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In this report the different aspects of reed and reed lands are discussed related to sustainable harvesting of biomass. This is based on a pilot project for Poltava Oblast, funded by Agency NL of the Dutch Ministry of Economic Affairs. Within the 'Pellets for Power project' several areas were identified, to test the approach and criteria applied for NTA8080. We show in this report that ILUC free reed harvesting is possible. Reed in the project area is harvested on land not used currently for agricultural purposes. The wetland should be maintained as much as possible in its natural state, and protected against fires. Based on this, it is concluded that the requirements for NTA8080 can be met. Biomass harvesting is in support of wetland protection, and can result in increased biodiversity, provided that the necessary precautions are taken, as described in the 'best practices'. In this way reed harvesting for biofuels also contribute to social wellbeing, increase income for local communities, and at the same time decrease greenhouse gas emissions.

Keywords: Biofuel, biomass, reed land, wetland management, certification, NTA8080, reed harvest, Phragmites, GHG, ILUC, biodiversity, Ukraine, Poltava

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Summary

In this report the different aspects of sustainable harvesting of reed and reed lands are discussed for bioenergy. This is based on a pilot project for Poltava Oblast, managed by Agency NL under the Sustainable Biomass Import Programme (DBI) funded by the Ministry of Economic Affairs (EZ) in the Netherlands.

A consortium of partners in the Netherlands, Belgium and Ukraine has developed a reed chain in accordance with the certification system NTA8080. The report describes all aspects which are relevant in the light of biomass harvesting, sustainability, social aspects, technical features of reed harvesting and Greenhouse Gas balance.
We test whether all aspects of NTA8080 can be met through collecting relevant data, testing the stakeholder participation approach, and developing criteria for sustainable harvesting and monitoring of reed land.

Common Reed (*Phragmites australis* Trin.) is a grass species, and one of the most widely distributed vascular plant species in the world. Reed has a high potential for biomass production with a sustained harvest of up to 15 t DM/ha/year. Reed can be utilised both as an energy source, construction material and industrial raw material. Reed is a key species and plays a significant role in wetland ecosystems, as a species it has the highest biomass and abundance within wetlands. Ukrainian wetlands cover over 1,200,000 hectare, in Poltava region there are 53,200 ha of wetlands (around 2% of the total land area). Burning of reed land (in winter) is common practice, often it is related to hunting but also fisherman may acquire easier access to the water after burning.

Within the ‘Pellets for Power project’ several areas were identified, to test the approach and criteria applied for NTA8080. After establishing local contacts with the villages, field work was done in those areas, to collect baseline data, assess the vulnerability, and prepare maps which can eventually form the basis for harvesting. The reed harvesting process is described step by step with details of the equipment and technical specifications.

We describe in chapter four in detail, the steps that are taken reed harvesting and processing. This includes aspects of equipment and machines involved, for large scale harvesting. Based on these specifications, an economic analysis is done, which makes it possible to compare reed pellets with other fuels, buth for the domestic (Ukranian) market and for export to Western Europe. Our research shows that it is best to focus on the domestic heating market with regards to the herbaceous biomass pellets produced in Ukraine. The current high gas price easily justifies the harvesting, transport and processing operations. Viability of international supply chains for non-wood biomass will depend on lowering the cost of supply and/or higher cost of fossil fuels. This shows that in both business cases reed pellets are competitive with other energy sources.

Stakeholder consultation is an essential element in developing, implementing and operating a biomass project. It plays a critical role in awareness raising of the project's impacts and helps to achieve agreements on the approach. The report describes how the consultation took place, and what problems were encountered in this process. The community consultations have resulted in broad support within the community, making the project at the same time less vulnerable to corruption and abuse by individual village council members and officials. Long-term reed harvesting programs were signed with thirteen villages.

