reported for Germany a theoretic biogenic residue potential of 151 million t_{DM}. About one third (31.9 million t_{DM}) of the technical biogenic residue potential (98.4 million t_{DM}) is currently unused (Brosowski et al. 2015) in Germany.

Table 2: country profile Germany – cascading use of biomass

Relevance of sectors with respect to gross domestic product	Unit	Value	Reference	Comment
Agriculture	%	0.7	(Eurostat 2015)	
Forestry	%	0.1	(Eurostat 2015)	
Timber processing industry	%	1.7	(Eurostat 2015)	National Accounts aggregates by industry
Chemical industry	%	1.6	(Eurostat 2015)	
Energy	%	2.0	(Eurostat 2015)	
Land use impacts	Unit	Value	Reference	Comment
wood	1,000 ha	11,419	(BMEL 2014a)	total wood area (=32% of total land area)
energy crops	1,000 ha	2,200	(FNR 2015)	mainly biogas, plant oil and bioethanol; arable land: 11.9 mio ha; agricultural area: 16.6 mio ha
industrial crops	1,000 ha	268	(FNR 2015)	mainly plant oil, starch, sugar, medicinal plants, fibre and dye crops
Wood flow	Unit	Value	Reference	Comment
wood logging	million m ³ /a	80	(BMEL 2014a)	2002 – 2012: 76 Mio. million m ³ timber harvested without bark)
wood for energetic use	%	around 50	(Mantau 2012a)	
cascade factor		not known		a factor of 1.57 is reported for EU27 ²⁶ (Mantau 2012b)

²⁵ For a general overview of possible biomass industrial material uses see: http://bio-based.eu/?did=2028&vp_edd_act=show_download

²⁶ As reported for the EU27 (Mantau 2012) wood resources from trees are used many times in the production process especially in paper (high proportion of recycling products) and panel industry (use of residues).

European regulations on circular economy affecting cascade use of biomass

The policy landscape affecting end-of-life management paths is fragmented within environment- and energy related laws. Furthermore from the resource use perspective there is a broad variation in the partial interests of industrial stakeholders in valorization of secondary raw materials. This raises the questions, if a policy reform based on monitoring of bottom-up information's on goal and interest conflicts or if a top-down redesign of waste management and energy policies would in the end be more effective in facilitating a more extensive cascade use of biomass. From several waste management organizations, NGOs and political representatives a broader policy package for circular economy was brought into the procedures of European legislation in the last year. After a first package²⁷ was shelved in 2014, in the coming month a next draft is in preparation strongly supported by the above mentioned proponents (FEAD 2015). From European policy arena the circular economy package is expected to have significant implications for EU member states in formulating recycling targets for waste streams such as plastics and wood packaging.

National regulations applicable on cascade use of partial material flows

Policies affecting End-of-life management paths for waste wood:

Policies mainly incentivize (increasing) wood use rather than increasing wood supply. The energetic use of wood (and waste wood) was stimulated most directly by the EEG [renewable energy act) with feed-in tariffs for power from wood CHP plants. The (direct) energetic use of agricultural biomass and residues was promoted in Germany as well as the cascading energetic use of waste wood and biowastes (partly within the EEG). The installation of new and efficient heating systems were incentivized by investment grants for e.g. pellet boilers. Bioenergy sector in general (biogas from maize and manure; biofuels; wood for heat and power) has developed strongly in the past years in Germany.

The material use of wood is mainly market-based and therefore largely depending on treatment costs for salvaging secondary raw materials, the market price for products with a share of recycled input materials and on the supply and market demand for wood-based secondary raw materials.

The main law of promoting closed substance cycle (and waste management) is the "Act for promoting closed substance cycle waste management and ensuring environmentally compatible waste disposal (Kreislaufwirtschaftsgesetz – KrWG)". The Waste hierarchy promoted in the KrWG established a priority order with an descending order from prevention, preparing for reuse, recycling, other recovery like energy recovery and disposal (see also EU Waste Framework Directive, 2008/98/EC). (KrWG 2012)²⁸ The Waste wood ordinance (AltholzV)²⁹ regulates the uses of the different wood categories (A1 – A4). With regard to the cascading use of waste wood the following three main utilization paths are further specified within the ordinance:

- a) Chipping of waste wood to chips and strands for production of fibre boards,
- b) The production of syngas for further chemical refining

Proposal for a DIRECTIVE OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Directives 2008/98/EC on waste, 94/62/EC on packaging and packaging waste, 1999/31/EC on the landfill of waste, 2000/53/EC on end-of-life vehicles, 2006/66/EC on batteries and accumulators and waste batteries and accumulators, and 2012/19/EU on waste electrical and electronic equipment (<http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex:52014PC0397>)

²⁸ <http://www.gesetze-im-internet.de/krwg/>

²⁹ <http://www.gesetze-im-internet.de/altholzv/>

- c) The production of activated carbon or charcoal

The energetic recovery of waste wood has to be conducted in power plants fulfilling the requirements of the BImSchG³⁰ and the KrWG. The “Federal Immission Control Act of Germany” (BImSchV) is regulating the building and operation of wood-fired heat and power plants.

The industrial associations in waste management and recycling promoted the laws on promotion of circular economy. The Association of the German Wood-Based Panel Industry (VHI) is engaged in convincing policy makers for a more broader set of incentives in cascade use of wood. Furthermore independent R&D research and policy research institutes such as the Nova Institut are claiming to ensure equality in policy design for development opportunities between material use and energy use strategies. For material flows of contaminated organic residues and bio-based waste fractions a shift from a disposal oriented towards a more energy supply oriented waste treatment infrastructure is claimed especially fostering a more efficient heat use of organic waste fraction in combustion plants (FVEE 2015).

Policies affecting End-of-life management paths for organic waste

For organic residues e.g. from household waste the organic waste ordinance (BioAbfV)³¹ and the German fertilizer ordinance (DüMV)³² are important regulations for the material recycling of food waste in soil amendment and fertilizer products. The recycling and the energetic use of biodegradable plastics are partially affected by the implications of the organic waste ordinance as well as by the packaging ordinance (VerpackV)³³.

Regarding the End-of-Life treatment of biodegradable plastics according to the biowaste ordinance (BioAbfV) in the Annex 1 also biodegradable polymer wastes are included as a waste fraction which can be disposed of by the households through the organic litter bin without special approval for treatment and valorization. This option is criticized by municipal waste treatment and logistics operators, as the plant operation conditions are regionally very diverse and therefore the disposal of bioplastics should not be regulated by law from a top down regulation (VKU 2013). The regulations of End-of-life treatment paths in place for bio-based and biodegradable plastics therefore thereby are opposed for exhibiting major weakness points regarding effectiveness and suitability of top-down policies not adequately considering product recyclability constraints and regional recycling infrastructures.

Energy and waste management-related motivations for the policies

Targets for renewable energy generation

Renewable Energy Directive sets binding renewable energy targets for EU Member States. To reach these targets, Germany have put in place financial or market incentives especially feed-in tariffs (Renewable Energy Act – EEG³⁴) for power and quotas for biofuels.

The mostly direct energetic use of wood (and waste wood) was stimulated by the EEG [renewable energy act] with feed-in tariffs for power from e.g. wood CHP plants. The installation of new and efficient heating systems were incentivized by investment grants (within the MAP program for e.g. pellet boilers). This led to a strong development of biomass for energy (see

³⁰ <http://www.gesetze-im-internet.de/bimschg/>

³¹ <http://www.gesetze-im-internet.de/bioabfv/>

³² http://www.gesetze-im-internet.de/d_mv_2012/

³³ http://www.gesetze-im-internet.de/verpackv_1998/

³⁴ http://www.gesetze-im-internet.de/eeg_2014/

(BMWi 2015; Naumann et al. 2014; Scheftelowitz et al. 2014)) especially biogas from maize and manure; biofuels; wood for heat and power. Temporarily, residues (e.g. straw, landscape conservation materials) and wastes (waste wood) have experienced special compensations within the EEG (DBFZ 2012) which lead to rapid capacity increase of bioenergy plants.

On the market side there are a number of aspects and activities influencing the cascading use of biomass like food safety issues, design for recyclability, eco labeling and (additional) costs for eco-friendly products.

The energetic use of biomass in combustion plants and waste fermentation plants and the composting of organic waste are subject of stringent and established environmental regulations under the waste laws and the emission control laws. Furthermore the energetic use is incentivized by the renewable energy law and voluntary sustainability standards may have major impacts on business models and sustainable supply systems. Until so far the material use of bio-based secondary raw materials underlies mainly market laws, economic pressures and persuasive initiatives such as labelling and green public procurement incentives.

Incentives and drivers for increased material use

Basic drivers for material use of biomass are environmental constraints such as the effectiveness of decarbonization strategies, the increasing costs for extraction and processing of fossil resources and the innovations for enhanced material properties and increased added-value creation from renewable biomass resources.

Regarding energetic use of wood and waste wood the European directive 2013/0442(COD)on limitation of emissions of certain pollutants into the air from medium combustion plants setting more restrictive of emission thresholds for wood chip fired heating and power plants than the TA Luft were accounted as threat for economically viable plant operation if transitional arrangements for existing plants are not appropriate in their timing of mitigation measures (C.A.R.M.E.N 2015).

Reasons for restrictions on wood removal from forests are unfavorable site specifications or conservation issues (or both) (BMEL 2014a).

Furthermore the ban of chipping the non-solid volume (above-ground wood below 7 cm diameter) for the sake of a lower nutrient removal and higher dead wood reserves under the FSC-certification of state forests within Germany are regarded by associations of plant operators as one factor increasing the pressure in competition for raw materials between wood-chip fired heating plants and the material use of wood (FSC Deutschland 2014; HEF 2014).

Effects

Since 2008/09 the use of wood for energetic uses increased with increasing wood prices and wood market remained high. Such a development is in line with the goal of national program ("Charta für Holz"³⁵ from 2004) to increase the use of the renewable resource wood while saving fossil resources. (BMEL 2014a)

Policies mainly incentivize (increasing) wood use rather than increasing wood supply. Whereas the forest area stays stable the wood reservoirs are increasing, but major investments in more efficient use of wood resources were incentivized. Even though perennial crops were investigated intensively in the last decades the prime locations in agriculture mainly focused on

³⁵ http://www.dhwr.de/fileadmin/user_upload/downloads/ChartaFuerHolz.pdf

cultivating annual crops as renewable resources. Major motivations for cascade use intensification in the agricultural sector may be triggered by the needs for reduction of factor inputs while simultaneously maintaining the soil fertility and increasing fiber yields.

Major import and export streams in terms of volumes and the number of trade relations have been noticed in Germany (besides liquid biofuels) for wood pellets and waste wood (Thrän et al. 2015). The increase of used cooking oil, grease and food waste from international and partially unsustainable supply chains in food processing provided a major incentive and debate on more efficient treatment and valorization of food waste under the waste management and energy laws.

