Chapter 2
Methods and Related Work

Abstract This chapter gives an overview of related research and outlines the methods applied in the present study. The study is analysing three real case biomass supply chains with an in-depth assessment of individual variables underlying actual market actions. Because of increasing biomass resources and recent dominance over pellet imports into the European market, the considered origin countries are Western Canada, Western Australia, and Northwest Russia. Studied supply phases include the raw material production and delivery, pellet production, transport to Europe, as well as delivery and conversion in a coal based co-firing power plant in the EU. The specific supply costs from origin country to the EU are derived from current market and country related data. For evaluating the pellets production and end-conversion in power plants, a full cost account is applied. For most vulnerable, market-related cost items the imputed risk is evaluated as effect of underlying price changes in a 3- to 10-year period. Corresponding de-risk strategies are concluded from expert interviews.

Keywords State of research • Case study approach • Cost account • Risk evaluation

2.1 State of Biomass Supply Chain Research

Since the last 10–15 years, several studies have been dealing with modelling and optimisation of particular biomass supply chains using GIS models, linear or mixed integer modelling (see e.g. Freppaz et al. 2004). These all have a specific focus (e.g. optimisation of logistics, costs or allocation of resources), and respond to a given framework and several assumptions. That is a local logistics network,

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specific transportation means or the allocation of resources for specific end-use demand. Though, these models represent the actual market situation only little.

More focussed on actual trade flows, a comprehensive model on biomass supply chains was accomplished by Hamelinck et al. (2005) comparing different international bioenergy chains to Europe with focus on logistics. An evaluation of supply costs from Argentina to the Netherlands was done by Uasuf (2010). Costs for the pellet supply from British Columbia to the EU has been assessed before by Sikkema et al. (2010). In several market reports, the given framework for international biomass trade and specific aspects like shipping (Bradley et al. 2009) or equity and investments (Bradley 2010) are discussed. Moreover, in a scenario-based study Heinimö (2011) determined critical factors for the future development of the global (solid) biomass market (Heinimö 2011):

- Price competitiveness of bioenergy
- Energy policy (subsidies, R&D)
- Imbalance between supply and demand of bioenergy (sources)
- International agreements
- Sustainability issues to the utilisation of biomass

These existing studies serve as profound background and for comparison of assessed supply chains in this thesis. Nevertheless, so far there has been hardly any study, which combines an analysis of real case biomass supply with a detailed assessment of individual variables underlying actual market, regulatory and technology actions.

2.2 Case Study Compilation

Three different case studies for pellet imports to Europe are investigated for associated supply costs from resource origin to end-user in the EU, following the pattern in Fig. 2.1. Studied phases include the raw material production and delivery, pellet production, transport to Europe as well as delivery and conversion in a coal-based co-firing power plant, located 75 km from EU import harbour. Because of increasing biomass resources and recent dominance over pellet imports into the European market, British Columbia (Canada), Western Australia, and Northwest Russia are chosen as the case studies (Junginger 2012; Lamers et al. 2012; Röder 2012). They further offer a good comparison as they differ significantly in biomass source, distance and region.

Related work was accomplished by Hamelinck et al. (2005) comparing different international bioenergy chains to Europe with focus on logistics. An evaluation of supply costs from Argentina to the Netherlands was done by Uasuf (2010). Costs for the pellet supply from British Columbia to the EU has been assessed before by Sikkema et al. (2010), who already discussed price sensitivities. These existing studies serve as profound background and for comparison of assessed supply chains in this work. The present study reassesses the Canadian case

