SolidStandards

Enhancing the implementation of quality and sustainability standards and certification schemes for solid biofuels (EIE/11/218)

D4.2

Implementation of European Quality Standards: 7 Case studies

Co-funded by the Intelligent Energy Europe Programme of the European Union

The SolidStandards project

The SolidStandards project addresses ongoing and recent developments related to solid biofuel quality and sustainability issues, in particular the development of related standards and certification systems. In the SolidStandards project, solid biofuel industry players will be informed and trained in the field of standards and certification and their feedback will be collected and provided to the related standardization committees and policy makers.

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About this document

This is **Deliverable 4.2** of the SolidStandards project. It is the report on feasibility studies for standard implementation in 7 companies. This document was finalised in March 2013 by:

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1. Introduction

This report documents the feasibility studies for the implementation of the new European quality standards (EN 14961 and EN 15234) in 7 companies.

The requirements for a quality assurance system formulated in the several parts of EN 15234 had to be adapted to the specific conditions of the selected supply chains and companies in the several countries.

Only for the wood pellets sector experience in the practical implementation of the quality assurance standard EN 15234 was available. The project partners selected supply chains that are typical for their countries and of high importance for the further development of the respective solid bioenergy sector. The described supply chains did not always fit into the structure given by the quality assurance standard EN 15234 (e.g. the wood chips supply chain described by VTT), so the requirements of the standard had to be adapted to the respective situation. The project partners involved into the work package needed more time than expected to find ways to transfer the requirements.

It turned out very soon that some standards are not applicable in some parts (e.g. quality assurance standard EN 15234-4 for wood chips). In these cases ways had to be found to develop alternatives which meet the spirit of the standard but also match to the possibilities of the stakeholders to create a quality assurance system.

In the table below the selected supply and production chains assessed in this report are shown as well as the project partners who carried out the studies.

Table: selected production and supply chains.

Partner	Country	Issue
DBFZ	Germany	Production of wood pellets
VTT	Finland	Wood chips supply chain
Regea	Croatia	Production of wood pellets
BAPE	Poland	Production of non-woody pellets
HFA	Austria	Production, trade & logistics of wood chips
ERATO	Bulgaria	Trade & Logistics of wood pellets & wood chips
FORCE	Denmark	End-use in power generation (wood chips)

2. Feasibility studies

2.1. Production of wood pellets in Germany (DBFZ)

2.1.1. Background information

2.1.1.1. Description of the company

Pfeifer Group is a wood industry company with 1,500 employees at nine production sites in Austria, Germany and the Czech Republic. Main field of activity is the production of sawn timber. Over the years facilities for the production of various derived timber products have been put into operation. Today Pfeifer Group runs four ENplus certified wood pellets production sites with an overall capacity of 380,000 tonnes per year.

In 2009 the subsidiary Pfeifer Holz Lauterbach GmbH came on stream producing about 600,000 m^3 sawn timber and about 200,000 m^3 pallet blocks per year. The limited liability company with currently 180 employees is situated at Lauterbach in central Germany.

The company is currently building up a new pellet plant with a production capacity of about 100,000 tonnes per year. A 2 to 3-shift operation is planned producing only high quality pellets according to EN 14961-2, class A1 (properties see annex) with a diameter of 6 mm. In the first years a yearly production of about 60,000 tonnes is planned. The company will seek an ENplus certification for the production site.

2.1.1.2. Description of raw material supply

In the beginning only the use of by-products from the company-own sawmills is planned. Feedstock for the production is about 60% norway spruce, about 40% scots pine and very small amounts of fir. The purchase of additional raw material from foreign sources is not planned yet but might be necessary from time to time in the long term. The raw material code according to EN 14961-1 is 1.2.1 (chemically untreated by-products ad residues from wood processing industry). The wood processed at this site of the company is PEFC certified.

2.1.1.3. Customer description

To put the pellets on the market, it is planned to cooperate with local pellet traders in order to supply small and medium scale end-users in the region, no direct marketing is planned.

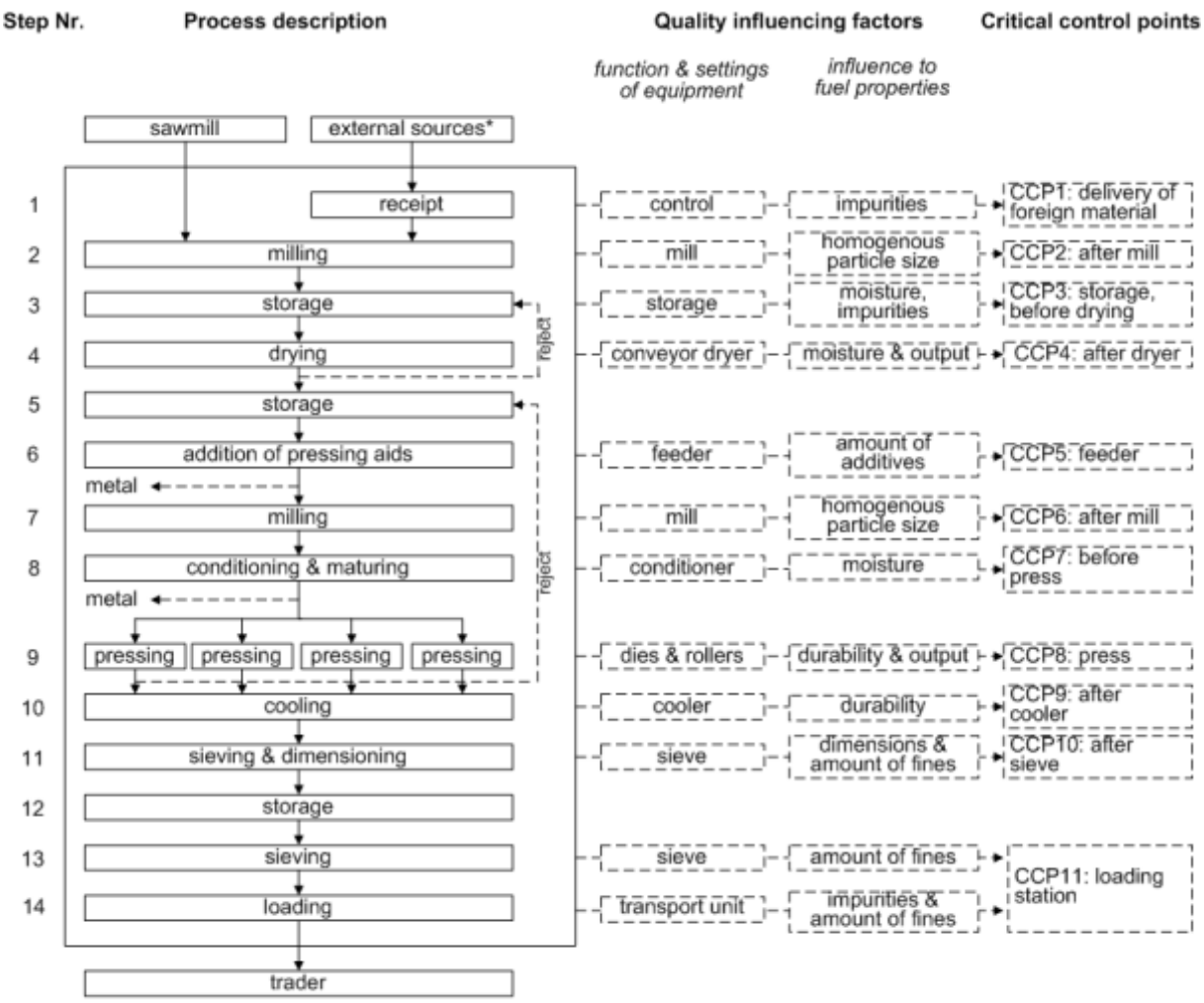
2.1.2. Production chain analysis

The methodology for the assessment of the production chain and the implementation of a quality assurance system has been done according to the procedure defined in EN 15234-2:

- (Step1: Definition of fuel requirements, see Appendix I)
- Step 2: Process description (see 2.2.2.1)
- Step 3: Identification of quality influencing factors (see 2.1.2.2)
- Step 4: Definition of critical control points (see 2.1.2.3)
- Step 5: Selection of appropriate quality assurance measures (see 2.2.3)
- (Step 6: Routines for separate handling of nonconforming raw materials and pellets, The rejection of non-conforming material is possible at two points in the production process, see 2.2.2.1)

For clarity purposes quality influencing factors as well as critical control points have been included into the process description.

2.1.2.1. Process description (step 2)



* foreign sources: Supply from other saw mills of Pfeifer Group (currently not planned)

2.1.2.2. Identification of quality influencing factors (step 3)

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1	receipt of raw material	suitability & cleanliness of transport unit	Impurities might cause problems during further processing of the material or during handling/ combustion of the fuel
2&7	milling	condition of mill and the attached sieves	Heterogeneous size distribution may influence the performance of dryer and pellet press; furthermore the amount of fines, mechanical durability and dimension of the produced pellets
3	storage	storage conditions	The uptake of moisture reduces the output of the dryer. Split sand and soil can contaminate the material when storing open air.
4	drying	temperature and time of residence	The durability of pellets is poor when raw material is to wet before pelletising.
6	feeding of pressing aids	amount of pressing aids in the pellets	Output of pellet presses, permissibility according to EN 14961-2 (max. 2%)
8	conditioning & maturing	amount and temperature of water, residence time	Output of pellet presses and durability
9	pressing	geometry of bores, condition of the roller, temperature	Output of pellet presses, durability of pellets and amount of fines
10	cooling	temperature	Durability of pellets
11 & 13	sieving & dimensioning	condition of sieves, setting of dimensioning equipment	Amount of fines and overlong pellets
14	loading	suitability & cleanliness of transport unit	Impurities might cause problems during handling/ combustion of the fuel

2.1.2.3. Definition of Critical control points (CCPs, step 4)

Critical Control Points are points within or between processes at which properties can be most readily assessed and the points that offer the greatest potential for quality improvement.

CCP Nr.	Critical control point	How to control	Frequency of control
CCP1	Delivery of raw material	visual control	when unloading transport unit
CCP2	After mill	visual control	periodical, once per day
CCP3	Before drying, when stored open air.	visual control	periodical, once per day
CCP4	After dryer	automatic control	permanent
CCP5	Feeder	calculation	periodical, once per week
CCP6	After mill	visual control	periodical, once per day
CCP7	Before press	automatic control	permanent
CCP8	Press	visual control/ automatic: temperature	periodical, once per week/ permanent
CCP9	After cooler	automatic control	permanent
CCP10	After sieve	visual control	periodical, once per week
CCP11	Loading station	Fines: sampling & analysis Suitability of transport unit: visual control	when loading

2.1.3. Definition of quality assurance measures

Since the company aspires an ENplus certification not only the requirements of EN 15234-2 but also those of the ENplus certification scheme will be respected.

2.1.3.1. Staff

The prospective facility manager of the new pellet plant has already been working at another pellet production site of Pfeifer Group. He will be the quality assurance manager of the site.

Measure	Frequency
Training workshop for the employees (analysis of fuels, documentation, other qa-measures)	once per year

2.1.3.2. Facilities & equipment

Since Pfeifer Group already runs four pellet plants, the construction of adequate facilities and the installation of adequate equipment can be presumed:

- the production equipment is suitable for the production of high quality wood pellets
- the storage facilities are constructed in a way that prevents the pollution of raw materials and pellets as well as the absorption of water by the produced pellets
- technical equipment for the automatic control of important production parameters (see 2.1.2.3) exist
- At two important CCPs (CCP4 and CCP8) non-conforming material can be rejected into the production process
- At two points in the production chain (after the addition of pressing aids and after the conditioner) metal impurities are removed
- Equipment to screen out the fines is incorporated into the loading station (process step 14)

Measure	Frequency	Related to process step(s)
Periodic visual controls of manipulation areas and storages and conveyors	Periodic, once per week	3
Controls of settings, functions and condition of the equipment at CCPs 2, 3, 6 (see 2.1.2.3)	Periodic, once per week	2, 3, 7
Controls of settings, functions and condition of the equipment at CCPs 5, 8, 10, 11(see 2.1.2.3)	Periodic, once per week	6, 9, 11, 13

2.1.3.3. Product quality

Measure	Frequency	Related to process step(s) nr.
Product testing: Dimension (EN 16127), Bulk density (EN 15103), Mechanical durability (EN 15210 or Lignotester), Moisture content (EN 14774)	once per hour	11
Product testing: Amount of fines (EN 15149)	once per hour	14
Quality check after repair and maintenance work	when necessary	2-14
Quality check after the correction of malfunctions of the equipment	when necessary	2-14
Search for the reasons for complaints	when necessary	

2.1.3.4. Intersection points to upstream and downstream stakeholders in the supply chain

Measure	Frequency	Related to process step(s) nr.
Visual inspection of incoming raw material from foreign sources	every time when loading	1
Control of pellet temperature (not more than 40°C)	every time when loading	14
Control cleanliness of transport units (not special vehicles for the exclusive transport of wood pellets)	every time when loading	14
Delivery; Reference sample (at least 1.2 kg/day, when more than 3 trucks per day, 0.5 kg/truck). Documentation of date, amount, license number of transport unit.	every time when loading	14

2.1.3.5. Documentation

All quality assurance measures mentioned above have to be documented. The form of documentation is up to the respective company.

Issue	Document *
Amount and origin of incoming raw material from own sources (incl. declaration of origin and source according to EN 14961-1, table1; amount of FSC & PEFC-certified material)	purchase journal
Amount and origin of incoming raw material from foreign sources (incl. delivery contracts, declaration of origin and source according to EN 14961-1, table1; amount of FSC & PEFC-certified material). Results of the visual inspections.	purchase journal
Pressing aids: dosage & type, chemical composition, supplier, results of the visual inspections	purchase journal, operation journal
Amount of certified and non-conforming material produced at the site.	operation journal
Malfunctions of the production process (date, type of malfunction, measures taken to remedy the problem, quantity and disposition of the non-conforming pellets; see 2.1.3.2)	operation journal
More extensive repair and maintenance type that could lead to a change in pellet quality (date, type of work performed; see 2.1.3.2)	operation journal
Proof of competence of the quality assurance representative (at Least 2 years of work experience in pellet production OR a master craftsman's diploma OR a graduated study course)	staff documentation
Annual employee trainings (date, participants, contents; see 2.1.3.1)	staff documentation
Areas of responsibility of the individual employees (function descriptions; see 2.1.3.1)	staff documentation
Results of the self-inspections (see 2.1.3.3)	laboratory logbook
Documentation of outgoing goods: date, amount, name of customer, number of reference sample (see 2.1.3.4), license number of transport unit. Last freight when the pellets are transported by a freight forwarding company.	sales journal
Customer complaints (date results of the findings, measures taken to remedy the defects if necessary)	complaints documentation

* recommendation

2.1.4. Cost-benefit analysis

2.1.4.1. Description of existing approaches

In contrast to most of other fields of solid biofuel production, most of the German wood pellet plants produce in industrial scale; procedures for production processes as well as documentation requirements are mostly described in a precise way. Furthermore 53 pellet production companies hold a DINplus certificate, 20 companies an ENplus certificate (status September 2012). Some of the ENplus requirements are even stricter than those formulated in EN 15234-2. For that reason a high awarenes for quality aspects can be assumed in the sector. As described in 2.1.1.1, the other pellet plants operated by Pfeifer Group are holding an ENplus certificate.

The following approaches for a quality assurance system have allready been included into the planning of the plant at Lauterbach site:

- The facilities as well as the technical equipment are state of the art and enable the production of high-quality pellets (see 2.1.3.2).
- A comprehensive planning of staff (incl. organisation chart, job specifications, substitution schedule) exists.
- Maintenance work at all relevant equipment (mills, dryer, feeding of pressing aids, conditioner, presses, cooler, sieves) is carried out periodically according to a maintenance plan.

2.1.4.2. Costs

Costs appearing once

The implementation of a comprehensive quality assurance system costs about 12,500 €. The fee for joining the certification scheme ENplus is not included.

Measure	Issue	costs
Development and implementation of a quality assurance system	5 days	4000 €
Preparation of QA documentation	2 days	1600 €
Purchase of test equipment	bulk density test bucket (150 €*), mechanical durability equipment (3750 €), moisture content equipment (2720 €*), sieve for fine particles (100 €*), scale (110 €*)	6830 €

* at DEPI online shop (www.depi.de)

Costs appearing permanent/periodical

The calculation of some of the costs in daily operation is difficult. Most of them only occur in case of unexpected incidents (e.g. malfunctions of the equipment). The appearance of these

incidents can be avoided or at least reduced by the implementation of preventive measures. That's why they are not considered at this point.

Running the quality assurance system will cost about 27,000 €/year. The self inspections and the periodic quality assurance measures are the two most important cost factors (11,000 €/year, each).

Certification costs as well as inspection costs for the external control requested by the ENplus scheme are not included into the calculation.

Measure	Issue	costs
Annual trainings for the other employees	Labour time QA manager (incl. preparation)	200 €/year
	Labour time other employees	75 €/year
Incoming goods inspection	Labour time: depending on the amount of raw material delivered from foreign sources- currently not planned	
Control of conveyors, storages & manipulation areas	Labour time 30 min/week	15 €/week
Controls of settings, functions and condition of the equipment at CCPs 2, 3, 6	Labour time 2h/week	50 €/week
Self inspections: dimensions, bulk density, mechanical durability, moisture content, amount of fines	Labour time	50 €/day
Sampling at delivery station, temperature measuring, control of cleanliness of transport unit.	Labour time	50 €/day
Documentation	Labour time: 2 days/year	1600 €/year

2.1.4.3. Benefits

The benefit by the implemenation of a quality assurance system is hardly quantifiable. On one hand, this is caused by the fact it is difficult to quantify the added value in Euro, on the other hand the described production plant does not exist already.

Benefit of the implementation of a comprehensive quality assurance system (and it's verification by a quality certification scheme) are:

- The reduction of non-conforming material causes a higher flow capacity oft he plant and reduces therefor the operating costs.
- Replacement costs and complaints can be reduced by avoiding quality problems (especially high amount of fines and fuel contaminations). Negative “word-of-mouth advertising” can be avoided.
- Gain of new costumers – in the next years a lot of combustion systems in Germany will have to be replaced. People used to the comfort of an oil-fired heating expect the same comfort from a wood pellets system. A company able to guarantee the stable high quality will be able to profit from this development.
- The use of a fuel with defined properties is a precondition for the operation of wood pellet burners according to German 1st Federal Imission Control Directive (1.BImSchV). By the existance of a quality assurance system, respective a certification seal the compliance of the produced pellets with the quality requirements can be proofed.