The overall reed biomass chain has a highly positive GHG balance with 75% savings. In case of export to the Netherlands (when used for co-firing with coal) and 86% when used for domestic heat production in Ukraine (replacing natural gas). The GHG savings comply with the minimum requirements as stated in the NTA 8080 (70% for Dutch mixture of electricity production). From a global climate change point of view it should be more efficient to use the biomass in Ukraine itself for

energy production, instead of exporting it. However, the import of reed biomass from the Ukraine is still an alternative which would comply with the sustainability criteria of the RED and NTA 8080.

Also, reed pellets could become one of the feed stocks for second generation fuel and chemicals production. Ten tons of reed pellets from Ukraine were tested in the municipal heating facility of Marum in the Netherlands. The system has been designed for locally sourced wood chips. Overall the test showed that reed pellets can be used for local heat production. Improvements in pellet quality are possible in the pellet production process. Also some adaptations should be made to the boiler system to handle the higher ash content and ash behaviour.
We show in this report that ILUC free reed harvesting is possible. Reed in the project area is harvested on land not used currently for agricultural purposes. And even in case of reed occupying land that was formerly used for agriculture (some of the area has been grazing land), this still refers to 'abandoned land' and thus there is no competition for food production.

We provide best practices for reed harvesting. To prevent nutrient depletion and a negative soil carbon balance we recommend not to harvest all reed area every year, but to reduce the harvesting frequency to once every two years. In this way there is more time for input of nutrients via natural sources, i.e. deposition and flooding, which reduces the risk on nutrient depletion. This is also in line with the 'best practices for biodiversity' (par. 11.5), which include a recommendation to harvest only part of the area, and leave at least 25% of older reed and natural areas. Further, the site selection is important, taking care to avoid protected areas and wetlands to abide with Ukrainian law. The wetland should be maintained as much as possible in its natural state, and protected against fires. Careful monitoring will ensure sustainable development. If all these aspects are taken care of, our study shows that wetlands can contribute to social wellbeing, and increase income for local communities.

It is concluded that the requirements for NTA8080 can be met. However, in some aspects, we suggest a wider interpretation of the criteria for NTA8080 (or a specific addendum to the NTA 8080 has to be made with regards to wetlands). This is in particular necessary where rather strict rules apply regarding wetlands, which should not be used for biomass. We show that biomass harvesting is in support of wetland protection, and can result in increased biodiversity, provided that the necessary precautions are taken, as described in the 'best practices'.

1 Introduction

1.1 Pellets for Power Project

This study was conducted in the framework of the Pellets for Power project, funded by NL Agency under the Sustainable Biomass Import Programme (DBI) under the Ministry of Economic Affairs (EZ) in the Netherlands. The project objective was the development of sustainable supply chains for biomass produced in Ukraine. Three types of biomass are included: reed, switchgrass *(Panicum virgaturm)* and (wheat) straw. In order to guarantee sustainability, all biomass based operations had to comply with the Dutch NTA 8080 standard (NEN Netherlands Standardization Institute, 2009). A basic sustainability principle of the NTA 8080 is full compliance with Ukrainian laws and regulations, but also other, internationally accepted aspects of sustainability have been reviewed (Hennenberg et al., 2010). Hence this report focuses on analysing the use, management and harvesting of Ukraine's reed resources.

The project has a focus on Poltava Oblast, approximately 250 km southeast of the capital city of Kiev (Figure 1). The territory consists of undulating plains, small rivers and streams with wetlands surrounding it. Land use is generally agricultural, with traditional and industrial farming. Land is mostly owned by local communities, some land is held (rented) from communities by large companies, for more intensive farming.

Figure 1 *Location of Poltava Oblast in the Ukraine.*

1.2 Approach

Within this project we test whether all aspects of NTA8080 can be met through collecting relevant data, testing the approach regarding stakeholder participation, and developing criteria for sustainable harvesting and monitoring of reed land. This report is therefore not only a description of how biomass harvesting could be done in Poltava Oblast, but also a methodological approach of how to apply sustainability principles regarding indirect land use change (ILUC), greenhouse gas (GHG)-balance, and biodiversity. Based on this, a guideline has been prepared for sustainable harvesting of reed (Chapter 11).