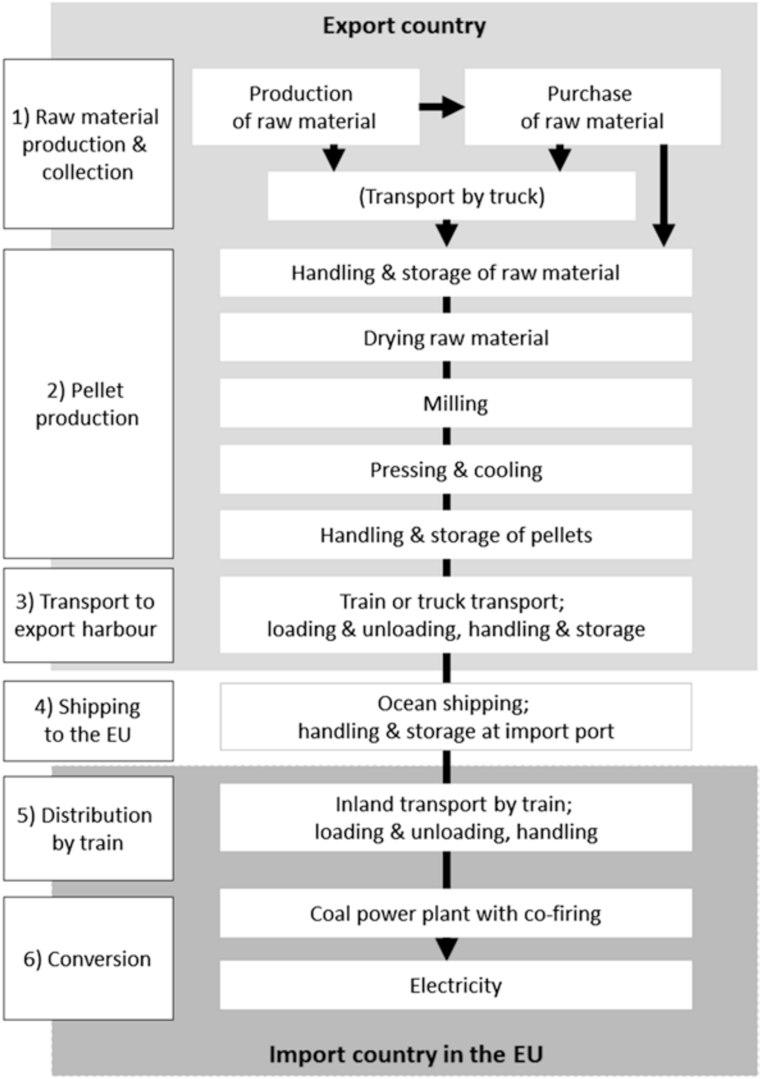

Fig. 2.1 Outline of pellet supply chain model

because of its prominent role in pellet exports to the EU, in order to vary input parameters and with the new target to explore price risks along the supply chain.

The pellet production phase and logistic operations are based on typical capacities and on technology in use in the respective countries. For all chains, two fuel options are distinguished for drying the raw material: biomass (Bio) and natural gas (NG). As result, a detailed description of the three pellet supply cases from resource origin to conversion plant in Europe is presented in Sects. 3.1–3.3.

Due to high ash contents caused by bark or other impurities, the considered pellets fulfil the B category according to the current standard for wood pellets (EN 14961-2:2011). Thus, the pellets are suitable for industrial use only. All information and calculations in this study are based on the net calorific value of fuels, which is 4.9 MWh/t for pellets with 6 % moisture content (mc) delivered at the conversion plant and 7.8 MWh/t for hard coal with <2 % mc. These specifications reflect average values for the considered fuels.

2.3 Cost Assumptions

The specific supply costs from origin country to the EU are derived from current market and country-related data. This approach has been applied in several other studies (Hamelinck et al. 2005; Sikkema et al. 2010; Uasuf 2010). Thereby, costs of raw material delivered to the pellet plant, transport rates and logistic costs, common for the specific chain, are requested from transportation operators, bioenergy traders and experts. The cost term refers to the costs, which occur from the end-user perspective. By nature, these costs are also composed of prices, such as for feedstock, fuels or freight rates. Thus, the price influence on costs is examined subsequently (see Sect. 2.4).

For evaluating the pellets production and end-conversion in power plants, a full cost account on annual base according to VDI 2067 is applied. This allows to consider different options for raw material, fuel use and varying other parameters. Corresponding technology and cost parameters for a 40,000 t/a or 120,000 t/a pellet plant and a 800 MW_{el} coal power plant are based on the studies by Obernberger and Thek (2010) and BMU (2010) and are outlined in the Appendices (Tables A.1, A.2, A.3). The annual capital costs are calculated according to Eqs. 2.1 and 2.2.

