SolidStandards

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

D4.3

Report on standard implementation

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.

SolidStandards is coordinated by:

WIP Renewable Energies
Sylvensteinstrasse 2
81369 Munich, Germany
Cosette Khawaja & Rainer Janssen
cosette.khawaja@wip-munich.de
rainer.janssen@wip-munich.de
Tel. +49 (0)89 720 12 740

About this document

This report is an outcome of Task 4.3 (Initial product testing) and Task 4.4 (Implementation on EN 15234). Task 4.3 is a precondition on the implementation on quality standards. Some of the partner companies in this work package don't want the results of the analyses of their product to be published. For this reason the project consortium decided to document the results to EACI in a confidential Task 4.3 report.

This document was prepared in **July 2013** and revised in March 2014 by:

Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Strasse 116
04347 Leipzig
Martin Hoeft
martin.hoeft@dbfz.de
Tel. +49 (0)341 2434 593

Intelligent Energy Europe

The SolidStandards project is co-funded by the European Union under the Intelligent Energy Europe Programme (Contract No. EIE/11/218).

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

Country specific reports

The country specific reports were written by:

Jakob Bosch and Martin Hoeft Tel +49-(0)-341-2434-593 Fax +49-(0)-341-2434-133 martin.hoeft@dbfz.de	DBFZ Deutsches Biomasseforschungs-zentrum gemeinnützige GmbH Torgauer Strasse 116 04347 Leipzig, Germany www.dbfz.de
Matti Virkkunen, Eija Alakangas & Ari Erkkilä Tel. +358 20 722 111 Fax +358 20 722 7001 Email: firstname.surname@vtt.fi	VTT - Technical Research Centre of Finland Koivurannantie 1 FI-40101 Jyväskylä, Finland www.vtt.fi
Velimir Šegon Tel: +385 1 3098 315 Fax: +385 1 3098 316 vsegon@regea.org	Regionalna energetska agencija jeverozapadne Hrvatske (REGEA) Andrije Žaje 10 10 000 Zagreb, Croatia www.regea.org
Ludmiła Wach Tel: +48 58 347 55 35 Fax: + 48 58 347 55 37 lwach@bape.com.pl	Baltic Energy Conservation Agency (BAPE) ul. Budowlanych 31 80-298 Gdansk, Poland www.bape.com.pl
Monika Steiner Tel +43-1-798 26 23-912 Fax +43-1-798 26 23-50 m.steiner@holzforschung.at	HOLZFORSCHUNG AUSTRIA (HFA) Franz Grill-Str. 7 A-1030 Wien, Austria www.holzforschung.at
Nikolay Vangelov Tel.: +359 2 978 3990 Fax.: +359 2 978 0744 n_vangelov@erato.bg	ERATO Plc (ERATO) 67, Saedinenie blvd. Haskovo 6300, Bulgaria www.erato.bg
Morten Tony Hansen Tel +45 72 15 77 55 Fax +45 72 15 77 01 mth@force.dk	FORCE Technology (FORCE) Hjortekærsvej 99 2800 Kgs. Lyngby, Denmark www.forcetechnology.com

Table of contents

List of figures

1. Introduction

This report documents the results of the initial product testing (task 4.3) and the application of quality assurance standards EN 15234 (Task 4.4). The aim of the analyses was to assess if the quality of the produced wood fuels meets the requirements of the appropriate parts of product standards of EN 14961. The results of the analyses have been taken into account when defining the quality assurance measures according to the quality standards of EN 15234 for the companies involved in the project. The final aim of this deliverable is to describe the implementation of product and quality assurance standards in seven companies. The standards for product testing and the standards for quality assurance have the same structure and are separated in six parts according to the kind of fuel.

Standard	Part	Solid Biofuel
Product standards: EN 14961 - Quality assurance standards: 15234 -	1	General requirements
	2	Wood pellets
	3	Wood briquettes
	4	Wood chips
	5	Fuelwood
	6	Non-woody pellets

All specified physical and chemical product parameters in the related standards had been tested. Not all of the industry partner companies in this work package agreed on publishing the initial product testing results. For this reason the participants decide not to publish the results as a public document. Instead the product testing results are collected in one document and handled as confidential. Conclusions out of this product testing and the further treatment are taken into account in this deliverable. The country specific issues and tested products are listed below:

Partner	Country	Issue
DBFZ	Germany	Production of wood pellets
VTT	Finland	Wood chips supply chain
RAGEA	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. Wood pellets in Germany (DBFZ)

Task: Production of wood pellets

2.1. Genral information

2.1.1. 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 (Hesse) in central Germany.
In 2012, the company has built up a new pellet plant with a production capacity of about 100,000 tonnes per year. Their plan is to produce high quality pellets according to EN 14961-2, class A1 with a diameter of 6 mm in 2 -shift operation. The company plans to hold an ENplus certification for the production site.

2.1.2. Description of raw material supply

In the beginning only the use of by-products from the company-own sawmills was planned. Since a lot of the residues from the own saw mill are currently used for pallet block production, additional raw material from external sources has to be used. About 30% of the currently used raw materials are bought from specialised traders or other saw mills. Feedstock for the production is about 70% Norway spruce, about 30% 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 not certified according to FSC or PEFC.

2.1.3. Customers description

The wood pellets quality meets the requirements according to the product standard EN 14961-2 Class A1 which was also confirmed by the initial product testing. The product is typically used in small furnaces for non-industrial use. To distribute the pellets on the market, Pfeiffer Holz cooperates with local pellet traders.

2.2. Production chain analysis

The production chain has been analysed according to the procedure defined in EN 15234-2:

- (Step 1: Definition of fuel properties)
- Step 2: Process description (see 2.2.1)
- Step 3: Identification of quality influencing factors (see 2.2.2)
- Step 4: Definition of Critical control points (see 2.2.3)
- Step 5: Definition of quality assurance measures (see 2.3, including step 6: Routine for the separate handling of non-conforming material)

2.2.1. Process description (step 2)

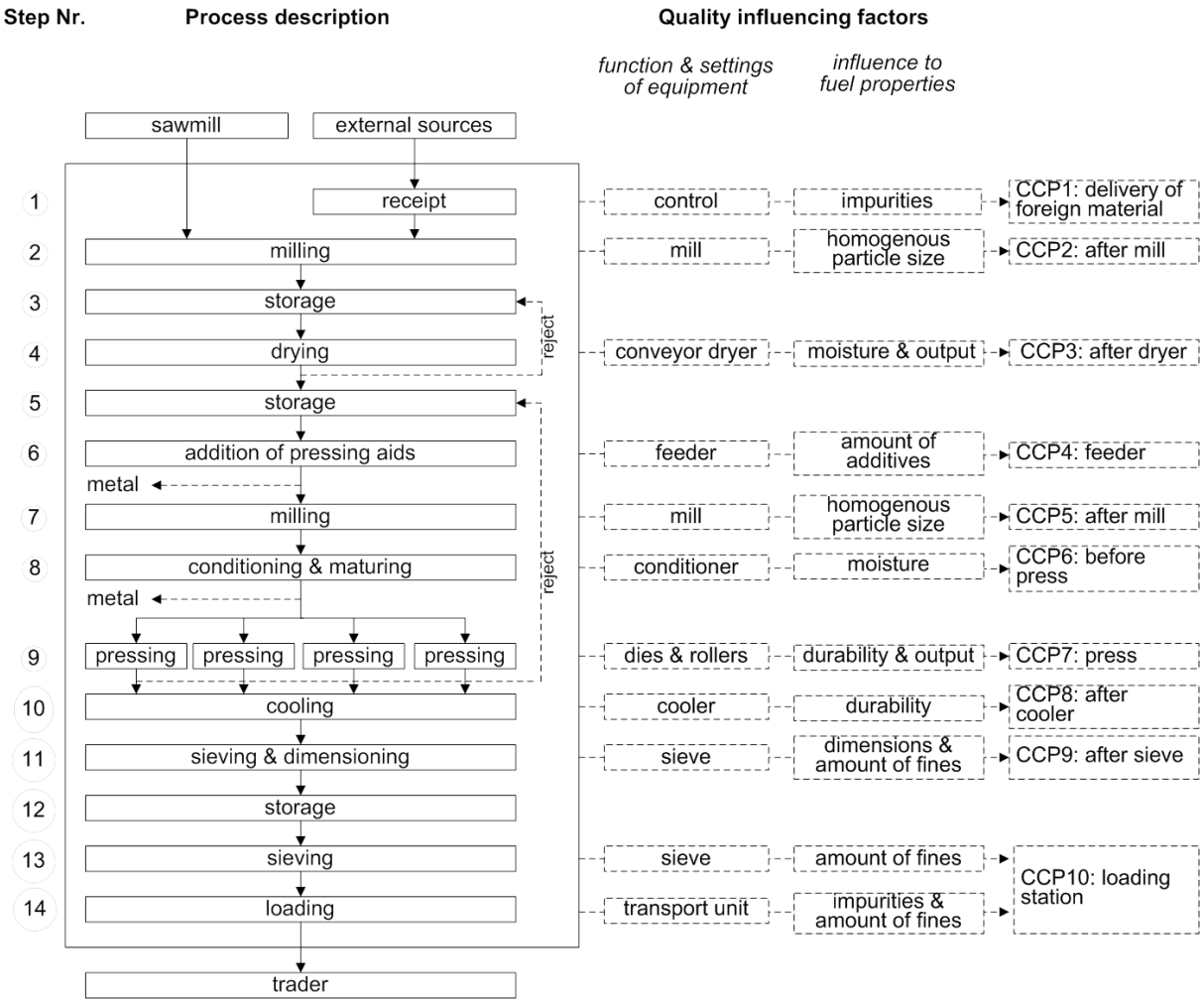


Figure 2.2-1: Flow chart with the process description

2.2.2. Identification of quality influencing factors (step 3)

In the following table the main factors that might have an influence on the pellet quality are listed as well as factors that might have an influence on the companies' production performance (see also 2.2.1.).

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	Influences 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 pelletizing.
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	Condition of the roller	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

2.2.3. Definition of Critical control points (step 4)

Critical Control Points (CCP) 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 week
CCP3	After dryer	Automatic control	Permanent
CCP4	Feeder	Calculation	Periodical, once per day
CCP5	After mill	Visual control	Periodical, once per week
CCP6	Before press	Automatic control	Permanent
CCP7	Press	Visual control/ automatic: temperature Analysis: Mechanical durability, Bulk Density, Moisture content	Periodical, once per week/ permanent Once per hour
CCP8	After cooler	Automatic control	Permanent
CCP9	After sieve	Visual control	Periodical, once per week
CCP10	Loading station	Fines: sampling & analysis Suitability of transport unit: visual control	When loading

2.3. Definition of quality assurance measures

Since the company holds an ENplus certification, not only the requirements of EN 15234-2 but also those of the ENplus certification scheme will be respected. Some of the certification scheme's rules specify the standard's requirements, some go even further than the standard.

2.3.1. Staff

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

Measure	Frequency
Training workshop for the employees (responsibilities, analysis of fuels, documentation, other qa-measures) [1)] The training workshop did not take place yet but every involved employee received a comprehensive introduction	once per year
[1)] Requirement defined in the ENplus-Handbook, but not in EN 15234-2	

2.3.2. 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 2.2.3) exists
- At two important CCPs (CCP3 and CCP7) non-conforming material can be rejected and returned at an earlier step of the production process.
- At two points in the production chain metal impurities are removed
- Overlong pellets are automatically sieved out
- Equipment to screen out the fines is incorporated into the loading station (process step 14)

Figure 2.3-1:Clean bituminised ground at the raw material storage

Measure	Frequency	Related to process step(s) nr
Periodic visual controls of manipulation areas and storages and conveyors	Periodic, once per week	2-14
Controls of settings, functions and condition of the equipment at CCPs 4, 6, 7 (die and rollers) (see 2.2.3)	Periodic, daily	6, 8, 9
Controls of settings, functions and condition of the equipment at CCPs 2, 5, 7 (general condition (see 0)	Periodic, once per week	2, 7, 9

2.3.3. Product quality

The analyses of the wood pellets produced by Pfeifer Holz at Lauterbach showed the high quality of the product. All quality parameters were within the limits.

The measures in the following table are all related to the control of pellet quality

Measure	Frequency	Related to process step(s) nr.
After dryer: periodical visual control of raw material dimension. [1)]	Once per day	2
Product testing: Bulk density (EN 15103), Mechanical durability (Lignotester), Moisture content (fast measuring equipment)	Once per hour	9
Visual: Dimension (a crusher limits the length of the pellets to maximal 30mm)	Once per day	11
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	1-14
[1)] Additional optional control		

Figure 2.3-2:Testing equipment for internal quality

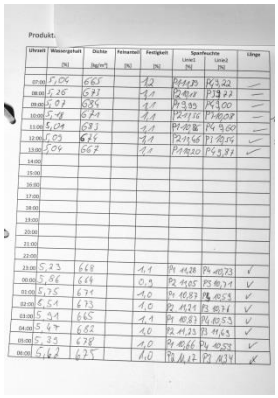


Figure 2.3-3: Documentation of test results

control

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

Measure	Frequency	Related to process step nr.
Visual inspection of incoming raw material from foreign sources. The material is dumped on a pile before the visual inspection.	Every time when unloading	1
Control of pellet temperature (not more than 40°C). Control is carried out by the truck driver.	Every time when loading	14
Control cleanliness of transport units (not special vehicles for the exclusive transport of wood pellets). The driver of the truck has to sign a declaration on the cleanliness and waterproofness of his vehicle [1)]	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. [2)] The truck driver has to take the sample at the loading station and has to bring it to the sales office.	Every time when loading	14
Implementation of a comprehensive complaint management system		

[1)] Requirement defined in the ENplus-Handbook, but not in EN 15234-2

[2)] Requirement defined EN 15234-2, specified in the ENplus-Handbook

2.3.5. Documentation

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

Issue	Document *
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 of saw mill
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
Malfunctions of the production process (date, type of malfunction, measures taken to remedy the problem, quantity and disposition of the non-conforming pellets; see 2.3.2)	Operation journal
More extensive repair and maintenance work that could lead to a change in pellet quality (date, type of work performed)	Operation journal
Proof of competence of the quality assurance representative (at least 2 years of work	Staff documentation

Issue	Document *
experience in pellet production OR a master craftsman's diploma OR a graduated study course)	
Annual employee trainings (date, participants, contents; see 2.3.1)	Staff documentation
Areas of responsibility of the individual employees (function descriptions; see 2.3.1)	Staff documentation
Results of the self-inspections (see 2.3.3)	Laboratory logbook
Amount of certified and non-conforming material produced at the site.	Operation journal
Documentation of outgoing goods: date, amount, name of customer, number of reference sample (see 2.3.4), license number of transport unit. Last freight when the pellets are transported by a freight forwarding company.	Sales journal
Self-declaration of the transport truck's driver on the cleanliness and the waterproofness of the vehicle.	Sales journal
Customer complaints (date results of the findings, measures taken to remedy the defects if necessary)	Complaints documentation

2.4. Assessment of the implementation process

2.4.1. Selection of quality assurance measures

The implementation of some of the suggested measures has been refused by the company. Nevertheless, in both cases ways have been found to assure the quality of the product.