The energy density of solid biofuels and biomass resources such as organic residues are the major factors for transport worthiness and trade of biomass resources (Bradley et al. 2014). Furthermore this is affecting the carbon abatement costs and efficiencies most relevant for effective fuel and material substitution strategies. As the oil price decreases in the last 1.5 years and along with missing CO₂ abatement credit system in material use of biomass sets low incentives for cascading use.

The strict detachment of renewable energy projects co-financed under the renewable energy law from the carbon financing of fuel substitution projects under the emissions trading law (TEHG)³⁶ made it unattractive to substitute internationally traded commodities such as hard coal with biomass in large scale power plants.

Thereby the bioenergy policies mainly provided incentives for small to medium scale plants within regional biomass sourcing and supply systems.

With regard to policies and their effectiveness to achieve set goals the regional level (EU-national-municipally-stakeholders/customers) and the impact of policies on biomass provision, biomass utilization and increased cascading use have to be considered. Exemplarily the main policies in the German context are displayed in Table 3.

Table 3: Examples of policies and their impact on biomass and cascading use within the German context

		Regional level			
		EU	National	Municipal	Stakeholder/ customer
impact	Biomass provision		Forest strategy	Certification schemes	Certification schemes
	Biomass utilization		Renewable energy law		Labels and Public procurement
	Increasing of cascading use	Circular economy package	Act on closed substance cycles	Organic waste ordinance	

³⁶ http://www.gesetze-im-internet.de/tehg_2011/

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APPENDIX B

Policy Implementation Of Cascading In Flanders

By Ruben Guisson, VITO

In Flanders the cascading principle has been gradually introduced, first in the form of the Ladder of Lansink in the Waste Decree³⁷ (1981, which was recently transposed to the Material Decree³⁸ (2011). With the introduction of the Material Decree the scope of the 'Ladder' was broadened from strictly waste sources to materials; including end-of-waste criteria allowing for waste products to re-obtain a resource status and hence allow for the creation of closed cycles in the circular economy.

In February 2013, the MINA³⁹ and SALV council⁴⁰ published a joint advice on the 'Sustainable use of biomass in a bioeconomy' as input for the Flemish Government to define its Bioeconomy Strategy. In the advice, it is recommended that the government should develop a policy framework that supports the cascade principle. By taking all relevant policy decisions with the cascading principle as a guide, the government should be better able to stimulate the sustainable use of biomass for both food and other applications throughout the chain. Additionally, using the cascading principle, could lead to a better harmonization policy frameworks.

An example of such harmonization can be found in a linkage between the energy⁴¹ and material⁴² policy frameworks. In material policy a binding priority sequence is defined, related to the management of materials and waste products (prevention, reuse, recycle, (energy) recovery, dumping). The priority sequence (in)directly⁴³ sets out a hierarchy or cascading. The sequence is also used in the energy policy, however this time in an advisory role, where the issuing of green electricity certificates from woody resources is subject to an 'industrial resource' check.

However, the advice from the MINA and SALV council also emphasizes that this (indirect) control of biomass following a cascade should not undermine the legal certainty of the entrepreneur. This means that instruments can be introduced, changed or abolished, but existing and ongoing commitments should be honored (e.g. no abolition of granted subsidies to existing engagements). A "stop-&-go" policy should be avoided, as this is pernicious for the investment climate.

With the advice as input, in 2014, the Flemish Government published its Biobased Strategy⁴⁴, in which the cascading principle was incorporated. The document calls for an alignment between visions on renewable energy and bioeconomy and couples this to the cascading principle. One of the Strategy's strategic objectives is to '*produce and use biomass optimal and sustainable over the complete value chain*'. Confirming this objective the Waste Agency drafted an '*Action*

³⁷ Decree of 2 July 1981 - Decree concerning waste management

³⁸ Decree of 23 December 2011 - Decree on sustainable management of material cycles and waste materials

³⁹ Environmental and Nature Council of Flanders

⁴⁰ Strategic Advisory Council for Agriculture and Fisheries

⁴¹ Flemish Energy Decree and its Decisions

⁴² Flemish Materials Decree and its Decisions

⁴³ Depending on the definition of cascading

⁴⁴ The vision and strategy of the Government of Flanders for a sustainable and competitive bioeconomy in 2030 (<https://www.vlaanderen.be/nl/publicaties/detail/bioeconomy-in-flanders>)

*Plan on sustainable management of biomass(rest)streams 2015-2020*⁴⁵. One of the defined actions concerned the 'sustainable use of woody biomass(rest)streams for renewable energy production'. The action was a response to the changed Energy Decree which changed the role of the Waste Agency and the sector federations to an advisory role. The action was put into practice by a Waste Agency study⁴⁶, executed by VITO⁴⁷, with the aim to come to a well elaborated and practical criteria for the assessment whether or not woody biomass(rest)streams are used as an industrial resource. The results of the study aim to enable the Waste Agency to quickly and correctly formulate their advice in view of their aforementioned advisory role. Main conclusions of the study are:

'In discussions around resource efficiency and optimum use of woody biomass, the principle of cascading of biomass is often put forward as the framework within which material needs and energy applications can be reconciled with each other.'

'Next to the discussion about what 'cascading' in practice actually means, even more complex is to define what is meant by an "optimal or desired cascade. A major difficulty is that the concept of "optimal or desired cascade" is a political concept, as it can be given meaning, depending on the set priorities and policy objectives. Also, the optimum or desired cascade in one region can look completely different in another region (e.g., depending on the regional wood supply, the local industry, the local demand for certain applications, existing processing infrastructure, the local interpretation of a region,...) or in certain cases streams are evaluated differently from one another depending on the perspective (e.g., from food safety standards, legal requirements, etc.). Hence, putting cascading of biomass into practice remains a difficult concept. It can indeed not be separated from the local context and the political choice how biomass should meet material and energy needs of society. A solely scientific approach will have difficulties to provide a conclusive objective answer that is universally applicable.'

'Basic principles for an assessment framework were developed within the study, based on which the optimal use of woody resources for material and energy should be balanced to be in accordance with the principles of cascading and resource efficiency. The basic principles are as follows:

- *From the perspective of resource efficiency, both material and energy policies should:*
 - *Encourage energy recovery of non-recyclable waste streams as the final step in cascading;*
 - *Promote efficiency increases throughout the value chain*
 - *Stimulate the mobilization and utilization of unused streams, taking into account constraints on sustainable production and protection of ecosystems.*
- *From the perspective of material hierarchy and cascading, energy policy should :*
 - *See to it that that desired and innovative material applications and cascades are safeguarded as much as possible;*
- *From the perspective of the promotion of renewable energy, material policy should:*
 - *See to it that desired and innovative energy applications are safeguarded as much as possible, in view of achieving the renewable energy targets ;*

The conclusions and basic principles of the study lead to following briefly outlined policy recommendations;

⁴⁵ Approved by the Flemish Government (July 2015) – Action Plan: <http://www.ovam.be/actieplan-biomassarestromen-2015-2020> (dutch version)

⁴⁶ Finalised March 2016 (not published yet). English title: Sustainability criteria and assessment framework for the use of woody streams. Publication title: Duurzaamheidscriteria en een afwegingskader voor de inzet van houtige stromen (to be published on www.ovam.be).

⁴⁷ VITO – Flemish Institute for Technological Research

- Stimulate the active set up of cascades and bio-refinery concepts, including the energy valorization of non-recyclable waste streams
- Keep focusing on energy saving on the one hand and increasing RES, like wind and solar, on the other.
- Stimulate the most resource efficient technologies as well in the field of energy as in the fields of materials and products.
- Focus on sustainable mobilization of (local) biomass and an increase of forested area.
- Reassess regularly the market situation
- Harmonise policy frameworks between countries and regions in Europe and worldwide.

In a next step the basic principles need to be translated into a concrete assessment framework with indicators. Such indicators are currently still missing. Some indicative examples of such indicators are:

- Environmental impact (GHG reduction)
- Economic impact (added value, market demand, competitiveness)
- Societal impact (employment, local embedding, resilience (availability of alternative feedstocks))

APPENDIX C

The Swedish Wood Fiber Law 1976-1991

By Anders Roos,

Swedish University of Agricultural Sciences

Introduction & context

Swedish forests cover 23 Mha or 57% of the land area. The forest industry is important for the economy although its relative significance is gradually decreasing accounting in 2013 for 2.2 % of GDP, 11% of export values and employed 82 000 jobs (corresponding figures for 1974 were 9.5%, 25% and 232 000 jobs). The sector is currently expanding but not in pace with the rest of the increasingly service dominated economy.

The forest use is regulated by the Forest Act ("Skogsvårdslagen") and forest industry activities by business, labor and environmental laws. An overall governmental concern for the forest-, energy- and industry legislation is to provide predictable conditions in order to enable the sector to generate sustainable growth and employment. The forest policy context is also characterized by soft policies and consensus, e.g. related to environmental concerns in forestry practices. However, over time, the forest related legislation has shifted in terms of detail and main focus. Regional economic subsidies, e.g. in regeneration and forest road building, were available in the 1970s and 1980s but have since been reduced.

The use of forest raw material is influenced by energy and environmental policies, which have shifted in their main motives, from previously mainly reducing fossil dependency to supporting climate policies today. Currently economic incentives favor renewable energy sources and energy efficiency and bio-energy is gaining competitiveness by its exemption from a carbon tax, certificates and other incentives (Energiläget 2015).

The annual wood harvests amounted to 67.5 Mm³ in 1974 and it was used for sawmilling and pulpwood. Only marginal quantities of raw materials were exchanged internationally. Forest industries, in particular pulp and paper have always been characterized by large facility investments, which, in turn, makes a steady, predictable supply important for the industry. The roundwood market for the pulp industry has historically been characterized as monopsonic since catchment areas for wood raw material can be classified as geographical (Brännlund 1988). However, as a counterforce, the forest owner's bargaining power is also high due to the fact they rarely depend on forest income. Annual harvests as well as lumber, pulp and paper production have increased since 1975 and the forest bioenergy assortment has become another standard forest product.

The motives for the wood fiber law

The background for the 1997 regulation of wood material use should be sought in a continuous increase of the forest industry capacity and a consequential need for raw material. Total gross removals did nearly equal annual growth in the early 1970-ies causing concerns in the industry and among policymakers of a raw material crisis (Hansing 1989). A state committee concluded in 1975 that the forest industry's planned capacity increases exceeded the expected raw material growth rates by 15-20 Mm³ (Figure 4).