Except for local experiences and local data which has been collected in this pilot project, the report also presents a summary of existing literature, in particular literature relevant to the context of Central and Eastern Europe.

This report is divided into thirteen chapters, dealing with all aspects of the reed harvesting and processes: Chapters 2 and 3 deal with general aspects of reed, and the harvesting sites. Chapters 4 and 5 deal with the reed harvesting process. Chapters 6 and 7 with legal aspects and involvement of stakeholders. Chapters 8 till 11 discuss the environmental aspects of the reed biomass chain, greenhouse gas emissions, Indirect Land Use Change ILUC and best practices for harvesting and thermal conversion to heat. Chapter 12 discusses social aspects of reed harvesting, and in Chapter 13 the conclusions and recommendations are presented.

The authors trust that this report will be of value for current and future businesses, as well as for law makers, Certification Bodies and others interested. It provides insight in Ukrainian laws and regulations and in the obstacles and opportunities for obtaining permits for sustainable reed management. We refer to another project report, NTA 8080 Analysis (Poppens and Hoekstra, 2013), providing a comparative analysis of Ukrainian laws and NTA 8080 sustainability requirements (NEN Netherlands Standardization Institute, 2009, NEN Netherlands Standardization Institute, 2010).

It is important to note that this report reflects primarily the knowledge and opinion of WUR, Phytofuels and the Biomass Institute (NGO, research organization established by Phytofuels), as well as information, a 'state of the art' of reed land management, based on existing publications[1].

Figure 2 *Wetland in Poltava, partly harvested, in spring 2011.*

[1] Note: The data from the Poltava Reed case have been reported by Phytofuels and Poltava SA and are their responsibility.

2 Reed characteristics and uses

2.1 Introduction

Common Reed (*Phragmites australis*) is a grass species, and one of the most widely distributed vascular plant species in the world. It is native to Eurasia and Africa, but has spread all over the world now (including US, South America and Australia). It is a typical wetlands species, and can cover vast areas almost in monoculture, outcompeting other plant species. Reed is a key species and plays a significant role in wetland ecosystems, as a species it has the highest biomass and abundance within wetlands.

Reed can be very versatile, depending on soil conditions, climate, hydrologic regime, and management. In continental climates, with high water tables in dynamic situations the reed can grow as tall as seven meters (Komulainen et al., 2008), whereas in more temperate climates under dryer and stable hydrological conditions and continuous harvesting, reed may form very open vegetation of only some 1.5 m tall. In Poltava the height is generally 4-5 meters, depending on hydrology. Reed production can be as much as 30 ton/ha (Allirand and Gosse, 1995).

Figure 2 *Petro Kraisvitnii in front of a tall reed stand in Poltava oblast, up to 6 m high.*

2.2 Reed ecology

Sexual reproduction takes place to a limited extent (Engloner, 2009). Seed dispersal is however important in dynamic wetland systems, where uninhabited mud flats appear and seeds of reed can massively colonise such areas. Reed germination is mostly affected by light availability and water depth, which should not be more than 5 cm (Engloner, 2009).

More important than sexual reproduction is the spread of reed through its root stocks: reed is a highly competitive species. The rootstocks form a thick, impenetrable layer where very few other species can compete. The plant is tall and dense, and thus the light at the bottom is decreased which diminishes the survival chances for other species. The dead leaves and litter from the plant form a thick mulch layer, which limits germination opportunities of other species.

Reed shows a high genetic adaptivity, as was shown in experiments with both north-south and east-west gradients: the genotype defines growth, timing of flowering, biomass allocation etcetera (Clevering et al., 2001).

Reed is fairly tolerant to saline conditions, although higher salt levels result in lower biomass. The biomass production as well as the height of the reed is affected by nutrient status of the water as well as dynamic water level conditions. However, the literature is ambivalent of what is the overriding factor. It seems that intermediate water level dynamics results in the highest biomass production. Biomass increases with a higher nutrient status of the water, however, hypertrophic conditions are detrimental for stability of the reed culms, and reed will break more easily.