Measure	Reason(s) for the refusal
Loading of pellets: control of cleanliness of transport units (not special vehicles for the exclusive transport of wood pellets). The vehicles are controlled only in exceptional cases but the truck driver has to sign a declaration that his truck is clean and dry.	Pfeifer Holz does not have the human resources for checking every truck. For this reason the responsibility for the cleanliness has been transferred to the truck driver.
Product testing when loading a transport vehicle: Amount of fines	Pfeifer Holz does not have the human resources for checking the amount of fines when loading every truck. Since all particles less than 6mm are screened out before loading, a high amount of fines is not probable. In case of problems the retain sample taken during the delivery of the truck can be analysed.

2.4.2. Costs and financial benefits

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 is why they are not considered at this point.

Running the quality assurance system will cost about 27,000 €/year. The selfinspections 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	20 €/week
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

The benefit by the implementation of a quality assurance system is hardly quantifiable. This is mainly caused by the fact it is difficult to quantify the added value in Euro.

Benefits 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 of the plant and reduces therefore the operating costs.
- Replacement costs and complaints can be reduced by avoiding quality problems (especially high amount of fines and fuel contaminations). Every qualified complaint costs the company about 1,000 – 2,000 €. Assuming that about 10 complaints can be avoided, every year up to 20,000 € can be saved. Furthermore 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 Emission Control Directive (1.BImSchV). By the existence of a quality assurance system, respective a quality certificate, the compliance of the produced pellets with the quality requirements can be proofed.

2.4.3. External reactions and further use of the implemented qa system

Since the market demands for quality certified pellets, all major pellet producers in Germany are holding a certificate by one of the two large certification schemes (DINplus or ENplus). Without holding a certificate, selling pellets for the small end-consumer market is nearly not possible. The majority of pellet traders ask for a certified product, some of the traders even ask the producer for a copy of the certificate.

The rules for the internal quality assurance system defined for the DINplus scheme are not as comprehensive as those defined for the ENplus scheme. But the majority of the traders make no difference between the two systems.

2.4.4. Opinion of the company's management about the standards

EN 14961-1 & EN 14961-2: Fuel Specifications

The operators of the pellet plant see the problem that the density of the pellets can be too high what can cause problems during combustion. For this reason they suggest to define an upper threshold value for the bulk density and the mechanical durability of the pellets.

EN 15234-1 & EN 15234-2: Quality Assurance

Implementing the quality assurance system, it was very helpful for the company that the ENplus-handbook defines ways for an easy implementation of EN 15234-2's requirements.

2.5. Conclusions

The company already runs three other pellet productions and therefore has a large experience in planning and operating pellet plants. The company grounds at Lauterbach enabled a good integration of the pellet plant into the saw mill facilities which runs since 2007.

In January 2013 the pellet plant has been ENplus certified. The result of the analyses of the sample, taken during the initial audit, shows the high quality of the product. All properties meet the requirements of the ENplus scheme and therefore the requirements of EN 14961-2.

Regarding the length of the produced pellets, the internal requirements are even stricter than those defined in standardization and certification. The standard length of pellets from Lauterbach is limited from 6mm to 30 mm (ENplus A1 and EN 14961-2, A1: 3.15 mm to 40 mm).

Most of the end-customer's complaints are about a high amount of fine particles in the load. A problem that is often caused by the handling of the pellets during transport or the conditions at the end-user's site and pellet storage. For this reason, most of complaints from end-consumers are handled by the respective pellet dealer. Only in exceptional cases Pfeifer Holz gets involved into the search for the reasons of the complaint. The company is currently developing a comprehensive 3-step complaint management system:

1. Survey of the suitability of the end-users storage together with the involved pellet trader and the company which installed the boiler.
2. The operation manager of the production site writes a comment about possible reasons for the bad quality of the product.
3. The manager of the plant decides how to handle the complaint together with the sales department.

The rules of the ENplus scheme on the company own quality assurance system are even stricter than the requirements defined in EN 15234-2 (see footnotes in 2.3.1 - 2.3.5). Additionally it shows in many cases how the requirements defined in EN 15234-2 can be implemented in practice.

In summary it can be stated that the requirements defined in EN 14961-2 and EN 15234-2 have been completely implemented in the pellet plant. The way some of the regulations have been realized, shows the large experience of company and production management in producing high quality pellets.

3. Wood pellets in Croatia (Regea)

Task: Production of wood pellets

3.1. General information

3.1.1. Description of the company

- *Name and place*
  Energy pellets d.o.o.

  Zrinska 18

  51300 Delnice

  CROATIA
- *Legal status*
  Private company, Ltd.
- *Business segment*
  Production of pellets
- *Number of employees*
  26
- *Machine outfit*
  Chipper, loader, crusher, dryer, sieve, shredder/grinder, pellet mill
- *Turnover*
  3,6 mil eur in 2012
- *Foundation date/experience*
  Company founded and started production of pellets in 2007
- *Annual production/trading quantity*
  Production in 2012: 28.000 t
- *Production/trading capacity*
  Installed capacity: 30.000 t/y
- *Information about product quality (e.g. according to EN 14961-2, classes A1 & B)*
  According to EN 14961-2, class A2
- *Quality certificates (e.g. DINplus/ENplus, ISO 9001,…)*
  In November 2013 company Energy pellets fulfilled requirements of ENplus A2 certificate

3.1.2. Description of raw material supply

The main supplier of raw materials is Hrvatske šume d.o.o. (Croatian Forests Ltd.) and small wood-processing companies in the vicinity of company. 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.

3.1.3. Customer description

The company Energy pellets Ltd. exports its products mainly to Italy and in smaller amount to Austria and Slovenia, while less than 5% of production is sold on Croatian market directly to end users. All transport is outsourced to outside forwarding companies.

3.2. Production chain analysis

The wood pellets quality meets the requirements according to the product standard EN 14961-1 which was also confirmed by the initial product testing.

3.2.1. Process description (step 2)

All major steps in the supply chain are documented.

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.

3.2.2. Identification of quality influencing factors (step 3)

Factors that have an impact on the quality of the finished product have been identified and documented as part of the requirements within EN 15234-1 and EN 15234-2 standards, as well as requirements for obtaining ENplus A2 certificate. The quality influencing factors have been identified in the following productions steps:

- procurement of raw material
- storage of raw material
- processing of raw material
  - impact of equipment maintenance,
  - impact of employees on product quality (employee training)
- process parameters,
- storage of finished goods.

In order to standardize process it was 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 a method of reporting and writing in a simple and straightforward way was developed to ensure information to the relevant people in the process, so mistakes could be prevented and possible subsequent analysis of causes of the problem could be made.

The quality influencing factors for the Energy pellets Ltd. company are presented 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*

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

Critical control points are also defined within the production process at the company Energy pellet, and have been formally documented in form of quality manual as required within the ENplus A2 certificate.

All control points within the production process were documented, 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.

The measurement range within the overall control system was defined, warning limits and limits for stopping the process for each measured (controlled) size of the process, as well as responsible persons and activities which should be taken in order for the production process to return within desired parameters.

All these data already existed within the manufacturing process, at the level of knowledge and experience of people who work in the process so all that was necessary was to document this existing knowledge and experience in a formal manner.

Critical control points identified in process are presented 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%

3.3. Definition of quality assurance measures

For the implementation of the quality assurance measures which were necessary for compliance with the ENplus standard additional testing and measuring equipment was obtained, specifically the following:

- Equipment for moisture content testing was upgraded;
- Equipment for mechanical durability and fines testing,
- Testing procedures and methods for bulk density were revised in order to be suitable for a reliable quality control.

3.3.1. Staff

One part-time staff which currently works in the factory was allocated at the documentation of the work system and the existing system of quality assurance of pellets. The existing quality assurance system worked well and needed just to comply with formal requirements for quality assurance.

Regarding employees all of following steps were implemented and documented:

• **The division of responsibilities**: For each step in the process the responsible personnel have been appointed,

• **Operating Instructions**: For each step in the process work instructions are available.

• **Training:** Staff is has been internally trained in quality assurance measures. Additional trainings are planned to be periodically organized through internal or external organizations. It is planned to implement periodical trainings (once every 6 months) for all personnel in process.

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

3.3.3. Product quality

Product quality control in the production process is described below:

- **Periodic visual controls** are 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 have been adequately documented.

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 visually inspected.

- **Product declaration:** Every pellet package is declared on the label of package. The label is in conformity with ENplus requirements.

3.3.5. Documentation

All quality measures have been documented. For the following quality relevant processes written operating instructions are available and have been approved by the quality representative:

- Incoming and outgoing goods
- Competence, responsibility
- Customer complaints
- Training of employees
- Service of testing equipment
- Implementation of monitoring tests

Incoming and outgoing data is fully collected, process parameters are traced in computer system, formal definition of process, controls and staff training are on the necessary level.

3.4. Assessment of the implementation process

3.4.1. Selection of quality assurance measures

The company Energy pellets Ltd. implemented all recommendations regarding quality assurance reported within the Feasibility study. The production process of the company was already organised in order to insure high quality of the produced pellets and as such most of the steps required for certification according ENplus certification scheme were already implemented. Additional measures recommended consisted of the following:

- Purchasing and installation of equipment for testing of mechanical durability, verification of conforming of existing testing (moisture content, bulk density) with ENplus requirements and adaptation if needed;
- Preparation of operating procedures and instructions for all relevant quality processes;
- Training of personnel, appointment of quality representative (responsible person).

It is necessary to mention that the company Energy pellets Ltd. undertook two inspections for the ENplus certificate, the first one carried out in April 2013 and the second in November 2013. The first inspection showed that the production process and quality of the products was not suitable in order to obtain the ENplus certificate, the main discrepancies included the lack of operating instructions for a part of the process, the lack of testing equipment for mechanical durability as well as lack of conformity of the tested pellets to ENplus A2 requirements. The company undertook a second inspection for which corrections were made to all issues/discrepancies from the first inspection and in November 2013 the company successfully passed requirements for the ENplus A2 certificate.

3.4.2. Costs and financial benefits

The costs of the implementation of the quality assurance process have been documented as follows:

• Additional training of workers:	2.500 eur
• Preparation of quality manual and operating instructions	3.000 eur
• Procurement of testing equipment	6.500 eur
• TOTAL	12.000 eur

The yearly costs for maintaining the quality assurance system have been estimated at 150 man-hours (approximately 2.300 eur).

The financial benefits of implementing the quality assurance system can only be estimated at this point, since the formal compliance with the quality assurance requirements within the ENplus certificate was ensured in November 2013. The company had already implemented its own quality assurance process prior to the certification according to ENplus and additional actions implemented within the ENplus requirements were focused mainly on the purchase of testing equipment and formalisation of operating procedures. As such, benefits in terms of avoidance of the production of defective goods will probably be very minimal. Information regarding achievement of higher prices for produced pellets will be available in 2014.

3.4.3. External reactions and further use of the implemented qa system

Considering that the company obtained the ENplus certificate in November 2013, at this point it is too early to comprehensively evaluate reacions from business partners or customers on the implementation of the QU system. However, the Energy pellets Ltd. company presented its newly obtained certificate and overall quality assurance system at the *4th International Energy Conference: How to use wood biomass for regional development and new investment projects in economy and local government in SEE,* which was held on 2nd December 2013 in Zagreb, Croatia. The conference was attended by over 100 participants which included pellet, briquette and wood chips producers, representatives of Croatian ministries, representatives from cities and municipalities, biomass boiler manufacturers, representatives of pellet consumers and other stakeholders, and a special presentation and section of the conference was dedicated to the introduction of standards and the SolidStandards project. The general opinion of all included was very positive.

3.4.4. Opinion of the company's management about the standards

The owner and director of the Energy pellets Ltd. company, Mr. Raoul Cvečić Bole has in numerous times expressed his satisfaction with the overall requirements and definitions/specifications within the EN 14961 and EN 15234 standards, and as such no suggestions were made regarding possible modifications/corrections of the standards.

3.5. Conclusions

The company Energy pellets Ltd. has successfully implemented the quality assurance process in its pellet production line in accordance to the EN 15234-1 and EN 15234-2 standards and in November 2013 the company fulfilled the requirements for the ENplus A2 certificate.

Overall the process of implementing the quality assurance system went smoothly, mainly since the company Energy pellets had already implemented its own quality control and quality assurance procedures. Thus in order to satisfy the requirements of the EN 15234 standards as well as the ENplus certification it was necessary to make minor corrections and updating in the form of preparing operating procedures and instructions, upgrading the testing equipment for the finished product (pellets), internal training of employees and formal appointment of responsible quality assurance personnel. The costs of the implementation of the quality assurance system according to the EN 15234 standards requirements were in that regard relatively minor. The benefits of the formal introduction of the quality assurance system for the company will be mostly in the form of achieving a higher price for the produced pellets on the EU market, due to the ENplus certificate. However, since the certificate was obtained only in November 2013 at this point it is too early to be able to quantify these benefits.

4. Wood chips in Finland (VTT)

Task: Wood chips supply chain

4.1. General information

4.1.1. Description of the company

- Name and place: Päijänne Forest management association (FMA), Jyväskylä, Finland
- Legal status: Association. The Forest Management Association is a forest owners' body, the purpose of which is to promote profitability of forestry practised by forest owners and the realisation of the other goals they have set for forestry, and to advance the economically, ecologically, and socially sustainable management and utilisation of forests. Forest Management Associations are governed and financed by forest owners. The Act on Forest Management Associations (534/1999) 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.
- Business segment: Forestry services including wood fuel services
- Number of employees: 35 regular, 150-170 seasonal
- Machine outfit: Machine operations outsourced to contractors
- Turnover: 9 M€/a
- Foundation date/experience: Forest management associations were established in 1907, forest services have been provided ever since. 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. In the case of Vakkalämpö MHY Päijänne is supplying wood chips directly to heat installation. In other supply chains Päijänne MHY is also forest residues and small-sized stem wood to road side storages to be sold to energy companies.
- Annual production/trading quantity: Average round wood harvest 1.54 M solid m^3
- Production/trading capacity: 1.7 M solid m^3 (annual planned harvest)
- Information about product quality (see 3.3)

4.1.2. Raw material provided by Päijänne MHY

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)

- *Quality certificates*: No any fuel certifications in use. Tapio´s guidelines for energy wood cultivation and harvesting (Äijälä et al. 2010[1]) are followed. More detailed description of criteria is available in the AFO publication (Kuusinen 2010[2]).
- Other certificates (e.g. FSC/PEFC): All wood fuel is supplied from PEFC certified forest. In Finnish Forest Certification System (FFCS) there are also criteria for energy wood. See (Alakangas 2013, WP 5 report).