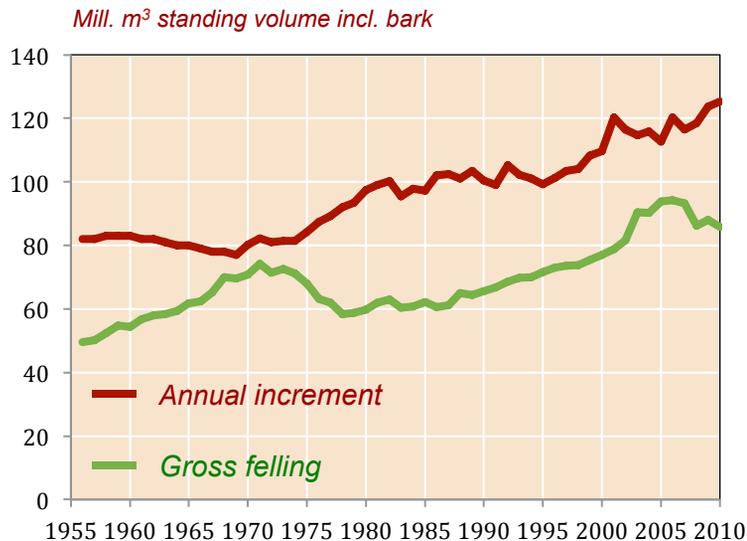


Figure 4. Annual fellings and increment in Sweden. Source: Swedish Forestry Agency

At that time Sweden had already introduced a law regulating the use of land and water resources and this framework was extended in 1976 to cover the consumption of wood raw materials. The law first focused on limiting greenfield investments but would later also include expansions of the wood industry capacity. It incorporated possibilities to allow investments under certain conditions, e.g. with conditions that the biomass raw material was imported. (Hansing 1989, Wibe 1992)

The wood fiber law would had specific importance for the bioenergy sector since woodfuel consumption began to increase after an all time low. This trend-shift prompted a debate whether it would be necessary to restrict wood for energy use to secure the supply to the forest industry. Further restrictions on the use of wood for energy were implemented in 1983. This law continued to be valid even post 1987 when the original building legislation had been removed with the aim to “counteract weaknesses with the forest industry’s raw material supply systems” (Hansing 1989).

In the preparation of the restrictions, different stakeholders expressed conflicting opinions about their relevance. The pulp and paper sector initially opposed the regulation because it would limit their degrees of freedom. However, when the bioenergy sector started to expand the forest industry shifted and became favorable to regulations claiming that the raw material should be consumed in a way that maximized total value added to avoid unnecessary waste of resources (Hansing 1989).

The labor union movements also supported some type of capacity regulation and the panels industry endorsed a law as it feared an increased competition from the bioenergy sector for its raw material.

Sawmilling and bioenergy companies lobbied against the fiber law, however. The wood products industry feared a thwarted demand for different sawmill by-products and the bioenergy producers would be the primary subjects under the legislation.

The implementation

According to the new law, applications for capacity increases had filed with the Housing department. The application was then sent for comments from the official agencies and departments, organizations, and local administration. Normally 15-20 stakeholders would be contacted for an application. In some cases municipalities asked for further viewpoints from local interest groups.

Effects

The original goals of the legislation - to avoid a crisis of under-supply of wood raw materials - became quickly irrelevant after the law was implemented as annual cuttings began to decrease post 1974. Hence, instead for securing a sufficient raw material supply to the sector, the law inhibited the further development of the forest- and bioenergy sector (Wibe 1992) and most applications that were submitted were finally approved, albeit with reductions or conditions e.g. that a percentage of the raw material should be imported. Some permits granted to the energy sector were also temporary (Hansing 1989)

A 1991 evaluation of the law found that the state could have used other means for reaching the same goals. The law had not had any additional beneficial effect, e.g. on the opportunity for independent sawmills to acquire raw timber for their operations (SOU 1991). This had been one argument for the legislation: to allow sawmill enterprises to access raw materials and continue operations and contribute to regional economic activity. It was, according to the review, almost impossible for a regulating authority to determine when an increased use for bioenergy would hamper raw material supply to the forest sector.

Studies found that there is not really a competition for the raw material between the forest- and energy sectors since the latter normally demand tops, branches and some industry residues (Lundmark 2006).

A thorough, scientific review of the regulations' consequences has not been done. However, different authors (e.g. Wibe 1992, Hansing 1991, Lundmark 2006) have indicated possible by-effects, supported by both theories on regulations and empirical observations. For instance that the law created a "negotiation economy" where allocation problems to some degree were solved through lobbying and negotiations instead of market forces. One example was that sawmill companies took opposing positions compared with the pulp industry but found common interests with the bioenergy sector (Wibe 1992). This would normally favor "strong" actors and organizations on the expense of less powerful ones, with ensuing welfare losses. The role of industry interests is also noticed for the pulp and paper sector that first opposed the regulation, until the bioenergy sector started to expand. Then it became favorable to regulations since bioenergy producers constituted potential competitors for raw materials. (Hansing 1989)

Another possible by-effect of the regulation concerned the "ease of doing business" since permit processing become very time consuming, 6-9 months or even some year (Hansing 1989). The regulations remained despite the fact that they had become obsolete (Hansing 1989). Moreover, the framing of the permits based on business units, and not facilities, may have prompted strategic actions by applicants that would, in turn, have slowed down the productivity improvements (Hansing 1989). Applicants gradually adapted and learned to formulate applications to receive a positive answer (Hansing 1989). "Mission creep" stands for the expansion of a mission beyond its original goals. In this case the law began to be used as a regional policy tool by securing raw materials to existing industries; although this may have not been the most effective ways for this additional purpose. The wood fiber law may also have stimulated the import of wood raw material from external countries (Wibe 1992). Yet another

unintended effect may have been that application requests were increased for strategic reasons.

The main consequences from the restrictions, derived from simple economic analysis, is normally labeled as “deadweight loss” as total volumes and prices were affected. Since restrictions were introduced on the capacity development, this should have reduced the volumes of wood fuel for energy promoting instead fossil fuel sources. This also involves de reduction of potential employment opportunities in the bioenergy sector. Economic theory also shows that in the absence of market failures, an unregulated market, maximizes welfare. An increased demand of biomass for energy does, in this case, only reflect the material’s increased value. Buyers of biomass will be incentivized to improve the energy efficiency of the use; and sellers may get an incentive to increase the biomass production The price mechanism also makes sure that the material flows are optimized where it generates most value. The state is not likely to perform this allocation task better (examples of regulation failures are plenty). Hence, according to Hansing (1989) competition for an input factor is normal and just a sign that the market works and develops.

The Industry Agency (Statens industriverk) gradually began to fear the law would hamper the introduction of newer and more efficient facilities or also slow down the industry’s development in other ways (Hansing 1989). Accumulated concerns led to the termination of the law in 1991.

The main actors involved in the wood fiber laws are listed below.

- The **pulp & paper industry**, was the largest consumer of wood raw materials. The main feature of the industry is that it has high capital investments and consequently is dependent on a safe supply of wood raw materials (Hansing 1989)
- The **sawmilling sector** was on the one hand buying roundwood materials and on the other selling chips and sawdust to pulp industries and bioenergy facilities.
- The **panels sector** used residues from sawmills in their production and it therefore suffered when the energy sector increased its demand for wood materials (the effect of the wood fiber law to stop this development was minimal, though).
- The **energy sector** increased at the period its use of wood materials. It covers several sub materials and markets. The largest user segments include the pulp and paper industries using auto-generated bioenergy in its processes, district heating plants/CHP and residential use. Biofuels in district heating has increased over time, especially after a carbon tax was introduced in 1991.

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APPENDIX D

Mandated Allocation Of Natural Gas: Directive 75/404/EEC

By Olle Olsson, Stockholm Environment Institute

Introduction and context

In this case study, we will particularly discuss the opportunities and problems of implementing “cascading-by-value”. For this purpose, we will analyze a historical case, where EU energy policy explicitly restricted the use of a resource to specific sectors while banning it from others, largely based on perceptions of profitability and value. The case we will examine concerns the European natural gas market in the 1970’s and 1980s and the effects of Council Directive EEC/75/404, which restricted the use of natural gas for electricity generation in the EEC.

At first sight, the relevance of this case for the current discussion on biomass cascading might not be obvious. However, there are interesting parallels, starting with the actual wording in the directive. Directive EEC/75/404 mandated that the use of natural gas for electricity production is should not be allowed to expand in the member states except “...*if the natural gas cannot be put to a more profitable use*” (Council of the European Union 1975 Article 1.2, emphasis added), which is quite reminiscent of the “cascading by value” notion that biomass should only be used for energy purposes only if there is no option with higher value available.

Why - Background of directive 75/404/EEC

From the early development of natural gas consumption in Europe in the 1950s and 1960s, there was a generally accepted view that natural gas was bound to be a local or regional fuel with limited prospects in terms of geographical expansion or different forms of utilization. The natural gas market was a very rigid structure associated with substantial central governmental influence on long-term demand patterns, with assumed (and desired) linear market growth in specifically designated sectors of utilization (Odell 1988). As for the supply side, assessments were made in the 1960’s that strongly indicated that available natural gas resources in Europe were very limited (Odell 1988). The oil crisis of October 1973 and the unprecedented strong oil price increases that followed further solidified the notion of scarcity pertaining to natural resources in general and hydrocarbons in particular. (Winskel 2002, p.583).

How - The specifications of the directive

Directive EEC/75/404, issued in February 1975, should be seen as an attempt to mitigate this perceived notion of resource scarcity⁴⁸. In short, the directive argued that natural gas supplies were limited and that it was therefore imperative that “...*natural gas should be reserved in the first instance for those applications for which it can be most profitably used*” (Council of the European Union 1975).

The directive included a specific list of exceptions, but the overall objective was clear: gas was to be used only for “premium” purposes, primarily space heating and cooking. Industrial use

48 Interestingly, quite similar restrictions were introduced on the other side of the Atlantic in the 1978 US Powerplant and Industrial Fuel Use Act (Gordon 1979)

was also deemed to be of higher value than electricity, which, it was argued, could “...be readily produced from abundant coal and nuclear energy sources.” (Williams and Larson 1988, p.470)

Effects

Immediate effects on the natural gas market

The use of natural gas for large-scale power production was at this time rapidly expanding. Technological development during the 1960’s had made natural gas turbines an increasingly competitive alternative to coal, heating oil and nuclear in power generation (Watson 1997; Winskel 2002) and the share of natural gas in the combined electricity mix of the EEC countries grew from 1% in 1968 to 13% in 1975, see Figure 5. The implementation of the directive clearly broke this trend and by 1980, the share had fallen to 9%.