2.1.5. Appendices DBFZ

2.1.5.1. Appendix I: Fuel properties

Fuel properties according to ENplus certification scheme, quality class ENplus A1

Parameter	unit	ENplus A1	Analyses according to
Diameter (D)	mm	6 ± 1 or 8 ± 1 (to be stated)	EN 16127
Length (L)	mm	3,15 ≤ L ≤ 40	EN 16127
Moisture (M)	w-% [1)]	≤ 10	EN 14774-1 EN 14774-2
Ash (A)	w-% [2)]	≤ 0,7	EN14775
Mechanical Durability (DU)	w-% [1)]	≤ 97,5	EN 15210-1
Amount of fines(F)	w-% [1)]	≤ 1 [4)]	EN 15210-1
Additives	w-% [2)]	≤ 2, type and amount to be stated	-
Net calorific value (Q)	MJ/kg or kWh/kg [1)]	16,5 ≤ Q ≤ 19,0 4,6 ≤ Q ≤ 4,3	EN 14918
Bulk density (BD)	kg/m^3 [1)]	≥ 600	EN 15103
Nitrogen (N)	w-% [2)]	≤ 0,3	EN 15104
Sulphur (S)	w-% [2)]	≤ 0,03	EN 15289
Chlorine (Cl)	w-% [2)]	≤ 0,02	EN 15289
Arsenic (As)	mg/kg [2)]	≤ 1	EN 15289
Cadmium (Cd)	mg/kg [2)]	≤ 0,5	EN 15289
Chromium (Cr)	mg/kg [2)]	≤ 10	EN 15289
Copper (Cu)	mg/kg [2)]	≤ 10	EN 15289
Lead (Pb)	mg/kg [2)]	≤ 10	EN 15289
Mercury (Hg)	mg/kg [2)]	≤ 0,1	EN 15289
Nickel (Ni)	mg/kg [2)]	≤ 10	EN 15289
Zinc (Zn)	mg/kg [2)]	≤ 100	EN 15289
Ash melting behaviour (DT)	°C	≥ 1200	CEN/TS 15370-1

[1)] As received, wet basis
[2)] Dry basis
[3)]..Amount of pellets longer than 40 mm can be 1 w-%. Maximum length shall be < 45 mm
[4)].. Fines at factory gate in bulk transport (at the time of loading) and in small (up to 20 kg)and large sacks (at time of packing or when delivering to end-user)

2.1.5.1. Appendix II: Simplified product declaration

Simplified product declaration based on EN 14961-2

Product declaration based on EN 14961-2 – wood pellets	
Supplier:	Pfeifer Holz Lauterbach GmbH
Amount of delivery	5 tons
Origin:	1.2.1.2 (spruce)
Country:	Germany (or more detailed location if needed; e.g. 36341 Lauterbach)
Traded Form:	Wood pellets
Class	EN 14961-2, **A1**
Diameter class	**D06 x** D08 ☐
Chemically treated material	**No x** Yes ☐

2.2. Production of wood chips in Finland (VTT)

2.2.1. Background information

2.2.1.1. Description of the company

Forest Management Associations (FMA) are governed and financed by forest owners. FMAs offer training and guidance and provide professional assistance in forestry issues thus protecting forest owners' interests and helping to achieve set objectives. The Associations take care of planning and implementation of forestry measures in private forests. The aim is to enhance economically, ecologically and socially sustainable forestry management and use. They also provide consulting services in wood sales planning and wood sales transactions.

The Act (534/1998) on Forest Management Associations enables them to collect a forest management fee from forest owners. Every forest owner pays the fee and thus is automatically a member of the FMA in the area where his or her forest is located. Forest management fees account for approximately 20% of the Päijänne MHY associations' turnover and it is used for advising forest owners. The rest is generated by the services provided.

Päijänne Forest Management Association is situated in Central Finland, operating in the municipalities of Laukaa, Jyväskylä, Hankasalmi, Jämsä, Luhanka, Toivakka and Leivonmäki. The association has 7,800 private forest owner members. Private forest owners' forest area covers 270,000 ha with the annual growth of 1,540,000 m^3. The Forest Management Association provides services for forest owners. The aim is to increase the value of the forest holdings and to ensure the preconditions for profitable forestry. Association does not buy the stem or energy wood, only acts as an agent. One of the service options for the forest owners is that the association handles the whole sale. The volume of harvested wood fuel is primarily dependent on the forests need for thinning. If a young stand is too dense to ensure proper growth, there's a need for thinning and thus we can provide wood fuel for the buyer. Price has a great importance both for the buyer and seller. The annual logging volume is around 1,500,000 m^3 (solid). In the area there are a couple of major forest industry factories, which produce and use a lot of forest energy.

MHY Päijänne has a permanent staff of 34 persons, including temporary workers in total 150 – 170 persons. The annual turnover of wood sales is 12 – 14 million €.

Harvesting and providing wood fuel started in the beginning of year 2000. The association provides wood fuel to the municipal heating plants and also to some private users. Thus they sometimes provide forest owner's wood for other operators, e.g. UPM. MHY Päijänne is supplying forest residues and small-sized trees to road side. Currently there is no overall quality assurance system available, but defined working procedures exist for wood sale planning, trade by procuration, as well as planning and placing of wood storages.

Finland´s Forest Act and the Act of Financing Sustainable Forestry gives guidelines to sustainable forest management. MHY Päijänne is also following the TAPIO´s guidelines[1] for sustainable energy wood supply and storage.

2.2.1.2. Description of raw material supply

The raw material is forest residues and small-sized trees mainly delimbed mixture of coniferous and bread-leaf species. MHY Päijänne does not harvest or chip the wood fuels

[1] Äijälä, O., Kuusinen, M. & Koistinen, A. (eds). Hyvän metsänhoidon suositukset energiapuun korjuuseen ja kasvatukseen. Metsätalouden kehittämiskeskus Tapio, 2010, 31 p. (Best practice forest management guidelines for energy wood harvesting. (In Finnish).
http://www.tapio.fi/files/tapio/Aineistopankki/Energiapuusuositukset_verkkoon.pdf

themselves, but they use subcontractors to do the harvesting and chipping. MHY Päijänne is employing 15 subcontractors for wood cutting, forwarding, chipping and transportation of round wood and wood fuels.

The wood fuel comes from the members', church owned and other communities' forests. The association provides wood fuel both from the young forests and from the final harvest fellings. Typical final cut stand is a spruce forest, from where logging residues and stumps are harvested. Most of the wood fuel comes from young forest thinnings. Round wood is harvested by independent contractors, which include both forest machine entrepreneurs and manual felling by lumberjacks. Only small amount of these young stands are harvested as whole trees i.e. also branches and tops are retrieved for combustion. Päijänne MHY is mainly using delimbed stem wood due to environmental reasons and a better fuel quality. Multi-tree handling technique enables this is also possible in mechanical harvesting.

All wood fuel is supplied from PEFC certified forest. In Finnish Forest Certification System (FFCS) there are also criteria for energy wood.

Raw material	Classification according to EN 14961-1 (Table 1)	Remarks
Delimbed coniferous and broadleaf harvesting wood (small-sized diameter trees)	1.1.3.1 and 1.1.3.2	Sold as wood chips
Logging residues Whole trees Stumps	1.1.4.2 1.1.1.2 or 1.1.1.1 1.1.5.2	Sold as a pile at roadside (not chipped or crushed)

2.2.1.3. Customer description

The majority of the MHY Päijänne activities are related with round wood supply for forest industry. The volumes of energy wood are much smaller and mainly related with pre-commercial thinnings of young forests. In some cases logging residues are sold as one timber assortment either to the forest industry together with industrial wood assortments, or separately to a forest fuel trading company or power plant.

The main partner for wood energy is a local utility company Jyväskylän Energia Oy, for which MHY Päijänne is supplying wood fuel for the Keljonlahti CHP plant (boiler output 495 MW_{th}). Keljonlahti CHP plant is cofiring 35% wood fuels with milled peat. Keljonlahti plant is owned by a subsidiary of Jyväskylän Energia Oy, Jyväskylän Voima Oy and MHY Päijänne is one of the owners. The trade with Jyväskylän Energia is based on road side pricing of energy wood. The energy wood is chipped/crushed at the plant by a stationary crusher by the customer.

Another partner is Vakkalämpö co-operative, which is in charge of the wood fuel supply for a local district heating system in the municipality of Toivakka (0.7 MW_{th}). Toivakka is a small rural municipality with 2,400 inhabitants. MHY Päijänne provides about 80% of the wood fuels used at the Toivakka heating plant. MHY Päijänne is one of the co-owners of Vakkalämpö.

There are also a couple of occasional customers, but their role and traded wood chip amounts are minor.

This feasibility study concentrates mainly on the supply chain with Vakkalämpö co-operative.

2.2.2. Production chain analysis

2.2.2.1. Process description (step 2)

In Figure 1 the flow chart of the wood chip supply chain with Vakkalämpö is presented. The supply chains of round wood (core business) and Jyväskylän Energia Oy are presented in the Appendix 1. With occasional customers, the supply chain is similar to the one with Jyväskylän Energia.

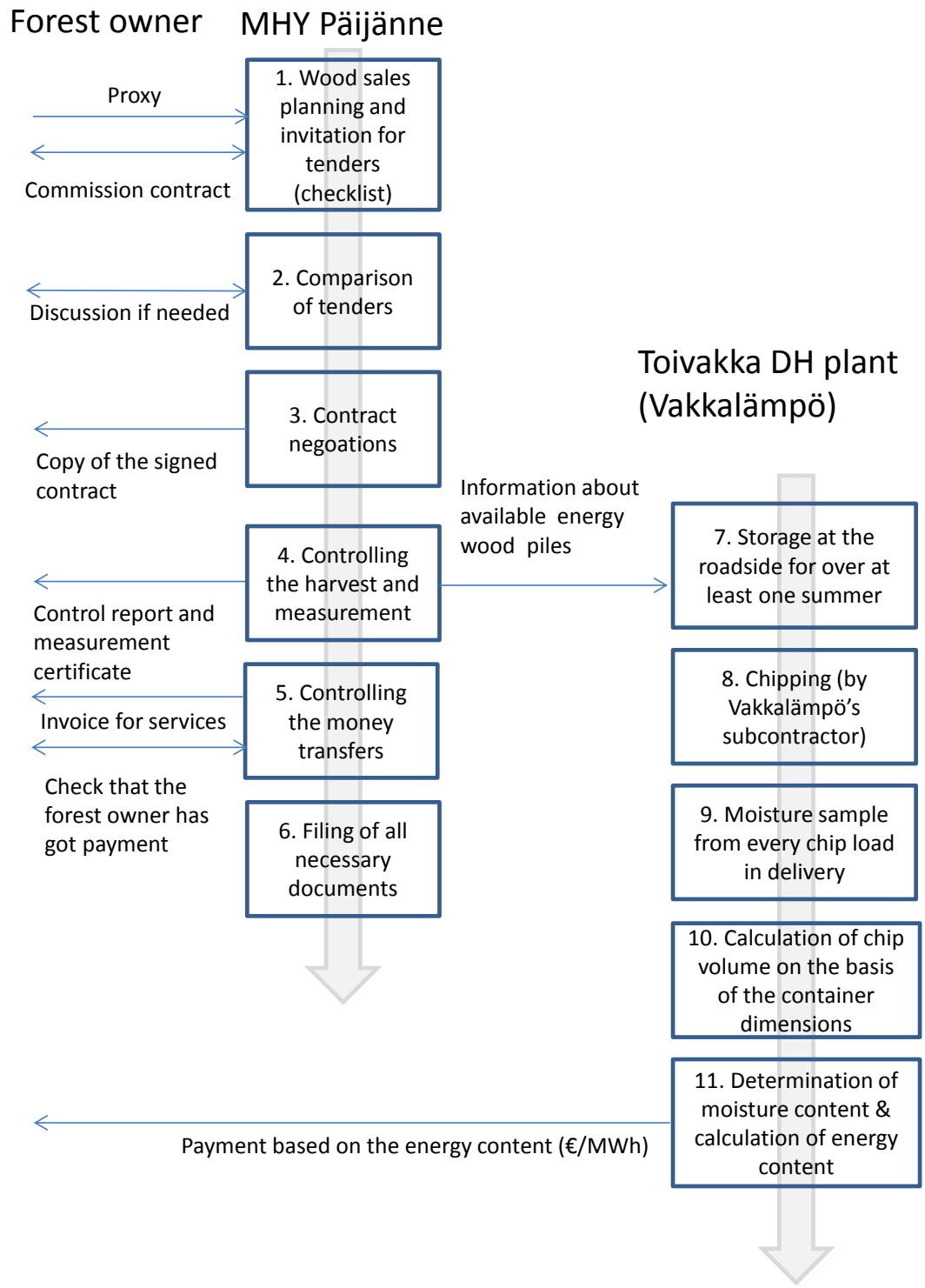


Figure 1. Wood chip supply chain for Vakkalämpö

The trade requirements for subcontractors are set in contractors´ contract. Round wood trade is based on solid m^3. Wood chipper contractor is paid according to produced chip m^3 and €/MWh. The association uses the services of independent contractors, with harvesters equipped with grapples designed for wood fuel harvesting. The buyer transports round wood from the road side storage to the final destination. Logging residues and small-size trees are chipped with truck-mounted chipper on the road side (Fig. 2). The other option includes transporting the wood to a crusher close to the user. This option usually concerns wood fuel including round wood which may have a lot of stones and other extra material to avoid injuries to the vulnerable chipper.

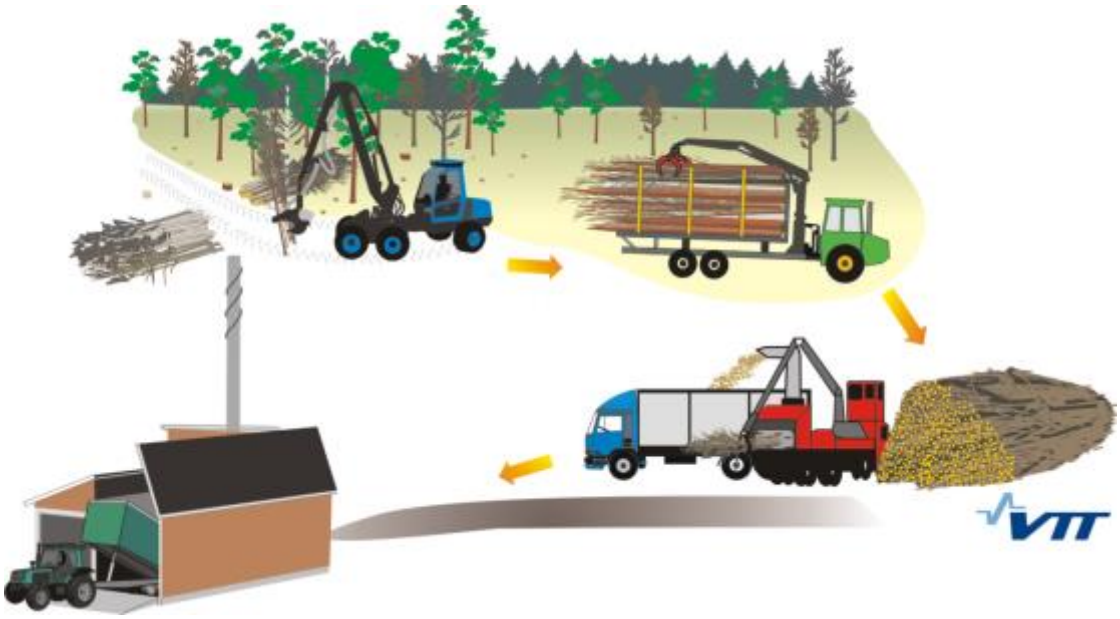


Figure 2. Supply chain from forest to Toivakka plant. Drawing: Eija Alakangas, VTT.

Requirements for storage place:

- Even, solid ground, open and windy place
- Large storage place
    - For logging residue a space requirement is about 15 – 18 m/harvested ha, when height of pile is 5 m and width 5 – 6 m and amount of round wood is 250 m^3/ha
    - For stumps a space requirement is about 15 m/harvested ha, when height of pile is 5 m and width 3 – 4 m
    - For thinning wood a whole space requirement is 12 m/harvested ha, when pile is 4-5 m height and 4 m width and amount of thinning wood is 50 m^3/ha. Amount for delimbed small-sized trees is 10 m/harvested ha.
- Avoid the following: no stones, stumps or trees near the machines and under the storage pile. Piles should have enough distance to electric and telephone lines.
- Pile is placed so that loading is possible by a grapple.
- Do not pile near buildings. Do not make a pile on ditches to avoid the nutrient loss to waterway and that energy wood stays dry.

Storage instructions of delimbed stems or whole trees (Figure 3)

- Under pile enough stems to avoid the moisture from ground or swaying of the pile and then ventilation of a pile is better
- Check that there are no stones in the pile or other impurities, which could affect chipping or combustion

- Pile should be as high as possible (4 – 5 m) so that only a small part of a pile will go wet. It is also recommended to cover the pile. Fresh wood pile should be first seasoned before covering the pile. Add some stem wood on the cover that wind does not move the cover. Also legislation of insect and fungi damages should be taken into account.
- Butts of trees should be directed towards road so that water moves toward tops. Make also one metre peak in front side of the pile.

Figure 3. A proper wood fuel storage has 1) a cover made from kraftpaper; 2) base construction to create an airspace between the storage and the ground; 3) a peak to avoid rain pouring in from the front side, and 4) adequate height (4-5 metres). Source: AFO project (www.afo.eu.com)

Figure 4. Chipping of small-sized trees by Giant drum chipper. Source: Kotimaiset Energiat Oy.