[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).

[2] http://www.afo.eu.com/default.asp?SivuID=27040

4.1.3. Description of raw material supply

The raw material is forest residues and small-sized wood from thinnings mainly harvested as delimbed stems. Thinning wood is a mixture of coniferous and broadleaved species. MHY Päijänne does not harvest or chip the wood fuels themselves, but they use subcontractors to do the harvesting and chipping. MHY Päijänne is employing 15 subcontractors for wood felling, forwarding, chipping and transportation of round wood and wood fuels.

The wood fuel comes from the MHY members', church owned and other communities' forests. The association provides wood fuel both from the young forests and from the final fellings. Typical final felling stand is a spruce forest, from where logging residues and stumps are harvested. However, most of the wood fuel comes from young forest thinnings. Delimbed small sized 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 (tops and branches are left in the forest for nutrition) and a better fuel quality. Multi-tree handling technique enables this method also in mechanical harvesting.

4.1.4. Customer description

The Forest Management Association is a forest owners' body, the purpose of which is to promote profitability of forestry practised by forest owners and the realisation of the other goals they have set for forestry, and to advance the economically, ecologically, and socially sustainable management and utilisation of forests.

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.

A key partner in wood chip supply of Päijänne MHY is Vakkalämpö co-operative, which is in charge of the wood fuel supply and operational management of 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.

4.2. Production chain analysis

4.2.1. Process description (step 2)

The wood chip supply chain of Vakkalämpö is presented in the following flow chart.

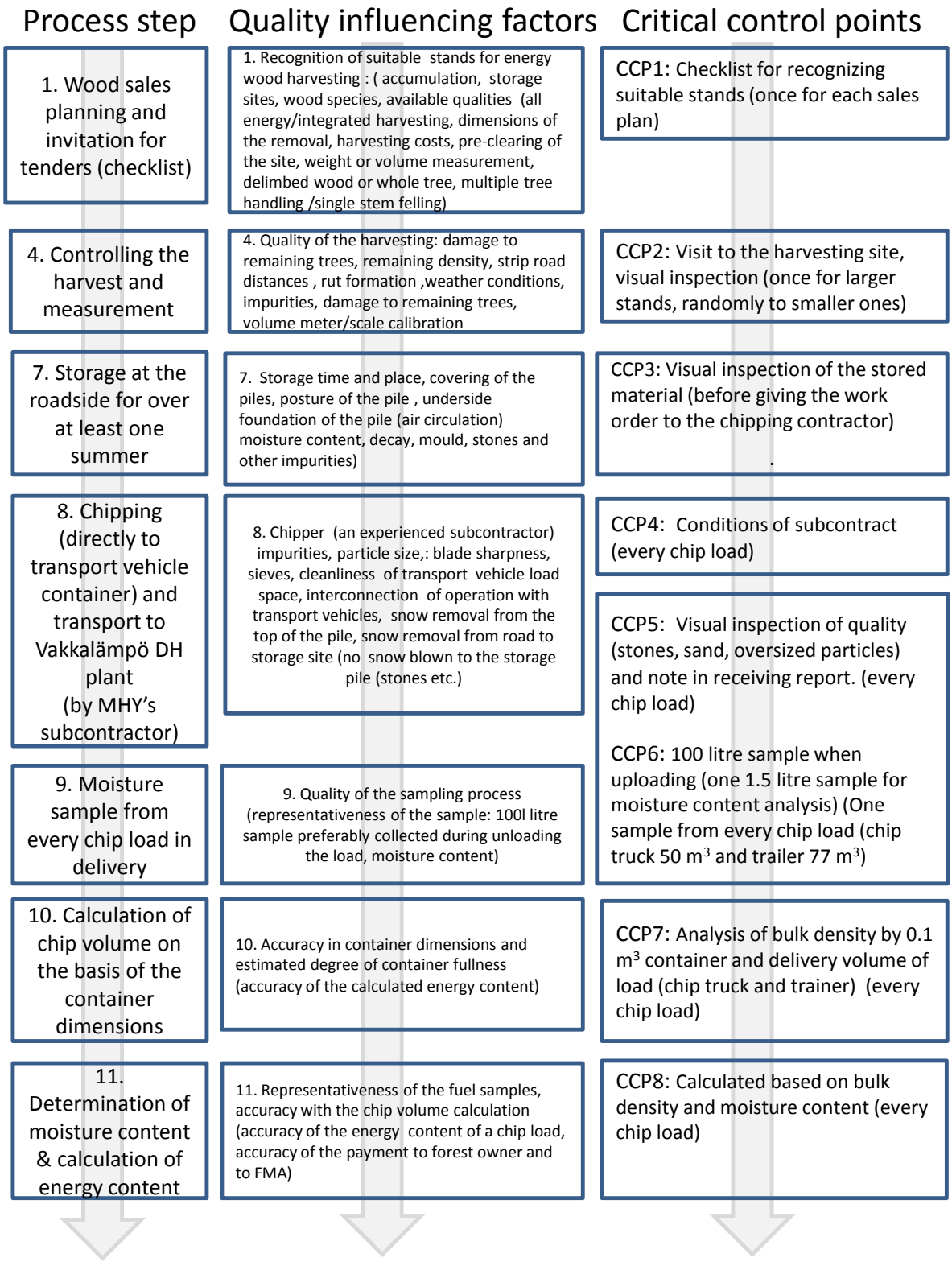


Figure 4.2-1:Päijänne MHY wood chip supply chain for Vakkalämpö by process steps, quality influencing factors and critical control points

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. In the case of Vakkalämpö MHY organises chipping and transports of fuel 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. The other option includes transporting the wood to a crusher close to the user. This option usually concerns wood fuel piles including round wood which may have a stones and other impurities to avoid injuries to the vulnerable chipper.

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
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 was 4,125 bulk m^3 (2 860 MWh) in 2012. Average energy density was about 700 kWh/loose m^3 (3.03 kWh/kg or 10.90 MJ/kg).

The plant operator takes 100 litre sample of each load for moisture content analysis. About 1.5 litre increment is taken 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 35 w-%, which can be achieved by an adequate storage time and following general storage guidelines. In 2012 the average moisture content was 37.9 w-%, because of wet summer and autumn 2012.

Also bulk density is analysed with 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. Average bulk density was 229 kg/m^3 in 2012.

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.

4.2.3. 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			

4.3. Definition of quality assurance measures

4.3.1. 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

This measure has already been implemented by the company before.

4.3.2. Facilities & equipment

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 attention paid to maintaining of cleanliness of the wood during harvest and storage of wood is very essential. In order to achieve high 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). Also the interconnection with transportation vehicles is essential, however in this case both chipping and transport are executed by the same company and thus good operational management between chipping and transport can be achieved easily. Contracts are made yearly basis. Kotimaiset Energiat Oy is storing each delivery document on internet based Pilvi-service, and remarks on the chipped fuel quality are also reported.

Measure	Frequency	Related to process step(s) nr.
Wood sales planning, planning of harvest, harvesting quality management and storage site planning (by FMA)	Every harvesting site	1, 4, and 7
Harvesting (felling and terrain transport) by a subcontractor FMA's harvesting service	Every harvesting site	4
Chipping and transportation to plant (subcontractor Kotimaiset Energiat Oy)	Every load	8
Moisture and bulk density analysis of received fuel by customer (Vakkalämpö Oy)	Every load	9, 10 and 11

This measure has already been implemented by the company before.

4.3.3. 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

The current sampling and fuel analysis procedures at Vakkalämpö Oy district heating plant and Päijänne MHY were surveyed in November 2012. VTT first introduced the sampling standard (EN 14778) and then sampling was carried out at plant by Timo Järvinen from VTT and the plant operator Juha Ilmonen on 22 November 2012. VTT also took a video film from the sampling.

VTT´s sampling was made according to the standard EN 14778

- 10 increments from falling stream, when truck was unloading the wood chips (for moisture content)
- Sampling from stockpile in a fuel storage, 3 sacks (moisture content, bulk density, ash content and particle size distribution)

At the same time Juha Ilmonen from Vakkalämpö Oy took one sample for moisture content analysis and measured the bulk density by 100 litre container.

Fuel analysis was carried out by ENAS Oy according to the following standards:

- Moisture content (EN 14774-2)
- Bulk density (EN 15103 modified, 10 litre measuring container)
- Particle size analysis (EN 15149)
- Ash content (EN 14775)

Average moisture content of 10 samples were 31.6 w-%, bulk density 233 kg/m^3 and ash content <0.7 w-% on dry basis. From this point of view their sampling succeeded quite well, but it has to be noticed that the operator took only few small increments. VTT gave the following recommendations:

- take at least 10 samples from falling streams and form a combined sample for moisture content and bulk density analysis
- divide sample to about 300 gr sample for moisture content analysis by corning and quartering method, which is easy to implement.
- use 50 litre container for bulk density analysis
- use laboratory oven with accuracy of 105^{o}C$\pm$ 2^{o}C.

VTT also provided Excel calculation tool to calculate moisture content, energy density of each load and annual average for energy density, bulk density and moisture content.

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

	Product declaration based on EN 14961-1			
Normative	Property	Unit	Average wood chip quality	Annual average measured quality by Vakkalämpö
	Raw material	-	1.1.3.1 and 1.1.3.2	1.1.3.1 and 1.1.3.2
	Dimensions, P	mm	P45*	not measured
	Moisture, M	w-% on wet basis	M40*	37.8 w-%
	Ash content, A	w-% on dry basis	A1.0*	< 0.7
Informative	Bulk density, BD	kg/m^3	BD250*	229
	Net calorific value as received	kWh/kg		3.03 kWh/kg (10.90 MJ/kg)
	Energy density, E	MWh/loose m^3	0.70	693 kWh/

* VTT´s estimation based on the product testing results (Alakangas, 2013. Product testing WP4: Päijänne MHY, Finland, May 2013).

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

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

This measure has already been implemented by the company before.

4.3.5. Documentation

Contracts and quality reports listed 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. The energy content of the received material is defined by the plant operator. The payment towards MHY and the chipping contractor is based on the energy content of the received fuel.

4.4. Assessment of the implementation process

4.4.1. Selection of quality assurance measures

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 and bulk density analysis of each load at Vakkalämpö plant and visual checking of wood chips quality. Also volume of each load is estimated. A particle size analysis has not been carried out. The best quality wood chips are used in Vakkalämpö plant and power plants quality is produced according instructions of the customer.

VTT will also produce a quality assurance manual in Finnish for wood chip production, which is published in Autumn 2013.

4.4.2. Costs and financial benefits

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.

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 driest piles for chipping. Also the security of supply is better with dry and good quality wood fuel.

One practical aid for assuring the high quality of chips delivered to Vakkalämpö is that MHY also delivers fuel to a large CHP located in the city of Jyväskylä. The moisture content for CHP's fuel is not as critical quality factor as for Vakkalämpö and thus the material with higher moisture content can be sold to company running the CHP.

4.4.3. External reactions and further use of the implemented QA system

- *Are there reactions from business partners or customers on the implementation of the QA system?*

Quality assurance system is already applied in principal by MHY Päijänne. Subcontractors have their own quality assurance systems, which is based on quality requirements of Vakkalämpö or other wood fuel purchasers. In Finland there are Tapio´s guidelines, which are followed by all wood fuel suppliers. Also sustainable forest legislation and PEFC forest certification system set requirements for wood fuel procurement. VTT´s product testing also brings valuable information on the quality.

- *Does the company partner use the advanced QA system to promote his products?*

Usually contracts are bilateral and products are not promoted. Contracts include the instructions of storage and chipping and fuel specification requirements e.g. moisture content, impurities and particle size.

- *Does the stakeholder plan to use the QA implementation to join a certification scheme?*

Wood fuel suppliers are following already PEFC forest certification system, which also includes requirements for wood fuel supply. In Finland there are FINBIO's wood fuel quality guidelines, which VTT is currently updating with a working group of representatives of energy utilities, wood fuel suppliers, related associations and energy authorities. These guidelines will be based on EN-standards and SolidStandards training material. These guidelines will be followed by about 90% of wood fuel trades.

4.4.4. Opinion of the company's management about the standards

There is not yet very much experience on European solid biofuels standards, because they have been published in 2012. Laboratories are applying most of the testing standards. VTT carried out in Finland a project how to apply sampling standards for forest fuels. Implementation of the sampling standards adapted Finnish conditions has started. Usually the number of increments is too small in small plants like Vakkalämpö Oy. Larger plants take usually 6 samples of truck loads (> 100 m^3) and make a daily combined sample for moisture content analysis. Ash content and net calorific value is analysed usually from monthly common sample once a month or when new raw material is used for wood chips. Smaller plants use typical values, because raw material is usually delimbed small-sized trees.

EN 14961-1 & EN 14961-4: Fuel Specifications

In Finland net calorific value is usually normative, because pricing of fuel is based on calculation by the moisture content and net calorific value on dry basis. In standard EN 14961-1 there are enough property classes. Finland has proposed to change particle size analysis, because it is too complicated, and it is difficult to understand. In Vakkalämpö case particle size is not measured, it is checked by visual inspection. Proposals have been sent to ISO/TC 238 for change for ISO 17225 standard series. In Finland it is also difficult to meet moisture requirement for A2 class in EN 14961-4. Usually in smaller plants the moisture

content requirement is less than 40 w-% on wet basis. A2 class requires less than 35 w-%, which cannot be in all cases fulfilled in Finland.

EN 15234-1 & EN 15234-4: Quality Assurance

According VTT studies quality assurance standard can be implemented for Vakkalämpö case and most of the measures listed in EN 15234-4 are already implemented in MHY Päijänne and its subcontracting companies, which carry out harvesting, forwarding, chipping and transportation.

Larger wood fuel suppliers use also ISO 9000 standards in their wood fuel production.