Capital costs

$$C_c = I_0 \cdot CRF \tag{2.1}$$

where C_C is the capital costs, I_0 the Initial investment costs and CRF the capital recovery factor.

Capital recovery factor

$$CRF = \frac{(1+i)^n \cdot i}{(1+i)^n - 1} \tag{2.2}$$

where i is the interest rate of the project, and n is the lifetime of equipment.

The electricity production costs (without heat extracts) are calculated according to Eq. 2.3.

Levelised costs of electricity

$$C_{el} = \frac{C_C + OM}{E} + \frac{C_F}{\eta \cdot 0.0036} + CO_2\,\text{costs} \tag{2.3}$$

Table 2.1 Currency exchange rates to Euro for the year 2011

1 € corresponds to	Currency
1.35	Australian dollar: AUS-$
1.38	Canadian dollar: CAN-$
40.88	Russian rouble: RUB
1.39	US dollar: US-$

Source Eurostat (2012a)

where C_{el} are the levelised costs of electricity [€/kWh], OM are the annual costs for operation, maintenance and other costs [€/a], calculated as relative share (%) of investment costs, E is the annual electricity production [kWh], C_F are the annual fuel costs [in € per primary GJ], η is the efficiency of the plant [%], and CO_2 costs are the charged EU emission allowances for combusting the used fuel [€/kWh].

In this work a 10 % co-firing of pellets (80 MW_{el} installed biomass capacity) is regarded as technically viable. Assumed extra costs due to co-firing pellets can be found in the Appendices (Table A.2).

The underlying cost data for energy conversion are adjusted using current fuel prices (EEX 2012a, b). The allocated CO_2 emissions from combustion of hard coal are calculated according to the EU's emission trading system (EC 2007). All calculations are estimated in € using the exchange rates for 2011 (see Table 2.1). VAT, profit margins or supply charges are not included. The results are presented either in €/t pellets (delivered at import harbour or conversion plant) or in €/MWh_{el} converted energy. The resulting structuring of cost data along the supply chain in Sect. 3.1–3.3 is inspired by Sikkema et al. (2010).

2.4 Evaluation of Price Risks

2.4.1 Methodology for Evaluating 10-year Price Variations

The defined supply costs are basis for evaluating market risks in the supply chain. Thus, for most vulnerable, market-related cost items the imputed risk is evaluated as effect of underlying price changes. This is a common approach during cost accounting for entrepreneurial activities. That means, based on historical price variations within one contractual period, the expected losses or revenues for the future period can be extrapolated (Mumm 2008). Certain attempts of this approach have been performed for individual price effects by Sikkema et al. (2010) or in connection with sensitivity analyses by Uasuf (2010). Sikkema et al. (2011) further explored the general market and trade conditions and prospects of the European pellets market. Anyway, so far there has been no comprehensive price risk analysis for pellet supply chains.

First, most relevant price variations within the recent 10 years are identified and determined. The 10-year period covers the time frame the pellet market has just

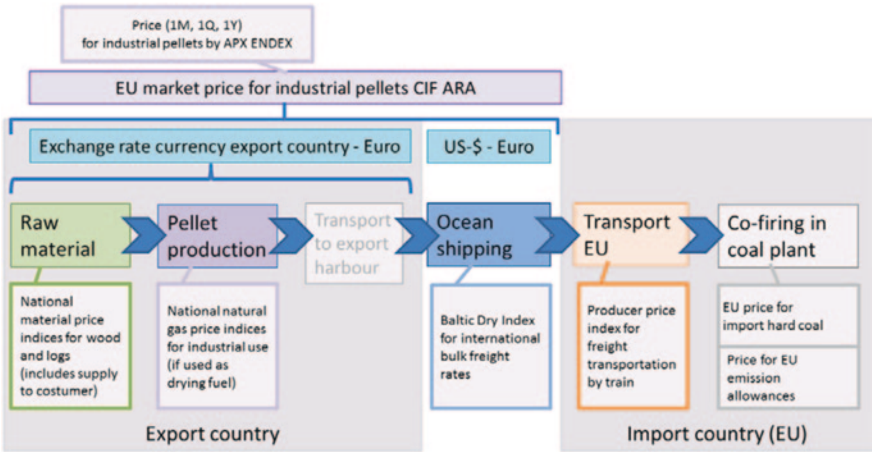

Fig. 2.2 Considered price indices for modelling price fluctuations along pellet supply chains destined for EU co-firing

evolved. Hence, a straightforward and unambiguous statistical analysis is applied by assessing the range of price variations as factors of total supply chain costs.