2.2.2.2. Identification of quality influencing factors (step 3)

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1	*Wood sales planning and invitations for tender*	*Recognition of suitable stands for energy wood harvesting*	*Wood species, available qualities, harvesting costs of wood chips*
4	*Controlling the harvest and measurement*	*Quality of the harvesting*	*Weather conditions, impurities*
7	*Storage at the roadside*	*Storage time and place, covering of the piles (storage instructions)*	*Moisture content, decay and mould and impurities*
8	*Chipping*	*Chipper (subcontractor)*	*Impurities, particle size*
9	*Moisture sample*	*Quality of the sampling process*	*Representativeness of the sample, moisture content*
10	*Calculation of chip volume*	*Accuracy in container dimensions and estimated degree of container fullness*	*Accuracy of the calculated energy content*
11	*Determination of moisture content & calculation of energy content*	*Representativeness of the fuel samples, accuracy with the chip volume calculation*	*Accuracy of the energy content of a chip load, accuracy of the payment to the forest owner*

Quality control of wood chips is done at Vakkalämpö plant by a plant operator. During winter about once a week 127 m^3 or full truck load (chip truck 50 m^3 and trailer 77 m^3) chip load is received. Annual delivery of wood chips by MHY Päijänne is about 4,000 bulk m^3. The plant operator takes 100 litre sample of each load for moisture content analysis. About 1.5 litre increment is staken from this amount for a moisture analysis. The moisture content is analysed by a normal cooking oven, and 24 hours is used for drying. Target for the moisture content is less than 35w-%, which is received by an adequite storage time and following general storage guidelines. In autumn 2012 the moisture content has been about 40w-%, because of wet summer and autumn. Also bulk density is analysed by a 0.1 m^3 container. Usually bulk density is less than 250 kg/loose m^3, but if moisture content is high bulk density can be more than 300 kg/loose m^3.

Every load is also checked visually to find out, if long sticks, snow or stones/sand is in the load. The quality remarks are stated in a fuel receiving report.

2.2.2.3. Definition of Critical control points (CCPs, step 4)

CCP Nr.	Critical control point	How to control [1)]	Frequency of control
CCP1	Planning	Checklist for recognizing suitable stands	Once for each sales plan
CCP2	Harvesting	Visit to the harvesting site, visual inspection	Once for larger stands, randomly for smaller ones
CCP3	Storage	Visual inspection of the stored material	Before giving the work order to the chipping contractor
CCP4	Chipping	Conditions of subcontract	Every chip load
CCP5	Receiving wood chips	Visual inspection of quality (stones, sand, oversized particles) and note in receiving report.	Every chip load
CCP6	Sampling	100 litre sample when uploading (one 1.5 litre sample for moisture content analysis)	One sample from every chip load (chip truck 50 m^3 and trailer 77 m^3)
CCP7	Chip volume and density	Analysis of bulk density by 0.1 m^3 container and delivery volume of load (chip truck and trainer)	Every chip load
CCP8	Energy content	Calculated based on bulk density and moisture content	Every chip load

[1)] e.g. *periodical visual inspections, periodical sampling and analysis or automatic instrumental controls*

2.2.3. Definition of quality assurance measures

2.2.3.1. Staff

Measure	Frequency	Related to process step(s) nr.
Working instruction for procedure description and checklist for wood sales planning Responsibility: regional forest managers (20 persons)	Every commission	1
Working instructions: procedure description for trade by proxy Responsibility: regional forest advisers (20 persons)	Every proxy assignment	1 – 6
Planning of storage and placement Responsibility: regional forest advisers (20 persons)	Every commission	7
Training of staff of MHY Päijänne for wood fuel supply	Yearly	1 – 6
Moisture content and bulk density analysis Responsible: a plant operator	Every load	9

2.2.3.2. Facilities & equipment

Measure	Frequency	Related to process step(s) nr.
Chipping and transportation to plant (subcontractor Kotimaiset Energiat Oy)		8

MHY Päijänne does not have any own equipment, all equipment is owned by subcontractors and they have their own working instructions. Chipping is done by Giant truck-mounted chipper at road side and directly to truck, which can take maximum 127 m^3 wood chips. The particle size is set by chipper screen and for smaller plants this 45 mm x 65 mm. Stones and sand cause problems for chippers, so adequate storage of wood is most essential. In order to achieve chipping efficiency also the piles should be high enough (4 – 5 m) and moisture content low, because chipping subcontractor is paid according to an energy content (chipping €/MWh and transport €/MWh/km). Contracts are made yearly basis. Kotimaiset Energiat Oy is storing each delivery document on internet based Pilvi-service, and remarks of the quality are also reported.

2.2.3.3. Product quality

Measure	Frequency	Related to process step(s) nr.
Storing over at least one summer and following storage guidelines	Every wood pile	7
Determination of moisture content and bulk density	Every chip load	9 & 11
Calculation of energy content	Every chip load	9 – 11
Ash content analysis	Occasionally, if problems e.g. sand has been detected	9

*Product declaration for wood chips produced from small-sized trees**

	Product declaration based on EN 14961-1		
Normative	Property	Unit	Average wood chip quality
	Raw material	-	1.1.3.1 and 1.1.3.2
	Dimensions, P*	mm	P63
	Moisture, M	w-%	M35
	Ash content, A*	w-% of dry matter	A1.0
Informative	Bulk density, BD	kg/m^3	BD250
	Energy density, E	MWh/loose m^3	0.80

* VTT´s estimation based on the data from Päijänne MHY.

2.2.3.4. Intersection points to upstream and downstream

Measure	Frequency	Related to process step(s) nr.
Forests owned by members of Päijänne MHY are in group forest certification. Raw material is certified and documented. Documents: a commission agreement and contract of sales	Once in each commission	1 - 3
Harvester subcontractor measures energy wood amount. Documents: an inspection report and final measurement declaration	Once in each commission	4
Vakkalämpö determinates chip amount, moisture and energy content	Once in each commission	9 - 11

2.2.3.5. Documentation

Contracts and quality reports listed in Fig.1 and in table 3.4 are stored at the office of MHY by a secretary. The chipping and transportation company is storing their own quality remarks in their own internet-based system. A plant operator reports in receiving report the moisture content, bulk density and volume and also makes quality notes in receiving report.

2.2.4. Cost-benefit analysis

2.2.4.1. Description of existing approaches

MHY Päijänne does not have any systematic quality assurance system. MHY Päijänne is following general guidelines for energy wood harvesting, storage and supplying guidelines, which are based on legislation or best practice guidelines. Main quality control measure is moisture content analysis of each load at Vakkalämpö plant and visual checking of wood chips quality. A particle size analysis has not been carried out.

MHY Päijänne aims to develop in cooperation with VTT a quality assurance system (EN 15234-1 or 4), fuel specification (EN 14961-1 or 4) and a quality manual for wood chip production.

2.2.4.2. Costs

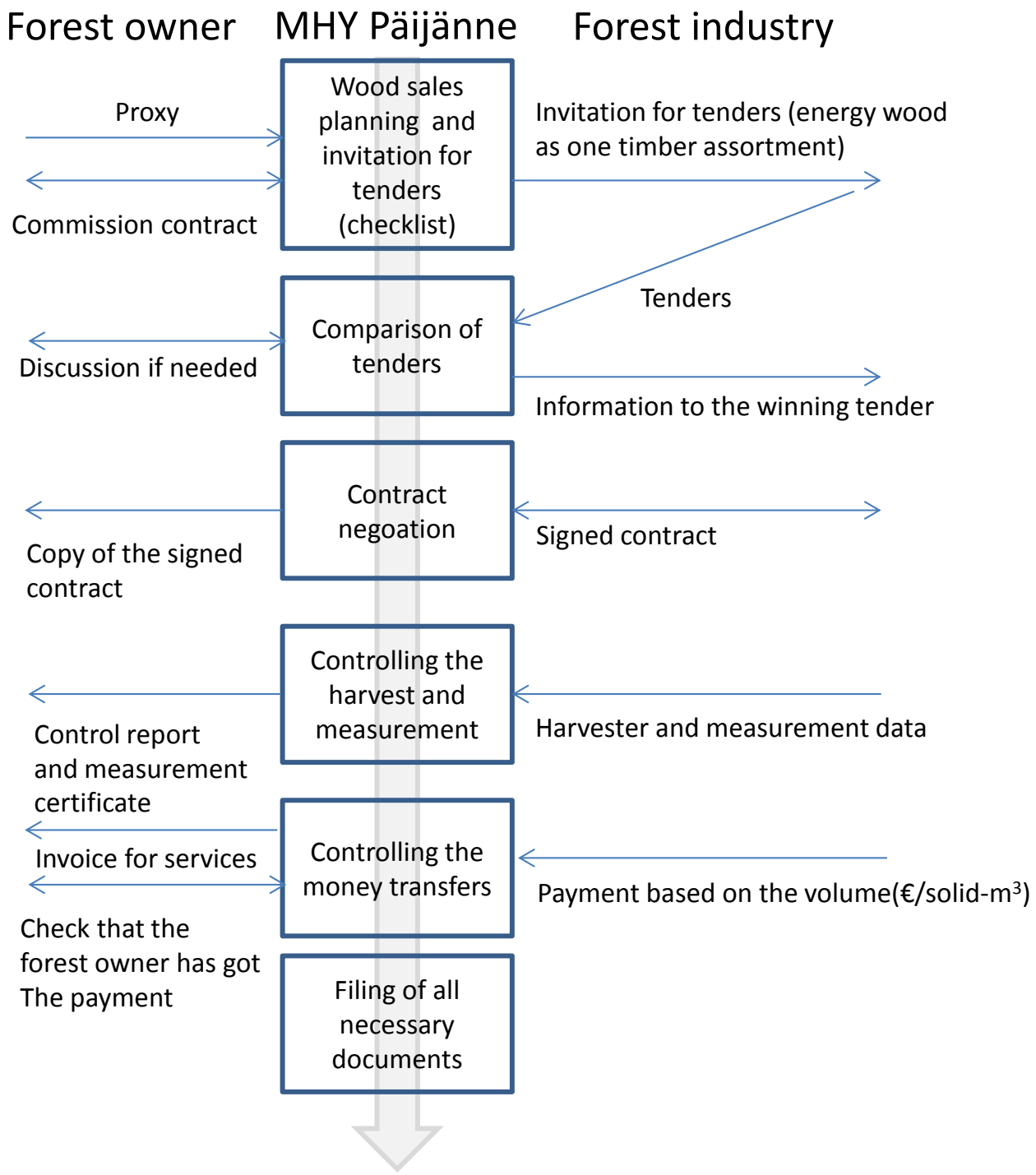
Main cost of quality control is the analysis of moisture content and bulk density of chip load. Costs have not been calculated separately. One moisture content analysis takes usually about 2 hours from plant operator. Annually this is about 60 hours and about 1 800€. The correct sampling and analysis is utmost important, because trade is based on energy content, which is calculated by moisture content. Chipping company is reporting that about 4% of their turnover is chipper maintenance costs caused by the wrong storage of energy wood and bad weather conditions.

2.2.4.3. Benefits

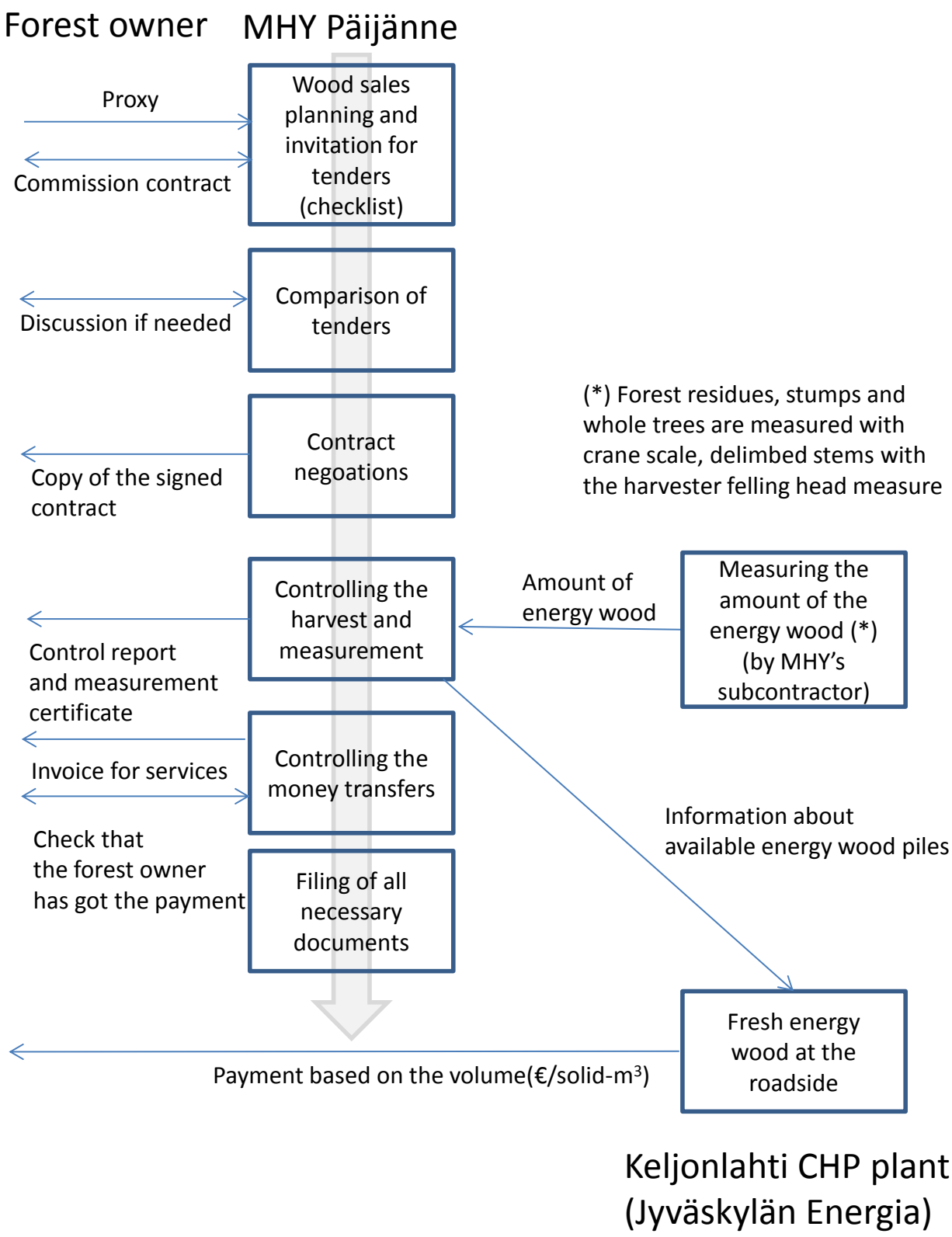
The main benefit of good quality is better price of wood chips and it also increases the reliability of the plant. MHY Päijänne is paid according to an energy content of the fuel. If fuel is wet, the energy content is low and price is decreasing. The low moisture content of wood fuel is mainly guaranteed by selecting the most dried piles for chipping. Also the security of supply is better with dry and good quality wood fuel.

2.2.5. Appendices VTT

2.2.5.1. Appendix I: Supply chain for round wood



2.2.5.2. Appendix: Supply chain with Jyväskylän Energia and occasional customers



2.3. Production of wood pellets in Croatia (Regea)

2.3.1. Background information

2.3.1.1. Description of the company

- *Name and place*
  Energy Pellets d.o.o.
- *Legal status*
  Private company
- *Business segment*
  Production of pellet*.*
- *Number of employees*
  26
- *Foundation date/experience*
  Year: 2007.
- *Annual production/trading quantity*
  28.000 tons
- *Production/trading capacity*
  50.000 tons

Company exists for 5 years. Exports its products to Italy, Austria and Slovenia. Company has implemented quality control and checks ash content, mechanical durability and calorific value of pellets. At the moment product certification is performed in outside laboratory, and all pellets produced conform to the A2 class. Company is interested in quality certification of their process and product in accordance with ENplus certificate.

2.3.1.2. Description of raw material supply

Croatian Forests Ltd. and small wood-processing companies in the vicinity of company are suppliers of biomass for pellet production. Similar mix of suppliers is used also in most pellet producing companies in Croatia. All incoming material is FSC certified. The raw material code according to EN 14961-1 is 1.1.3 stem wood, mix of hardwood and coniferous.

2.3.1.3. Customer description

Company exports its products to Italy, Austria and Slovenia to traders with minimal quantities sold on Croatian market directly to end users (1%). All transport is outsourced to outside forwarding companies.

2.3.2. Production chain analysis

2.3.2.1. Process description

All major steps in the supply chain are documented, but no formal flowchart is available.
Incoming material is fresh stem wood supplied by Croatian Forests Ltd. All incoming material is FSC certified (http://portal.hrsume.hr/index.php/hr/h-consult-doo/252). On incoming inspection wood is visually controlled, and cleaned if necessary. (CCP01) First process step is chipping. After chipping, wood chips are stored in process warehouse by wood species. Visual control for separation of species and impurities is performed (CCP02). From process warehouse chips are transported into dispensing hopper. After hopper there is magnet drum for separation of metal particles and sieve for eliminating too large wood particles (CCP03). From this point wood is transported to mill. After milling there is another magnet drum for removal of metal particles and centrifugal device for removal of sand, stones and similar unwanted material. After milling wood is transported into wood fired drying owen. Moisture is reduced to 12%. Moisture is continuously measured with automatic laser moisture meter (CCP04) and returned to drying process if moisture content is too high. After this there is sieving and transport to secondary milling process. After this operation there is another magnetic separation of metal particles. From sieving material is transported to pellet mill for pelletizing. After pelletizing is first visual control (CCP05) and cooling of pellets. Cooled pellets are transported to automatic packaging machine. Before packaging there is control of mechanical properties (length, diameter, bulk density…)(CCP06). Pellets are packed in bags, put on pallet and wrapped or packed in big bags. After packaging finished product is checked visually (package, label…) (CCP07) and transported to storage before shipment.

2.3.2.2. Identification of quality influencing factors (step 3)

Factors that have an impact on the quality of the finished product are identified but have not been documented through the scheme of the production process. Starting from the procurement of raw material through the input storage and through the production process (the impact of equipment maintenance, the impact of employees on product quality, training, process parameters, storage of finished goods ...). Most of the above mentioned factors the company Energy pellet already identified.