Reed is steady under adverse gas regime with high content of hydrogen sulphide, carbonic anhydride, methane in the water and soil, and also is well resistant against such toxic elements as phenol, naphthenic acid, chlorides, cyanide, ferrous iron salts etcetera.

Reed is very important for biodiversity, reed land often form islands in areas largely modified and cultivated by man which form important wildlife refuges. This is discussed in detail in Chapter 3 (Reed lands) and Chapter 11 (Biodiversity impact).

2.3 Reed use in Ukraine and Poltava region

Reed is known to have a long history in Ukraine and has always been a dominant species in wetlands, and appeared during thousands of years (Kremenetski, 1995). Since ancient times reed has been used for making vibrating mechanism of clarinets and flutes. Folk medicine uses reed roots as sudoriferous and urinative, and discharge of the stems are useful in the case of insects stings (Дубина et al., 2003).

For a long time reed has been used as building material. Reed-fibre mats are widely used in building and construction. Reed is used as roofing, and also for making walls and partitions in small houses, fences, float-boat for crossing small rivers etcetera. It is used for production mats for feeding of worms of silk moth, mats for greenhouses, and as a fuel in the steppe regions. Today it is used to produce pressed sound- and thermo insulating panels, flooring boards, panels, mixed fibreboard, gypsum-fibre plates, plastics and other building materials.

In Table 1 an overview is given of current use of materials from reed lands, based on a study for Belarus (Wichtmann and Tanneberger, 2009, Allirand and Gosse, 1995). For Poltava the following uses are relevant:

- Building
- Thatching
- Cellulose production
- Paper pulp
- Fuel, other
- Fishing, hunting

Beside traditional agricultural uses as fodder, reed can be used for industrial raw material and for energy production. Biomass use for industrial raw material (e.g. as thatch) is rather common in European countries such as The Netherlands, UK, Germany, Poland, and Romania. In the Netherlands and Germany, the demand for reed as roofing material and for the production of mats cannot be satisfied by inland reed harvest. Imports from South- and East-European countries such as Romania and Poland cover the current demand. Also only recently developed products such as packaging material or vegetation- and plaster-porter mats seem to be economically interesting (Wichtmann, 1999).

Reed (*Phragmites australis*) has a high potential for biomass production. A sustained harvest of 15 t DM/ha/year can be achieved in combination with continuing peat accumulation (Wichtmann 1999a). Reed can be utilised both as an energy source and as an industrial raw material. Traditionally harvest for roofing material takes place in winter. Cultivation and application has been described extensively (Rodewald-Rodescu, 1974, Timmermann, 1999, Wichtmann, 1999, Wichtmann et al., 2000).

Table 1
Examples of biomass utilisation from peatlands (adjusted after (Wichtmann et al., 2000). Q = demand for quality: + = high. 0 = medium, - = low (Wichtmann and Tanneberger, 2009).*

Utilisation		Vegetation	Harvest	Q*
Agriculture	Mowing, fodder	Wet meadows, reeds	Early summer	+
	Grazing	Wet meadows, reeds	Whole year	+
	Litter	*Carex* meadows, reeds Wet	Summer	-
	Compost	meadows, reeds	Late summer	-
	Pellets	Wet meadows, reeds	Early summer	+
Industry	Roofing material	Reeds	Winter	+
	Form-bodies	Wet meadows, reeds	Autumn/winter	0
	Paper-cellulose	*Phalaris-Phragmites* reeds	Winter	0
	Basket-wares	Willow	Autumn	+
	Furniture/timber	Alder swamps	Frost	+
	Chemicals	Reeds	Early summer	+
Energy	Direct combustion and gasification	Alder swamps, willow, reeds	Autumn/winter	-
	Fermentation	Wet meadows, reeds	Early summer	0
	Liquid 'sun fuels'	Wet meadows, reeds	Whole year	-
Other	Officinal	Natural mires/plantations	Early summer	+
	Food	Natural mires/plantations	Summer	+
	Substrate	Peat moss farming	Whole year	+