As shown in Fig. 2.2, different price indices along the supply chain have been identified. The stated data series for a 10-year period are inflation-adjusted using the relevant consumer price indices (Eurostat 2012b).

Based on the evaluated costs for Canadian, Australian and Russian pellets exported to the EU, the total supply costs free conversion plant are assumed to be arithmetic mean. With that, the relevant price variation—in terms of their standard variation or range—is charged as multiplier of the respective cost share in the supply chain (see Eqs. 2.4 and 2.5). In that way, the price effect of each factor on total costs can be revealed.

Supply costs subject to standard variation of price index xp

$$\boldsymbol{C}_{\boldsymbol{Total}(x,\sigma_{xp}^{+/-})} = \boldsymbol{C}_x \cdot \left(\mathbf{1} + \boldsymbol{\sigma}_{xp}^{+/-}\right) + \sum_{i=1, i \neq x}^{n} \boldsymbol{C}_i \tag{2.4}$$

where $C_{Total(x,\sigma_{xp}^{+/-})}$ are the total supply costs, which are subject to the standard deviation of price index xp in cost item C_x[€/t], $\sigma_{xp}^{+/-}$ is the negative (−) or positive (+) standard deviation of index xp, described as percentage of arithmetic mean of index xp [%] and C_i are the cost components 1 to n in the supply chain [€/t].

Supply costs subject to lower and upper range limit of price index xp

$$\boldsymbol{C}_{\boldsymbol{Total}(x,R_{xp}^{+/-})} = \boldsymbol{C}_x \cdot \boldsymbol{R}_{xp}^{+/-} + \sum_{i=1, i \neq x}^{n} \boldsymbol{C}_i \tag{2.5}$$

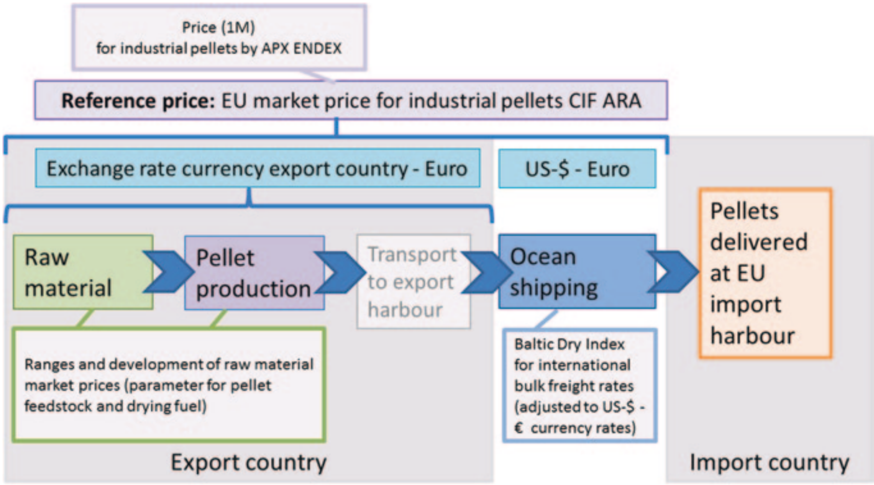

Fig. 2.3 Considered indices and prices for simulating 3-year-price fluctuations

where $C_{Total(x,R_{xp}^{+/-})}$ are the total supply costs, which are subject to the lower $\left(R_{xp}^{-}\right)$ or higher $(R_{xp}{}^{+})$ range of price index xp in cost component x.

The corresponding results are described in Sect. 4.2.

2.4.2 *Methodology for Evaluating Recent 3-year Price Variations*

After the observation of long-term price variations, actual price changes in the 3-year period from 2008 to 2011 are investigated. A period of 3 years complies with the typical (long-term) planning and contracting horizon of pellet producers and end-users (Alakangas et al. 2012; Sikkema et al. 2011).