In order to standardize process it is necessary to formally document all relevant influential factors across the three main groups of factors:
-material input, input storage
-process of production, equipment, maintenance, process parameters
-qualification of employees, training and knowledge transfer

For any non-compliance that could be detected in the process it is necessary to provide a method of reporting and writing in a simple and straightforward way to ensure information to the relevant people in the process, so mistakes could be prevent and possible subsequent analysis of causes of the problem could be made. We have documented quality influencing factors in following table:

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1.	*Incoming material*	*Check list for incoming inspection*	*General quality of incoming material (wood class, species, soil or stone contamination…)*
2.	*Chipping*	*Visual control, dimensions of chips, contamination*	*Ash content, equipment maintenance (soil, stones)*
3.	*Sieving*	*Visual control, automatic removal of bad material (big wood pieces, metal particles)*	*Moisture content, equipment maintenance*
4.	*Drying*	*Automatic moisture meter*	*Moisture content*
5.	*Pelletizing*	*Visual control before cooling*	*Mechanical durability*
6.	*Before packaging*	*Visual control, bulk density, ash content, dimensions*	*Checking of product parameters*
7.	*Storage*	*Visual control after packaging (label, packaging)*	*Product label, packaging*

2.3.2.3. Definition of Critical control points (CCPs, step 4)

Critical control points are also defined within the production process at the firm Energy pellet, but are not formally documented in form of quality manual.

It is necessary to document all control points within the production process, with the expected measurement results and the necessary corrective activities and the consequences if some of measured (controlled) parameters go outside the previously defined fields.

It is important to properly define the measurement range within the overall control system, warning limits and limits for stopping the process for each measured (controlled) size of the process, and to define who and what activities should be taken that the production process returns within desired parameters.

All these data already exist within the manufacturing process, at the level of knowledge and experience of people who work in the process. Now is necessary their knowledge and experience put on paper. Critical control points identified in process are in following table:

CCP Nr.	Critical control point	How to control [1)]	Frequency of control
CCP1	Incoming inspection	Visual, scale (weight)	100%
CCP2	Chipping	Visual inspection	Every hour
CCP3	Sieving	Visual inspection	Every hour
CCP4	Drying	Automatic laser moisture meter	100%
CCP5	Pelletizing	Visual inspection	Every hour
CCP6	After cooling	Visual inspection and measuring (bulk density, length, diameter…)	Every hour
CCP7	Final control	Visual (packaging, label…)	Before transport to warehouse, 100%

2.3.3. Definition of quality assurance measures

For the implementation of the quality assurance measures which are necessary for compliance with the Enplus standard, it is need to complete control equipment. Regarding the equipment there will be necessary to obtain tester for the mechanical resistance which complies within EN 15210-1. Approximate price of this device is 3000 €.

Regarding the current condition, year of production and maintenance of existing equipment there are expectations that there wouldn't be any need for additional investments to satisfy quality standards.

Regarding quality assurance measures costs, there is need to allocate one part-time staff which currently works in the factory at the documentation of the work system and the existing system of quality assurance of pellets, which works well and need just to comply with standards for quality assurance.

At this point possibly expectation is need for external training staff which will deal with the measurement of the pellets quality.

2.3.3.1. Staff

Regarding employees all of following steps are implemented, but are still not 100% documented:

• **The division of responsibilities**: For each step in the process is defined but not document.
• **Operating Instructions**: For each step in the process work instructions are available.
• **Training:** Staff is not regularly trained. Trainings can be organized through internal or external organizations. It is planned to implement periodical trainings (once every 6 months) for all personnel in process.

2.3.3.2. Facilities & equipment

Facilities and equipment are in good condition to guarantee that the required level of quality of the final product can be achieved. Relevant factors:

- Prevention contamination of raw materials and products is assured
- Avoidance of moisture is assured (all finished goods under roof)
- Avoidance of mixing different classes of finished products is simple because they produce batches of one quality
-

2.3.3.3. Product quality

Product quality control in process:

- **Periodic visual control** is done regularly in whole process by skilled employees (CCP1 to CCP7).
- **Periodic analysis of sample** is done in an external laboratory (declaration of the product).
- **Automatic control** is used inside process (CCP4) for guiding process parameters.

Measure	Frequency	Related to process step(s) nr.
Product testing: Dimension (EN 16127), Bulk density (EN 15103), Mechanical durability (EN 15210 or Lignotester), Moisture content (EN 14774)	once per hour	CCP6
Product testing: Amount of fines (EN 15149)	once per hour	CCP6
Quality check after repair and maintenance work	when necessary	In process
Quality check after the correction of malfunctions of the equipment	when necessary	In process
Search for the reasons for complaints	when necessary	

The frequency of doing control is very high in proportion to stability of the process.

- **Procedures for handling nonconformity products and materials: P**rocedures for handling nonconforming materials and products exist but are not adequately documented.

2.3.3.4. Intersection points to upstream and downstream stakeholders in the supply chain

- **Input documentation:** Traceability of raw material for pellets is provided in accordance with EN 14961-1 (Table 1). Regarding that the origin of raw materials in the company Energy pellet is in the majority supplied from company Hrvatske šume, this requirement is satisfied (FSC).
- **Inspection of transport equipment:** outgoing trucks are checked for cleanliness.
- **Product declaration:** Every pellet package is declared on the label of package. Full level of information is available (picture)

2.3.3.5. Documentation

All quality measures must be thoroughly documented, if Energy pellet wishes to certify it's process. At the moment level of documentation is not satisfactory. Incoming and outgoing data is fully collected, process parameters are traced in computer system, but formal definition of process, controls and staff training are not on the level and will have to be improved.

2.3.4. Cost-benefit analysis

2.3.4.1. Description of existing approaches

In Energy Pellet company most of the steps required for certification according ENplus certification scheme is already implemented. The pellets produced in company satisfy quality class A1 according to EN 14961-2, and through the Italian distributors they are selling at this quality class. The manufacturing process is very good organized and employees know experientially all aspects of the process. One part of the necessary control of the finished product is already being performed on a regular basis. To evaluate the justifiability of introducing a quality management system is necessary to consider the long-term costs and benefits of the system.

2.3.4.2. Costs

In following table are initial costs of certification (€):

Initial costs of certification (occuring once)		
Additional training for workers	200 hours	3000
Preparation of Quality Manual	200 hours	3000
Procurement of test equipment	bulk density test bucket	150
	mechanical durability equipmen	3000
	moisture content equipment	2720
	sieve for fine particles	100
Audit and analysis of the sample	HFA	2500
Issuance Certification	HFA	500
License to use Enplus label (15c / T per year)	50.000 t/year	7500
	TOTAL:	22470

Following table contains yearly costs for maintaining of the certificate:

Permanent costs		
Maintaining certificate fee		250
Permanent workload for quality system	200 hours/year	3000
Additional training for workers	100 hours/year	1500
License to use Enplus label (15c / T per year)	50.000 t/year	7500
Audit	HFA	2500
	TOTAL:	14750

2.3.4.3. Benefits

The process of implementation Quality System has several good points:
• Reduction of production costs due to lower amounts of non-conforming products to be reprocessed.
• Less ability for complaint.
• A marketing tool which prove the quality of our products and possibly achieve a better market price.

2.4. Production of non-woody pellets in Poland (BAPE)

2.4.1. Background information

2.4.1.1. Description of the company

OPEC-BIO Ltd. is a part of a capital group of OPEC GRUDZIĄDZ Ltd. It is situated in Grudziądz which is a city in a Kujawsko-Pomorskie Region (Northern part of Poland). The company was established on 1st January 2006 and the production of non woody pellets for industrial purposes began in 2008. There are few non-woody pellets producers in Poland for non-industrial use, but they were not interested neither in implementation of the quality assurance system at this moment nor sharing their experience in quality matters with others.

The company's main fields of activities are solid biofuel production and straw collection after harvest.

The capital group that the company is part of, is in the development phase of electricity production from renewable sources. Thus the demand for renewable fuels of agricultural origin is growing. Therefore, the company will seek a certification for the production site. The company is interested in stable and strong partners interested in the production and sale of agricultural biomass. The company offers purchasing any type of cut straw (as the company has its own set of equipment for collecting it and baling) and/or baled straw.

Experience gained by the company during its activities and a large number of completed contracts BIO-OPEC ranks in the forefront of companies specialized in the production of pellets from straw.

Pellet production is based on Kahl production line with 2 presses. The company currently employs 47 employees working in the three shifts. Average production quantity equals to 3,5 tons/h (ca. 24 000 tons/year) and the production capacity is 5 tons/h (ca. 40 000 tons/year).

As the product is sold to the CHP plant of OPEC Grudziądz Ltd. and it might be sold to other heating plants in the future, there are no plans to introduce pellets for non-industrial use in accordance with EN 14961-6. The company is considering to produce non-woody pellets in accordance with EN 14961-1. The raw material code according to EN 14961-1 is either 2.1.1.2, 2.1.2.2 or 2.1.8. It is planned to base pellet production on wheat, barley and rape, so in the future these are going to be 2.1.1.2, 2.1.3.2 and 2.1.8. The planned quality of pellets according to table 4 of EN 14961-1 can be described by the following classes: diameter - D08 (8mm ± 1mm), moisture - M10 (≤10 w-% as received), ash - A10.0 (≤10 w-% of dry basis), mechanical durability - DU95.0 (≥95 w-%), amount of fines - F5.0 (≤5 w-%), no additives, bulk density - BD600 (≥600 kg/m^3), net calorific value - Q min. 15 MJ/kg.

The company has not obtained any quality certificates so far. Nevertheless it has some elements of a quality assurance system that will be gradually expanded into a comprehensive system including harvesting biomass from the field.

2.4.1.2. Description of raw material supply

The company purchases the straw of rye, rapeseed, wheat, oats, corn, hay and energy crops. Biomass is purchased either in bales or loose (after it's been cut) and the company collects the straw, bales it and transports to storage places.

The company has been changing suppliers permanently so far. It doesn't have long-term supply contracts with suppliers but is considering to do so.

The company is aiming at receiving the raw material where moisture content does not exceed 20 w-%. It will be also acceptable with moisture content up to 35%. In case of purchasing baled straw the company requires squared bales only as the production line is set for them.

2.4.1.3. Customer description

Currently, the only recipient of pellets is the CHP plant OPEC Grudziądz - the parent company of OPEC-BIO. However, the company is preparing to sell the fuel to other recipients.

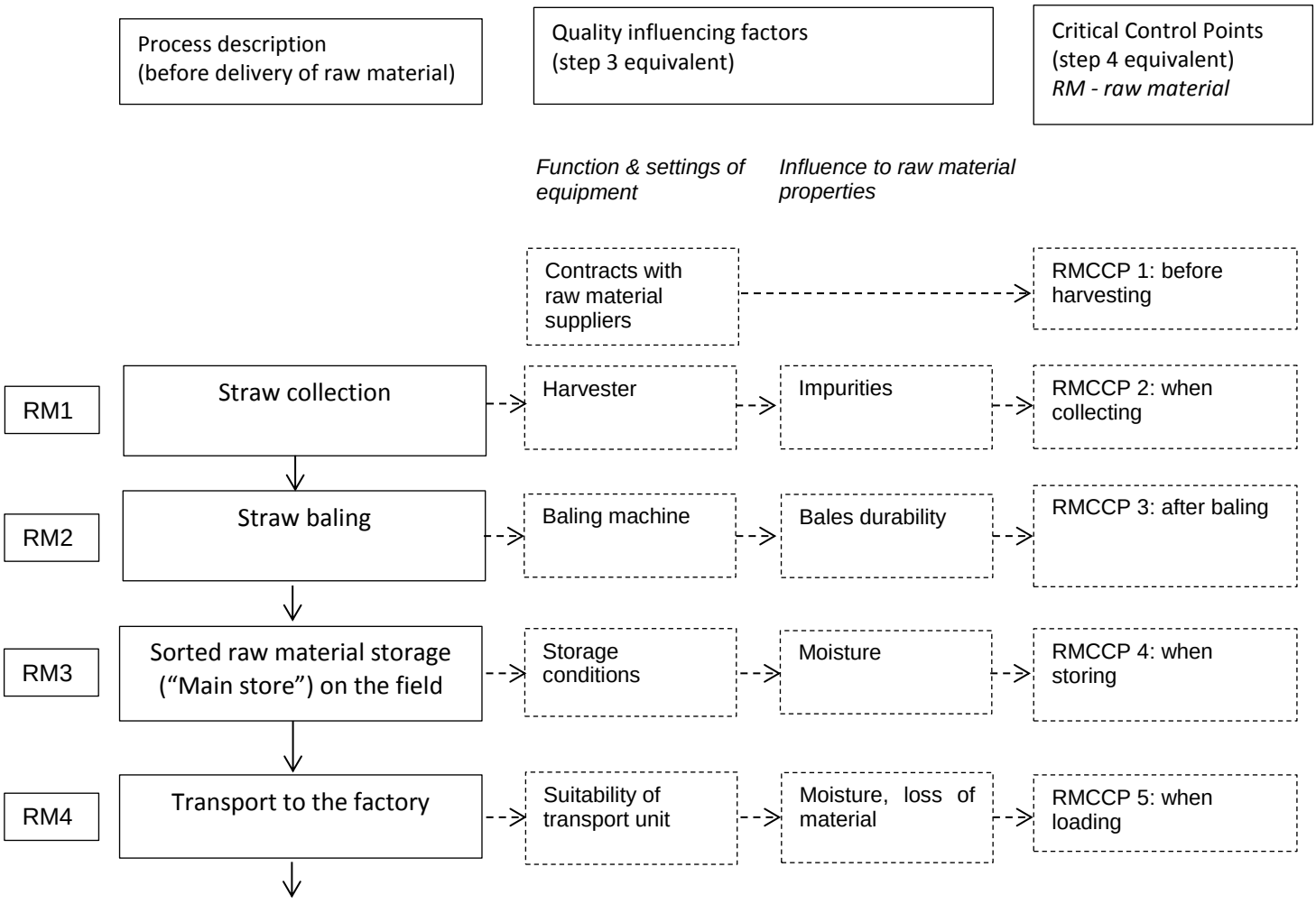
OPEC GRUDZIĄDZ Ltd. was founded in 2001. The company cogenerates heat and electricity, which is used for own needs, and the excess is sold to other parties. The recipients of heat are municipal entities, housing sector and other end-users utilising heat for heating and technological purposes and preparation of domestic hot water.

2.4.2. Production chain analysis

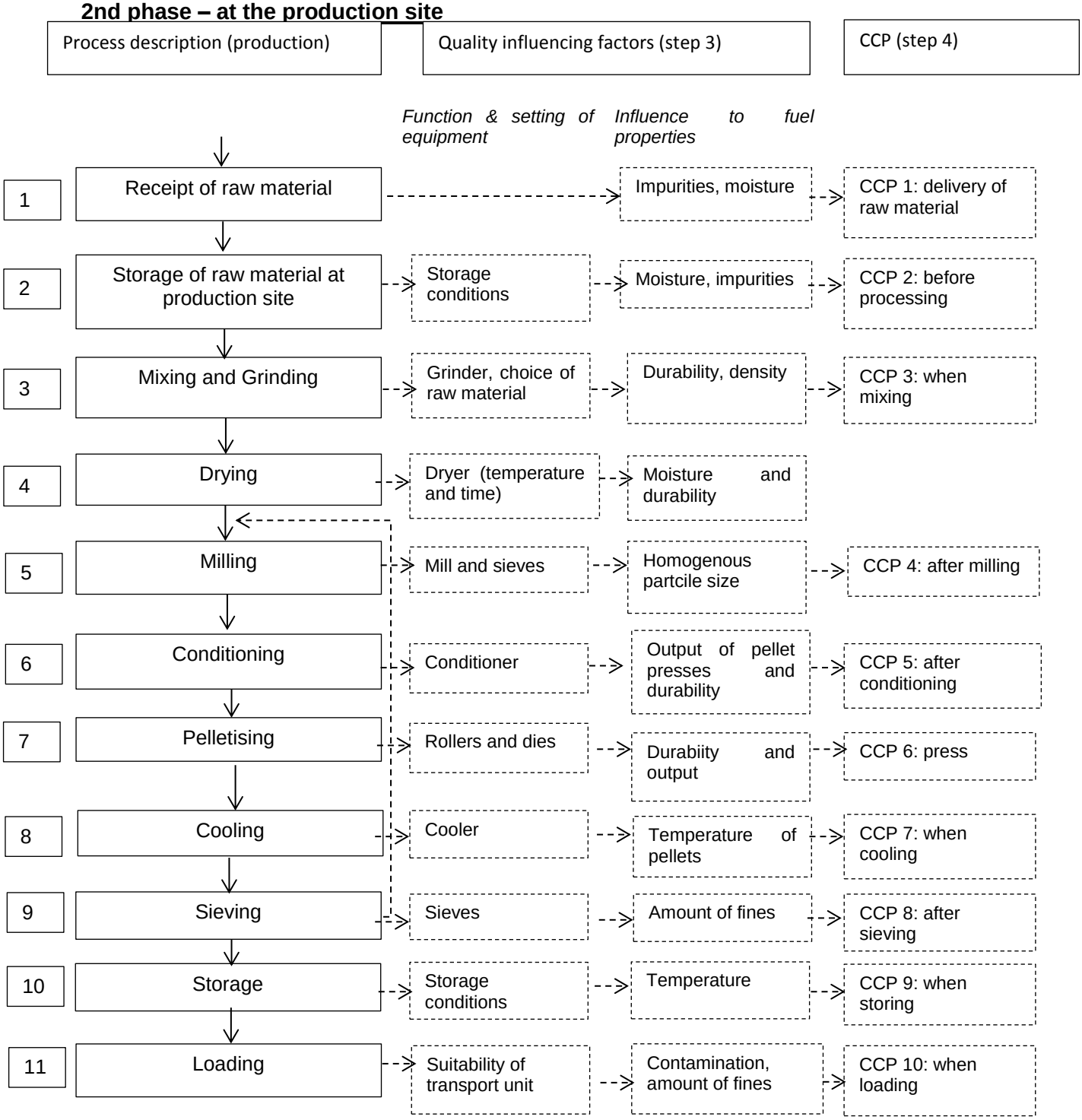
2.4.2.1. Process description (step 2)

Chain analysis includes both the phase of biomass preparation for pellet production (on the field) and the phase of pellet production. Raw material preparation phase is seen by the company as a key element for the production of good quality pellets from agricultural biomass. However, as such, is not covered by any standard. Therefore, in order to fulfill company's needs, both phases "on the field" and "at the production site" are shown in the process description.