4.5. Conclusions

VTT, MHY Päijänne and Vakkalämpö had several meetings, training actions and product testing for implementing fuel specification and quality assurance standards. Training material and training sessions has helped stakeholders to understand the standard implementation in practice. Implementation phase also show that some of quality control measures are not according to European standards. Also importance of the correct sampling has been pointed out for stakeholders. Good quality is important both wood fuel producers and users. MHY Päijänne has requested VTT to provide also a simplified manual for quality assurance and control measures in Finnish, which will be made in autumn 2013.

5. Wood chips in Austria (HFA)

Task: Production, trade & logistics of wood chips

5.1. General information

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.

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.

5.1.3. 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.

5.2. Production chain analysis

5.2.1. Process description (step 2)

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

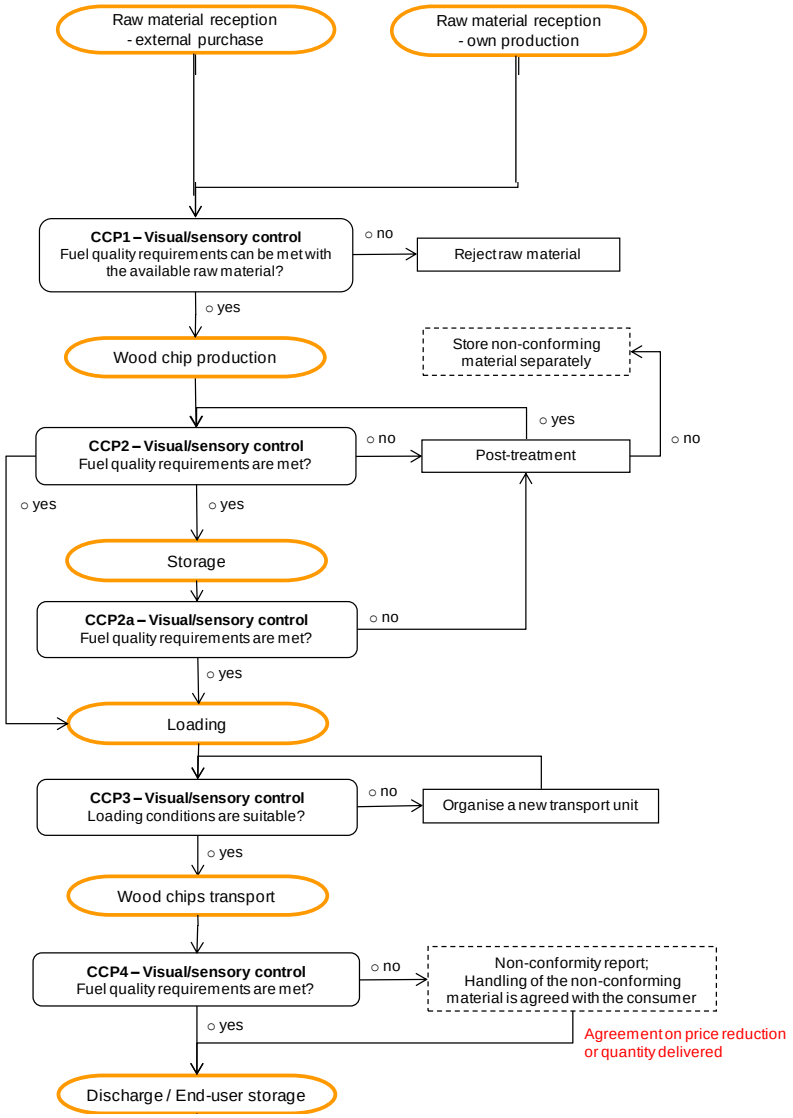


Figure 5.2-1: Flow chart of the wood chip supply chain of MR Salzburg

5.2.2. Identification of quality influencing factors (step 3)

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

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

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

5.3. Definition of quality assurance measures

5.3.1. Staff

An organization chart of the staff of MR Salzburg (Annex) and job descriptions for all employees are already available. 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
- 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

Measure	Frequency	Related to process step(s) nr.
Preparation of job descriptions for each employee and an organisation chart to allocate responsibilities within the company.*	yearly update	all
Participation of the division manager forest/energy in the SolidStandards wood chip training on 12.04.2012.	onetime	all
Participation of the forest team leaders in the SolidStandards wood chip training on 11.04.2013.	onetime	all
Internal training/update of the forest team leaders through division manager forest/energy.	update as necessary	All
*) This measure has already been implemented by the company before.		

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, processible 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.

Measure	Frequency	Related to process step(s) nr.
A list of 10 wood chippers including machine specifications is available.*	update as necessary	step 2
Completion of the list with quality parameters for wood chips like, processible raw material, particle size, maximum oversize of the wood chips	update as necessary	step 2

*) This measure has already been implemented by the company before.

5.3.3. Product quality

The possibilities for the company to produce or deliver a specific wood chip quality are very limited. Apart from a visual control of the material no quality control measures are planned. The only possibility to improve wood chip quality is the information of all subcontractors and raw material suppliers on the quality influencing factors in the wood chip supply chain.

Measure	Frequency	Related to process step(s) nr.
Training of all subcontractors in the course of the SolidStandards workshop in autumn 2013.	onetime	all
Internal training/update of the subcontractors through forest team leaders.	1x/year	all

5.3.4. Intersection points to upstream 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

*) This measure has already been implemented by the company before.

**) This measure is planned.

5.3.5. 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** inclusion of origin and source of raw material necessary
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	**available**
Areas of responsibility of the individual employees or subcontractors	Personnel file	**available**
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** inclusion of wood chip declaration necessary
Customer complaints (date, reason, measures taken to remedy the defects if necessary)	Customer complaint list	**available**

5.4. Cost-benefit analysis

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.

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.

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.

5.5. Product testing

For pretesting 3 wood chip samples were taken in spring 2012 by employees of Holzforschung Austria directly at the production site after chipping. The results of these tests prove that a specification of wood chips without analyzing each batch is difficult because of the inhomogeneity of the material.

Therefore, the idea for the further product testing was to train employees of MR Salzburg in the use of OENORM C 4005, which facilitates the 'estimation' of wood chip properties. This was accomplished by reducing the amount of possible property classes and by suggesting typical values for certain raw material groups. In April 2013 employees of MR Salzburg took 7 wood chip samples after they have attended the SolidStandards training in Gmunden/Austria on 11 April 2013. In the training course they were instructed by Holzforschung Austria in correct sampling and how to use EN 14961-1 and OENORM C 4005 for the product declaration of wood chips. Together with the samples the 'estimated' product declaration for all samples was handed in.

The whole report on product testing can be found in the Annex.

5.6. Assessment of the implementation process

5.6.1. Selection of quality assurance measures

Requirements of the customers

The OENORM M 7133 was withdrawn in February 2013 and OENORM EN 14961-1, respectively OENORM C 4005 (for forest chips), should be used as basis for sales contracts.

Need for action:

There is no need to change existing sales contracts, because so far they don´t refer to any standard.

For new sales contracts the required quality of the wood chips should be defined together with the customers according to the new specifications of OENORM C 4005 based on OENORM EN 14961-1.

Measure	Reason(s) for the refusal
Update of the sales contracts according to the new standards	The existing sales contracts are not based on any standard; therefore there is no need for an immediate action. In addition the EN-standards will be changed into EN ISO standards with 2014 and it wouldn´t make sense to change sales contracts twice within a year. The company plans to refer to ISO/FDIS 17225-1 and to OENORM C 4005 in their future sales contracts.

Internal process instructions

At the moment the knowledge how to handle a commission, including e.g. quality control and customer complaints, is not written down but is part of the work experience of every employee. In a quality control system this knowledge should be available for each employee to assure

- that there is no loss of know-how in case an employee leaves the company and
- to make sure, that all employees use the same criteria in e.g. quality declaration of the wood chips.

Need for action:

Elaboration of process instructions for:

- acceptance of the raw material (declaration of origin and source, purchase journal)
- quality influencing factors and specification of the wood chip quality (checklist); it may be useful to elaborate a short guideline for the correct handling of the raw material, which can be passed on to the raw material suppliers and the subcontractors for wood chip production and transport, to avoid excessive contamination with soil.
- sales (declaration, sales journal)
- handling of customer complaints (customer complaint list)
- training of employees (training list)

Measure	Reason(s) for the refusal
Elaboration of process instructions	The division manager forest/energy regularly meets with the forest team leaders to discuss all processes; therefore no written instructions are required at the moment. A short information on quality influencing factor is planned to be handed out to subcontractors and raw material suppliers. This will be done in the course of the SolidStandards workshop in autumn.

Employee training

All employees working in the process chain of wood chip production have to use the new specification according to OENORM EN 14961-1/OENORM C 4005 in the future.

The five forest team leaders attended the wood chip training organized by HFA together with FAST Ort in the course of the project SolidStandards on 11th of April 2013. To improve the training effect, each forest team leader sent a wood chip sample, for which the declaration of origin and source and normative properties was prepared, to Holzforschung Austria, where the accuracy of the property classes was checked through analysis in the course of the SolidStandards product testing. With the results the forest team leaders got feedback to improve their further assessment. This procedure could be part of a continuous improvement process within the quality assurance system of MR Salzburg.

Need for action:

The attendance at the wood chip training should be documented in internal training lists. After that the division manager forest/energy will do the yearly training of the forest team leaders himself.

The subcontractors for chipping/transport will be introduced into the new quality system by the forest team leaders. This training will be documented in training lists as well.

Measure	Reason(s) for the refusal
Filled in training lists for MR Salzburg employees	A template for a training list is available (Annex) but still has to be filled in for the recent trainings.
Training of the subcontractors and raw material suppliers - filled in training lists	The subcontractors are going to be trained only in autumn in the course of the SolidStandards workshop.

Complaint management

A template to fill in customer complaints in excel exists.

Apart from passing on the information of a complaint directly to the wood chip producer to avoid similar complaints in the future, the evaluation of this list, e.g. once a year, helps MR Salzburg in tracking down systematic errors in the declaration of the wood chips or in

inappropriately defined product requirements for a customer. As a result of such an evaluation specific sales contracts can be adjusted, employees or subcontractors get an additional training or single chipping machines have to be used differently.

Product declaration

At the moment wood chips are sold as “forest chips 1” quality without further declaration of the properties.

Need for action:

The declaration of origin and source of the raw material as well as the normative properties P, F, M and A shall be stated on the delivery note.

Measure	Reason(s) for the refusal
Include product declaration on the delivery note and in the list of outgoing goods	In a meeting of all forest team leaders of MR Salzburg with the division manager forest/energy the results of the product testing compared to the estimated product declaration of the forest team leaders were discussed (see report on product testing in Annex). Their common conclusion was that it is impossible for MR Salzburg to determine the properties of the wood chips or the origin and source of the raw material, because they don´t get the necessary information of the preceding steps in the supply chain.

5.6.2. Costs and financial benefits

So far costs of approximately € 5.000,- for the initial implementation of a quality control system according to ÖNORM EN 15234-1 incurred. Costs of another € 5.000,- are expected with the training of the subcontractors in the course of the SolidStandards workshop in autumn (Table 1). As the quality control system is not fully implemented yet, there is no experience on the yearly costs.

MR Salzburg sees no possibility to make a proper product declaration for the traded wood chips, let alone influence the quality. Therefore they see no benefit in fully implementing the quality control system.

5.6.3. External reactions and further use of the implemented qa system

As the quality assurance system is not fully implemented, there are no external reactions to comment the system and the company doesn´t use this system to promote their products.

5.6.4. Opinion of the company’s management about the standards

EN 14961-1: Fuel Specifications

This standard helps to specify solid biofuels in the laboratory but is no help in specifying ‘forest’ chips, with no possibility to do analyses of certain quality parameters.

EN 15234-1: Quality Assurance

Even though the company´s management was very eager to implement EN 15234-1, they see no possibility to deliver a product declaration for their traded chips. Still they want to improve the quality of their products in the long run; a task they want to fulfil mainly by spreading information on quality influencing factors within the supply chain.

5.7. Conclusions

The concept of EN 15234-1 was designed for homogeneous material like pellets or briquettes. This became obvious during the implementation process at MR Salzburg.

The company Maschinenring Salzburg, partner in the Austrian feasibility study, is doing the logistics of wood chip production and trade. They work with subcontractors for chipping the wood and logging residues directly in the forest (forest chips). The feasibility study shows, that analysis of the wood chip properties would be far too expensive and the typical values offered in EN 14961-1 are of little help because of the inhomogeneity of the material. Therefore it was decided to train the responsible employees of Maschinenring Salzburg in the estimation of the wood chip properties in the course of the second Austrian wood chip training in April 2013, in which the use of the recently published ÖNORM C 4005 for the specification of forest chips was explained. The product testing following this training made clear that it is very difficult for the employees of Maschinenring Salzburg to make a proper specification for the forest chips by a visual control of the material only. Possible explanations for the difficulties in a correct estimation of the wood chip properties are:

- For an inhomogeneous material, like forest chips, great efforts have to be taken to get a representative sample. Inadequate sampling can falsify the results substantially.
- Raw material supply and production of the wood chips are not included in the responsibilities of the MR Salzburg forest team leaders. In many cases the ‘history’ of the forest chips is not known.
- The visual estimation of the wood chip properties can only cover the top layer of the raw material pile. It is impossible for the forest team leaders to judge the quality within the pile if this differs greatly.
- The forest team leaders still have to gain more experience in the use of the new standards.

At the present situation the implementation of a quality control system doesn´t seem to be necessary. With less than 10 customer complaints out of about 4300 commissions in the year 2012 the benefits of the introduction of such a system seem negligible.

MR Salzburg therefore decided not to include a product declaration on the delivery notes of their products but they nevertheless want to increase the awareness of wood chip quality within the supply chain. It is planned to use the SolidStandards workshop in autumn 2013 as a discussion platform for all customers and subcontractors of MR Salzburg to discuss possibilities for a correct estimation of the forest chip properties and how the quality can be improved. At the moment it is not clear, whether Maschinenring Salzburg can implement the European standard at all, but this study on standard implementation nevertheless increases the awareness of the new standards and of existing quality problems.

6. Non-woody pellets in Poland (BAPE)

Task: Production of non-woody pellets

Implementation of the quality assurance system in OPEC-BIO Sp. z o.o. is an ongoing process and it has not been completed up to date. Therefore, below there is an intermediate version of the Report on standard implementation. Measures not implemented so far are marked in red.

6.1. 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.