2.4 Potential for heating in Poltava Oblast

If a few assumptions are made for heating cities, e.g. for the town of Lubny with 25,000 inhabitants, situated near one of the reed lands, we can estimate how much reed land or straw is required. This is based on the assumption that an average household size is three persons, and an average house measures some 80 m2, excluding high-energy consuming buildings such as swimming pools, public buildings etcetera. With a production of 12 tons biomass/ha some 3,000 ha would suffice to heat the entire town. Additional benefit would be the provision of employment, for staff involved in the harvesting process and at the power plant.

Table 2

Calculation of required biomass for the town of Lubny (25,000 inhabitants) in Poltava oblast, with an assumed reed production of 6 ton/ha, harvest 100% of territory (based on calculations from P. de Jamblinne, 2ZK).

Average heat consumption / m2 / year	90	150	300	kwh / m2 / year
Gross consumption for dwellings only	60,000,000	100,000,000	200,000,000	Kwh
	60,000	100,000	200,000	Mwh
In tons agrobiomass (MWh/ton) (straw)	15,000	25,000	50,000	tons biomass
(reed)	12,000	20,000	40,000	tons biomass
Yield per Ha				
Required area (straw)	3,750	6,250	12,500	ha of straw biomass
(net) Required area (reed land)	**2,000**	**3,350**	**6,700**	**ha of reed biomass**

Figure 3 *Reed storage.*

3 Reed land and wetlands

3.1 Introduction

The previous Chapter describes Common reed at the 'species level': plant ecology, physiology etcetera. In this Chapter the more general ecosystem level is described.

Wetlands are 'areas of marsh, fen, peat land or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres' (Art. 1 of the Ramsar Convention).

The wetland system includes its vegetation zones and structure as well as animal populations. The most important factor affecting the biotic system is the duration of flooding. Other important factors include nutrients and salinity.

Species are highly dependent on water chemistry. The chemistry of water flowing into wetlands depends on the source of water and the geological material in which it flows through as well as the nutrients discharged from organic matter in the soils and plants at higher elevations in slope wetlands. Sources of water flow into wetlands are predominately precipitation, surface water, and ground water. Landscape characteristics control wetland hydrology and hydrochemistry. Hydrochemistry within wetlands is determined by the pH, salinity, nutrients, conductivity, soil composition, hardness, and the sources of water. Water chemistry of wetlands varies across landscapes and climatic regions.

There are four main kinds of wetlands: marsh, swamp, bog and (mire) fen. Bogs and fens are both types of mires. Some experts also recognize wet meadows and aquatic ecosystems as additional wetland types. Wetlands independent from local or regional hydrology, depending on rainwater; oligotrophic conditions.

Different reed land types can be defined: water reed versus land reed, brackish reed land versus freshwater reed land etcetera.

Wetlands are generally minerotrophic with the exception of bogs. Bogs receive their water from the atmosphere and therefore their water has low mineral ionic composition, because ground water has a higher concentration of dissolved nutrients and minerals in comparison to precipitation. Bogs can be situated in a depression, where water collects (lowland bog) or connected to larger wetland systems or rivers. Here eutrophic or mesotrophic site conditions prevail, although locally nutrient poor situations may develop as well.

The water chemistry of fens ranges from low pH and low minerals to alkaline with high accumulation of calcium and magnesium, because they acquire their water from precipitation as well as ground water.

The wetlands are in all natural and climatic zones of Ukraine. In Ukrainian Polissya (Polesia, i.e. the northernmost zone of Ukraine, mostly forested with the Pripyat marshes included) most wetlands are oligotrophic pine-acid-grassy bogs. In the forest steppe of Ukraine eutrophic sedge and reed bogs are more common. In the steppe they are changed by fresh-water and salty grassy bogs. Generally there are three main zones of wetlands availability:
- Polesia acid bogs,
- Polesia and forest steppe grassy-moss bogs,
- Polesia forest bogs.