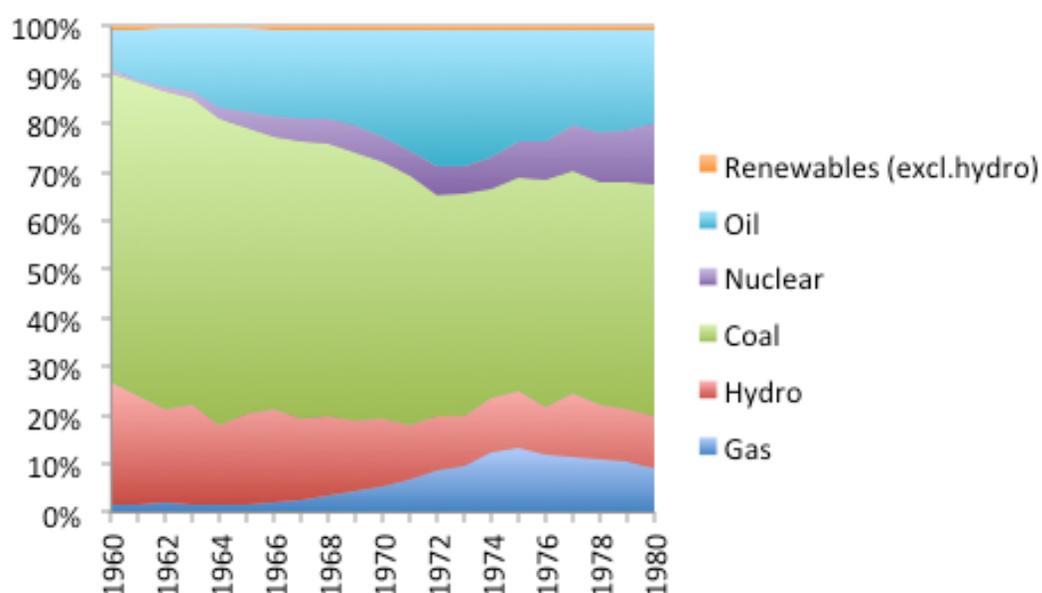


Figure 5. Electricity generation mix in the EEC 1960-1980
(Data source: IEA & World Bank)

The directive was thus quite effective in achieving its set goal. The expansion of natural gas in power production was halted and eased competitive pressures on other sectors using natural gas as well as on competing forms of electricity generation (Winskel 2002, p.583).

As for reactions from market actors, there seemed initially to have been very little opposition to the directive. The environmental movement was relatively positive to natural gas as the cleanest fossil fuel, but it was not prepared to lobby in favor of gas expansion (Odell 1988). The West German government supported the directive as there was a view that the use of natural gas for power production could prove a threat to its coal production sector (Hancher 1989). Similar notions were seen in the UK, where the directive “...bolstered established interests and commitments (particularly those around nuclear power).” (Winskel 2002, p.583).

Later effects – directive EEC/75/404 is revoked

In the mid-to-late 1980’s the directive became increasingly criticized, especially in the UK. The use of gas for power production became viewed as an increasingly promising alternative for a host of reasons:

- Further technological advances in gas-fuelled power production with the introduction of the Combined Cycle Gas Turbine (CCGT) led to substantially higher power generation efficiency.
- The fears of resource scarcity following the oil crisis appeared to have been significantly exaggerated, especially with the rapid oil price fall that began in 1986.
- The increasing awareness of the environmental problems with coal combustion and uncertainties about nuclear safety following the 1986 Chernobyl disaster significantly increased the relative attractiveness of natural gas-fueled power generation
- A strive towards more liberalized energy markets, which emphasized the importance of cost-efficiency, gradually began to dismantle the traditionally rigid structures of the gas industry.

Although the commission in late 1986 was not willing to take any steps to relax the restrictions of the 1975 directive (European Commission 1986), developments in individual member states went faster. The UK saw particularly strong tendencies with the expansion of its domestic natural gas production and strong tendencies towards energy market liberalization (Watson 1997). This meant that by 1988, both the UK hydrocarbon production industry and the Thatcher government lobbied for the revocation of the directive. In fact, in 1988, the UK government overrode the directive and granted permission for the construction of a CCGT power station, albeit with reference to one of the possible exceptions listed in the directive (Watson 1997; Winskel 2002).

A few years later, in 1991, European restrictions on the use of natural gas for electricity production were lifted with Council Directive 91/148/EEC. Subsequently, the share of natural gas in the European power mix expanded rapidly, from 9% in 1991 to 27% in 2010, see Figure 6.

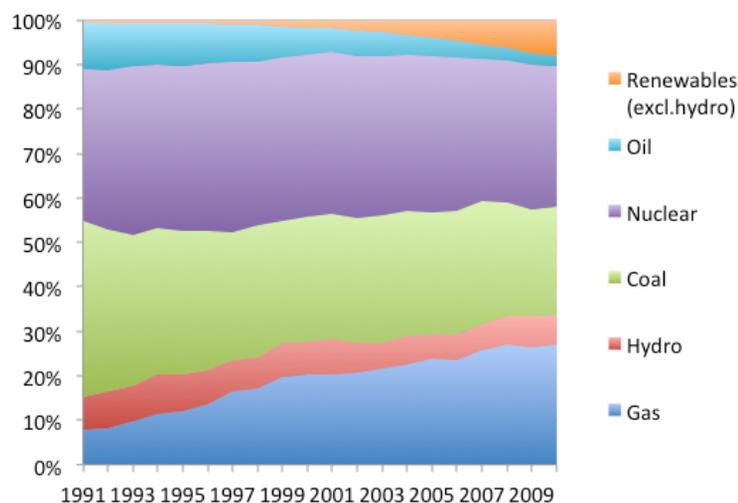


Figure 6. Electricity production mix in the EEC countries 1991-2010.
(Data sources: IEA and World Bank)

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APPENDIX E

Cascading vs. Companion Markets: The Southern US Forest Products Sector

By

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Summary

The US currently does not have a cascading policy in place that regulates wood use in the forest products sector. EU aspirations for a hierarchical use of wood however could potentially affect respective US exports. This case study illustrates the forest products markets in the US, with a specific focus on the US South due to its current dominance in US wood pellet exports. The number of forest product establishments has declined nationally since 2002 with an increased rate of decline after 2007. However, by 2015, the number of US South mills consuming pulpwood and residual chip fiber is the same as in 2000; as there has been a sector shift from pulp and paper to wood pellet production. Wood pellet mills typically use residual chip fiber and pulpwood; the same feedstock as panelboard, OSB or pulp and paper mills. During the decline of the US housing market and following recession, available pulpwood and sawmill residual chip supply declined significantly in the US South for both soft- and hardwood. This decline has increased demand (and stumpage prices) for pulpwood and residuals.

Unless forests are owned by companies and grown for a specific assortment, forest management and harvest timing are usually driven to maximize the most valuable fractions. For softwoods, managed forests in the US South are geared to maximize their sawtimber quantities. Chip-n-saw as well as pulpwood fractions are secondary products. Woody feedstock for energy production is traditionally derived from harvesting and processing residues, which are often not part of traditional forest management objectives, although they can provide economic revenue streams. As such, these low-value harvest fractions, e.g., tops and branches or residual, i.e., non-merchantable sawtimber or pulpwood due to shape (crooked) or condition (e.g., beetle or fungi infestation) require a high-revenue companion market to provide sufficient financial incentives for harvest operations in the first place. In other words, without a companion market such as sawtimber, less pulpwood and residual quantities are available to the market, including energy production, as illustrated in this case study.

1. Context

The United States (US) currently does not have a cascading policy in place that regulates wood use in the forest products sector. Ongoing discussions, particularly in the European Union (EU), about potential legislation on a hierarchical use of wood however could potentially affect exports of the US forest products sector. This case study illustrates the forest products markets in the US, with a specific focus on the US South due to its current dominance in US wood pellet exports to the EU.

2. Regional forest products markets across the United States

The forest products industry in the US varies regionally based on the types of forests present. For practical purposes, the contiguous US can be broken down into four regions with three of these being broken down further into sub regions (Table 4).

Table 4. Forest product businesses across the contiguous US in 2012 (USCB 2015c).

Region	Sub-region	Share (Number of Establishments)
North	Northeast	22%
	North Central	21%
South	Southeast	18%
	South Central	21%
Rocky Mountain	Great Plains	1%
	Intermountain	5%
Pacific Coast	<i>n/a</i>	12%
		100%

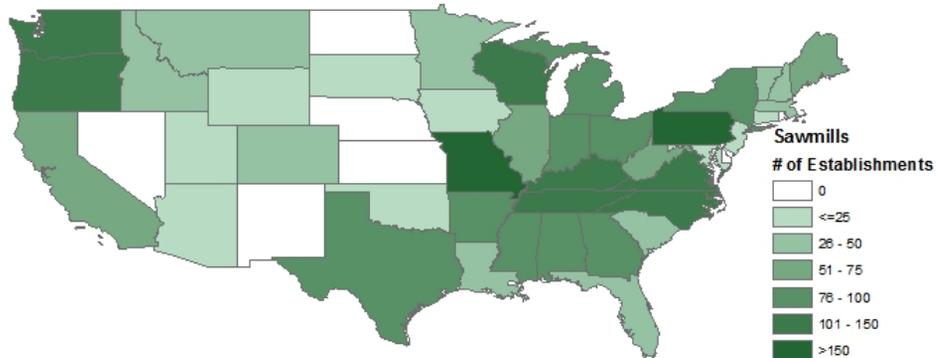
In the North, South and Pacific Coast regions, accounting for roughly 94% of the US forest products establishments, the majority (62%) of the industry is producing solid lumber, either for construction or furniture and cabinetry (Figure 6A). The Northeast has the highest proportion of sawmills with 71% of the sawmill establishments, followed by the South Central sub region which has 66% of the established forest products establishments as sawmills. For these two regions the majority of the mills are located in areas that produce hardwood lumber. Hardwood lumber is most widely used for appearance applications such as furniture, cabinetry, and mill work (Bumgardner *et al.* 2014). In the remaining regions sawmills represent a greater than 50% share of the forest products establishments, except for Rocky Mountain Region.

Pulp, paper and paperboard represent the smallest proportion of forest products businesses in the US, with only approximately 8% of the establishments (Figure 6B). The distribution of the pulp and paper industry is more regionalized than the sawmill industry with specific pockets of high importance within the sub-regions. Six of the states with the highest number of establishments are located along the Great Lakes or New England. Additionally, there is an area of high production in the South with Alabama and Georgia leading in the number of establishments. Pulp and paper production, similar to sawmill locations, is centered in areas that have high volumes of pine or hardwoods propagated by coppice silviculture and/or gentle

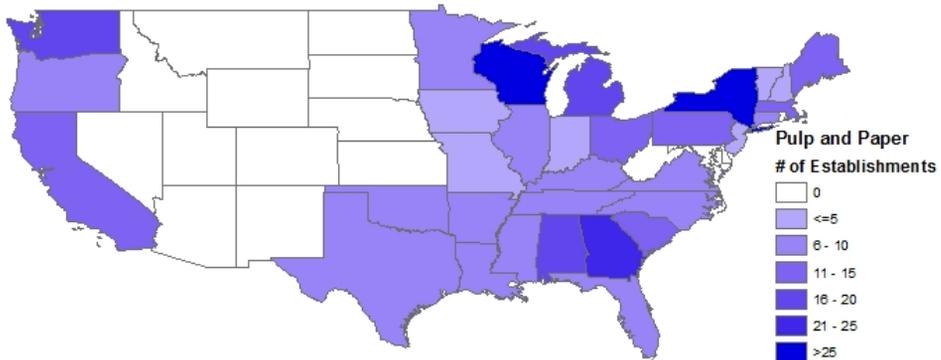
topography. Primarily the material used as feedstocks for pulp and paper are smaller in size or of lower quality than the material that is used by traditional sawmills. Both of these resources allow for highly automated mechanical harvest, which increases production and reduces the cost for the raw material.