1st phase – on the field



2nd phase – at the production site



2.4.2.2. Identification of quality influencing factors (step 3)

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1st phase – on the field			
RM1	Straw colletction	adequate height of cutting the straw, proper straw raking	Prevention of excessive contamination of straw with soil and stones
RM2	Straw baling	Bale size, the degree of density of straw	Impact on the durability of bales, storage, transport costs and performance of chippers
RM3	Sorted raw material storage on the field	Protection from rain and protection from arson Setting bales according to types of straw and its quality (moisture)	Protection against excessive moisture and the loss of raw material. Influence on the performance of pellet production. Facilitates delivery of raw material to the production site
RM4	Transport to the factory	Protection from precipitation and loss of raw material	Protection against excessive moisture and the loss of raw material
2nd phase – at the production site			
1	Receipt of raw material	suitability & cleanliness of transport unit and protection from moisture	Impurities might cause problems during further processing of the material or during handling/ combustion of the fuel Increased moisture causes necessity for drying the raw material or possibly mixing dry straw with moist straw, what increases the production costs
2	Storage of raw material at production site	Storage conditions	Too long improper storage (without protection from the weather conditions) reduces the straw quality, it can cause excessive moisture
3	Mixing and grinding	Proper selection of various kinds of straw when it is mixed	Proper proportions of dry and wet straw and different types of straw affect the volume of production and pellet properties: durability, density, and the combustion process

4	Drying	Temperature and time	Higher moisture causes higher production costs and limits the production Moisture influences also durability of pellets
5	Milling	Condition of mill and the attached sieves	Heterogeneous size distribution may influence the performance of dryer and pellet press.
6	Conditioning	Amount and temperature of water	Output of pellet presses and durability
7	Pelletising	Geometry of bores, condition of the roller, temperature	Output of pellet presses, durability of pellets and amount of fines
8	Cooling	Temperature	Durability of pellets
9	Sieving	Condition of sieves, setting of dimensioning equipment	Amount of fines and overlong pellets - durability of pellets
10	Storage	Storage conditions, temperature	Durability of pellets
11	Loading	Suitability & cleanliness of transport unit	Impurities might cause problems during handling/ combustion of the fuel

2.4.2.3. Definition of Critical control points (CCPs, step 4)

CCP Nr.	Critical control point	How to control [1)]	Frequency of control
RMCCP1	Before harvesting	Terms and conditions of the agreements with raw material suppliers, the stability of the contract, delivery schedule to ensure proper supply of straw in the factory	Every year
RMCCP2	when collecting straw	visual control, each field	every day when collecting
RMCCP3	after baling	visual control, each field	every day when baling
RMCCP4	when sorting and storing	visual control of each bale (coverage - protection from weather conditions; Monitoring - protection against arson); moisture measurement;	every day when sorting permanent each bale
RMCCP5	when loading	visual control (type of raw material) and moisture content measurement	each bale every weekday when loading
CCP1	delivery of raw material	visual control; moisture measurement	each delivered bale random, each transport
CCP2	before processing	visual control; moisture measurement	each bale
CCP3	when mixing	visual control	permanently when mixing
CCP4	after milling	visual control; moisture and fines measurement (automatic control)	periodical, once per shift permanent
CCP5	after conditioning	moisture measurement (automatic control)	permanent
CCP6	press	visual & sensory control automatic control: temperature, hydraulic pressure in press	periodical, every 1/2 hour permanent

CCP7	when cooling	automatic control	permanent
CCP8	after sieving	visual control automatic control (amount of fines returned into the process) sampling and analysis	after every change of raw material and exchange of equipment every 1/2 hour once per shift (or when raw material changed)
CCP9	when storing	automatic control (temperature, level of material in silos)	permanent
CCP10	when loading	visual control: suitability of transport unit fines: sampling and analysis	when loading (approx. 7 times a day) once per shift (or when raw material changed)

2.4.3. Definition of quality assurance measures

2.4.3.1. Staff

The quality assurance manager of the site will be a production specialist or the chief of production.

Measure	Frequency
Training workshop for the employees (analysis of fuels, documentation, other QA-measures)	once per year
Training of staff responsible for factory operations	quarterly
Training of the staff responsible for the operations on the field	once per year

2.4.3.2. Facilities & equipment

The production equipment is suitable for the production of good quality non-woody pellets.

The storage facilities are constructed in a way that prevents the pollution of raw materials and pellets as well as the absorption of water by the produced pellets.

Technical equipment for some automatic control of important production parameters exist. Some control is performed manually (mainly moisture analysis on the field). Some production parameters are set in the computer manually by chiefs of shifts.

At CCP8 non-conforming material can be rejected into the production process. Non-conforming material can be stored in the silo and either sold at a lower rate or returned to process step no. 5 (milling).

Measure	Frequency	Related to process step(s) nr.
visual controls of on field storages	permanent	RM3
Periodic visual controls of manipulation areas and open air storages	Periodic, once per shift	2
Planned repairs and maintenance of the equipment	Periodic, once per week	3-11
Controls of settings, functions and condition of the equipment	Periodic, once per shift	3-11

2.4.3.3. Product quality

Measure	Frequency	Related to process step(s) nr.
Measurements of moisture content of the raw material on the field	each bale	RM4
Product testing: Dimension (EN 16127), Bulk density (EN 15103),	once per shift (or when raw material changed)	9
Product testing: Mechanical durability (EN 15210), Moisture content (EN 14774)	once per shift (or when raw material changed)	9
Product testing: Amount of fines (EN 15149)	once per shift (or when raw material changed)	11
Quality check after repair and maintenance work	when necessary	2-11
Quality check after the correction of malfunctions of the equipment	when necessary	2-11

Monitoring on the field is necessary due to arsons. Straw with moisture content higher than 35% will not be accepted for production.

2.4.3.4. Intersection points to upstream and downstream stakeholders in the supply chain

Measure	Frequency	Related to process step(s) nr.
Visual inspection of incoming raw material	each incoming transport	1
Control of pellet temperature (not more than 40°C)	when loading	11
Declaration of origin and source	when necessary	1
Product declaration	on sale or on change of raw material	
Establish system for complaint management	once	

2.4.3.5. Documentation

Issue	document
Amount and origin of incoming raw material (incl. delivery contracts, declaration of origin and source according to EN 14961-1, table1). Results of the visual inspections.	Delivery journal
Plans for transport of raw material from the field storage to the production site	Delivery plans (weekly)
Proportions of mixing (by the guidelines of the chief of production)	Shift reports and yearly report
Malfunctions of the production process (data, type of malfunction, measures taken to remedy the problem, quantity and disposition of the non-conforming pellets)	Operation journal + software
More extensive repair and maintenance type that could lead to a change in pellet quality (date, type of work performed)	Operation journal
Employee training regarding the effect of the various production factors on the pellet quality (date, participants, contents)	Staff documentation
Areas of responsibility of the individual employees (function descriptions)	Staff documentation
Working instructions for each work stage and linking them with CCPs	Staff documentation

Results of the self-inspections	Laboratory logbook
Procedures for handling of non-conforming pellets produced at the site	Non-conforming material procedures
Outgoing goods (date, fuel specifications, quantity and name of the customer, number of reference sample, product declaration)	Sales journal
Customer complaints (date, results of the findings, measures taken)	Complaints documentation

2.4.4. Cost-benefit analysis

2.4.4.1. Description of existing approaches

The following approaches for a quality assurance system have already been included into the planning of the plant at Grudziadz:

- Periodic maintenance for relevant equipment: mills, dryer, conditioner, presses, cooler (maintenance plans). Once a week there is general equipment check-up. During each shift the equipment is checked regularly. Power demand of presses, flow pressure, air temperature and temperature of roller bearings, pressure in cooler are permanently (automatically) controlled. Moisture of raw material is examined at the factory site (but it is planned to do it on the field).
- There is a calculation sheet for mixing the material and weekly plans for the delivery of right quantities of raw material.
- Visual inspections of pellets are performed every 15 minutes. Testing of pellets is irregular, more or less once a week by the client – OPEC Grudziądz Ltd. Amount of fines, mechanical durability, length, specific weight of pellets are tested. OPEC-BIO does not own proper testing equipment.
- Monitoring on the field against arsons is permanently run.

2.4.4.2. Costs

Costs appearing once

Measure	**Issue**	**costs**
Preparation and implementation of quality assurance system	Labour time: 10 days	2200 €
Preparation of QA documentation	Labour time: 15 days	1800 €
Purchase of test equipment	moisture content equipment (ca. 1300 €), scale (ca. 700 €), bulk density test bucket (ca. 110 €), mechanical durability equipment (ca. 3000 €), sieve 3,15 mm with cover and container (ca. 250 €), scale for bulk density (ca. 640 €), digital caliper (ca. 85 €) (net prices)	6085 €
Total		10085 €

Costs appearing permanent/periodical

Measure	**Issue**	**costs**
Annual training workshop for the employees	Labour time QA manager (incl. preparation): 2 days	240 € /year
	Labour time other employees: 4 h	420 € / year
Training of staff responsible for factory operations	Labour time: 4h/employee	960 € / year
Moisture content measurement of each bale when loading on the field	Labour time: 2h/day	5460 € / year
Periodic visual controls of manipulation areas, storages and conveyors	Labour time: 15 min/day	2000 € / year
Controls at RMCCPs 2, 3, 4	Labour time: 15 days/year	3600 € / year
Planned repairs and maintenance of the equipment	Labour time: 3h/week	2340 € / year
Controls of settings, functions and condition of the equipment	Labour time: 1h/shift	8190 € / year
Self-inspections	Labour time: 1h/shift	10200 € / year
Documentation	Labour time: 15 min/shift	6100 € / year
Total		39510 € / year

2.4.4.3. Benefits

- Higher productivity - better use of working time, fewer production stoppages;
- Lower equipment exploitation costs - increased equipment life, reduced frequency of replacement of components sensitive to impurities in straw (stones, sand), increased operational reliability of equipment;
- Transfer of control and sorting of raw materials to the field, prior to delivery to the processing plant allows the reduction of working time associated with sorting straw at the storage at the production site;
- A higher degree of utilization of automation of the production line;
- Gain of new customers in the future;
- Stable pellet quality, stable price, customer satisfaction;
- No complaints and the associated costs.

2.5. Production, trade & logistics of wood chips in Austria (HFA)

2.5.1. Background information

2.5.1.1. Description of the company

Maschinenring Salzburg reg.Gen.m.b.H. (in the following 'MR Salzburg') is a regional cooperative, which organizes the logistics of demand and supply of machinery, service and personnel leasing. It was founded in 1975 and is a sub-organization of Maschinenring Austria. The cooperative is well known in Austria.

2011 MR Salzburg had about 4.666 members (effective 31.12.2011), which corresponds to nearly 56 % of possible members within the province of Salzburg. The operating area of wood chip production, trade and logistics is organized under the energy sector of the cooperative. 2011 the energy sector produced around 150.000 – 200.000 loose m³ wood chips (4.000 commissions with about 50 loose m³ per commission) generating a turnover of about 3.3 Mio Euro. In their pool of available wood chippers there are several different trademarks and technologies available.

The province of Salzburg is divided into 5 separate regions – Flachgau, Tennengau, Pinzgau, Pongau and Lungau (**Figure 1**).

Figure 1: Regional organization of MR Salzburg (Source: MR Salzburg Aktuell, Issue 2, May 2012)

In each region a forest team leader is responsible for the handling of the single commissions. The division manager forest/energy coordinates all commissions.

2.5.1.2. Description of raw material supply

"Forest, plantation and other virgin wood (1.1 according to Table 1 of EN 14961-1)" is used as raw material. Most of the chipped wood is coniferous as big parts of Salzburg are mountainous areas with spruce being the dominant tree species. Apart from forest wood (95 %), roadside maintenance generates a different kind of raw material. MR Salzburg only has little scope to influence this raw material. The suppliers and the quality of the raw material change frequently. The material is provided by the forest owners either already harvested or MR Salzburg does the harvesting with its own division of forest service. At the moment there don´t exist any requirements on the quality of the raw material. The reason for that is that competition on raw material is high and up to now the consumers have a low awareness to which extent woodchip quality influences their economic output.

2.5.1.3. Customer description

Wood chip trade is based on sales contracts between MR Salzburg and each customer. MR Salzburg currently delivers wood chips to 41 heating facilities and 3 CHP plants with an output between 500 kW and 6 MW. In the course of this feasibility study the fuel requirements of each customer were documented in a comprehensive list (Annex).

2.5.2. Production chain analysis

2.5.2.1. Product quality – requirements

Up to now the Austrian standard ÖNORM M 7133:1998 “Chipped wood for energetic purposes; requirements and test specifications” was the basis for the production of wood chips and the customer’s specifications. Normative properties in this standard are moisture content and particle size distribution. At the moment there doesn´t exist a quality certificate label for wood chips. MR Salzburg delivers wood chips to heating facilities and CHP plants, therefore in the future the fuel requirements for wood chips according to ÖNORM EN 14961-1 have to be taken into account. The deliveries of wood chips to non-industrial users are negligible, that´s why ÖNORM EN 14961-4 for non-industrial use has no relevance for this feasibility study. The cooperative intends to work with the new European standards, including a new Austrian standard ÖNORM C 4005 “Wood chips and hog fuel for heating purpose in heating appliances > 500 kW – Requirements and test methods”, which is currently elaborated to facilitate the specification and declaration of “forest chips” and is based on ÖNORM EN 14961-1.

So far the properties of the delivered wood chips are defined in sales contracts between MR Salzburg and each customer. A distinction is made in 2 different qualities ‘forest chips 1’ names the quality which is defined in sales contracts as required quality. In case of a justified customer complaint about the quality of the wood chips, the division manager forest/energy is informed and decides whether the quality of this commission is downgraded to ‘forest chips 2’, reducing the price for this material. ‘Forest chips 2’ means poorer quality with e.g. a high amount of needles or partially degraded wood chips with a lower net calorific value. No property analyses of the wood chips are made by MR Salzburg or their subcontractors throughout the production and supply chain. The classification is done by visual/sensory inspection. Of the three normative properties of ÖNORM EN 14961-1 currently only particle size and moisture content are key parameters because they can be assessed to a certain extent visually and sensory. Although it is possible to give typical values for the ash content, based on the origin and source of the raw material, it is difficult to define the ash content of a specific lot due to the high inhomogeneity of the commonly used material.

In some heating facilities/CHP plants the moisture content of a delivery is analyzed and the price for the delivery calculated accordingly; about 2/3 of the sold volume is charged according to this system. For about one third of the traded wood chips there is no possibility at the customer’s site to weigh the delivery trucks. For these commissions, which are charged by volume, 3 sub qualities of the “forest chip 1” quality were introduced, namely “forest chips – logging residues”, “forest chips – whole trees” and “forest chips – stem wood”, with usually decreasing moisture content and therefore different prices.

2.5.2.2. Process description

Step 1 – Raw material reception:
One of the **forest team leaders** gets the information of type, amount and location of a certain available biomass. He visits the storage location, estimates quantity, quality and value of the material and decides to which heating facility/CHP plant it could be sent.

Step 2 – Wood chip production:
As soon as an order was placed by the respective heating facility/CHP plant, the forest team leader forwards the commission to a **subcontractor** for wood chip production and transport

Step 2a – Intermediate storage:
The material which is stored intermediately after chipping amounts to less than 1 % only.

Step 3 – Loading /Transport

Step 4 – Discharge:
In case of customer complaint the **division manager forest/energy** is informed to decide on an agreement

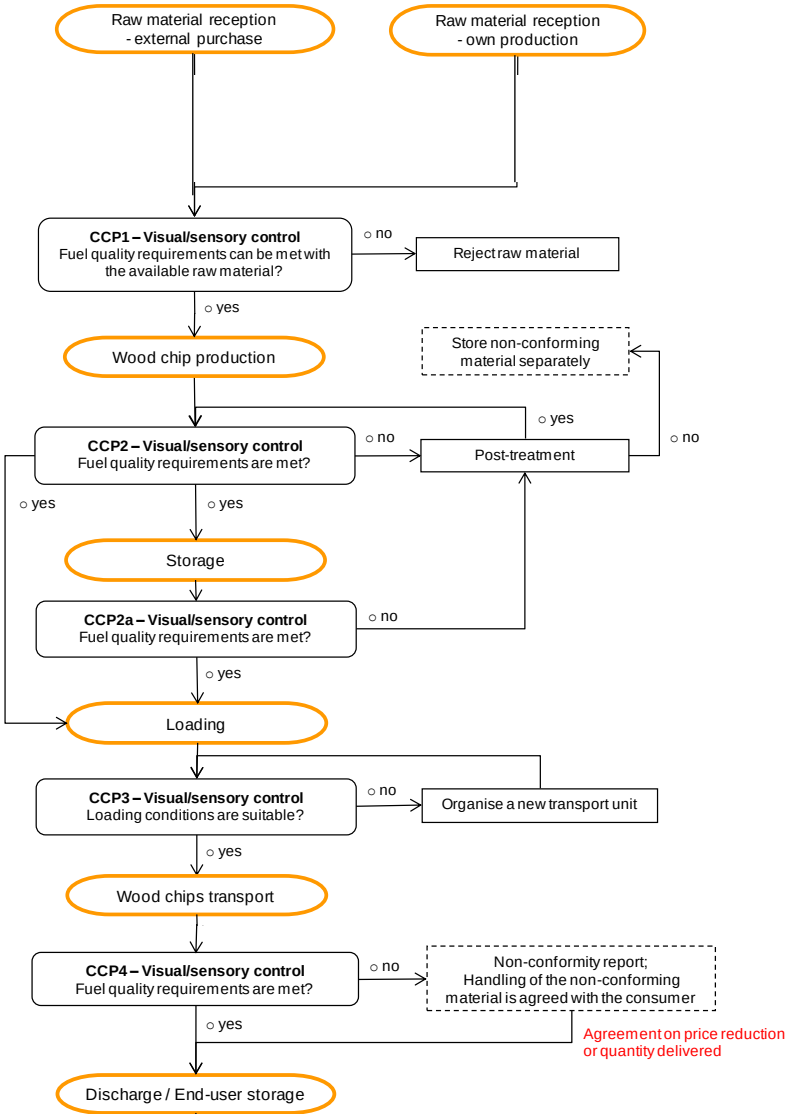


Figure 2: Flow chart of the wood chip supply chain of MR Salzburg

Intersection points to up- and downstream stakeholders in the supply chain

Measure	Frequency	Related to process step(s) nr.
A 'Declaration of origin and source according to ÖNORM EN 14961-1, table 1' should be provided by the raw material supplier. If the forest owner is registered in the PEFC certification system, the raw material is considered certified - visual / sensory control of the raw material by MR Salzburg - collection/control of PEFC registration	 - at each reception - with each new customer	1
Discharge of the wood chips at the heating facility/CHP plant by MR Salzburg respectively a subcontractor for chipping and transport - correct determination of the delivered quantity and quality	 - at each delivery	4