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 took efforts to implement a quality assurance system at the production site. The company is interested in stable and strong partners involved 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 44 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 considered 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. The pellet production is based on wheat, barley and rape, so it is raw material classified in EN 14961-1 as 2.1.1.2, 2.1.3.2 and 2.1.8. The 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. 14,5 MJ/kg.

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

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 until 2013. However, recently, as a result of co-operation with BAPE, in the frame of SolidStandards project on the quality standards assurance, the company has started to sign long-term supply contracts with suppliers. The agreements were introduced in mid 2013.

The company introduced conditions for the raw material accepted for the production where average moisture content does not exceed 20 w-%. 25 w-% is acceptable only for single bales (provided the average is within the 20 w-% limit). In case of purchasing baled straw the company requires squared bales only as the production line is set for them.

Customer description:

Currently, the only recipient of pellets is the CHP plant OPEC-INEKO – one of the companies in OPC Grudziądz Group. However, the company is preparing to sell the fuel to other recipients.

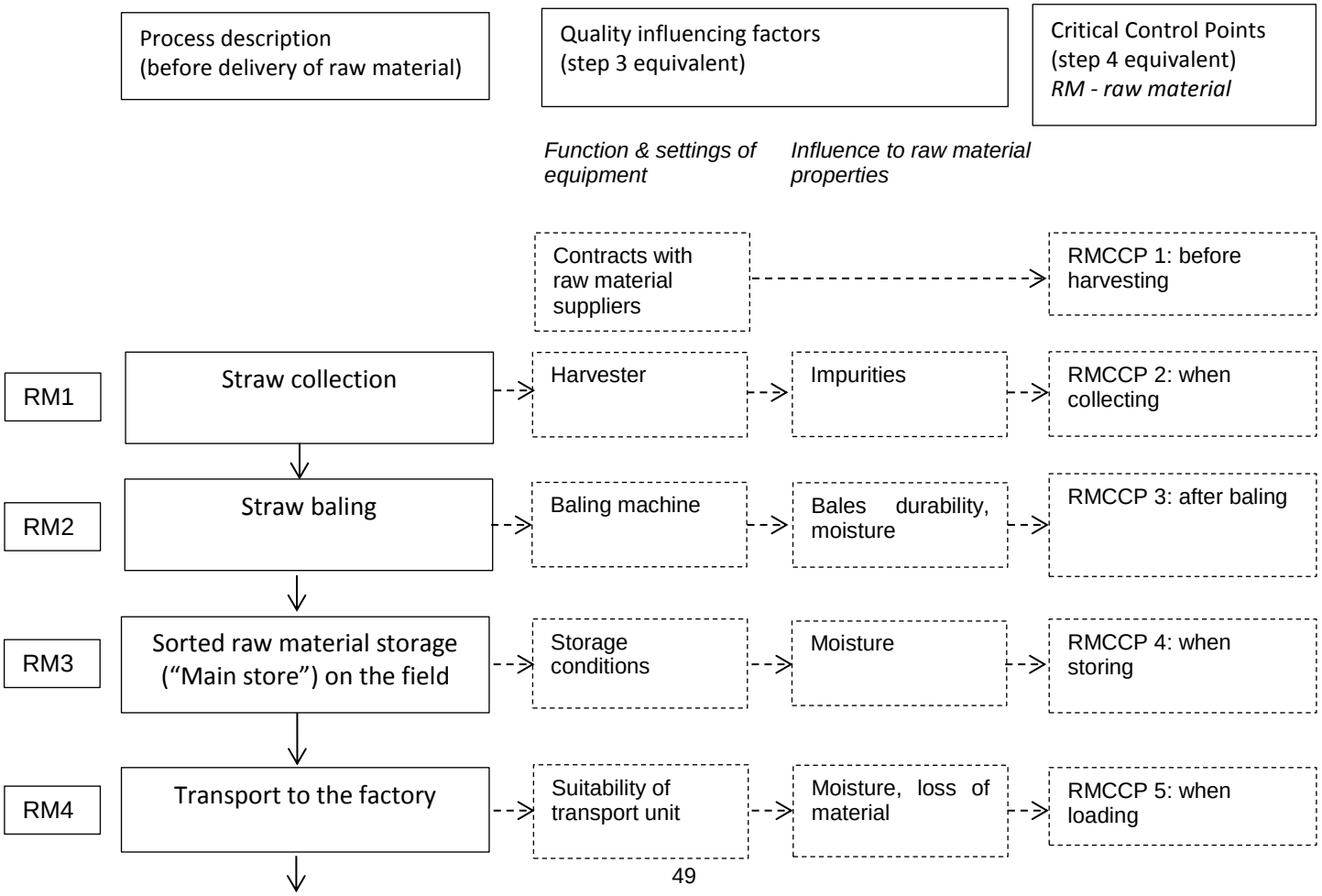
OPEC INEKO cogenerates heat and electricity, which is used for own needs, and the excess is sold to other parties. The recipients of heat are municipal entities, housing sector and other end-users utilizing heat for heating and technological purposes and preparation of domestic hot water.

6.2. Production chain analysis

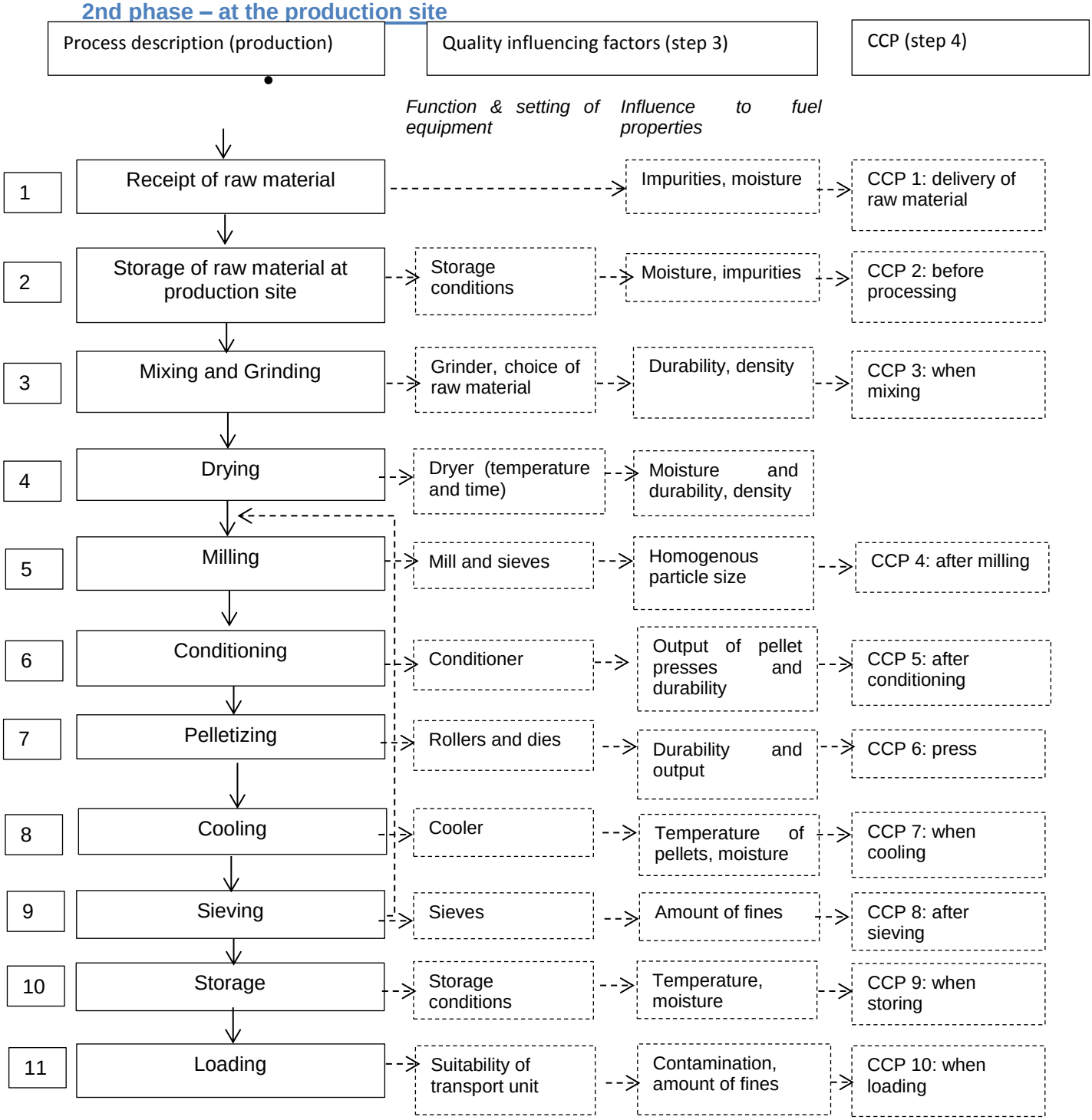
6.2.1. Process description (step 2)

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 yet. 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



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
1st phase – on the field			
RM1	Straw collection	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, moisture
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, moisture
11	Loading	Suitability & cleanliness of transport unit	Impurities might cause problems during handling/ combustion of the fuel

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

CCP Nr.	Critical control point	How to control	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, no round bales	Every year
RMCCP2	when collecting straw	visual control, each field	every day when collecting
RMCCP3	after baling	visual control, each field, initial sorting	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

		(instrumental);	
RMCCP5	when loading	visual control (type of raw material) and moisture content measurement	at random when loading
CCP1	delivery of raw material	visual control; moisture measurement sorting (quality, type)	each delivered bale random, each transport each bale
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 sampling and analysis [1)]	after every change of raw material and exchange of equipment 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 [1)]	when loading (approx. 7 times a day) once per shift (or when raw material changed)

[1)] *not introduced yet, planned*

6.3. Definition of quality assurance measures

6.3.1. Staff

The quality assurance manager is performed by the chief of production. Responsibility for the raw material quality lies with the raw material department.

Measure	Frequency
Training workshop for the employees (analysis of fuels, documentation, other QA-measures)	once per year
Training of staff responsible for factory operations [1)]	quarterly
Training of the staff responsible for the operations on the field	once per year

[1)] This measure has already been implemented by the company before

In June 2013, as a part of implementing quality assurance system, there was organized a training on solid biofuels standards for employees of OPEC-BIO Sp. z o.o. and another company from the same consortium performing laboratory tests of the fuel. The training was organized by BAPE in cooperation with the Wood Technology Institute (the only institution in Poland issuing certificates on conformity with EN 14961 series).

6.3.2. 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 automatic control of important production parameters exist. Some control is performed manually (mainly moisture analysis on the field). The company has already purchased equipment for measuring moisture of the straw. Some production parameters are set in the computer manually by chiefs of shifts. Another improvement is the weight with automatic reading and data transfer used on the delivery of raw material and transport from storage to production site.

Furthermore, equipment for measuring moisture content of the raw material on the fields was purchased. Moisture of the raw material one of the most important properties to be measured before the material gets to the pellet production facility.

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[1)]	permanent	RM3
Periodic visual controls of manipulation areas and open air storages[1)]	Periodic, once per shift	2
Planned repairs and maintenance of the equipment[1)]	Periodic, once per week	3-11
Controls of settings, functions and condition of the equipment[1)]	Periodic, once per shift	3-11

[1)] This measure has already been implemented by the company before

6.3.3. 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[1)]	when necessary	2-11
Quality check after the correction of malfunctions of the equipment[1)]	when necessary	2-11

[1)] This measure has already been implemented by the company before

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

The company has developed a model agreement with raw material suppliers including records on the quality of raw material. According to the agreement the company may refuse to accept raw material if it does not fulfill the requirements. The quality issues of raw materials are crucial for the production process of non-woody pellets, therefore it was very important to establish set of rules for raw material producers to comply with.

Measure	Frequency	Related to process step(s) nr.
Visual inspection of incoming raw material [1)]	each incoming transport	1
Control of pellet temperature (not more than 40°C) [1)]	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	

[1)] This measure has already been implemented by the company before

6.3.5. 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)
Raw material sorting system (type of straw, basic parameters, date)	Sorting plans (weekly, daily)
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

6.4. Assessment of the implementation process

6.4.1. Selection of quality assurance measures

Measure	Reason(s) for the refusal
Training workshop for the employees (analysis of fuels, documentation, other QA-measures)	There was a training organized, however, due to lack of full testing equipment in the factory the part regarding 'analysis of fuels' was theoretical.
Product testing: Dimension (EN 16127), Bulk density (EN 15103)	The company OPEC-BIO has not purchased equipment for product testing. OPEC-BIO did not find it necessary to purchase such equipment as cooperating OPEC-INEKO has its own laboratory that carries out the tests. However, they are performed once a week based on the samples collected during this period. Analyses are performed in accordance with methods developed by a group of Polish laboratories before European standards on solid biofuels were introduced and implementation of these methods had already imposed expenses. However, these methods do not fully comply with EN standards. The main differences between these procedures and EN standards are included in Annex 1 to this report. However, the laboratory considers implementing EN standards in the first half of 2014. It is planned to continue subcontracting product testing to the laboratory. Up to date, due to organizational reasons, samples have been taken on delivery of product. OPEC-BIO stores the samples until the product is tested at the laboratory. It is useful in case of conflicts regarding pellet parameters.
Product testing: Mechanical durability (EN 15210), Moisture content (EN 14774)	
Product testing: Amount of fines (EN 15149)	
Product declaration	The company does not issue product declarations (prepared in accordance with EN standards) yet as their only client is the company from the same consortium (group) and it carries out tests on solid biofuels delivered by OPEC-BIO as a producer. Moreover, suppliers and raw material for pellet production are stable. Therefore, the company has not found this tool useful yet. Nevertheless, for external clients such product declaration is issued, however prepared in accordance with IChPW procedures. When the full quality assurance system is introduced, complying with EN standards the company is going to introduce proper product declaration.