The industry that makes up the balance of the forest products industry is the engineered wood products manufacturing (Figure 7C). Similar to the pulp and paper industry, the engineered wood products sector can make use of lower quality, smaller size feedstocks. This makes it a potential resource competitor for pulp and paper. Engineered wood also can utilize larger timber resources for veneer in the production of plywood and lumber can also be used to make engineered framing members such as roof trusses and glue laminated timbers. Because of the wide array of materials that can be utilized, the distribution of engineered wood products manufacturers is nationwide accounting for approximately 30% of all forest product businesses.

A. Sawmills in the US



B. Pulp, Paper and Paperboard Manufacturers in the U.S.



C. Engineered Wood Products Manufacturers in the U.S.

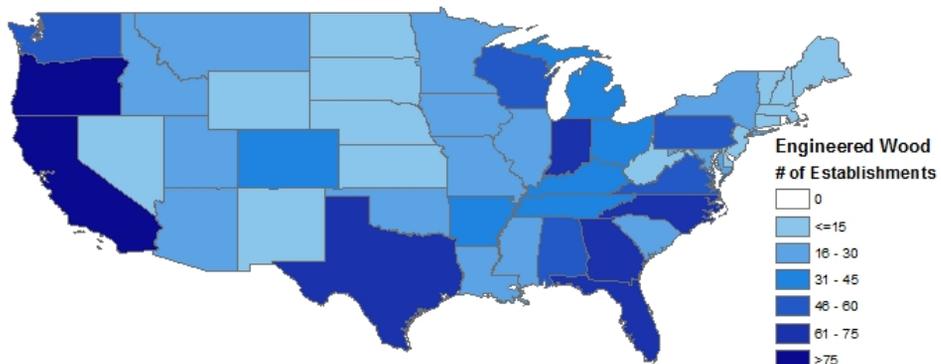


Figure 7. Geographic distribution of the forest products industry (USCB 2015c, USCB 2015b, USCB 2015a).

3. Markets in the US South

The number of forest product establishments has declined nationally since 2002 with the rate of decline increasing after 2007 (see supplementary graphs at the end of this case study). Reasons for the decline are structural such as an increased internationalization but also singular such as the global recession. Although the industries may not return to pre-recession

levels, the recent slow but steady recovery of the US housing market is expected to support a recovery of the sawmill and engineered wood product sectors. The pulp and paper sector however has seen a structural decline in newsprint and paper mills due to the increase of digital content.

In the US South, 119 mills consuming pulpwood and residual chip fiber were operating by 2015; the same amount as in 2000 (Forest2Market 2015). However, there had been an internal shift in the sector from pulp and paper to wood pellet production. 16 new wood pellet facilities were built in the US South since 2005. Between 1995-2015, 14 pulp and paper mills permanently closed across the US South (Forest2Market 2015). The panelboard and oriented-strand-board (OSB) sector experienced both openings and closings across the same period with a net loss of three panelboard and a net growth of four OSB facilities (Forest2Market 2015).

A recent survey highlighted the following market factors affecting wood fiber supply and demand in the US South across the past 20 years (Forest2Market 2015):

- Land ownership change from industry to financial and private ownership
- Sawmill ownership change leading to a separation between pulp/paper and residual chip supply
- Decline in newsprint, increase in containerboard, fluff pulp and performance fiber demand
- US housing market crash plus global recession
- Change in long-term precipitation patterns and average rainfall
- Growth of competitive fiber demand from pellet mills (Figure 8, Figure 9).

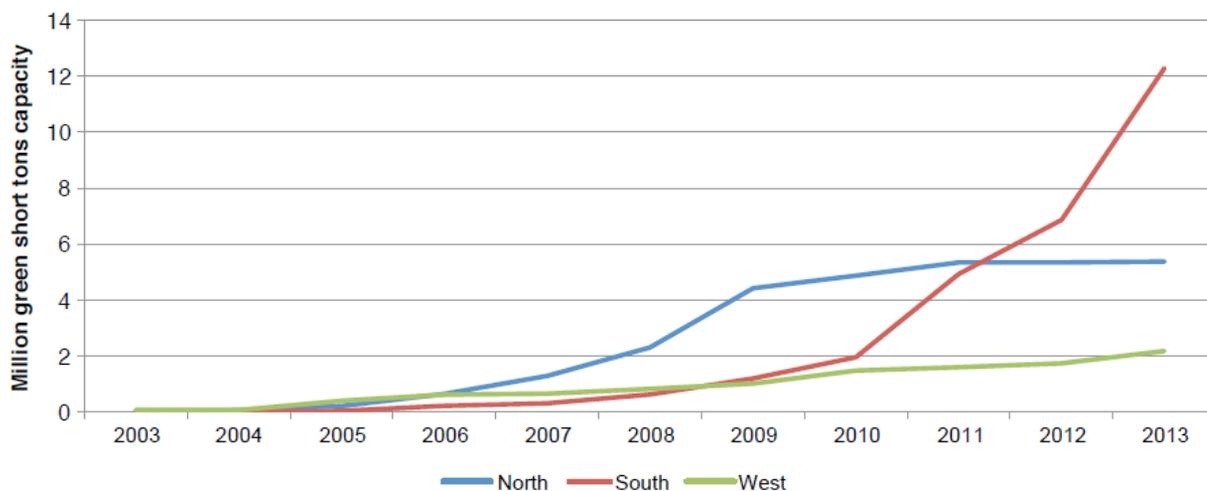


Figure 8. Growth in pellet production capacity by US region from 2003 through 2013 (Forisk Consulting in Abt et al. 2014)

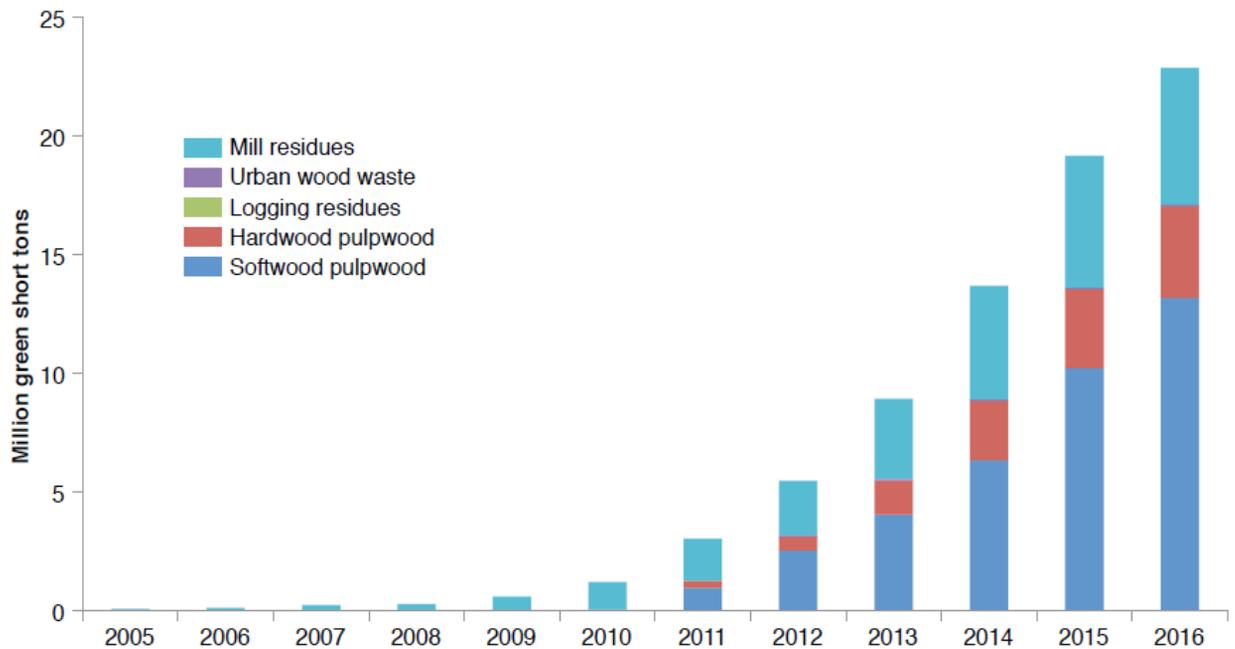


Figure 9. Actual and announced feedstock source for use in pellet production in the US South for 2005–2016 (Forisk Consulting in Abt *et al.* 2014).

As shown in Figure 9, pellet mills typically use residual chip fiber and pulpwood; the same feedstock as panelboard, OSB or pulp and paper mills. During the decline of the US housing market and following recession, available pulpwood and sawmill residual chip supply declined significantly in the US South for both soft- and hardwood (Figure 10 through Figure 13). This decline has increased demand (and stumpage prices) for pulpwood and residuals (Figure 10, Figure 12). In some years, significant precipitation events magnified pulpwood supply restrictions (Forest2Market 2015).

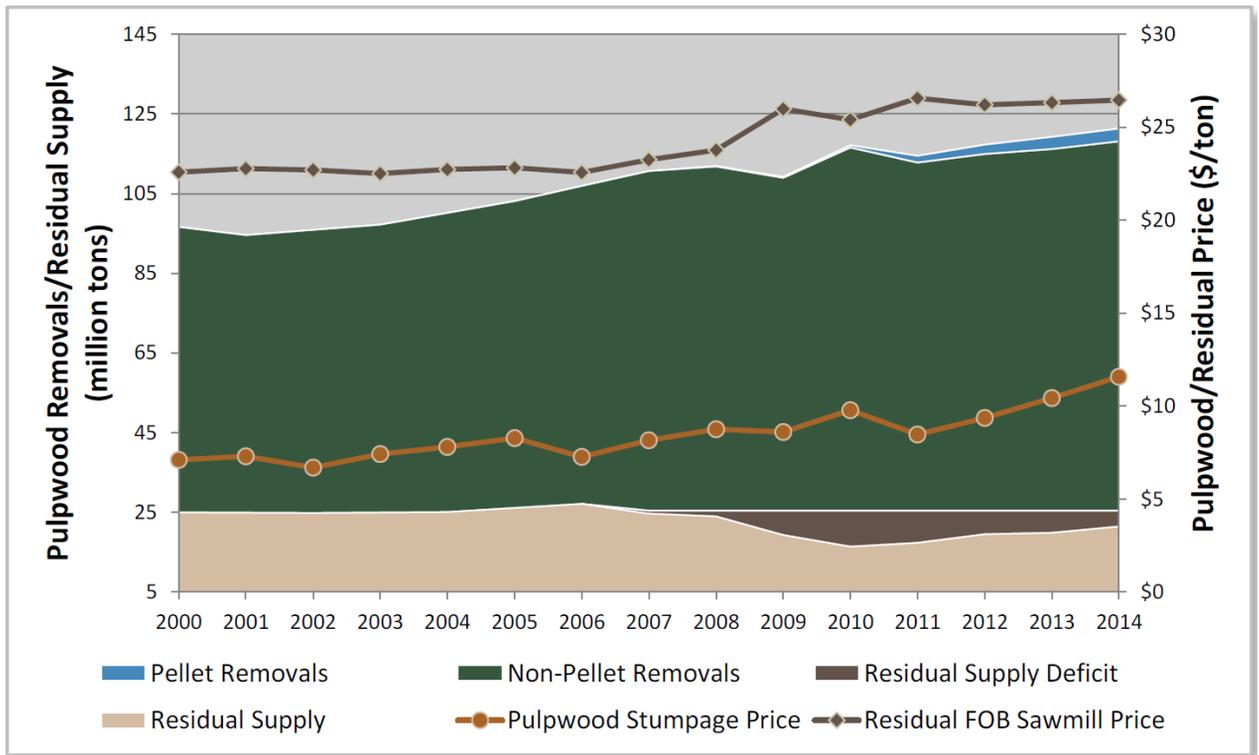


Figure 10. US South market dynamics for pine 2000-2014 (Forest2Market 2015).