2.5.2.3. Identification of quality influencing factors

Step no.	Process step	**Influencing factors** function & settings of equipment / management procedures	**Influence on** fuel properties / management performance
1	Raw material reception	wood species, assortment / quality, previous storage, weather conditions impurities (e.g. left behind metal objects from harvesting), stones experience of the forest team leader	moisture content, ash content, particle size / fines, net calorific value damages on chipping machines leading to reduced wood chip quality or additional cost due machine down time and repair correct pre-classification and distribution of the produced wood chips
2	Wood chip production	type of chipper/shredder, blade advance, sieve size, kind of discharge system (blower or conveyor) experience of the subcontractor (to decide to leave certain material unprocessed in the forest to influence the quality; e.g. dead wood, tops of trees)	particle size (fines and course fraction) moisture content, ash content, particle size / fines, net calorific value
2a	Intermediate storage	condition of the storage site, weather, duration experience of the subcontractor	moisture content, ash content, net calorific value
3	Loading / Transport	suitability of the vehicle, weather conditions, distance experience of the subcontractor	ash content, moisture content
4	Discharge	experience of the subcontractor (e.g. correct sampling) Responsibility of the customer: condition of end-users storage place	correct determination of the delivered wood chip quantity and quality ash content, moisture content, net calorific value

2.5.2.4. Definition of Critical control points CCPs

CCP Nr.	Critical control point	Method of control	Frequency of control
CCP1	Raw material reception	visual/sensory control	at each reception
CCP2	Wood chip production	visual/sensory control	for each commission
CCP2a	Intermediate storage	visual/sensory control	for each commission
CCP3	Loading	visual/sensory control	for each commission
CCP4	Before discharge	visual/sensory control	for each commission

2.5.3. Definition of quality assurance measures

2.5.3.1. Staff

An organization chart of the staff of MR Salzburg is already available (Annex). In the following job specification, qualification & training for the staff in the forest/energy sector of MR Salzburg is listed:

Division manager forest/energy:

- Qualification: Master degree in forestry,
  Participation in SolidStandards wood chip training
- Responsibility: Economic and technical responsibility for the division forest/energy;
  Sales contracts, handling of customer complaints,
  Quality management representative - training of employees
- Training: No further training is planned, continuous exchange and update of knowledge in the field of standardization and wood chip quality

Forest team leaders:

- Qualification: Forestal education,
  Participation in SolidStandards wood chip training planned
- Responsibility: Handling of single commissions, including acceptance of an order, classification of the raw material (process step 1), logistics, smaller customer complaints
- Training: Internal training through division manager forest/energy once per year

Subcontractors chipping/transport:

- Qualification: no qualification necessary
- Responsibility: Chipping, transport (process step 2-4)
- Training: Internal training through forest team leaders planned once per year

2.5.3.2. Facilities & equipment

A list of 10 wood chippers including machine specifications like, screen basket and feeder opening is available (Annex). In the course of this feasibility study the list was completed with quality parameters for wood chips like, processable raw material, particle size, maximum oversize of the wood chips. The wood chipping companies work as subcontractor for MR Salzburg. Maintenance and service of the machinery is not checked by MR Salzburg; this lies in the responsibility of the subcontractors.

2.5.3.3. Documentation

The list below shows all documents necessary for an implementation of quality control according to ÖNORM EN 15234-1. Some of these documents are already available others still have to be elaborated and introduced into the work process of MR Salzburg.

Issue	Document	Status
Amount and origin of accepted raw material (incl. declaration of origin and source according to EN 14961-1, table1; amount of PEFC-certified material)	Purchase journal	**available**
Requirements of the customers	Sales contracts; list of all customers including agreed on requirements	**available** update according to new standards necessary
Appropriate chipping machine	List of all subcontracted wood chippers including machine specifications	**available**
Internal quality control during the whole production/supply chain (raw material reception, careful handling of the material)	Internal process instructions	**required**
Proof of competence of the quality assurance representative (division manager forest/energy)	Personnel file	**available**
Annual employee trainings (date, participants, contents)	Internal training list	**required**
Areas of responsibility of the individual employees or subcontractors	Personnel file	**required**
Documentation of outgoing goods: • date, name of customer, amount of wood chips • wood chip declaration (raw material declaration of origin and source, specification of the properties 'particle size, moisture content, ash content, fines')	Sales journal	**available**
Customer complaints (date, reason, measures taken to remedy the defects if necessary)	Customer complaint list	**required**

2.5.4. Cost-benefit analysis

2.5.4.1. Description of existing approaches

At the moment the quality control system at MR Salzburg works top down. Due to the lack of a reasonable determination of certain wood chip properties like ash content, all material is sold as 'forest chips 1' quality. If the wood chip quality of a commission does not meet the requirements of the customer, the division manager forest/energy gets to know this in the way of a customer complaint. As a consequence the responsible forest team leader gets the feedback, that e.g. the raw material should have been rejected or mixed with material of higher quality before delivering the wood chips to the consumer. At the moment it is not possible to produce a certain defined wood chip quality.

2.5.4.2. Costs

The expected costs for the initial implementation of a quality control documentation according to ÖNORM EN 15234-1 are estimated with about € 10.000,- or about 235 man-hours. The yearly expenses for maintaining the quality control system amount to nearly € 2.500,- or about 60 man-hours per year (**Table 1**).

Table 1: Expected expenditures in the course of quality control implementation and of maintaining the quality control system at MR Salzburg

	number of persons / commissions	time / person	average staff costs	total costs
		h	€/h	€
Elaboration customer list	1	10	50	500
Elaboration list of machines	1	2,5	50	125
Elaboration flowchart production/supply chain	1	2	28	56
Elaboration of an organigramm	1	2	28	56
Elaboration of internal process instructions	1	4	50	200
Elaboration of training material	1	5	50	250
External training of forest team leaders	6	15	38	3.420
Internal training of wood chip producers (subcontractors)	10	4	50	2.000
Internal training - teaching by forest team leader	5	16	38	3.040
Σ one-off expenses				**9.647**
Periodic update of internal process instructions and lists	1	5	50	250
Yearly internal training of forest team leaders	1	2	50	100
Yearly internal training of wood chip producers (subcontractors)	6	1	38	228
Yearly internal training - teaching by forest team leader	6	8	38	1.824
Σ periodic expenses				**2.402**

Scenario 1: Internal product specification by means of typical values

The frequent internal wood chip specification with e.g. the help of a checklist as well as the preparation of 'origin and source' of the raw material (if not handed over by the forest owner) produces cost of about € 35.000,- per year considering a number of 4000 commissions (**Table 2**).

Table 2: Expected yearly costs in the course of internal product specification

	number of commissions	time / person	average staff costs	approx. costs
		h	€/h	€
Declaration of origin and source (raw material group)	4000	0,1	38	15.200
Use of a checklist for specification	4000	0,1	50	20.000
Σ product specification				**35.200**

Under the supposition of 150.000 to 200.000 m³ produced wood chips in 2011 the extra cost for this scenario would sum up to approx. 0,2-0,25 €/m³. Synergies with the existing work process, especially in raw material acceptance, are expected.

Scenario 2: Internal product specification by means of analyses

In case of internal testing of the product specifications the overall costs for the necessary equipment to perform the tests for moisture content, ash content and particle size analysis amount to approximately € 25.000,-, depending on exact type and discount of a testing equipment (**Table 3**).

Table 3: Estimated costs of different laboratory equipment based on internet research and quotations

laboratory equipment	needed for analysis of	approx. costs
		€
oven (usual baking oven can be used)	moisture content, ash content, particle size	500
scale (accuracy 0,1 g)	moisture content, particle size	1400
sieving machine	particle size	4000
set of 6 sieves according to ISO 3310-2	particle size	2000
scale (accuracy 0,1 mg)	ash content	2100
cutting mill	ash content	10000
high temperature laboratory furnace	ash content	4500
Σ investment costs		**24500**

Because forest chips are a very inhomogeneous material it would be necessary to analyze the properties of each commission to be able to specify the wood chips exactly.

The time needed for sampling and for tests of moisture content, ash content and particle size is calculated with 2 man-hours per commission, resulting in yearly costs of about € 400.000,- or 8.000 man-hours considering 4000 commissions (**Table 4**). These costs don´t include the transport of a sample from the forest site to a centrally located company laboratory.

Table 4: Estimated yearly costs of internal product testing

	number of commissions	time / person	average staff costs	approx. costs
		h	€/h	€
Sampling	4000	0,25	50	50.000
Testing of moisture content, ash content, particle size class	4000	1,75	50	350.000
Σ product specification				**400.000**

It can be assumed that the testing of the samples in an external laboratory would amount at least to the same cost.

Assuming 150.000 to 200.000 m³ produced wood chips per year, the extra costs per m³ chips for this scenario (without transport costs of the sample) sum up to 2-2,7 €/m³,

If the analyzing is done as support for a better estimation it might be enough to analyze only a certain share of the commissions, for example 1 %. This data could lead to a better overall estimation of the wood chip properties.

2.5.4.3. Benefits

At the present situation the implementation of a quality control system doesn´t seem to be necessary. With 17 customer complaints out of 4000 commissions in the year 2011 with resulting costs of about € 5.000,- the benefits of the introduction of such a system seem negligible.

Considering that the currently used ÖNORM M 7133 is going to be withdrawn in near future, MR Salzburg has to adapt their work process to the new specification and declaration system of ÖNORM EN 14961-1 anyway, including an adaption of sales contracts and trainings for all employees concerning the new standard.

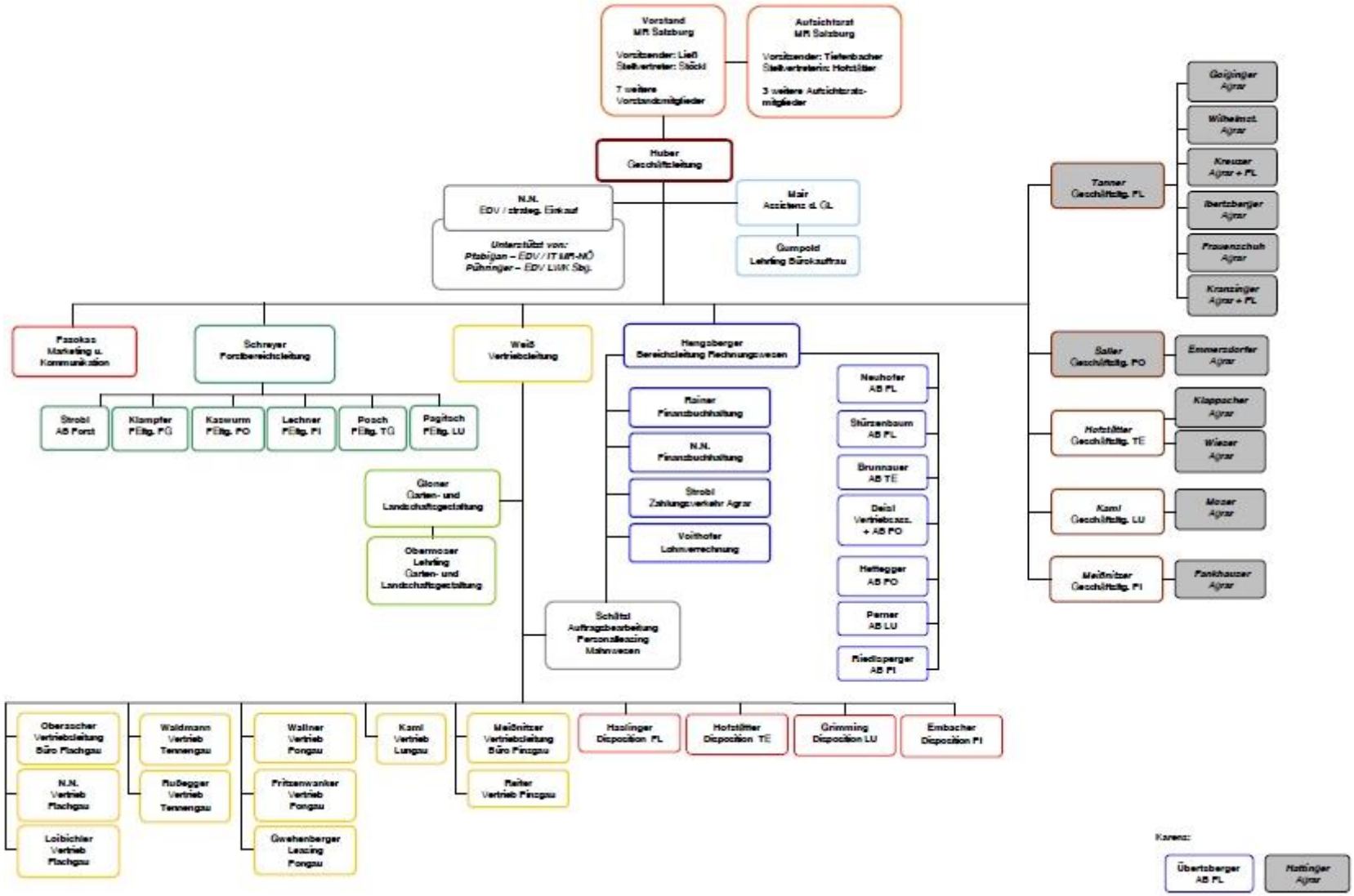
Apart from that it seems, that customers are becoming more sensitive about the quality of the biofuel to avoid malfunctions and damages of the heating facility and to increase the efficiency of their facility. If this scenario takes place, it may be possible to realize higher prices for a quality managed product. A minimum price-increase of 0,5 €/m³ on the average seems to be necessary to justify the investments in a quality control system.

2.5.5. Appendices HFA

2.5.5.1. Appendix I: List of customer requirements

	Customer, heating facilities / CHPs		Accepted wood chip qualities								
No.	Name	Location	Raw material group	Particle size - main fraction, mm	Max. length, mm	Max. cross sectional area, cm²	Fines	Moisture content	Ash content	Bulk density	Nitrogen
1	Salzburg AG	Siezenheim	C1-C3	30-100	350	10	ns	k.A.	ns	ns	ns
2	Nahwärme Fuschl GmbH	Fuschl	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
3	S.Nahwärme	Thalgau	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
4	Schwaighofer	Hallein	C1-C3	30-100	350	10	ns	k.A.	ns	ns	ns
5	Hackschnitzel- und Heizgenossenschaft Hof reg. Gen.m.b.H.	Hof	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
6	S.Nahwärme	Eugendorf	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
7	HW Schleedorf	Schleedorf	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
8	Hackschnitzel- und Heizgenossenschaft Lamprechtshausen reg. Gen.m.b.H.	Lamprechtshausen	C1-C3	30-100	350	10	ns	M45	ns	ns	ns
9	Nahwärme Obertrum Ges.m.b.H. & Co KG	Obertrum	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
10	Bio Energie Seeham reg. Gen.m.b.H.	Seeham	C1-C3	30-100	350	10	ns	M35	ns	ns	ns
11	Bäuerliches Hackschnitzelwerk Kuchl reg. Gen.m.b.H.	Kuchl	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
12	Bioenergie Pongau	Bischofshofen	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
13	Bioenergie Pongau	Schwarzach	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
14	Bioenergie Pongau	St.Johann	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
15	Bioenergie Wagrain GmbH	Wagrain	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
16	HW Haus	Haus	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
17	HW Schladming	Schladming	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
18	Holzwärme Alpendorf Ges.m.b.H.	Alpendorf	C1-C3	30-100	350	10	ns	M45	ns	ns	ns
19	Nahwärme Kleinarl GesmbH	Kleinarl	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
20	Hackschnitzel- und Heizgenossenschaft Großarl reg. Gen.m.b.H.	Großarl	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
21	Salzburg AG	Abtenau	C1-C3	30-100	350	10	ns	k.A.	ns	ns	ns
22	Holzwärme Gastein reg. Gen.m.b.H.	Hof Gastein	C1-C3	30-45	350	10	ns	M55	ns	ns	ns
23	Holzwärme Gastein reg. Gen.m.b.H.	Dorfgastein	C1-C3	30-45	350	10	ns	M45	ns	ns	ns
24	REMA	REMA	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
25	Holzwärme Altenmarkt GmbH	Altenmarkt	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
26	Holzwärme Flachau GmbH	Flachau	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
27	Filzmoos	Filzmoos	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
28	Heizwerk Obertauern - AESG	Obertauern	C1-C3	30-100	350	10	ns	M45	ns	ns	ns
29	Wärmeversorgung GmbH & Co KG Tamsweg	Tamsweg	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
30	Bäuerliche Hackschnitzel- und Heizgenossenschaft St. Michael reg. Gen.m.b.H.	St.Michael	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
31	Heizwerk Bruck - Salzburg AG	Bruck	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
32	BWD Biowärme Dorfgastein GmbH	Dorfgastein	C1-C3	30-100	350	10	ns	M45	ns	ns	ns
33	Hackschnitzel- und Heizgenossenschaft Rauris reg. Gen.m.b.H.		C1-C3	30-100	350	10	ns	M55	ns	ns	ns
34	Hackschnitzel- und Heizgenossenschaft Lofer reg. Gen.m.b.H.	Lofer	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
35	Mittersill	Mittersill	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
36	Wald	Wald	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
37	Heizwerk Bramberg - Salzburg AG	Bramberg	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
38	Hackschnitzel- und Heizgenossenschaft Maria Alm reg. Gen.m.b.H.	Maria Alm	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
39	Piesendorf	Piesendorf	C1-C3	30-45	350	10	ns	M55	ns	ns	ns
40	Heizwerk Saalfelden - Salzburg AG	Saalfelden	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
41	Nahwärme Krimml	Krimml	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
42	Neukirchen	Neukirchen	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
43	Fusch	Fusch	C1-C3	30-100	350	10	ns	M55	ns	ns	ns
44	Schößwendter	Schößwendter	C1-C3	30-100	350	10	ns	M55	ns	ns	ns

2.5.5.2. Appendix II: Organization chart MR Salzburg



2.5.5.3. Appendix III: List of available wood chippers

	Chipper / Shredder				Production parameters			
No.	Type		screen baskets, mm	Feeder opening, mm	Raw material group	Particle size - main fraction, mm	Max. length, mm	Max. cross sectional area, cm^2
1	Jenz	700	30/100	800*1200	C1-C3	30/100	350	10
2	Heizohack	14-800	30/45/100	800*1200	C1-C3	30/45/100	350	10
3	Bruks	804 CT		750*900	C1-C3	100	350	10
4	Mus Max	WT 11	45/100	750*1140	C1-C3	45/100	350	10
5	Jenz	Chippertruck HEM 581	35/80	680*1200	C1-C3	35/80	350	10
6	Jenz	HEM 560 D	35/40/60	550*1000	C1-C3	35/40/60	350	10
7	Jenz	Chippertruck HEM 582	35/80	680*1200	C1-C3	35/80	350	10
8	Mus Max	WT 10	35/80	700*1000	C1-C3	35/80	350	10
9	Wüst	BBHK 100	45/100	500*1000	C1-C3	45/100	350	10
10	Heizohack	HM14-800KL	30/50/70/100	800*1400	C1-C3	45/100	350	10

2.6. Trade & Logistics of wood pellets & wood chips in Bulgaria (ERATO)

2.6.1. Background information

2.6.1.1. Description of the company

- *Name and place: ERATO Plc, Haskovo, Bulgaria*
- *Legal status: Legal entity/Public liability Company*
- *Business segment: Biomass heating and biofuels*
- *Number of employees: 43*
- *Machine outfit:2 Scania Vehicles (25 tons capacity each), 4 Middle trucks Fiat Ducato (3.5 tons capacity each), Small cargo vans Fiat Doblo and Daewoo (1 tons capacity each), Middle cargo vans Shkoda (8 ton capacity), Truck with tipper trailer (20 tons capacity), handling equipment and forklifts*
- *Turnover:8 MEuro*
- *Foundation date/experience:1996/16*
- *Annual production/trading quantity:842.1 tons trading quantity for year 2011*
- *Production/trading capacity:1,680 tons trading capacity*
- *Information about product quality: wood pellets: EN 14961-2, classes A1 &A2, Wood chips: EN 14961-4*
- *Quality certificate: ISO 9001:2000*
- *Other certificates*

2.6.1.2. Description of raw material supply

ERATO Plc knows very well requirements regarding row material properties and quality of wood pellets, wood chips and fire woods. The used for commercial purposes and logistics wood pellets are made from softwood and hardwood without adhesives and chemicals.