Reed is one of the important wetland species, but other important wetlands species are:

- Cattail (*Typha latifolia, T. angustifolia*) may result in harvests of up to more than 20 t DM ha-1 a-1 (Table 3 Timmermann 2003, in Wichtmann and Joosten (2007)). The optimum water levels for cattail beds are 20 to 150 cm above the surface.
- Reed canary grass (*Phalaris arundinacea*) dominated stands developed by natural succession over large areas in restoration projects e.g. in Northeast Germany (Wichtmann and Tanneberger, 2009). Rewetting resulted in substantially retarded or stopped peat oxidation. Like reed, it should be harvested in winter as lower S-, Cl-, and K-concentrations improve the combustion properties.
- Sedges (*Carex spec.*) can also be utilized both energetically and industrially. Experiments in Northeast Germany and the Netherlands resulted in a successful establishment of Sedges. The productivity is variable, depending on the species of sedges but may range from 3.3 up to 12 t DM ha-1 year-1 (Table 3).

Table 3
Productivity of potential dominant species after rewetting (Timmermann 2003, in Wichtmann and Joosten, 2007).

Species Productivity	(t DM ha-1 year-1)
Common reed (*Phragmites australis*)	3.6 - 43.5
Cattail (*Typha latifolia*)	4.8 - 22.1
Reed canary grass (*Phalaris arundinacea*)	3.5 - 22.5
Sweet reed grass (*Glyceria maxima*)	4.0 - 14.9
Lesser Pond-sedge (*Carex acutiformis*)	5.4 - 7.6
Great pond-sedge (*Carex riparia*)	3.3 - 12.0
Peat mosses (*Spagnum spec.*)	2.0 - 8.0

Figure 4 *Reed land with scattered shrub in Poltava oblast.*

3.2 Distribution of wetlands

Reed has a wide distribution in Ukraine, although there seem to be few studies which quantify this properly. Ukrainian wetlands cover over 1,200,000 hectare with stocks of air-dried peat over 3 MT. Most of the wetlands are in Polissya (900,000 ha), less in forest steppe (around 300,000 ha) and on steppe and in the mountains. In Poltava region there are 53.200 ha of wetlands, that is around 2% of the total land area.

Large areas of reed lands are in the delta of the river Danube. Southern reed (*Phragmites australis Trin. ex Steud*) is present in wetland ecosystems on huge territories of the Northern Black Sea region. It covers nearly 300,000 ha of this region, that is 12% from total areas of wetland landscape (Zhmud, 2011, http://awsassets.panda.org/downloads/zhmud_elena.pdf). In Belarus, mires in former times covered 2,939,000 ha, i.e. about 15% of the country's area. However, most of these mires have been drained (Козулин et al., 2010).

Small wetlands are vulnerable for external factors such as drainage, grazing animals, fires or land conversion. A large body of water is less impacted, or not so easily changed than small wetlands, and for that same reason many smaller wetlands were converted, drained and have disappeared.

Wetlands are in particular vulnerable for the following:
- Change in hydrology
- Climate change (related to hydrology)
- Water quality
- Fire

3.3 Wetland biodiversity

3.3.1 Flora and fauna

In dense reed lands plant species are few, which can be explained by the competitive nature of reed, in combination with the extreme conditions (fluctuating water levels) and limited light penetration at the bottom of the reed bed (Ikonen and Hagelberg, 2007). To increase plant diversity often summer mowing is propagated, which will extract nutrients from reeds and their roots, decrease the growth of reed and give way to other plant species. Also, the reed is not easily browsed by animals, and the natural decay is slow (in Nordic climates decomposition rates of Phragmites is three years for 50% dry weight loss).