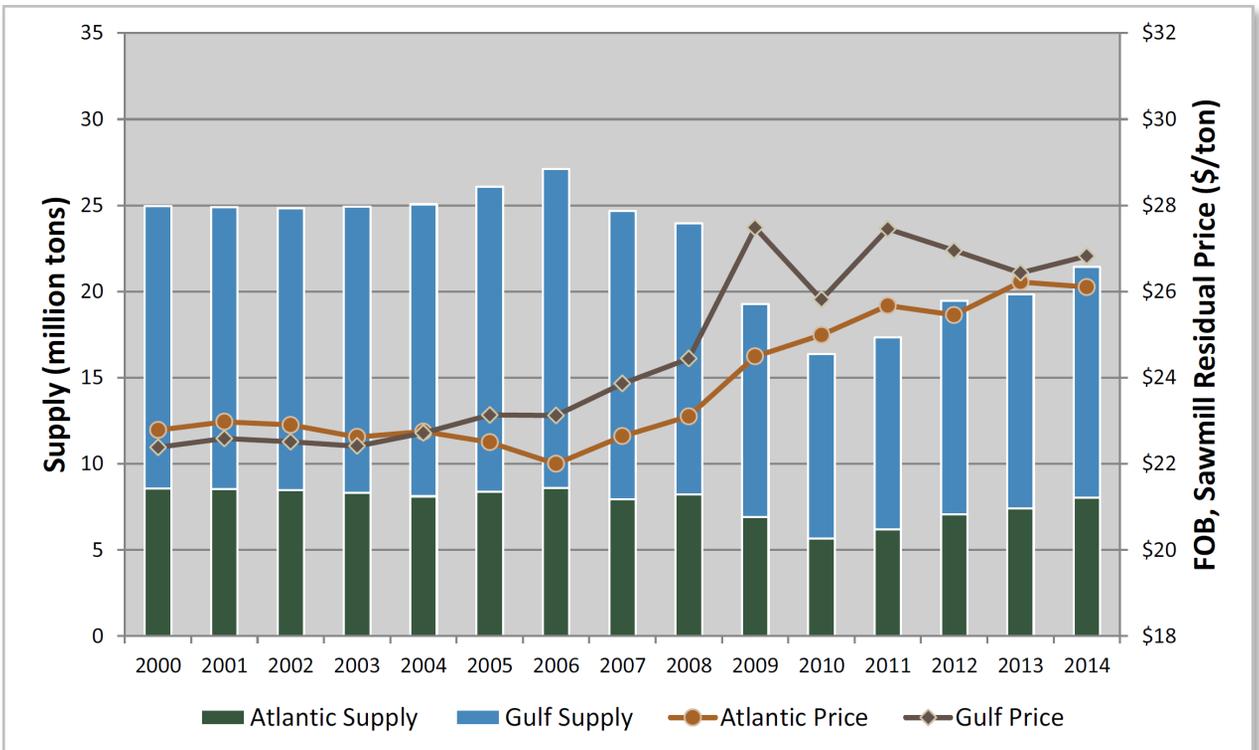


Figure 11. US South residual chip supply and price for pine species 2000-2014 (Forest2Market 2015).

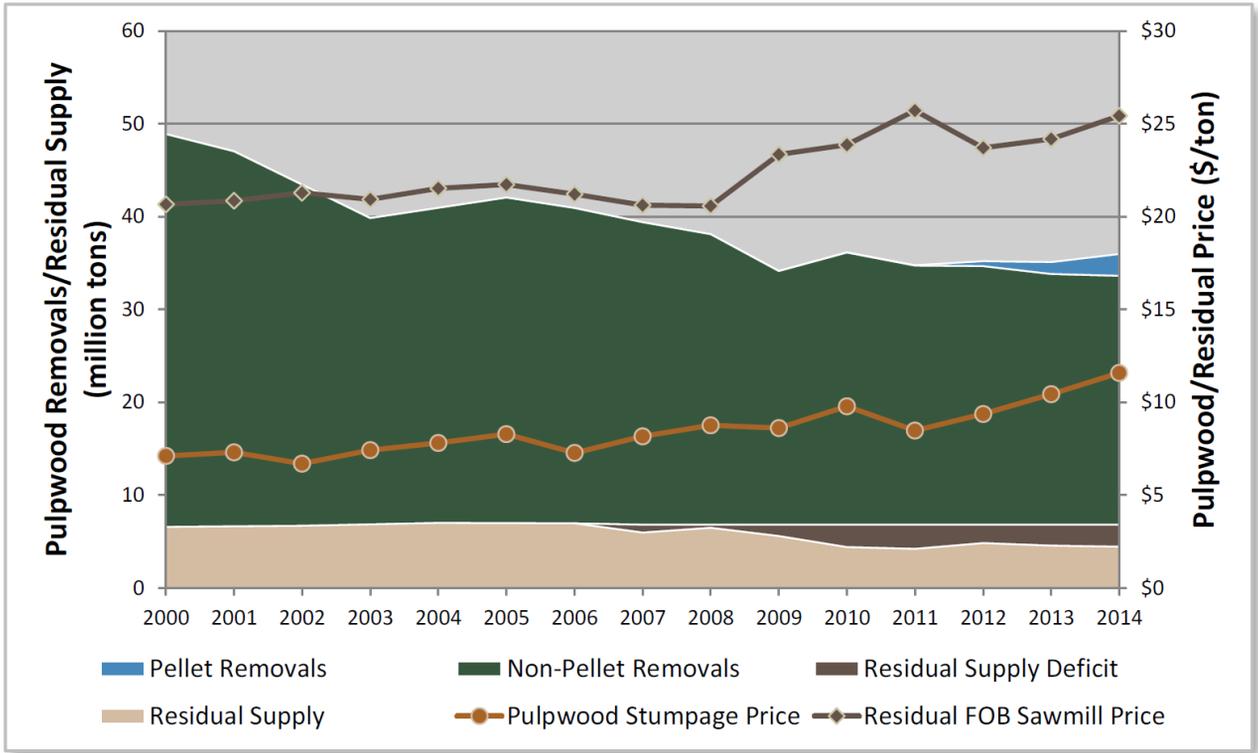


Figure 12. US South market dynamics for hardwood 2000-2014 (Forest2Market 2015).

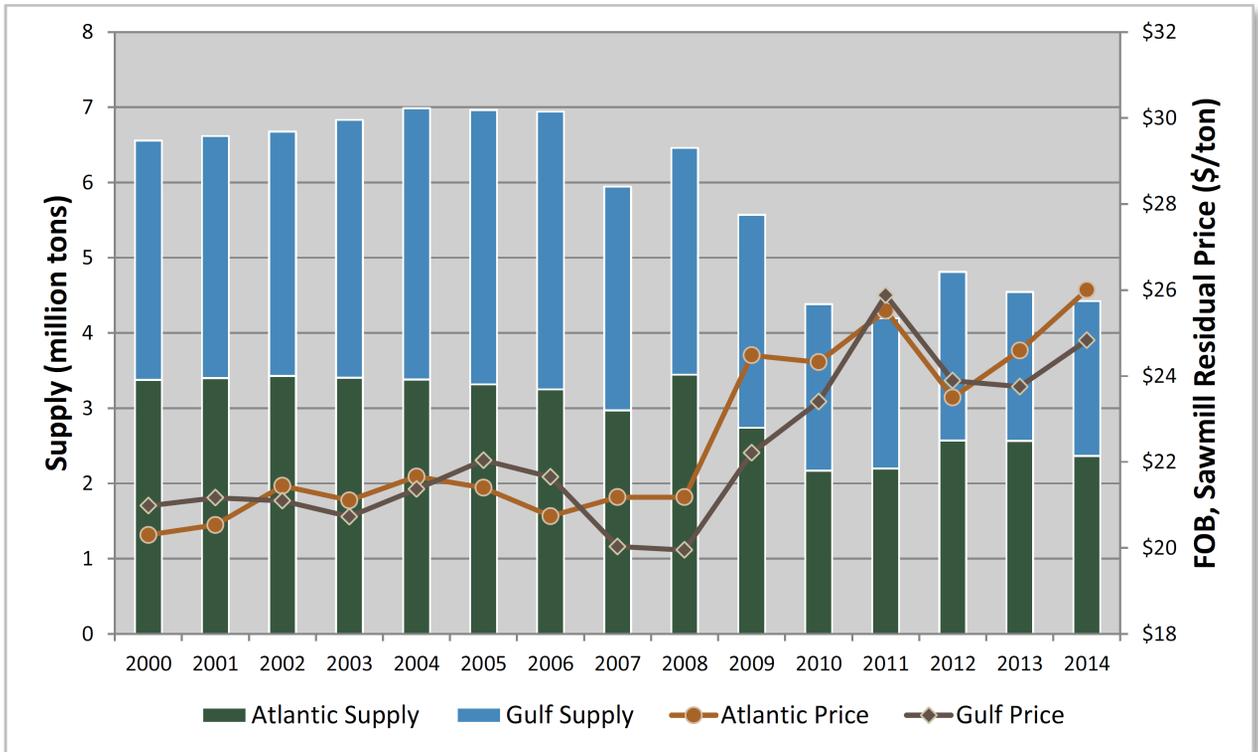


Figure 13. US South residual chip supply and price for hardwood species 2000-2014 (Forest2Market 2015).

4. Operational perspective

An owner's decision when to harvest a certain forest parcel is driven by the assortment that provides the highest revenue, while meeting management objectives. The most valuable harvest fraction is veneer logs, followed by sawtimber, chip-n-saw and pulpwood; respectively. Unless forests are owned by specific industry operations and grown solely for a specific assortment - e.g., short rotation pulpwood plantations - forest management and harvest timing are usually driven to maximize the most valuable fractions. If the forest is owned by a party independent of any industry, it is in his/her best interest to grow and sell various fractions to hedge investment risk, and be able to respond to current market conditions. Access to multiple markets, including energy, enhances the revenue opportunities, and provides alternative income streams during changes in market conditions. Figure 14 illustrates the different requirements per harvest fraction in the US South. For softwoods, managed forests in the US South are geared to maximize their value by maximizing sawtimber quantities. Chip-n-saw as well as pulpwood fractions are secondary products that are the byproduct of sawlog management.