ERATO Plc has long term partnership with biofuels producer in Bulgaria. The company is a partner and buyer of wood pellets and wood chips with companies which have traditions in the field of biofuel production. For 2011 ERATO Plc has signed contacts for wood pellets delivery with 3 wood pellets producers in the total quantity of 800 tons. ERATO Plc signs contracts with biofuel suppliers (producers) year by year. The existing requirements on the quality of the raw material are origin and source of raw material, normative parameters EN14961-1.

2.6.1.3. Customer description

The main target groups of ERATO plc in the field of wood pellets purchase is following:

- Traders - Distributors (installers of biomass heating equipment);
- Municipalities (tenders under public procurement procedure);
- End users (customers of biomass heating equipment).

2.6.2. Supply chain analysis

The supply chain of wood pellets and wood chips of ERATO Plc is presented on Figure 1.

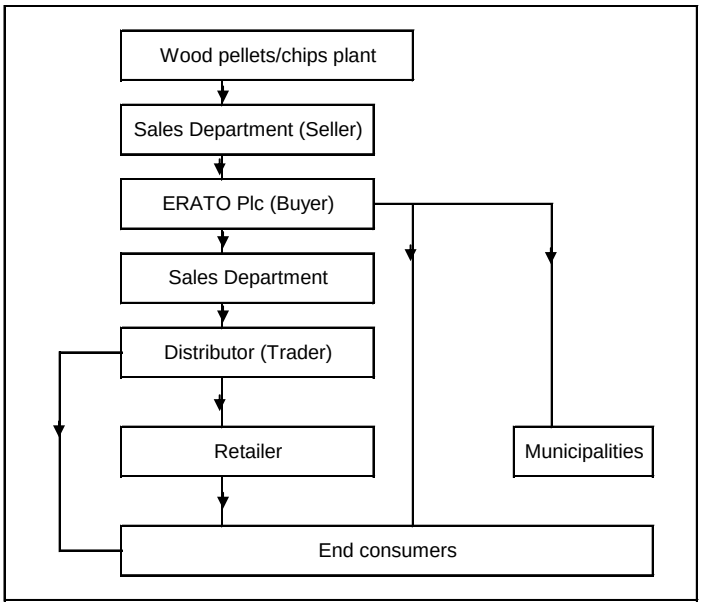


Figure 1. Flow chart of wood pellet/chips supply chains of ERATO Plc.

ERATO Plc use the purchased wood pellets for own needs (the company sell wood pellets burners, wood pellets boilers, pellets stoves in Bulgaria and EU countries) to ensure the customers with biofuel during the heating season - wood pellets supply chains. ERATO Pls does not have quality assurance standards for wood chips EN 15234-4) and wood pellets (EN 15234-2) at the moment. The purchased wood pellets and wood chips are transported to warehouses. Although presented information provided by producers of biofuels such as protocols and certificates ERATO additional do measurements and tests of all type of the purchased fuels before final trade and logistic to customers. ERATO Plc has own biofuel testing laboratory in the town of Haskovo. All biofules are tested befor trading to the costumers. In the buofuel laboratory are measured quality parameters, such as ash content, moisture content, mechanical durability. The main installed and operated equipment in the laboratory as follows:

1. Electric muffle oven:
- Workspace dimensions 200 x 125 x 270 mm
- The heating - triangular, heaters in ceramic tubes
- Operating temperature 1000 °C
- Power 2.7 kW/220V
- Temperature control - toggle with regulation in section
- Thermocouple NiCr-Ni

2. Hygrometer for wood chips, BLL-1
Hygrometer long probe for direct measurement of moisture wood chips (wood chips, sawdust). Range of 10 to 50 percent. Supplied with probe and battery.

3. Electronic scales
Kern precision electronic scales with external calibration model: PCB 1000-2 (Max load 1 kg; precision 0.01g; blyudoto130 size x 130 mm).

4. Device for determining the mechanical durability of the pellets (automatic)

5. All auxiliary process equipment (Esikator 200mm, Porcelain crucibles 60/38mm, 3.15 mm sieve openings et.c).

2.6.2.1. Process description (step 2)

The process of trade and logistics of wood pellets/chips of ERATO Plc is given on Figure 2.

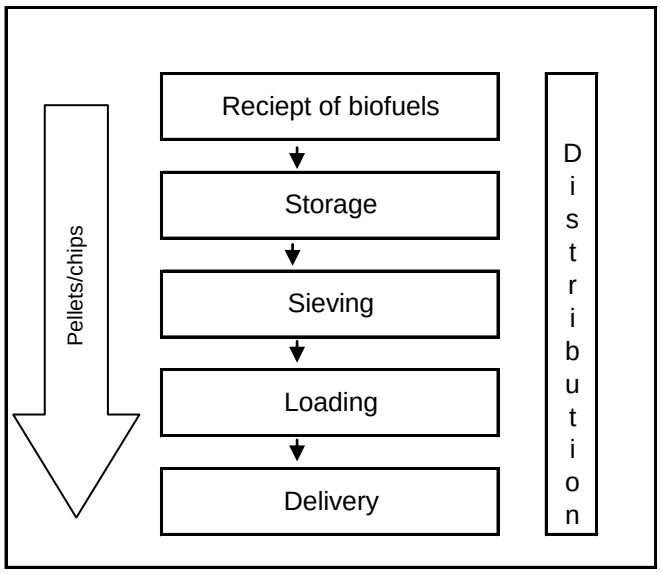


Figure 2. Flow chart of the process of trade and logistic of wood pellets/chips of ERTO Plc.

2.6.2.2. Identification of quality influencing factors (step 3)

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1	*Receipt of wood pellets/chips*	*Procedure for preliminary inspection of fuel - testing and analyses in laboratory*	*Moister, Bulk density, Ash content, Mechanical durability*
2	*Storage*	*Conditions of ground, Metal shelves, Machine outfit*	*Amount of fines*
3	*Appropriate equipment using*	*Existing laboratory equipment*	*Incorrect data*
4	*Sieving*	*Conditions and settings of machine*	*Bulk density, Amount of fines*
5	*Loading*	*Machine outfit*	*Amount of fines*
6	*Staff knowledge, competence and qualification*	*Procedure for holding of periodical work instructions and training*	*Not influence directly*
7	*Delivery*	*Management operational procedure*	*Not influence directly*

2.6.2.3. Definition of Critical control points (CCPs, step 4)

CCP Nr.	Critical control point	How to control [1)]	Frequency of control
CCP1	Testing and analyses of the receipt fuel in laboratory	Periodical inspection based on our internal rules	1 time per month
CCP2	Conditions of ground, metal shelves, machine outfit in the storages	Visual and written report for the condition	2 times per year
CCP3	Conditions of testing equipment in laboratory	Periodical inspection of the conditions	2 times per year
CCP4	Condition of sieving machine	Periodical visual inspection and it is necessary report for maintenance and repair	Every week
CCP5	Conditions of machine outfit	Periodical inspection	2 times per year
CCP6	Delivery	Automatic control based on PC programme “Promoter”	Every week

1) e.g. p*eriodical visual inspections, periodical sampling and analysis or automatic instrumental controls*

2.6.3. Definition of quality assurance measures

2.6.3.1. Staff

Measure	Frequency	Related to process step(s) nr.
Work instructions	Every tree months	6
Training of staff	2 times per year	6
Operation management and control	Every week	6
Report of the responsible staff to the company management	Every week	6

2.6.3.2. Facilities & equipment

Measure	Frequency	Related to process step(s) nr.
Periodic maintenance or repair of the storages	2 time per year	2
Periodic maintenance or repair of machine outfit	2 times per year	5
Periodic maintenance of laboratory equipment	2 times per year	3

2.6.3.3. Product quality

Measure	Frequency	Related to process step(s) nr.
Wood pellets and wood chips quantities reception in the storages and its stowage	A timetable under the contract	1
Receiving of protocol for wood pellets quality analyses after testing in laboratory despite a manufacturer certificate	Three representative samples from each batch for delivery (e.g. one truck with capacity 24 tons)	3
Signing of contracts for wood pellets/chips delivery with the producers. Receiving of producer certificate from an independent fuel testing laboratory and delivery note and invoice for each delivery.	1 per every heating season	7
Signing of contracts for wood pellets/chips delivery with the customers and the protocol for biofuel analyses is an Annex to the contract	1 per every heating season	7

2.6.3.4. Intersection points to upstream and downstream stakeholders in the supply chain

Measure	Frequency	Related to process step(s) nr.
Discussing and signing of detailed agreements with stakeholders	1 time per year	7
Providing of control of the agreements implementation	2 times per year	7
Keeping strict records including reports, minutes of meetings held, results from laboratory analyses	2 times per year	7
Collecting and handling of complaints	2 times per year	7

2.6.3.5. Documentation

ERATO Plc implements strict documentation of the planned measures. The staff is instructed according to the rules of procedure and instruction completion is reflected in the instruction book. The situation with periodical trainings of the personnel is similar. In all storages are collected copies of agreements, annexes, delivery notes, invoices etc. There is maintenance plan, and calendar schedule for all facilities and equipment. In the PC programme product "Promoter" the information for all quantities of wood pellets and wood chips in the storages, data laboratory analyses, purchased and sold quantities and logistics and transportation orders/delivery, turnover and gross profit data are given and is used for detailed management and analyses. There is also control plans connected with control and cleaning of storage ground, control and cleaning of transport units

2.6.4. Cost-benefit analysis

2.6.4.1. Description of existing approaches

The main existing approach which was used based on capital loan is the IRR – Internal Rate of Return is to be greater than interest rates on the bankable loan. On another hand the expected cash flow from the project investments to be greater than annuities. The 4th scenarios on sensitive and risk analyses for the project business plan were taken into account too.

2.6.4.2. Costs

The costs for implementation of QA System for the year 2011 in the amount of 135,730 EUR include:

- Costs in the amount of 114,530 EUR for bankable credit (loan principal and interest repayment, taxes, amortization);
- Running costs in the amount of 4,800 EUR (transportation cost, handling costs, electricity consumption costs, consumables, costs for testing in laboratory);

- O&M Costs in the amount of 16,400 EUR (maintenance of equipment, storages and machine outfit labour costs including insurance, personnel salary and social security costs);

The ratio between bankable loan costs and own contribution costs is 84%:16%. The total man-hours of the involved staff are 5,328 hours or 666 hours per man for year 2011.

2.6.4.3. Benefits

The total benefits in the type of Earnings before interest, taxes, deprecations and amortization (EBITDA) from the sales are in the amount of 32,270 EUR. The net profit is 18.5% or 25,171 EUR. The implementation of the comprehensive QA System will lead to increasing of company profit with 2.5% per year.

2.7. End-use of wood chips in power generation in Denmark (FORCE)

2.7.1. Background information

2.7.1.1. Description of the company

Name	Assens Fjernvarme A.m.b.a
Address	Stejlebjergvej 4, DK-5610 Assens
Contact person	Mr. Marc Hintze, Managing Director
Contact information	T: +45 64711024 E: mrh@assensfjernvarme.dk

Size of the company

Assens Fjernvarme operates a 5 MW(e) wood chip fired steam turbine CHP plant to generate heating for the district heating network in the town of Assens and electricity to be sold to the grid. Following figure provides main general data.

Data for Assens Kraftvarmeværk	
Commercial operation	1999
Supplier of boiler plants	Ansaldo Vølund A/S
Fuels	Forest chips, wood pellets and sawdust
Consumption of woodfuels	45,000 tonnes/year
Fired output	22MW
Boiler type	Drum boiler
Firing concept	Vibrating grate
Steam pressure	77 bar
Steam volume	5.8kg/second
Steam temperature	525°C
Electricity efficiency	24 per cent
Boiler efficiency	94 per cent
Flue gas cleaning	Electrostatic precipitator
Electrical power efficiency	5MW
District heating output	15MJ/second (including condensing)

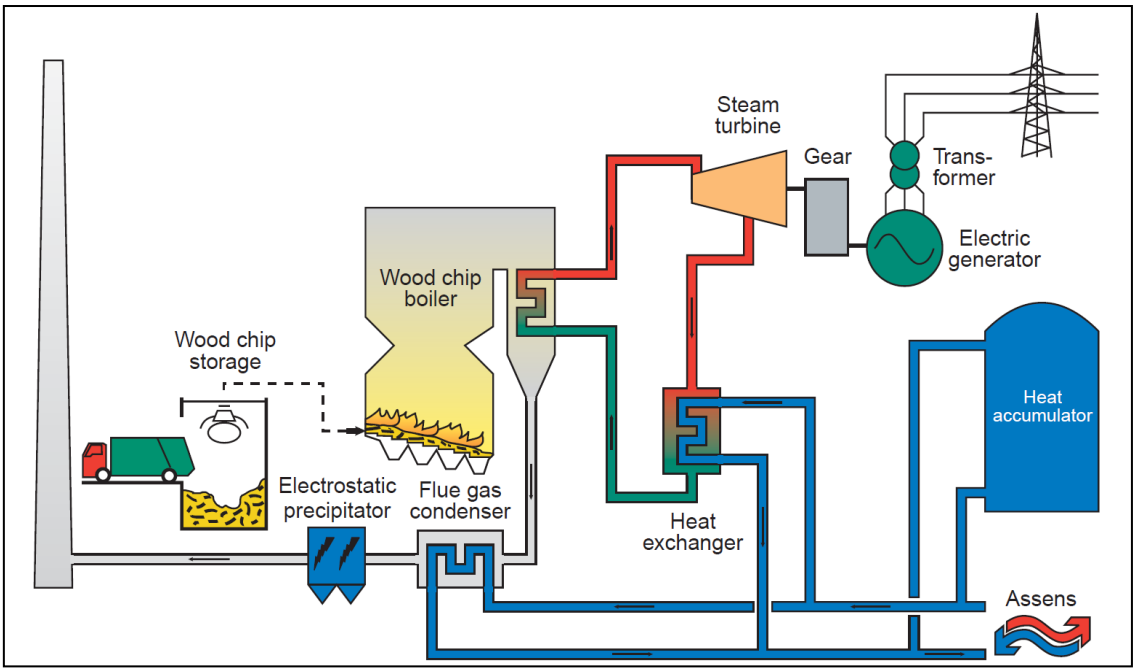
General data for Assens biomass CHP plant. (Source: Bioenergy for electricity and heat - experiences from biomass-fired CHP plants in Denmark, DONG Energy)

The company is a cooperative society and is controlled by a board with eight members. In total the company has 12 employees.

In 2011/2012 the company had 3.097 customers that consumed 67.551 MWh of heat. The sale of electricity was 27.050 MWh. The annual turnover was 6.5 M€ in the period.

Experience

Assens Fjernvarme has been delivering heat for Assens for decades. In 1999 the wood chip fired CHP plant was put into operation. The plant is one of the smallest biomass fired steam turbine CHP plants in Denmark. The plant contributes with the major share of heat necessary for the heating network in Assens, however the original heating block I in the heart of the town remains for back-up and peak load. Block I consists of three coal boilers each with a capacity of 6.3 MW. They have been retrofitted for wood pellets and dry wood chips. From October to March it supplies 15% of the annual heat production in the system.



Schematic overview of the biomass CHP plant (in reality, the electrostatic precipitator is placed before the condenser). (Source: Bioenergy for electricity and heat - experiences from biomass-fired CHP plants in Denmark, DONG Energy)

2.7.1.2. Description of raw material supply

The fuel is mainly wood chips but a wide range of clean wood fuels with moisture contents from 5 to 55% can be used, e.g. wood pellets and sawdust or other residues from wood processing industries.

The company buys wood chips from Denmark and abroad. A large share of the fuel is received via Assens Harbour as whole logs or chips imported from e.g. Germany, Poland and Estonia. The chips are transported to the plant by trucks. The logs are chipped by a contractor at the harbour premises. Some of the logs are stored to dry on the plant site and chipped by a contractor. A stock of logs or wood chips is kept at the plant site to be used as a backup supply in case of lack of new supplies at the right price.

During the last couple of years, the company has been engaged with local farmers in order to grow willow and generate a local fuel supply. The aim is that the willow chips should account for one fifth of the fuel supply at the plant. The first harvest took place in the winter 2011/2012 and the reported results are positive. The fuel had a high moisture content (>50%) which the flue gas condensing system of the plant proved to be able to handle.