Wetlands in central Europe are in particular known for their biodiversity of birds and insects (Wichtmann, 2006).
The diversity of aquatic invertebrates is very large, both in number of individuals and species richness (Ikonen and Hagelberg, 2007). This may be due to the habitat present for feeding, but also available cover to protect it against predating species. Birds, as the most numerous group of vertebrates in the fauna of Ukraine and representative of the higher trophic level, can be reliable indicators of any changes in wetlands ecosystems, of both natural and anthropogenic origin since they are sensitive to the smallest changes of their natural environment.

Some five bird species are exclusively found in reed land habitats: the Bittern (*Botaurus stellaris*), Bearded tit *(Panurus biarmicus),* Eurasion reed warbler (*Acrocephalus scirpaceus),* Great reed warbler (*Acrocephalus arundinaceus),* and Water rail (*Rallus aquaticus*) (Ikonen and Hagelberg, 2007).

The most numerous species of wetlands in Polissya and the forest steppe of Ukraine is the Wild duck (*Anas platyrhynhos*), with a total share of 60.8% of all bird observation. Second are the Black-headed gull (*Larus ridibundus*) (10.7 %) and Caspian gull (*Larus cachinnans)* (4.8 %), Common tern (*Sterna hirundo*) (3.1 %), Common coot (*Fulica atra*) (2.4 %), Great crested grebe (*Podiceps cristatus*) (2.0 %), White-winged tern (*Chlidonias leucopterus*) (1.8 %), Purple heron (*Ardea cinerea*) (1.2 %), Lapwing (*Vanellus vanellus*) (1.2 %), and Garganey (*Anas querquedula*) (1.0 %).

These 10 species of wetlands birds form almost 88 % of the ornithofauna of this biotope, so the rest of species form just nearly 12%. This makes it difficult to find species-indicators, since most of them are rare species (with a share less than 1 % of the total), which makes it difficult to use them as indicator of any type of biotope (Давиденко, 2006).

More frequently used indicators are however: Savi's warbler (*Locustella luscinioides),* Bluethroat *(Luscinia svecica),* Bearded tit, Common reed bunting (*Emberiza schoeniclus),* Eurasian reed warbler, Great reed warbler and Western marsh harrier (*Circus aeruginosus).* No indicators species were defined for dense reed and Cattail vegetations.

Indicator for Sedge and herb wetlands is Short-eared owl (*Asio flammeus),* Common crane *(Grus grus),* Great snipe (G*allinago media),* Common snipe (*Gallinago gallinago),* Citrine wagtail *(Motacilla citreola),* and Black-tailed godwit (*Limosa limosa)* (Давиденко, 2006).

Figure 5 *Common crane (Grus grus) observed during inventory work at Velyke boloto, spring 2011.*

A species such as the aquatic warbler (*Acrocephalus paludicola*), is a characteristic fen mire flagship species and today the only globally threatened passerine species of continental Europe (Birdlife International 2008). It finds its natural habitat probably in low productive fen mires that remained treeless because their loose, water saturated peats guaranteed a permanently high water level and a limited weight carrying capacity. With increasing drainage and eutrophication, such habitats became more and more land use dependent. Whereas in the mesotrophic sites according to the mire typology of Succow (2001), sporadic mowing, grazing or burning are sufficient to maintain aquatic warbler habitats (AWCT-Aquatic Warbler Conservation Team, 1999, Kozulin and Flade, 1999), eutrophic - moderately rich sites depend on annual late land use (Kloskowski and Krogulec, 1999, Tanneberger et al., 2008), and eutrophic - rich sites on annual early land use. A tendency towards more management-intensive conditions is expected to take place in all breeding sites that are subject to succession to higher and denser vegetation due to drainage and high nutrient loads (HELCOM, 2006).

Some species show a clear preference for older reed lands, such as Bittern (*Botaurus stellaris*), Savi's warbler (*Locustella luscinoides*) and Bearded tit (*Panurus biarmicus*), but most species show higher densities in younger reed stands (Beemster et al., 2010).