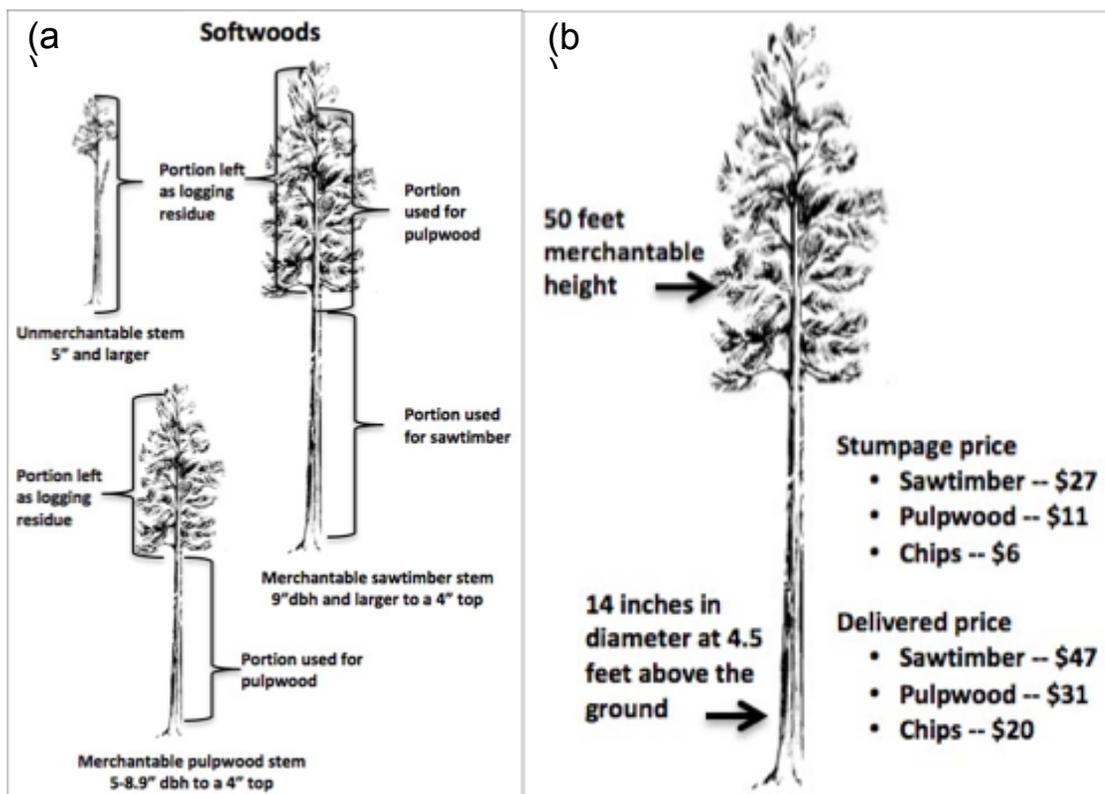


Figure 14. (a) General softwood product classes, and (b) an example of the stumpage and delivered values of a softwood tree in the southeastern United States (IBSS 2014). The requirement for softwood sawlogs is a straight tree at minimum 36 cm (14") in diameter at breast height (dbh). The next valuable fraction is chip-n-saw of 13-33 cm (4-13") dbh and pulpwood 13-23 cm (5-9") dbh. Harvesting residues include the tops and branches of merchantable trees as well as non-merchantable trees due to size (i.e., less than 10 cm or 4" dbh), quality (burnt, infested, etc.), or species.

Woody feedstock for energy production is traditionally derived from harvesting and processing residues. These are often not part of traditional forest management objectives, although they can provide economic revenue streams. In fact, most forest harvesting or thinning operation will generate residual biomass that can be used for energy production and provide forest owners

with additional income and reduce their business risk by widening their client and thus market portfolio.

At the same time, these low-value harvest fractions, e.g., tops and branches or residual, i.e., non-merchantable sawtimber or pulpwood due to shape (crooked) or condition (e.g., beetle or fungi infestation) require a high-revenue companion market to provide sufficient financial incentives for harvest operations in the first place. In other words, without a companion market such as sawtimber, less residual quantities would be available for energy production; as seen in the aforementioned example of the US South (Figure 10 through Figure 13).

Analysis by the Georgia Forestry Commission states that biomass stumpage prices will need to rise dramatically before non-industrial private forest landowners in the US South will consider the management of pine plantations solely for biomass for energy production (Love 2011). Thus, biomass will need to be produced in conjunction with traditional forest products to maximize financial returns (Love 2011). Forest market simulations by Munsell and Fox 2010 also demonstrated that intensive regimes managed solely for biomass for energy production are not financially attractive at assumed prices across the US South. However, incorporating biomass production for energy as part of an integrated management regime that includes traditional forest products will increase returns to growers (Munsell and Fox 2010). Also, a change towards a pulpwood-dominated forest landscape across the US South is seen as unlikely, despite the aforementioned supply shortages of residuals and the resulting demand increases for pulpwood. Analysis by FORISK 2011 suggests that pine pulpwood prices (\$12 per ton) would need to increase above chip-n-saw prices (\$17 per ton) for landowners to be economically indifferent between pulpwood- and sawtimber-dominated forests.

Finally, the prices for individual wood assortments are connected to the respective industry's willingness-to-pay (WTP), which is defined by plant economics and end market product value. As shown exemplarily in Figure 15, the panelboard and pulp and paper industry can pay a higher price for the feedstock than wood pellet or bioenergy operations. As such there is no risk that feedstock demand for wood pellet production will outcompete other industries relying on the same feedstock.

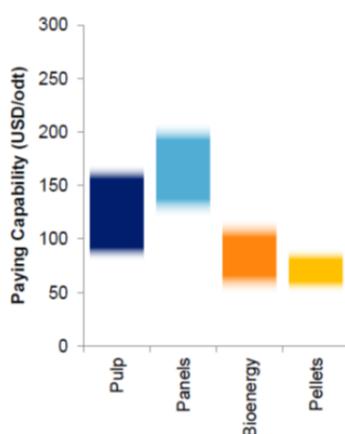


Figure 15. Comparison of the paying capability (willingness-to-pay) of different wood industries in the US SE (Teir 2013). Note: ODT = oven-dry metric tonnes

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Appendix E Supplementary Graphs

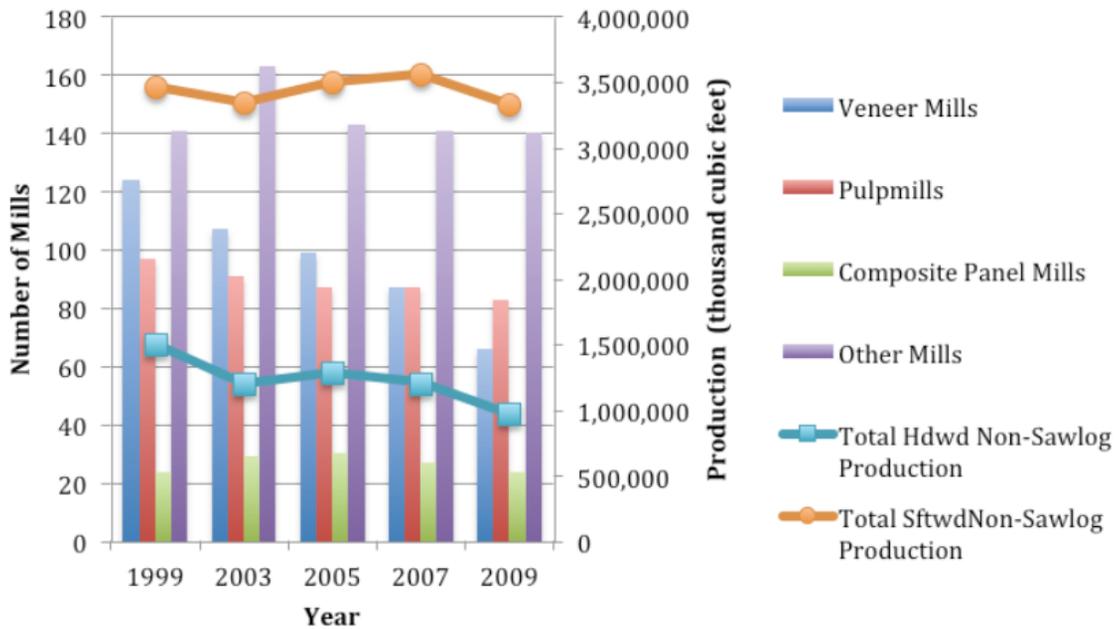


Figure 16. US South: Trends in mill numbers and production 1999 – 2009 (Hodges *et al.* 2012)

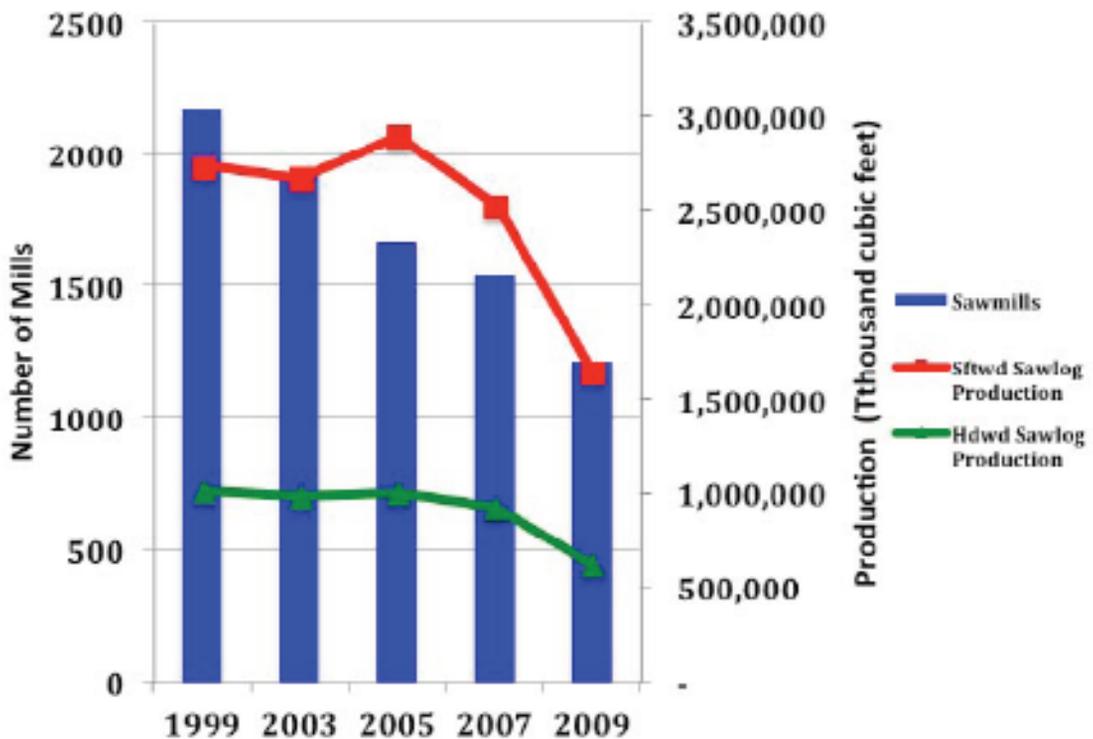


Figure 17. US South: Trends in sawmill numbers and sawlog production 1999 – 2009 (Hodges *et al.* 2012).