6.4.2. Costs and financial benefits

Costs appearing once

Measure	Issue	costs
Preparation and implementation of quality assurance system	Labour time: 5 days	1050 €
Preparation of QA documentation	Labour time: 15 days	1700 €
Total		2750 €

Remaining costs

Measure	Issue	costs
Preparation and implementation of quality assurance system	Labour time: 5 days	1050 €
Preparation of QA documentation	Labour time: 3 days	340 €
Total		1390 €

Costs appearing permanent/periodical

Measure	Issue	costs
Annual training workshop for the employees	Labour time QA manager (incl. preparation): 2 days	230 € /year
	Labour time other employees: 4 h	400 € / year
Training of staff responsible for factory operations	Labour time: 4h/employee	910 € / year
Moisture content measurement of each bale when loading on the field	Labour time: 1h/day	2600 € / year
Periodic visual controls of manipulation areas, storages and conveyors	Labour time: 15 min/day	1900 € / year
Controls at RMCCPs 2, 3, 4	Labour time: 15 days/year	3430 € / year

Measure	Issue	costs
Planned repairs and maintenance of the equipment	Labour time: 3h/week	2230 € / year
Controls of settings, functions and condition of the equipment	Labour time: 1h/shift	7800 € / year
Total		18500 € / year

Remaining costs appearing permanent/periodical

Measure	Issue	costs
Testing at the laboratory	Labour time: 1h/shift	26000 € / year
Documentation	Labour time: 15 min/shift	5800 € / year
Total		31800 € / year

6.4.3. External reactions and further use of the implemented qa system

The main customer of OPEC-BIO is a CHP owned by OPEC-INEKO. OPEC-INEKO runs the laboratory as well. The company performs analyses of parameters of the pellets delivered to the CHP at least once a day. Parameters analyzed in accordance with Technical Procedure IChPW (laboratory accredited) are: moisture content, ash content, sulphur, coal, gross calorific value and net calorific value; and parameters analysed in accordance with internal, not accredited procedures are: kinetic durability and amount of fines. Once OPEC-INEKO adjusts laboratory equipment and processes to EN standards OPEC-BIO is going to subcontract laboratory testing of pellets. During the first period laboratory is going to run tests with both methods: IChPW procedures and EN standards in order to check and compare the results received.

At the time being product declarations are issued to customers other than OPEC-INEKO. However, product testing is performed in accordance with IChPW procedures. The goal is to issue product declarations to all pellets produced in the factory, based on the analysis performed in accordance with EN standards.

In the future (first half of 2014) the company is planning to use the advanced QA system to promote its products.

Once the company fully introduces QA system they are going to consider applying for certificate from Institute for Wood Technology.

6.4.4. Opinion of the company's management about the standards

The management of both companies (OPEC-BIO and OPEC-INEKO) see potential benefits of implementation of standards. Therefore, OPEC-INEKO is planning to purchase necessary equipment for the laboratory in order to be able to perform analyses in accordance with EN standards. The drawback is lack of officially translated standards (into Polish). In 2013 the company has purchased translation of the standards performed by the network of

laboratories LABIOMEN. In OPEC-INEKO's opinion introduction of analyses performed in accordance with EN standards is not going to be difficult, however it has been the costs of testing equipment hindering utilisation of these standards (including apparatus for testing hydrogen content). The management of OPEC-BIO is convinced that they can fully comply with the parameters given in EN standards on non-woody pellets, especially for pellets for industrial use and class B pellets, but also class A pellets when necessary.

Furthermore, preparation of necessary documentation and training of stuff has already proved positive and improved communication and performance of staff. The management underlined the importance of matters related to raw material – before it reaches the factory gate such us long term delivery contracts, moisture requirements, training on harvesting, proper storage. Very important issue is handling the material at the production site, proper storing and sorting.

EN 14961-1 & EN 14961-6: Fuel Specifications

The standards set relatively high requirements for ash content in class A non-woody pellets which might be sometimes difficult to achieve due to quality of raw material.

EN 15234-1 & EN 15234-6: Quality Assurance

When the company does not deliver product to the customer and has to rely on external transport services it might be problematic to deliver pellets without losing some of their properties (higher amount of fines, foreign objects, etc.).

6.5. Conclusions

Implementation of the quality assurance system in OPEC-BIO Sp. z o.o. is an ongoing process and it has not been completed up to date.

1. The support system for green energy production in Poland is based on tradable green certificates. Certificates are issued by the Polish Energy Regulatory Office to energy producers on the basis of documented production of renewable energy. Sale of these documents on dedicated stock exchange allows to compensate for the increased (compared to conventional energy sources) costs of green energy production. At the beginning of 2013 the value of green certificates has dropped significantly due to oversupply of these certificates. It resulted in significant reduction of biomass demand from energy producers and cancelling previously signed long-term agreements for biomass supply. Present situation on the market can be described as unstable and all market actors await for the new Renewable Energy Sources act that should introduce more certainty to the market and support mechanisms for RES use. Therefore, in general Polish solid biofuel producers are reluctant to uptake EN standards in this matter mostly because they are discouraged by too big uncertainty on the necessity of such investment and eventual return on investments.

2. OPEC-INEKO is planning to purchase necessary testing equipment. Transition to analyses performed in accordance with EN standards are relatively easy (although EN standards are more complicated than IChPW procedures). An important barrier has been the costs of testing equipment.

3. OPEC-BIO can fully comply with the parameters given in EN standards on non-woody pellets, especially for pellets for industrial use and class B pellets. Quality of pellets was confirmed by the tests carried out by Deutsches Biomasseforschungszentrum GmbH laboratory under the SolidStandards project.

4. Under the SolidStandards project the quality control system was catalogued, analyzed and revised. Possible corrective and improving measures were discussed including potential costs and benefits.

5. OPEC-BIO introduced more rigorous rules of handling raw material – from proper contracts with suppliers to the production line.

6. Systems of monitoring straw storages at the production site as well as sorting management were implemented and further improved.

7. Companies' staff was trained on quality assurance systems and EN standards on solid biofuels.

There has been already benefits related to the measures introduced so far such as: lower equipment exploitation costs - reduced frequency of replacement of components sensitive to impurities in straw (stones, sand) and increased operational reliability of equipment as well as transfer of control and sorting of raw materials to the field, prior to delivery to the processing plant allowing the reduction of working time associated with sorting straw at the storage at the production site.

Benefits still expected after implementation of a full QA system include:

- new customers in the future - a company able to guarantee the high quality of pellets will be able to profit from this development;
- stable pellet quality, stable price, customer satisfaction;
- no complaints and the associated costs.

To sum up, OPEC -BIO operates under specific conditions producing pellets for practically one recipient which is OPEC-INEKO (having their own laboratory). Nevertheless, the two companies aim to gradually implement the EN standards. However, it is associated with high capital investment and system maintenance costs. Under those circumstances full implementation of standards is reasonable for OPEC -BIO in case of production of pellets for external customers, not related structurally to the company. However, at the time being the Polish market of renewable energy from solid biomass is suffering from a lack of proper system solutions, which would boost the demand for this type of fuel followed by increased role of fuel quality on the market. Nevertheless, OPEC -BIO has undertaken several actions to gradually implement a quality assurance system in accordance with the EN standards and produce stable and good quality pellets.

6.6. Annex

Differences between EN standards and procedures developed by the Institute for Chemical Processing of Coal (Instytut Chemicznej Przeróbki Węgla – IChPW)

	European standards	IChPW technical procedure
Sample preparation	1. Scope Standard is applied for preparation of samples from solid biofuels	1. Scope The procedure states sources of biomass (product from agriculture and forestry, botanical wastes from agriculture and forestry; botanical wastes from food industry; wastes from wood, cork, fibre plants, meat-and-bone meal)
	2. Terms and definitions The standard gives 15 definitions specifying that the general analysis sample should have a nominal top size of 1 mm or less	2. Terms and definitions Procedure gives definitions of analytical sample particle size distribution < 0,425 mm) and sample for moisture determination (particle size distribution < 60 mm)
	3. Rules for appropriate sample preparation According to the standard one should avoid loss of moisture and fines during grinding and other operations; sub-sample for moisture analysis should be separated at the initial stage of sample preparation	3. General requirements The procedure gives conditions for the facility where samples are prepared (temperature 20-25°C, moisture up to 65%)
	4. Equipment Standard specifies: devices for and sample division and particle size reduction (riffle boxes, rotary sample dividers, shovels and scoops, coarse cutting mill or wood crusher, cutting mills, axes, hand saws, sieves with aperture size of 1,0 mm and 0,25 mm, balance with scale with accuracy of 0,1% of the sample mass	4. Equipment Procedure specifies: cutting mill, dryer, balance with accuracy of 0,1g, trays from stainless material, sieves with aperture size of 0,425 mm and 1,0 mm, containers for samples, thermometer, hygrometer
	5. General rules of sample preparation Standard gives guidelines for minimum masses to be retained after each sample division stage, it contains step-by-step scheme of the samples preparation process. The standard defines also methods and procedures of sample division into two or more analytical samples which are further divided into sub-samples.	5. General rules of sample preparation The procedure defines a method of sample division (coning and quartering) in order to receive sub-samples for the purpose of determining total and analytical moisture content
Determination of total moisture content	1. Particle size The standard sets nominal top size in a sample of max. 30 mm	1. Particle size The procedure sets nominal top size in a sample of max. 60 mm
	2. Mass of the test portion Sample mass should be minimum 300 g (for sawdust, shavings sample can be reduced to 200 g)	2. Mass of the test portion Sample should weight approx. 50 g
	3. Drying time The standard does not set the time for drying a sample. The sample should be dried in the temperature of	3. Drying time Drying should be in the temperature of 105°C for minimum 4 hours. Sample should be cooled in

	European standards	IChPW technical procedure
	105°C until constant mass is reached and the container with the sample should be weighted when still hot. Checking mass – period of 60 min.	desiccator or in place as dry as possible and weighed immediately. The sample should be dried until constant mass is reached (difference between weighings smaller than 1g). Checking mass – period of 30 min.
Determination of moisture content in analytical sample	1. Sample size The standard sets the nominal top size of 1 mm or less (0,25 mm)	1. Sample size The procedure gives nominal top size of 0,425 mm or less than 1 mm
	2. Test sample mass minimum 1 g	2. Test sample mass approx. 2 g
	3. Drying time According to standard 2h to 3h. Dry until constant mass is reached (mass difference between check weighing not higher than 1 mg), check mass – 60 min period.	3. Drying time According to the procedure minimum 3h. Dry until constant mass is reached (mass difference between check weighing not higher than 1 mg), check mass – 30 min period.
Determination of ash content	1. Temperature of ashing (550±10)°C, test sample mass minimum 1g (or more when very low ash content is expected)	1. Temperature of ashing (600±15)°C, test sample mass from 3g to 5g
	2. Calcination check It should be performed when doubts occur regarding incomplete incineration (e.g. presence of soot) – sample should be reloaded into the hot furnace for 30 min periods until change in mass is lower than 0,5 mg	2. Check calcination It should be performed each time. Sample should be reloaded into the hot furnace for 10 min periods until change in mass is lower than 0,1 mg
	3. Acceptable differences between results For ash content < 10% - 0,2% absolute; for ash content ≥ 10% - 2,0% of the mean result.	3. Acceptable differences between results For ash content ≤ 20% - 0,2% absolute; for ash content > 20% - 0,5% absolute.
Determination of gross calorific value	1. Test sample nominal top size < 1,0 mm (or 0,5 mm, 0,25 mm to ensure the requisite repeatability and complete combustion)	1. Test sample nominal top size < 0,425 mm
	2. Test sample mass minimum 1g	2. Test sample mass - 0,8 - 1,5 g for classic calorimeters; - 0,25 – 1,0 g for automatic calorimeters
	3. Test form pellet form or powder form closed in a combustion bag or capsule	3. Test form pellet or powder form
Determination of hydrogen content	1. Temperature According to the requirements set by the equipment producer	

7. Wood pellets and wood chips in Bulgaria (ERATO)

Task: Trade & Logistics of wood pellets & wood chips

Implementation of the quality assurance system in ERATO Plc is an ongoing process and it has not been completed up to date of the SolidStandards Project. Below there is shown a version of the report for standard implementation.

7.1. General information

7.1.1. Description of the company

By decision of the Haskovo District Court № 393 of 20.12.1996 is the first entry of the company in the Commercial Register named Erato Unicom Ltd., which 06.02.1998 a decision of the same court was changed to Erato VIADRUS LTD. At the start of operation of the Commercial Register to the Registry Agency , the company has been duly re-registered and is assigned a unique identification code (UIC) 126 149 041.

The company was transformed into a joint stock Erato VIADRUS AD, by decision of the working ability of 09.07.1998. With the last change in the decision of the working ability of 05.10.2007 the company is named Erato Corp., with headquarters in the city of Haskovo, bul Compound 67 with activity " trading heating , air conditioning and ventilation equipment, sale of plumbing and heating spare parts and materials , maintenance and operation of stores for Heating Technology, commissions, freight forwarding , warehousing and leasing transactions, commercial representation and mediation of domestic and foreign natural and legal persons. By decision N2218/05.10.2007 In 2007 a working ability increased the amount of capital of 1.6 million lev of 2.72 million lev, divided into 160,000 registered shares.

ERATO Plc is a daughter company of ERATO Holding Plc. The company has over 9 years of experience in the field of biomass equipment and technologies, logistic and trade of wood pellets, wood chips and fire wood. The selected company has interest to quality certifications and standardization of solid biofuels, implementation of quality management in solid biofuel production, trade and logistics. Erato Plc has also a long term engagement to the biofuels market in Bulgaria related to customer’s requirements.

The ERATO Plc was selected in comparison with another companies because ERATO Plc have very good background and long term engagement to the Bulgarian and EU market in the field of the solid biofules. For example 2 years before implementation of the EN 14961-2 ERATO Plc started using own methodology for classification of the produced wood pellets. This methodology includes 10 classes of wood pellets depending on theirs ash content and mechanical durability. The selected company really has potential to develop appropriate certification schemes and sustainability standards for trade and logistic. ERATO Plc has been on the Bulgarian market of heating facilities for 15 years already. This period of time has been sufficient for it to prove in practice that most important for the company team is the quality of the offered products and the honesty in serving the clients.

For these 14 years a distribution network has been developed of more than 60 companies in the country, which respectively distributed in regions offer all the necessary for the construction of complete heating, air-conditioning and water and sewerage systems

ERATO Plc has QMS International Standard ISO 9001:2008, in accordance with ISO/IEC 17021:2006 and rules for certification of Moody International Certification Group.

ERATO Plc according to IMS works in accordance with the standard ISO 9001:2008. Management of the organization demonstrates commitment to the maintenance and continuous improvement of the QMS. The requirements through Governance Handbook, version 6 02/01.09.2010, and documented management procedures. Management has defined, documented and disseminated quality policy, signed in 2010. Identified the processes needed for the operation of the QMS. Have been documented quality objectives for 2011 planning process, provide services that meet customer requirements, measuring

and monitoring in accordance with documented regulations and requirements of the standard.

Responsibilities and authority are laid out and communicated within the organization. Top management has ensured appropriate communication processes are established within the organization affecting QMS customer's solutions to optimize processes. The organization has created conditions for compliance with requirements of the systems for quality management.