Logs and chips stored at the plant site for backup. (Photo: Morten Tony Hansen)

In 2011/2012 the plant in total consumed 41,820 tonnes of wood chips and 760 tonnes of wood pellets along with 12 m^3 of oil. The activity generated 911 tonnes of wood ash.

2.7.1.3. Fuel handling

The fuel is received at the plant site and each truckload is weighed at a weigh bridge. The truck drivers take out a sample of each load for moisture analyses that are performed by the plant staff and used for the price settlement.


Wood chips in two of the four fuel intakes. (Photos: Morten Tony Hansen)

Each fuel truck unloads the chips into one of the four intakes at the fuel storage. By means of automatic grab cranes, the chips are moved from the intakes to the storage that holds fuels for 10 days of full load operation.

According to feed signals from the boiler system fuel is moved from the storage via a rotating screen to a special mixing system where it is possible to make a mixture consisting of 70% wood chips and 30% fines. From a dosing hopper it continues to two air sprouts that throw the fuel into the combustion chamber. The light elements will burn out while they float towards the vibrating grate in the combustion chamber, while the larger pieces burn out on the grate.


Automatic grab crane and rotating screens. (Photos: Morten Tony Hansen)

2.7.1.4. Fuel quality issues

Due to the fuel mixing functionality, the plant is able to operate on a variety of fuel moisture levels. The fuel procurement function keeps focus on fuel alternatives with the lowest possible price levels yet keeping it within the "wood chips" term. In practice this means that

the plant receives fuels from a variety of origins and with quite large variation in moisture and fines. To mention some, the chips can origin from quite dry coniferous logs with no or little bark, fresh blackcurrant shrubs, newly harvested willow or branches.

The different raw material sources require careful storing and mixing procedures. Yet the fuel quality - especially the moisture content - and the operational stability of the plant is influenced. On this basis the company and especially the operational personnel experiences a need for controlling the quality of the fuel in a better way.The company has in-house equipment for analyzing moisture content and ash melting point.

2.7.1.5. Customer description

The company is a district heating company whose direct customers are local heat consumers and one or more regional electricity traders as well as the national electricity grid company.

The customers would not have direct interest in fuel quality issues. However, they would be interested in an economically optimal operation of the plant e.g. the lowest possible heating price and to some extent that the plant is operated as far as possible in a sustainable manner. This indirectly calls for the best possible quality control of the fuel and other operational parameters of the plant and thus a quality management system.

Recently, the plant has been LEC certified as the first 100 percent biomass-fired power plant in Northern Europe to deliver green electricity to the UK. The certificate opens a new market to generate additional income for the plant.

Wood chip piles at Assens Harbour. (Photo: Morten Tony Hansen)

2.7.2. Supply chain analysis

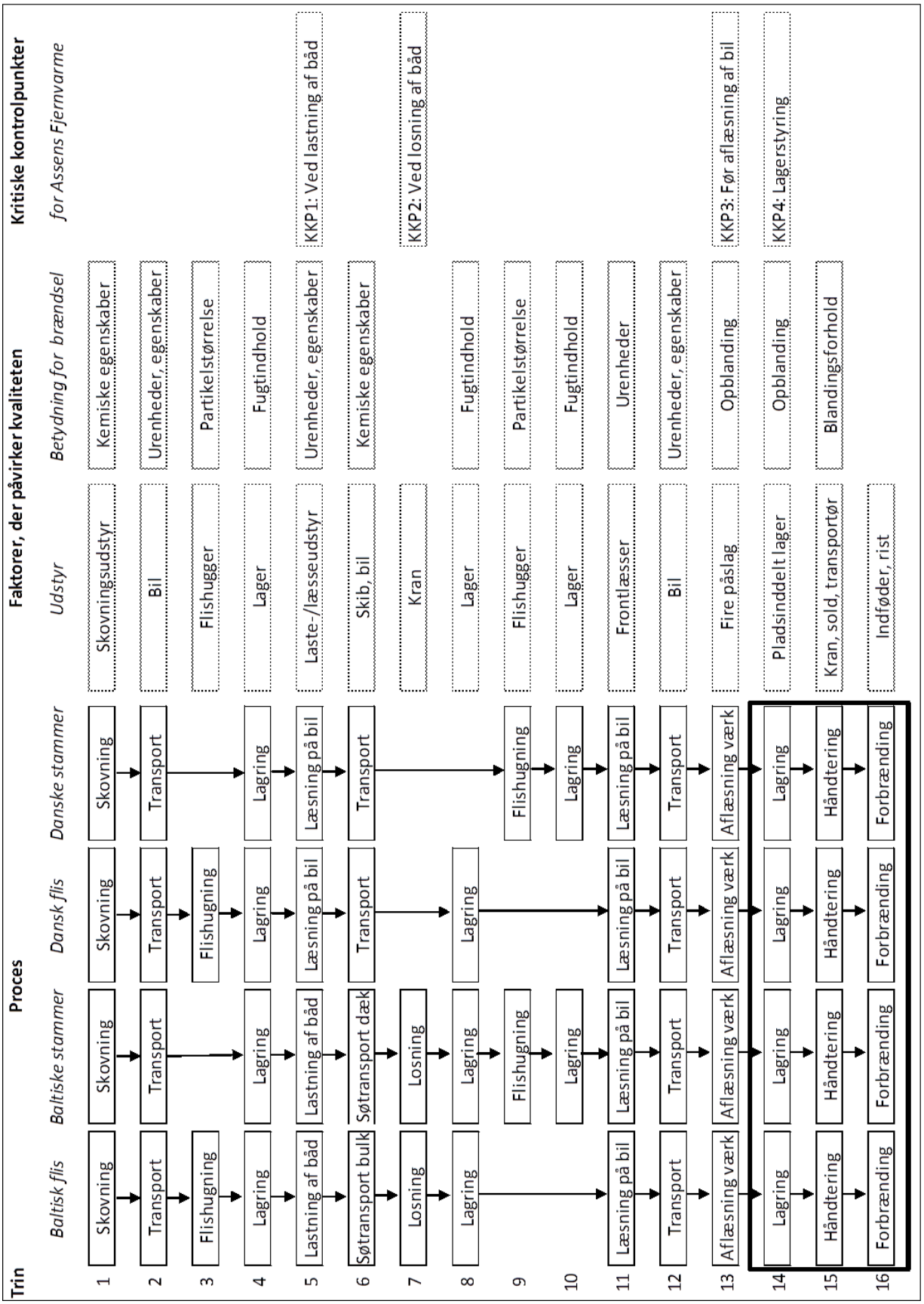
The methodology for the assessment of the supply chain and the implementation of a quality assurance system at Assens CHP plant has been done according to step 2-6 in the procedure defined in EN 15234-2:

- Step 2: Process description (see 2.2.2.1)
- Step 3: Identification of quality influencing factors (see 2.1.2.2)
- Step 4: Definition of critical control points CCPs (see 2.1.2.3)
- Step 5: Selection of appropriate quality assurance measures (see 2.2.3)
- (Step 6: Routines for separate handling of nonconforming fuels

For clarity purposes quality influencing factors as well as critical control points have been included into the process description.

2.7.2.1. Process description (step 2)

Assens Fjernvarme uses different wood fuels each with a different origin. The following figure describes the four most common supply chains.



2.7.2.2. Identification of quality influencing factors (step 3)

The table below contains a more detailed description of how the factors influence the properties of the fuel or the operation of the CHP plant.

Step	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
1	*Logging*	*Logging equipment and timing*	*The logging method and the timing determine which parts of the trees that are taken out and thus the chemical composition*
2,5,6, 11,12	*Loading and transportation*	*Loading equipment suitability & cleanliness of transport unit*	*At every loading event or if the equipment is not properly clean, impurities might get into the load*
3,9	*Chipping*	*Chipper and screen*	*Chipping and screening are crucial to the particle size distribution and the content of outliers*
4,8,10, 14	*Storage of fuel*	*Storage facilities*	*The storage influences the content of moisture and dry matter and thus the heating value of the fuel*
7,13	*Landing/unloading*	*Storage facilities, cleanliness of fuel reception hopper*	*Umproper landing/unloading gives a risk of contamination of the chips or mixing in a way that the traceability is lost*
15	*Handling*	*Crane and storage control*	*If information on the fuel is lost during handling, information on the fuel that is finally fed into the boiler is also lost*

2.7.2.3. Definition of Critical control points, CCPs, (step 4)

Critical Control Points are points within or between processes at which fuel properties can be most readily assessed and thus the points that offer the greatest potential for intervention and quality improvement in order to prevent operational fluctuations or problems.

CCP	Critical control point	How to control [1)]	Frequence of control
CCP1	*At loading of ship*	*Visual inspection of fuel mixing and loading procedure*	*Annual visit*
CCP2	*At unloading of ship*	*Visual inspection of fuel of fuel placement before it is unloaded*	*Once per ship load*
CCP3	*Before unloading at the plant*	*Visual inspection of fuel, guidelines for unloading, sampling*	*Every truck load*
CCP4	*Storage control*	*Careful book keeping of all amounts and corresponding properties*	*Every time the fuel crane is operated*

[1)] *E.g. periodic, visual inspections, periodic sampling and analyses or automatic surveillance.*

2.7.3. Choice of quality assurance measures

This part lists quality assurance measures and quality assurance activities which are necessary to maintain fuel the quality and stable operation of the plant. Each measure is connected with their respective process step from part 2. A number of measures have already been implemented in the operation of Assens Fjernvarme.

2.7.3.1. Staff

The main responsibility for fuel quality are at the fuel purchases function which in Assens Fjernvarme is headed by the Director. The focus of the purchaser is for the lowest price possible to obtain sufficient fuel quality to maintain an economical operation with high efficiency and few unplanned stops. Inside the cadastre the responsibility is divided between the director and production manager. The latter is mainly focused on optimal and uninterrupted operation and thus favours high and consistent fuel quality over lowest possible price. Responsibilities:

- Fuel purchase - Director
- Storage control of fuel - Production manager
- Storage control of fuel and feeding - Operations staff

The following measures will qualify the staff to control fuel quality:

Measure	Frequency	Relates to step no.
Education of personnel in control of fuel quality (inspections, sampling, analyses, documentation etc.)	Annually	13, 14, 15, 16
Internal meetings where quality is on the agenda	Quarterly	13, 14, 15, 16
Exchange of experiences with visual control of ash content for every fuel sample	Quarterly	13, 14, 15, 16

2.7.3.2. Facilities and equipment

Assens Fjernvarme has a number of facilities and equipment, that in use can help to keep control on fuel quality:

- Weighbridge
- Four fuel intakes by which fuels with different characteristics can be kept apart
- Covered fuel storage with four divisions and underlying zoning that can help to maintain the separation of fuels with different characteristics
- Storage crane that can be controlled to automatically keep fuels with different characteristics separated during the move from intake to storage and provide adequate mixing while moving fuels from storage to the rotating screen
- Rotating screen to filter out coarse outliers in the chips
- Fuel laboratory for determination of moisture content (for settlement) and ash content (as needed)

The following measures ensure that the plant possesses the necessary equipment and that it is kept in a condition so fuel quality can be controlled and maintained:

Measure	Frequency	Relates to step no.
Periodic visual inspection of weighbridge, intake, storage, crane, screen and transport system	Weekly	14, 15, 16
Periodic control of settings and functionality as well as maintenance of weighbridge, storage, crane, screen and transport system	Monthly	14, 15

2.7.3.3. Fuel

The measures below are focusing directly on the fuel:

Measure	Frequency	Relates to step no.
Weighing at the weighbridge	Every truck	13
Samling of wood chips	Every truck	13
Determination of moisture content for settlement	Every truck	13
Keeping journal on the correlation of fuel placement in storage (zone) and fuel properties (moisture content, origin etc.)	Daily	13, 14, 15
Visual inspection at nonconformity or if special types of wood chips	As needed	14
Determination of ash content	As needed	16
Accredited chemical fuel analysis	As needed	16

2.7.3.4. Connections to upstream stakeholders in the supply chain

Assens Fjernvarme should inspect the fuel and conditions of the suppliers and transport companies, including Assens Harbour to predict whether the fuel has been above the deck, exposed to salt water spray.

Measure	Frequency	Relates to step no.
Visual inspection of wood chips at supplier in Baltic states	Annually	3, 4, 5
Visual inspection of wood chips production at DK supplier	Annually	3, 9
Visual inspection of shiploads in Assens Harbour	Every ship	7

2.7.3.5. Documentation

This section describes how measures of quality assurance are documented in the organization.

Subject	Document
Amount, origin and moisture content of incoming fuel	Fuel purchase journal
Results of inspection of fuel at harbour facilities etc.	Log book
Handling of nonconforming fuel	Operations journal
Maintenance plan	Digital planning tool
Results of control inspections	Log book
Operational data, production data, fuel consumption, key plant data	Operations journal
Deviations in plant operation	Operations journal
Directory of personnel competences and resposibilities	Staff documents
Annual continuing training of personnel within quality assurance	Staff documents

2.7.4. Cost-benefit analysis

2.7.4.1. Description of existing approaches

Assens Fjernvarme has already implemented some of (or to some extent) the measures mentioned in section 3.

Measure - Personnel	Frequency	Relates to step no.
Education of personnel in control of fuel quality (inspections, sampling, analyses, documentation etc.)	Annually	13, 14, 15, 16
Internal meetings where quality is on the agenda	Quarterly	13, 14, 15, 16
Exchange of experiences with visual control of ash content for every fuel sample	Quarterly	13, 14, 15, 16
Measure - Facilities and equipment	**Frequency**	**Relates to step no.**
Periodic visual inspection of weighbridge, intake, storage, crane, screen and transport system	Weekly	14, 15, 16
Periodic control of settings and functionality as well as maintenance of weighbridge, storage, crane, screen and transport system	Monthly	14, 15

Measure - Fuel	Frequency	Relates to step no.
Weighing at the weighbridge	Every truck	13
Samling of wood chips	Every truck	13
Determination of moisture content for settlement	Every truck	13
Keeping journal on the correlation of fuel placement in storage (zone) and fuel properties (moisture content, origin etc.)	Daily	13, 14, 15
Visual inspection at nonconformity or if special types of wood chips	As needed	14
Determination of ash content	As needed	16
Accredited chemical fuel analysis	As needed	16
Measure - Upstream in the supply chain	**Frequency**	**Relates to step no.**
Visual inspection of wood chips at supplier in Baltic states	Annually	3, 4, 5
Visual inspection of wood chips production at DK supplier	Annually	3, 9
Visual inspection of shiploads in Assens Harbour	Every ship	7

2.7.4.2. Costs

The cost of introducing a quality system can be divided into two:

1. One-off costs, ie. investment in equipment and systems, or training costs, etc., to be made in order to implement and operate the quality management system
2. Running costs, ie. operating costs in the form of continuous acquisitions of equipment or services and the cost of staff during the time spent on the system

It is estimated that Assens Fjernvarme has the physical environment to implement a quality system. Recurring costs associated with implementation will therefore consist of consultancy to get the system designed and implemented as well as the basic introduction of the staff in the system. Consultant assistance in this project is payed by FORCE Technology / the project itself. The costs stated below are estimates assessed in cooperation with the former director, John Jessen.

Estimates of one-off costs:

Measure	Extent, hours	Costs, DKK
Investment in equipment	0	0
Consultant assistance by implementation of system	100	100,000
Basic training of staff in quality system	50	15,000
Collection of experience from other plants	50	25,000

Estimates of running costs are estimated below for measures exceeding the measures already in operation:

Measure - Personnel	**Frequency**	**Cost, hours/y / DKK/y**
Education of personnel in control of fuel quality (inspections, sampling, analyses, documentation etc.)	Annually	100/ 50,000
Internal meetings where quality is on the agenda	Quarterly	25 / 12,500
Exchange of experiences with visual control of ash content for every fuel sample	Quarterly	25 / 12,500
Measure - Facilities and equipment	**Frequency**	
Periodic visual inspection of weighbridge, intake, storage, crane, screen and transport system	Weekly	100 / 50,000
Periodic control of settings and functionality as well as maintenance of weighbridge, storage, crane, screen and transport system	Monthly	10 / 5,000
Measure - Fuel	**Frequency**	
Weighing at the weighbridge	Every truck	0 / 0
Samling of wood chips	Every truck	Already done
Determination of moisture content for settlement	Every truck	Already done
Keeping journal on the correlation of fuel placement in storage (zone) and fuel properties (moisture content, origin etc.)	Daily	150 / 75,000
Visual inspection at nonconformity or if special types of wood chips	As needed	100 / 50,000
Determination of ash content	As needed	50 / 25,000
Accredited chemical fuel analysis	As needed	10 / 15,000
Measure - Upstream in the supply chain	**Frequency**	
Visual inspection of wood chips at supplier in Baltic states	Annually	10,000
Visual inspection of wood chips production at DK supplier	Annually	10,000
Visual inspection of shiploads in Assens Harbour	Every ship	10 / 5,000

2.7.4.3. Benefit

The direct benefit by implementing a quality assurance system is difficult to quantify. The figures below are to be taken as an attempt. The benefits have been estimated in close cooperation with the former director, John Jessen.

A more permanent and more comprehensive effort than before to ensure a fuel with a higher and more consistent quality and ensure that the actors upstream in the supply chain contribute positively to this effort, will result in a more continuous plant operation with fewer fluctuations in electricity production and lower risk of unplanned stops or actual breakdowns.

Benefit	Frequency	Value, DKK.
More stable plant operation - higher annual plant efficiency - estimated 2 percentage points	Continuously	Savings in primary production costs are approx. 200,000 DKK/y each percentage point
Reduced risk of unplanned stops due to fluctuating fuel quality	Continuously	One stop of 24 hours will cost around 150,000 DKK. Realistically, missing control causes five stops. Value approx. 500,000 DKK/y.
Deduction due to ash content and too high moisture content	Continuously	50,000 DKK/y

2.7.4.4. Result

The outcome of the above considerations and tables is that a quality assurance system can be established for around 150,000 DKK and operated for an annual cost of about 300,000 DKK, while the reflections indicate that the system can result in savings in the order of up to 1 million DKK.

Estimates indicate that even if the sampling of chips (DKK 15,000/year) and the determination of moisture content in connection with the settlement (DKK 150,000/year) already made today are recognized as expenditure when a new quality assurance system, the costs will be recovered in less than one year.