APPENDIX F

Forest resource allocation systems in Canada - the role of bioenergy⁴⁹

By

Bo Hektor, Svebio/First Bioenergy AB

Preamble

This case study deals with the effects of strict administrative rules and regulations with regard to allocation of biomass resources. The Canadian situation is not fully representative for “cascading rules”. However, the effects from application of strict legal rights and administrative rules related to various stake holders for forest-related values, including utilization of biomass, would still be of interest in the discussion on cascading.

General description of laws and rules regulating the allocation of forest-related values - in particular biomass resources - between stake-holders

Canada has about 400 million hectares of forests and other wooded land, about 94% of which is publicly owned. The federal, provincial and territorial governments share responsibility for these public forests. Canada’s 10 provinces and 3 territories have direct jurisdiction over 90% of the country’s forests. Each provincial and territorial government develops and enforces legislation, regulations and policies related to forests (Natural Resources Canada 2016).

Forest-related laws and regulations may differ between provinces (and territories), but the goal is the same across the country: sustainable forest management (SFM). SFM-focused laws, regulations and policies address land-use planning, forest practices and forest regeneration. This approach to forest management considers not just timber, but many other forest-related values, including wildlife, biodiversity, soils, water, scenery, and Aboriginal interests. (e.g. First Nations) **However, “energy” is not mentioned among the forest-related values, the implications of which are discussed later in this case study.**

Regarding wood utilization, a variety of tenure arrangements (“licenses”) are used to grant rights and responsibilities to companies operating in public forests. In most cases a license means a commitment from the provincial authorities to a company or person to utilize a certain quantity of timber for a specified number of years from within a specified larger area. License areas often overlap with those of other licensees. Thus, these tenure arrangements do not mean ownership, etc. to specified areas, and neither do they give companies the full authority to harvest timber. Before any trees are felled, government authorities must first approve forest management plans and authorize the proposed harvesting. The management plans take into consideration that no stakes of other interests (mentioned above) are violated. Failure by a tenure holder to comply with approved plans and harvesting permits can result in stiff penalties (cf. Sedjo 2006).

⁴⁹ In addition to the sources explicitly referenced herein, the analyses in this case study draw on interviews with a number of anonymous Canadian actors active in the forest sector and/or business development in Canada.

Provincial and territorial governments collect royalties (or “stumpage fees”) for trees harvested on public lands. The methods for assessment of these fees are discussed later on in the paper. The governmental authorities closely monitor the companies and persons operating in public forests, and require formal reporting on their activities. As well, systems of checks, e.g. scale data, track the timber that is removed from these lands. Moreover, also compliance audits can be carried out.

While the provinces and territories have authority over the management of most forested land, forestry operations are also bound by national legislation. The comprehensive laws and regulations enforced by the provinces and territories are therefore designed to address the requirements of federal legislation relevant to forests, such as the Species at Risk Act, the Fisheries Act, the Migratory Birds Convention Act, and the Plant Protection Act. These Acts are by-and-large also compatible with international agreements Canada has signed.

Nearly 4% of Canada’s forests are under federal government and Aboriginal ownership. These forests are mainly located in national parks, lands owned by the Department of National Defense (DND) and federal lands held in reserve for-, or lands otherwise controlled by Aboriginal peoples. The regulation and management of forestry operations on these lands is the responsibility of several federal government departments, including DND, Parks Canada, Natural Resources Canada, Aboriginal Affairs, and Northern Development Canada. Moreover, as mentioned above, Aboriginal interest must be taken into consideration also with regard to forest-related values in provincial, etc. forests.

Only 6% of Canada’s forests are privately owned. Timber companies in some provinces own large tracts of forest (for example, in Nova Scotia, New Brunswick and British Columbia). The rest of the private forestland base is divided primarily among thousands of small family-owned forests and woodlots located across Canada. About one-tenth of the total volume of roundwood and pulpwood harvested in Canada comes from private lands. Forest management on private lands is supported by provincial/territorial and municipal regulations, guidelines and partnership programs.

Many private landowners use forest management plans and take advantage of government support programs. Timber production normally carries a higher weight than other forest-related values for private owners, but the plans cover also other forest value factors. Some provinces have laws that set standards for forest management practices on private lands. Rules apply to track timber harvested from private lands so that it can be differentiated from public timber (for which royalties must be paid). These mechanisms include regulations for timber scaling, timber marking and transportation.

Thus, allocation of forest products and services are to a very great extent related to laws and regulations. The implications of that structure with regard to new aspects, e.g. bio-energy and climate mitigation are discussed later below.

The Softwood Lumber Agreement(s) (SLA)⁵⁰

Also the utilization of wood resources (harvesting, manufacturing, transport, etc.) is subject to strict regulations. In addition to the requirements to monitor the allocation rules mentioned above, the long lasting controversy between Canada and the US regarding pricing of standing timber, has led to the development of sets of rules on the subject matter.

⁵⁰ For an extensive history of the US-Canada softwood trade dispute (up until 2007), see Zhang (2007).

The heart of the dispute is the claim by the USA that the Canadian sawn timber industry is unfairly subsidized, as most forests in Canada are owned by provincial governments. The prices charged to harvest the timber (stumpage fees) are set administratively, rather than through the competitive marketplace, which is the norm in the US. As the US claims this constitutes an unfair subsidy, and therefore should be subject to U.S. trade remedy laws, where foreign goods benefiting from subsidies would be subject to countervailing measures to offset the subsidy and bring the price up to market rates (Sedjo 2006).

Since 1982, there have been four major agreements with regard to the dispute. The two leading principles for these agreements are that the stumpage fees should reflect a true market price, and that Canadian softwood sawn timber would be subject to an import duty if the price was below a certain price level.

In order to make the pricing of stumpage fees transparent and accepted under the SLA a detailed system of cost assessment was developed in several provinces. These "Stumpage Assessment Manuals" consist of standard values for all relevant cost items (including reasonable values for profit and risk) in the production chain from the point of export back to the timber harvest. (Income from by-products, etc. is deducted). The balance in this model constitutes the charge for "stumpage". However, the charge is never negative: at or below zero the fee would be a symbolic charge.

The base data were submitted by the sawmill and logging companies, scrutinized by controlling political and administrative bodies. It goes without saying that this process consisted of delicate talks and negotiations both on parameter values and on the structure of the model. It is generally regarded to be a compromise between the interest of the Canadian timber industries and that of provincial governments and the US trade policy administration.

Discussion and conclusions

Clear and concise policies and rules would have several positive values related to Canadian forests. Uncertainty is reduced as the regulations generally are predicted to remain stable in the foreseeable future. Such predictions seem rational. Stable conditions are mostly preferred to uncertainty even in cases not fully optimal. These attitudes seem to prevail both for stakeholders of the allocation model (for timber, services, etc.) and for the parties covered by the pricing monitoring model under the SLA.

In cases when conflicts and calls for changes still appear, the solving process tends to involve all stakeholders in the systems, which leads to complex and lengthy procedures. As the systems are based on legal grounds, lawyers and administrators have leading roles for the outcome of the work.

For the timber industry this regulated system has led to the development of high effectiveness in the production of bulk products, e.g. "the 2x4 economy" (sawn timber: 2 inch by 4 inch, standard length). Stability of conditions, both related to policy and to access to and pricing of standing timber, has made companies confident in investing in effective technologies for large scale bulk production. The monitoring administration, "Forest Service", and the producing companies have mutually developed norms on smooth adherence to the rules for e.g. timber allocation for bulk production.

However, the SLA models seem to bring some unforeseen conserving effects on the forest industry sector. Technical and methodological innovations are rare and few new or niche business ideas have been implemented. The contrast compared to e.g. Northern Europe and East Asia is obvious. Possibly, that can be explained, at least partly, by that fact or notion, that any major cost reduction will result in higher stumpage fees, and that applications of new

methods will mean need for tedious negotiations with other stakeholders, politicians and administrators.

It has become apparent, that this strict legal and administrative norm system meets great difficulties when new and unforeseen things happen. Examples of such new interests with potential impact on the system are bioenergy, the role of forests for climate mitigation, and the increasing roles given to first nations. In the western provinces also the massive disaster caused by the Mountain Pine Beetle has led to changes of the balance of timber allocation.

The Canadian history of bioenergy had an early and successful start compared to that of most other countries. Interest in wood pellets started in the eastern provinces and spread to British Columbia in particular, leading to fast development of a large production capacity. Other bioenergy applications took place gradually also in the forest industry sector. The fuels consisted of mill residues, initially of high quality and on low price levels. Moreover, these residues were not regulated by the allocation model, and their utilization had no or very limited impact on the outcome of the SLA models. So far, the bioenergy sector was not regarded a threat by established stakeholders, and as most of the production was exported it was not disturbing the stability of the energy market.

However, when companies in the bioenergy sector started to show interest in using standing trees and logging residues for fuel and energy the traditional legal and administrative systems were challenged. The reactions differed for the various provinces in a wide range, from a total ban to harvest trees for energy purposes to starting change processes to amend the legal and administrative structures. Even minor changes took a long time, typically several years, based on talks and negotiations with all stakeholders and on political opinions. In most provinces the outcome was that bioenergy companies were allowed to compete for those timber licenses that were idle or abandoned, and that logging residues could be utilized under strict environmental restrictions. A few new projects started based on those premises, but biomass from idle and abandoned licenses are rarely the most suitable for biomass based fuels, neither with regard to the geographic location nor the wood quality.

In the meantime, bioenergy in form of wood pellets, increased very fast in other parts of the world. The fastest growth took place in US Southeast, but also Europe and Vietnam grew faster than Canada. This could happen in spite of the fact that Canada has several superior basic factors in her favor in that comparison; i.a. abundant biomass resources of good quality, suitable infrastructure, and high effectiveness of production and transport.

A distinguishing factor between Canada and successful other countries is the difference in business conditions, especially with regard to access and use of biomass raw material, but also to opportunities for financial and other support from public sources. In countries with fast bioenergy growth, the markets for biomass raw material are (more or less) free which leads to lower costs and more flexibility than in the Canadian case. Dedicated support to bioenergy may be issued by political decision makers without legal consent from other interests. In the Canadian legal structure no individual stakeholder can be favored without the agreements from the others; in particular for non-traditional activities like bioenergy.

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