The simulation of the recent 3-year variations reflects the cumulative annual price changes due to raw material prices, exchange rates and ocean shipping rates as the most crucial price factors (see Fig. 2.3). Apart from that, all other costs are assumed to be constant as defined for 2011, the "base price" (see Sect. 3.4). The EU pellet market price for imported pellets reported by APX (2012) serves as reference.

For actual pellet feedstock price variations (see Sect. 4.1.1. for explanation) the use of alternative assortments is considered. Due to higher quality, the delivery over long distances or demand from other industries, this feedstock is associated with higher purchase prices, see Table 2.2. For Australia, the case of cheaper alternative sawdust at minor costs is investigated as well (May 2012).

The results of the 3-year price simulation are displayed in Sect. 4.3.

Table 2.2 Price variation of raw material in the case study countries

Country	Price changes (in brackets the base price considered for cost analyses in Sect. 2.3)	Unit and biomass assortment	Sources
Canada	65 (32)	€/t_{dry} harvest residues	Bradley (2012), Murray (2012)
Russia	40 (22)	€/t_{dry} sawmill residues purchased	Cocchi et al. (2011)
Australia	70 (39)	€/t_{dry} low value plantation whole tree chips (assumed)	Clean Energy Council (2010) Stucley et al. (2012)
	11	€/t_{dry} sawdust	May (2012), Clean Energy Council (2010)

2.4.3 Expert Interviews on Supply Risks and De-risk Strategies

The risk analysis is complemented by personal communications with pellet market actors and related literature regarding their evaluation and hedging mechanisms against price risks in international biomass trade. The interviews were conducted face-to-face or via e-mail, following a semi-structured guideline. For confidentiality reasons, interview results containing potential sensitive data are indicated in aggregated form (Interviews 2011–2013). With these, insight is gained into possible hedging and contractual provisions to catch arising price gaps. Resulting findings can be found in Sects 4.1 and 4.4.

References

Alakangas E, Junginger M, van Dam J, Hinge J, Keränen J, Olsson O, Porsö C, Martikainen A, Rathbauer J, Sulzbacher L, Vesterinen P, Vinterbäck J (2012) EUBIONET III – Solutions to biomass trade and market barriers. Renew Sustain Energ Rev 16(6):4277–4290

APX-ENDEX (2012) Historical pellets market prices, Weekly prices. Compilation by Sipke Veer, Amsterdam, 14.07.2012

Bradley D (2010) Canada Report on Bioenergy 2010, Sponsored by Canadian Bioenergy Association, Natural Resources Canada, Canadian Wood Fibre Centre, Wood Pellet Association of Canada, Ottawa, 15 Sept 2010

Bradley D (2012) Canada—biomass supply/demand, export availability. In: Proceedings of world bioenergy 2012, Jönkoping, Sweden, 30 May 2012

Bradley D, Diesenreiter F, Wild M, Tromborg E (2009)World Biofuel Maritime Shipping Study. Report accomplished for IEA Task 40. Ottawa, Vienna, 01 July 2009

Clean Energy Council (2010) Bioenergy industry, report prepared by stephen schuck. Killara, Australia, June 2010

Cocchi M, Nikolaisen L, Junginger M, Sheng Goh S, Heinimö J, Bradley D, Hess R, Jacobson J, Ovard LP, Thrän D, Hennig C, Deutmeyer M, Schouwenberg PP, Marchal D (2011) Global wood pellet industry market and trade study, prepared for IEA Bioenergy Task 40: International sustainable bioenergy trade, Florence, Dec 2011

European Commission (2007) Commission decision of 18 July 2007 establishing guidelines for the monitoring and reporting of greenhouse gas emissions pursuant to Directive 2003/87/EC of the European Parliament and of the Council. (2007/589/EC), Official Journal of the European Union, L 229/1, Brussels, 31 Aug 2007

European Commission, Eurostat (2012a) Euro/Ecu Exchange rates 2000—2011. Quarterly data, Brussels, last update 04 July 2012

European Commission, Eurostat (2012b) Harmonised Consumer Price Index—Inflation rate 1997—2011 European and Non-European countries, Brussels, 2012