One precondition for the production and the handling of high quality bioenergy carriers is the experience of the operating staff. In order to be able to identify all risks and all related critical control points, the ERATP Plc should have at least three years of experience in its field of activity. The company should already produce or process solid biofuels with defined quality properties according to existing product standards or company guidelines (defining at least 3 quality parameters, e.g. ash content, moisture content, mechanical durability).

In the last few years ERATO Plc participated in public procurement bids for delivering and logistics of wood chips and wood pellets to the municipality buildings. The company should have a size that is common for its kind in the respective country in order to guarantee the transferability of the best practice examples. Experiences from previous projects show that small companies are often not interested in investing in quality assurance measures. Large companies might already have installed such a system. ERATO Plc is SME and its structure includes logistic and trade for solid biofuels. The total number of employers in ERATO Plc is 43 from which 8 people are including in trade and logistics of wood pellets and wood chips.

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 Plc has own biofuel testing laboratory in the town of Haskovo. All biofules are tested before trading to the costumers. In the buofuel laboratory are measured quality parameters, such as ash content, moisture content, and mechanical durability.

The average quantities of the trade and logistic of wood chips is 1,000 tons and 800 tons of wood pellets respectively for the year 2012.

The logistic transport park of the company includes the following units:

- Vehicles Scania - 2 units - 25 ton capacity each;
- Middle trucks Fiat Ducato – 4 units – 3.5 tons capacity each;
- Small cargo vans Fiat Doblo – 4 units – 1 ton capacity each;
- Small cargo vans Daewoo – 1 unit with 1 ton capacity;
- Middel cargo van Skoda – 1 unit with 1 ton capacity;
- Specialized truck with tipper trailer Skoda – 1 unit with 20 ton capacity.

7.1.2. Description of wood pellets and wood chips trade and logistic

ERATO Plc purchases the wood pellets and wood chips by the pellets producers and wood chips manufacturers in Bulgaria. Before annual contracts signing for solid biofiels delivering, they are tested in the company laboratory. After that the company makes negotiation for all issues in an agreement with the manufacturers. Discussion between both parties regarding the terms of delivery and way of payment for pellets and chips is also implemented. According to the approved calendar schedule the quantities of wood pellets and wood chips are transported to the company storages for biofuels. Some of quantities of wood chips are transported directly to the local warehouses near to the municipality buildings.

There are not certified and notification testing laboratories for wood chips and wood pellets in Bulgaria at the moment.

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. 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. There are 3 warehouses for wood pellets and wood chips owned by ERATO Plc.

7.1.3. Customer description

There are three large customer groups for buying of wood pellets and wood chips:

1. Consumers – end users in residential (domestic) sector including block of flats.
2. SMS's – small and middle enterprises such as hotels, greenhouses, auto service stations, small production plants and companies in the field of services.
3. Municipalities – local authorities and its building like kindergartens, schools, hospitals, administration buildings and others.

In general the customers use installed technologies for combustion of wood pellets and wood chips. The generated hot water is used for heating or domestic hot water needs (DHW) or for both.

7.2. Trade and logistic analysis

The wood pellets and wood chips supply chain of ERATO Plc is given in the flow chart on Figure 1. The supply chain analysis includes the stages started from the storage produced solid biomass in the type of wood pellets and wood chips and different phases of the sales market structure in Bulgaria.

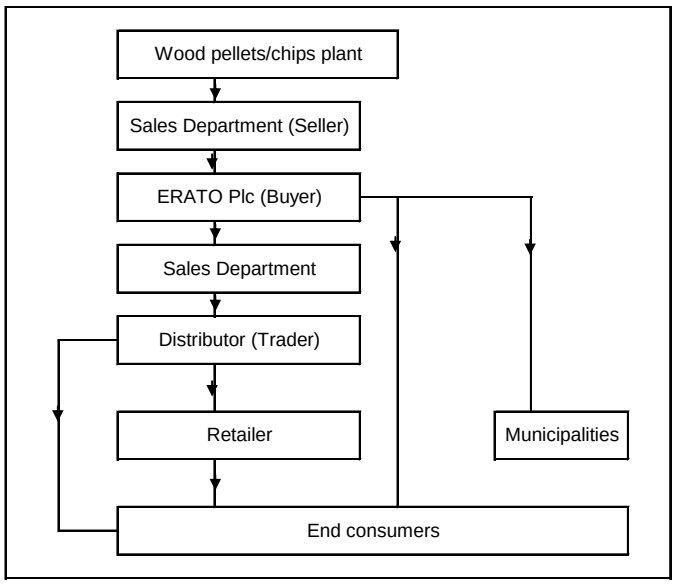


Figure 1: Flow chart of wood pellet/chips supply chains of ERATO Plc.

ERATO Plc 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 solid biofuel testing laboratory in the town of Haskovo. All type of biofules are tested before trading to the costumers. In the solid buofuel laboratory are measured quality parameters, such as ash content, moisture content, and mechanical durability.

7.2.1. Process description (step 2)

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

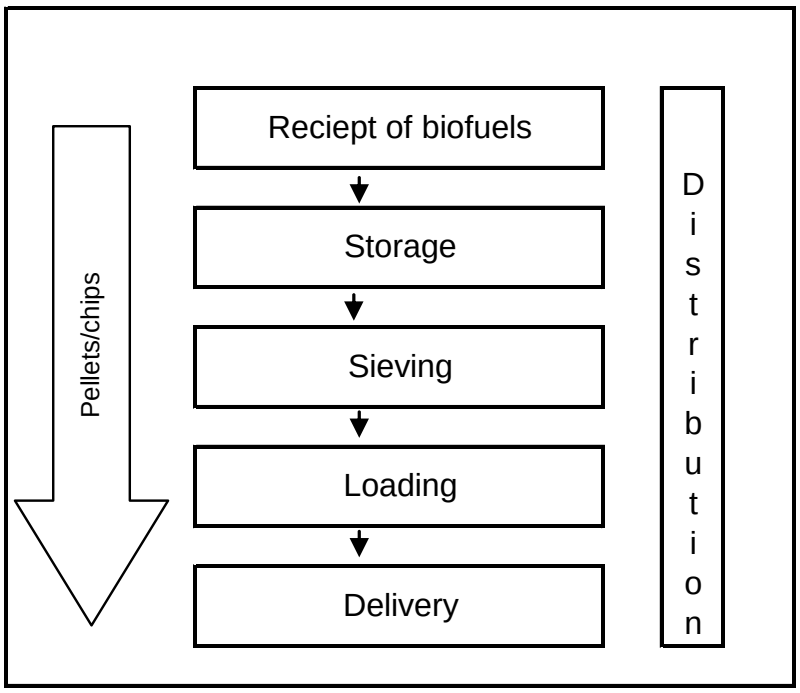


Figure 2: Process of trade and logistic of wood pellets and wood chips of ERTO Plc.

7.2.2. 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

Step no.	Process step	Function & settings of equipment / management procedures	Influence on fuel properties / management performance
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

7.2.3. 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. *periodical visual inspections, periodical sampling and analysis or automatic instrumental controls*

7.3. Definition of quality assurance measures

7.3.1. Staff

The quality assurance manager is performed by the chief of production. Responsibility for the raw material quality lies with the raw material department.

Measure	Frequency	Related to process step(s) nr.
Operational instructions	Every tree months	6
Training of responsible 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

7.3.2. 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

The warehouses' facilities and equipment are repaired two times per year by the specialized company. The facilities have very good heat insulation on the roofs and walls and they are massive construction. This construction prevents the stored wood pellets and wood chips against the moisture and dust.

The existing machine outfit including the forklifts and palette trolleys are repaired two times per year by the service company from Plovdiv.

Two times annually the periodic maintenance of the equipment's in the solid biofuel tested laboratory is implemented.

7.3.3. 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

Measure	Frequency	Related to process step(s) nr.
Receiving of actual protocol for wood pellets quality analyses after testing in laboratory despite a manufacturer certificate	3vrepresentative samples from each batch for delivery (e.g. one truck with capacity 24 tons)	3
Signing of agreements 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 agreements for wood pellets and wood chips delivery with the customers and the protocol for solid biofuel analyses is an Annex to the contract	1 per every heating season	7

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

ERATO Plc has an approved agreement with the wood pellets and wood chips manufacturers. According to two articles in the agreement, ERATO can reject to pay the delivered quantities of wood pellets and wood chips if they do not fulfill the requirements in the agreement between both parties.

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

7.3.5. 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 est. 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 logistic 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.

Issue	Document
Origin of the delivered wood pellets and wood chips based on the agreement and declaration of origin received by the producer. Visual inspections on site.	Registered daybook for delivering of biofuels
Transport documents for the delivered solid biofuels from the producer storage to the ERATO's warehouses.	Batch register (each transport shipment)
Trade and logistic process (detailed information for data, batch, type of wood pellets and wood chips, quantity, type of wood palettes and condition of the packages)	Operation daybook and in the software
Periodical repair and maintenance process description (date, type of performed operations, responsible staff)	Operation daybook and in the software
Training of the operational staff concerning trade and logistic of wood pellets and wood chips (date, names and position on employments participants, contents of training)	Training daybook
Description of responsibility of the separate employees	Staff daybook
Operational instructions for each work phase and theirs connection with CCPs	Staff daybook
Sales of pellets and wood chips (quantity, quality, name of the clients, product protocol)	Operation daybook and in the software

7.4. Assessment of the implementation process

7.4.1. Costs and financial benefits

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.

The costs for implementation of QA System for the year 2012 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.

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.

7.5. Conclusions

The process of the quality assurance system implementation of ERATO Plc is an ongoing process and it has not been completed up to date of the SolidStandards Project. Although the current complicated political financial and economic situation in Bulgaria there is big potential for standards implementation. The following conclusion can be made:

- There are strategic additions in the Forestry Low which will support the beginning of the process connected with the raw materials and production of solid biofuels.
- The Low for using of energy from the renewable energy sources will allow a lot of stakeholders to invest in the QA system implementation regarding the production, trade and logistic of wood pellets and wood chips.
- There are more of 60 producers of wood chips and wood pellets in Bulgaria at the moment. Many of them produce and import the production in the Western Europe. The requirements of their customers regarding the quality of solid biofuel production will educate them and the market will reflect to the Bulgarian producer to acquiring QA system in theirs facilities.
- There is not notified certification organization connected with the standards implementation in Bulgaria at the moment.
- The process of looking for EU certification bodies and the next business steps are expensive and take time.
- The market for production trade and logistic of wood pellets and wood chips in Bulgaria is very well development for the different specific customer groups like domestic, public and industrial sectors.
- The government support to the stakeholders in the sector for the production, trade and logistic of solid biofuels in Bulgaria is needed.
- There are not national private associations or other non-government organization of the producers and traders of wood pellets or wood chips or for both in Bulgaria.

8. Wood chips in power generation in Denmark (FORCE)

Task: End-use in power generation (wood chips)

8.1. Background information

8.1.1. 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

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.

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. The following figure shows a schematic overview of the biomass CHP plant. In reality, the electrostatic precipitator is placed before the condenser.

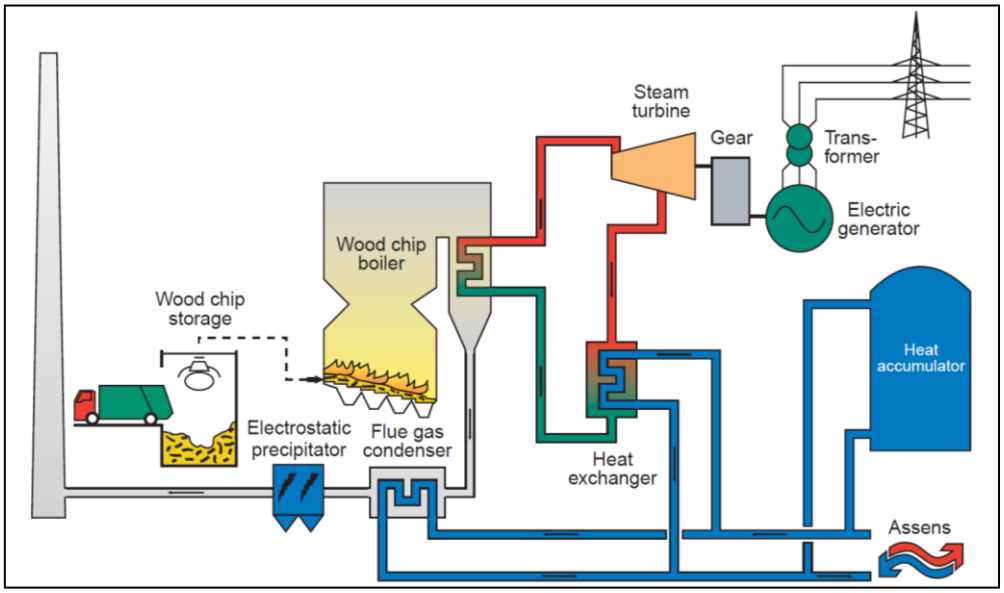


Figure 8.1-1: Schematic overview of Assens biomass-fired CHP (Source DONG Energy)

8.1.2. 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 based on detailed contracts specifying the fuel properties and origin. 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. In 2011/2012 the plant in total consumed 41,820 tons of wood chips and 760 tons of wood pellets along with 12 m^3 of oil. The activity generated 911 tons of wood ash.

Figure 8.1-2: Logs and chips stored at the plant site for backup. (Photo: Morten Tony Hansen)

8.1.3. 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.

Figure 8.1-3: 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.

Figure 8.1-4: Automatic grab crane and rotating screens. (Photos: Morten Tony Hansen)

8.1.4. 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.

8.1.5. 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.

Figure 8.1-5: Wood chip piles at Assens Harbour. (Photo: Morten Tony Hansen)

8.2. 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
- Step 3: Identification of quality influencing factors
- Step 4: Definition of critical control points CCPs
- Step 5: Selection of appropriate quality assurance measures
- (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.

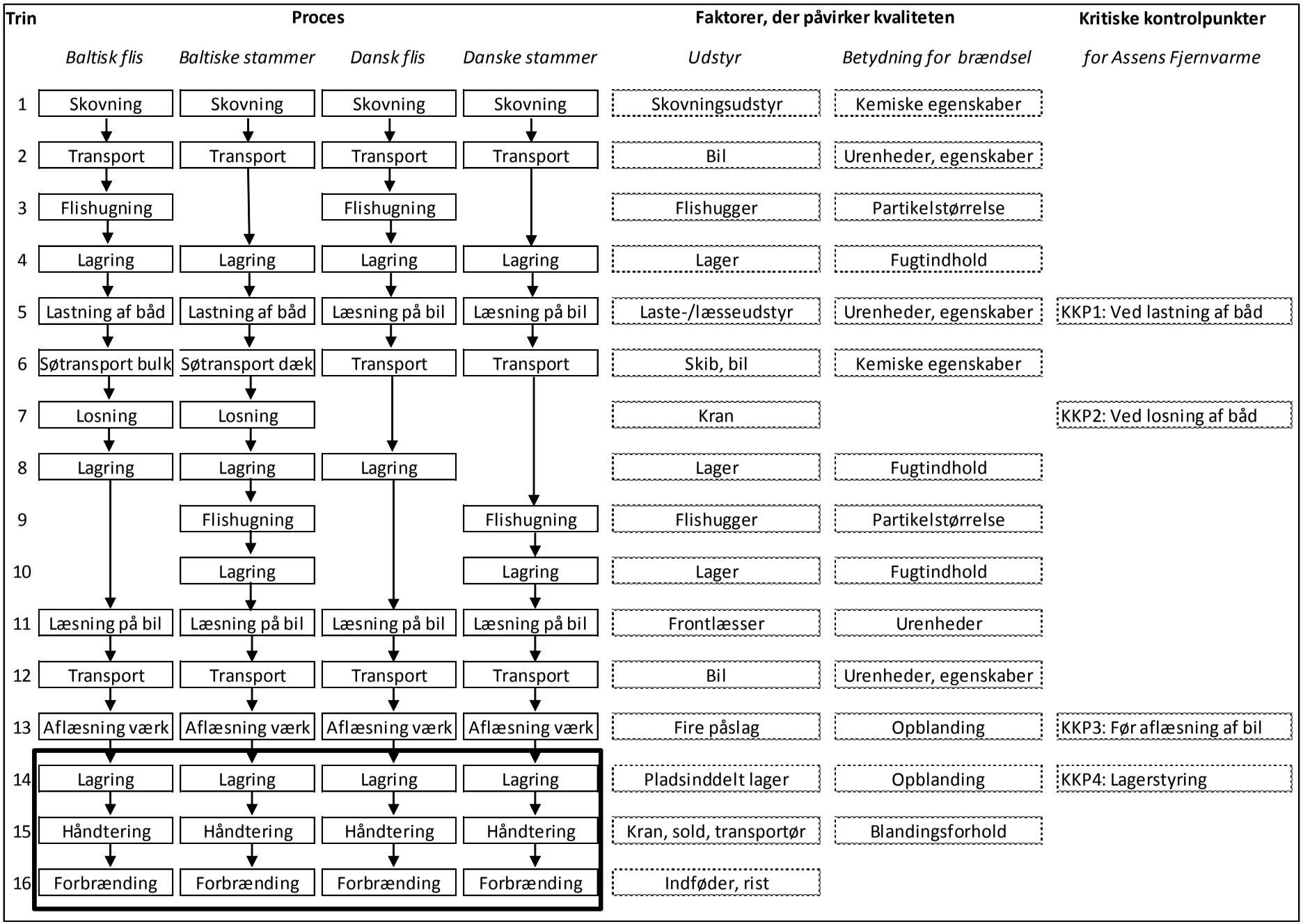
8.2.1. Process description (step 2)

Assens Fjernvarme uses different wood fuels each with a different origin. The figure at page 7 describes the four most common supply chains.

8.2.2. 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


Trin
Proces
Faktorer, der påvirker kvaliteten
Kritiske kontrolpunkter
Baltisk flis
Baltiske stammer
Dansk flis
Danske stammer
Udstyr
Betydning for brændsel
for Assens Fjernvarme
1 Skovning Skovning Skovning Skovning Skovningsudstyr Kemiske egenskaber
2 Transport Transport Transport Transport Bil Urenheder, egenskaber
3 Flishugning Flishugning Flishugger Partikelstørrelse
4 Lagring Lagring Lagring Lagring Lager Fugtindhold
5 Lastning af båd Lastning af båd Læsning på bil Læsning på bil Laste-/læsseudstyr Urenheder, egenskaber KKP1: Ved lastning af båd
6 Søtransport bulk Søtransport dæk Transport Transport Skib, bil Kemiske egenskaber
7 Losning Losning Kran KKP2: Ved losning af båd
8 Lagring Lagring Lagring Lager Fugtindhold
9 Flishugning Flishugning Flishugger Partikelstørrelse
10 Lagring Lagring Lager Fugtindhold
11 Læsning på bil Læsning på bil Læsning på bil Læsning på bil Frontlæsser Urenheder
12 Transport Transport Transport Transport Bil Urenheder, egenskaber
13 Aflæsning værk Aflæsning værk Aflæsning værk Aflæsning værk Fire påslag Opblanding KKP3: Før aflæsning af bil
14 Lagring Lagring Lagring Lagring Pladsinddelt lager Opblanding KKP4: Lagerstyring
15 Håndtering Håndtering Håndtering Håndtering Kran, sold, transportør Blandingsforhold
16 Forbrænding Forbrænding Forbrænding Forbrænding Indføder, rist

8.2.3. 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.*

8.3. 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.

8.3.1. Personnel

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

8.3.2. 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

8.3.3. 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

8.3.4. 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

8.3.5. 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

8.4. Cost-benefit analysis

8.4.1. Description of existing approaches

Assens Fjernvarme has already implemented some of (or to some extent) the measures mentioned in section 8.3.

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

8.4.2. 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.

One-off costs

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

Running costs

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

8.4.3. 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

8.4.4. 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.

8.5. Description and assessment of the implementation

We have faced an unfortunate delay in the reporting of the implementation work. This is caused by a number of factors. After a slow start up of the work package, the Danish host was chosen during 2011 and final confirmation obtained in May 2012. Activities on the feasibility study were then initiated. Due to structural changes and subsequent resource shortage at FORCE Technology and staff change at the host company the timing of the activity was affected at more occasions. The feasibility study was finalised during 2013 and it shows a positive business case for the implementation of EN 15234 which was a precondition for the host to engage in the implementation task.

Since January 2013, Assens Fjernvarme is managed by a new director, Mr. Marc Hintze. Mr. Hintze has been a member of the board since 2001. The director during the previous 30 years, Mr. John Jessen, has retired.

Until 2013 the fuel purchase function followed the strategy to ensure best economical operation via a focus on the lowest possible fuel price which has sometimes compromised fuel quality. This philosophy has proven its worth, as the company has for many years been one of the district heating companies with the cheapest heat price in Denmark and as heating season 2012/2013 proved to be one of the best ever - very little interruption and production records in some months[1].

The philosophy has, however, now changed slightly. In general, it is the perception that the best overall performance is obtained with an increased focus on high and constant fuel quality. Thus, during 2013 more emphasis has been put on purchasing better fuels and improving external and internal quality control measures.

[1] According to the Annual Report 2012/13

While different general purchase philosophies have been applied, wood chips for the plant are traded on the basis of contracts where fuel properties and origin are specified. The raw material basis should be clean stem wood and the size specification is based on a fact sheet from the former Center for Biomass Technology which refers a screening method applying a rotating screen developed during the 1990'ies becoming the industry standard for wood chip fuelled district heating plants. Further, the contract specifies the allowed moisture content, the ash content etc., it specifies how the payment will be influenced due to no-compliance and it says the deliveries may not contain green chips and only a minimal amount of needles.

When Assens Fjernvarme has experienced operational problems caused by fuel quality the reason has usually been rapid property changes in the fuel flow into the boiler. Looking more into the details, these variations in reality occur when the fuel received has not met the specifications in the contract, e.g. when the chips have been green, or chipped from berry-bearing shrubs etc. This means that either the contract has not been clear enough or clearly marketed or the enforcement of it has (deliberately or accidentally) not been sufficient at all times.

This indicates a need for further focus on as well specification of the fuel - for instance by implementing EN 14961 in fuel contracts - as managing the fuel quality in daily operation.

8.5.1. Selection of quality assurance measures

The plant operates combining two strategies of how to influence fuel quality. One strategy is based on improved information level and a close, trustful relationship between end user and other actors along the supply chain. The other strategy is strictly based on implementation of standards that cover all activities. Assens Fjernvarme is aware of the quality improvement that implemented standards may bring to the operation but also sees trust and a high information level as useful means for obtaining an acceptable fuel quality in practice and at low cost.

Assens Fjernvarme sees fuel and quality standards as a tool to beat suppliers that do not deliver the specified quality (and to reject the fuel), but in the reality that Assens Fjernvarme is a part of, such a tool is not considered the only valuable option. The main challenge shows once a certain truckload of fuel has been rated suspicious and tests have showed noncompliance with the agreed quality. Then it is typically too late to react as the fuel has already been fed into the boiler. The system can in the view of Assens Fjernvarme thus primarily be used as a means to influence the suppliers invoice (reduce the fuel price) and improve quality awareness in possible future deals, and less to avoid firing the specific fuel and the possible related operational problems/consequences.

Furthermore, implementation of all the suggested measures - especially a thorough visual inspection of all fuel deliveries and taking action on all dubious loads and also implementing the fuel declaration scheme are in the view of the managing director associated with too high staff costs and thus not feasible. Also, the existing staff that is very experienced and has the abilities to spot a dubious fuel load does not have excess resources to perform these actions.

The above and the fact that systems already exist are the main reasons for Assens Fjernvarme to currently take steps to implement EN 15234 in small increments rather than a whole package even though the feasibility study would show a positive outcome.

The initial effort has been mainly on improving focus on existing tools and procedures that are of course a part of the EN 15234 measures.

8.5.1.1. Fuel suppliers and haulage contractors

The company pursues rising the information level in the supply chain regarding fuel quality and operational consequences arising from non-complying fuel loads. Operational consequences may also have consequences for the company's ability to maintain trade with the certain supplier whose loads do not comply.

The company has lately increased focus on visiting the suppliers' operation sites e.g. in the forests, at chipping sites and at supplier sites abroad. It is considered that the national visits subsequently have influence on the quality of the received fuel while visits abroad more works a relation-building events. The company also has invited forest owners to arrangements including visits to the plant giving possibility to show how important delivery of a stable quality is to the plant.

As an increased quality control measure, the company now pays a visit to every ship bringing wood chips for the plant to Assens Harbour.

Regarding the haulage contractor, Assens Fjernvarme has put emphasis on the delivery instructions. The driver is supposed to take samples from each load for moisture evaluation. This system is generally working satisfactorily, however, the company has experienced fuel samples that were taken and bagged on before hand - "from back home" - as well as fuel samples with over good composition data. This of course rises suspicion.

Apart from the instructions, the company has increased the random control and sampling of truck loads slightly. The company has considered to further increase the randomized sampling of the deliveries by truck. At this point this has not been carried out as the results of the improved instructions are pending. During the project it has been discussed to increase the sampling for each truck which however is considered to be too resource demanding compared to the benefit for the plant.

When weighing in, the truck driver receives a weighing slip with a barcode and is instructed to take a sample. This slip then follows the sample. Scanning the barcode means that the company has a high degree of certainty that there is no mix-up of data and samples.

Weighing data are entered into the company's server and are stored here. One of the wood chip suppliers would like to get online access to data, and in the future install Ipads in their trucks. This will allow for optimization of their logistical operations.

Advanced technologies are slowly finding their way into the industry. Also, during the project meetings it was discussed whether camera technology/image analysis applied at the weigh bridge would be able to improve the correlation between samples, sample data and supplier information and if it could be a feasible way to assist the company's staff in controlling quality. The system should simply take photos of each wood chip load correlating it with the supplier, supply time, placement in which of the four fuel intakes etc. and enabling the staff to simply assess the quality by assessing the colour, the presence of outliers. The company management was interested yet not convinced of the existence of such equipment nor of the feasibility.

Instructions for truck drivers incl. sampling for moisture analysis exist and are carried out according to established/specific rules.

In general Assens Fjernvarme acknowledges the experience of truck drivers as an important measure in assuring fuel quality. The truck drivers personalize the important contact between supplier and CHP plant and thus have contact with both parties' needs and ways of defining quality. The company also recognizes the possible ethical dilemma that truck drivers may face in satisfying stakeholders in both ends of the route while only being employed by one. The plant would like to pursue possibilities for a closer involvement of the truck drivers as key persons.

8.5.1.2. Staff and systems

The plant staff has long experience with plant operation and thus fuel quality. Wihtout necessarily having a way of expressing quality in correct standardization terms they have important "silent knowledge" that is used in daily operation to handle fuel deliveries. The staff can easily distinguish between deliveries of varying quality, focus being on "can we handle this truck load?" Emphasis has lately been on verbalizing fuel quality at staff meetings.

Further, a new fuel quality registration database has been designed and taken into operation at the plant. The database is used to collect information on operational incidents from the staff and correlate it with fuel and delivery data. Once the database has a number of entries contact is taken to the supplier and the information used to illustrate problems and verbalize quality needs and the consequences of poor fuel quality. General instructions for the personnel on duty exist and are used according to established/specific rules.

8.5.1.3. Fuel

Moisture analyses are carried out for each truck load. If the operational staff conceives suspicion of a high ash content in a delivery, a sample is taken out for analysis. The plant has its own equipment for determination of ash content. Instructions for taking a fuel sample and preparing it for analysis of ash content exist and are carried out according to established/specific rules if suspicion has been conceived. This routine has gained more attention lately.

As described above, the plant receives fuel loads that do not comply with the fuel specifications in the contracts. This will continue even with the increased quality awareness and randomized controls. The important activities here are to make sure the right measures are put into force. If the load cannot be rejected, the price can be adjusted to match the quality level. The plant is able to handle a large variation in fuel properties, however, sudden changes are likely to cause problems - the properties should be known in advance.

Figure 8.5-1: Fuel storage and mixing possibilities outside storage. (Photo: Morten Tony Hansen)

More attention is therefore now given to handling non-conforming deliveries. If the fuel of low quality is mixed carefully with high quality stem wood chips and large particles are removed, it may be combusted with good results, i.e. not causing breakdowns and loss of income due to missing electricity generation. The company has possibilities of tracking the different deliveries in the storage due to the four fuel intake pits and the storage cranes can be operated to mix the fuels. The company also has the possibility to mix fuels at the large space outside the covered fuel storage with their front-end loader.

8.5.2. Conclusions

Generally, all the aspects of the quality assurance measures recommended in the feasibility studies have been implemented or they were already in use but have been emphasized at Assens Fjernvarme.

It has not been possible to evaluate the implementation in detail. It is the view, however, that the feasibility study is true and the costs and benefits are relevant.