European Energy Exchange (2012a) ARA Coal Year Futures, Request of historical prices from 2006 to Oct 2012 at: http://www.eex.com/de/Marktdaten/Handelsdaten/Kohle/Coal. Accessed 15 Oct 2012

European Energy Exchange (2012b) Prices and trade volume of EU Emission Allowances, Request of historical prices and volumes at: http://www.eex.com/de/Marktdaten/Handelsdaten/Emissionsrechte. Accessed 15 Fib 2012

Freppaz D, Minciardi R, Robba M, Rovatti M, Sacile R, Taramasso A (2004) Optimizing forest biomass exploitation for energy supply at regional level. Biomass Bioenergy 26:15–25

Hamelinck C, Suurs R, Faaij A (2005) International bioenergy transport costs and energy balance. Biomass Bioenergy 29(2):114–134

Heinimö J (2011) Developing markets of energy biomass—local and global perspectives. Ph.D. thesis at Mikkeli University, Mikkeli, Finland

Interviewed pellet producers, traders and end-users (2011–2013) Personal communication with: Dusan S (2011), Black pellets manager of Vattenfall Europe AG, 08 Aug 2011. Hermes HD (2012) Director Business Development Biomass of Vattenfall Europe GmbH, 29 Oct 2012. Mertens J (2013) Biomass Procurement Officer at GDF Suez, 07 Feb 2013. Lugner M (2012) Sales Manager Max Lugner from pellets producer Schweighofer, 15 Jun 2012. Pease H (2013) Senior Biofuel Portfolio Manager for RWE Supply and Trading, 18 Aprl 2013

Junginger M (2012) Overview of global solid and liquid biomass trade for energy. In: Proceedings of IEA Bioenergy Conference 2012, Vienna, 13–15 Nov 2012

Lamers P, Junginger M, Hamelinck C, Faaij A (2012) Developments in international solid biofuel trade—An analysis of volumes, policies, and market factors. Renew Sustain Energ Rev 16(5):3176–3199

May B (2012) Personal communication about biomass prices and the australian biomass market with former researcher at commonwealth scientific and industrial research organisation (CSIRO). Aust Natl Sci Agency 06(08):2012

Mumm M (2008) Kosten- und Leistungsrechnung: Internes Rechnungswesen für Industrie- und Handelsbetriebe. Springer, Hamburg

Murray G (2012) Personal e-mail communication with executive director of the Wood Pellet Association of Canada, 22 Oct 2012

Obernberger I, Thek G (2010) The pellet handbook. The production and thermal utilisation of biomass pellets, Earthscan, London

Röder H, (2012) Global development of bioenergy, presentation from Pöyry consulting at University of Applied Sciences Wiener Neustadt. Wieselburg, Nov 2012

Sikkema R, Junginger M, Pichler W, Hayes S, Faaij A (2010) The international logistics of wood pellets for heating and power production in Europe: Costs, energy-input and greenhouse gas balances of pellet consumption in Italy, Sweden and the Netherlands. Biofuels Bioprod Biorefinery 4(2):132–153

Sikkema R, Steiner M, Junginger M, Hiegl W, Hansen MT, Faaij A (2011) The European wood pellet markets: current status and prospects for 2020. Biofuels Bioprod Biorefinery 5(3):250–278

Stucley C, Schuck S, Sims R, Bland J, Marino B, Borowitzka M, Abadi A, Bartle J, Giles R, Thomas Q (2012) Bioenergy in Australia, Status and Opportunities. Report, Surrey Hills, Victoria, Nov 2012

Uasuf A (2010) Economic and environmental assessment of an international wood pellets supply chain: a case study of wood pellets export from northeast Argentina to Europe. Doctoral thesis, Albert-Ludwigs-Universität Freiburg im Breisgau, Faculty of Forest and Environmental Sciences, Dec 2010

Umweltbundesministerium (ed) (2010) Leitstudie 2010—Langfristszenarien und Strategien für den Ausbau der erneuerbaren Energien in Deutschland bei Berücksichtigung der Entwicklung in Europa und global, Appendix II, Stuttgart, Kassel, Teltow, Dec 2010

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