The Aquatic warbler also is shown to depend on winter mowing of reed, since its optimal habitat of open sedge vegetation becomes more and more overgrown by reed. Winter mowing sets back the succession of reed lands and favors this species (Wichtmann and Tanneberger, 2009). However, also here counts that stripes of uncut reed should remain. The edges of flooded reed beds are important for biodiversity, in particular the edges towards open water (Ikonen and Hagelberg, 2007).

Mammals are relatively scarce in wetlands, which is due to the environment (wetlands are not well accessible for many species), but also as a result of hunting pressure. Mammals that are adapted to wetlands, are the European otter (*Lutra lutra*), European beaver (*Castor fiber*), Eurasian water shrew (*Neomys fodiens*) and Muskrat (*Ondatra zibethicus*). Other common mammals found in wetlands are the Daubenton's bat (Myotis *daubentonii*), Brown rat (*Rattus norvegicus*), European water vole (*Arvicola amphibius*) and European polecat (*Mustela putorius*).

Species which occur on the edges of wetlands, or more dry parts of the area are Wild boar (*Sus scrofa*), Fox (*Vulpes vulpes*), Hare (*Lepus europaeus*). All these species are present in Ukraine.

The Eurasian elk (*Alces alces*) is a typical indicator for large wetlands, but doesn't occur in Poltava though, only in Western Ukraine. A good indicator species for large, intact wetlands would be the European otter.

Although all amphibian species need at some stage in their life cycle wetlands or aquatic habitats, some species are rather terrestrial. Common amphibian species occurring a lot in wetlands are, Garlic toad (*Pelobatus fuscus*), Red-bellied toad (Bombina bombina), Common toad (*Bufo bufo*), Common frog (*Rana temporaria*), Marsh frog (*Pelophylax ridibundus*) and Pool frog (*Pelophylax lessonae*). Most species were observed during field work at Poltava oblast.

For reptiles in particular the Dice snake (*Natrix tessellata*) and Grass snake (*Natrix natrix*) are important.

The size of wetland areas is very important: small wetlands obviously offer less habitat for species with large territorial demands such as Elk, Beaver, or Otter. Not only is habitat perhaps limited for one or two pairs, also the risk of extinction is large in small wetlands in particular: one large fire can kill a pair, or make the area unsuitable for several years to come.

Except for the total area, also the distribution of wetlands, the so-called 'spatial configuration', is important. If the small wetland forms part of a network or chain of wetlands, the dynamics are such that animals can freely move from one area to another, or if an area became unsuitable, it can (temporarily) move to another area, or if there are young animals or plants they can easily find new habitat in adjoining areas. If the area is isolated this won't happen so easily, and only large wetland areas can maintain large, viable populations of plants and animals.

3.3.2 Historical Reed management in Central Europe

In the past mowing used to be a common rural practice in fen mires in Belarus (Joosten and Clarke, 2002, Kotowski, 2002). Mowing was done largely by hand scything, and created a small-scale mosaic of open vegetation (Sutherland 2002). Litter was used as bedding material for cattle This practise was abandoned in most regions but in Central and Eastern Europe it is sometimes still present or it was replaced by more intensive mowing or grazing. Abandonment of traditional mowing, along with nitrogen and phosphorous enrichment, have led to a change in vegetation and nutrient conditions that caused the loss of habitats of many plant and animal communities (Kotowski 2002, Hodgson et al. 2005, Wassen et al. 2005). The more eutrophic a site is, the more intensive land use needs to be to reduce the trophic level and keep the vegetation short and sparse.

Reed was historically used for thatch for roofs in Ukraine. Optimal thatching reed is straight, fine, stable and rather short (1.6 m) (Wichtmann and Tanneberger, 2009) and grows under mesotrophic and slightly eutrophic soil conditions.

Traditionally reed was also used for building fykes for fishing. This method of fish capture is over 2500 years old (Русев and Русева, 2003). In 1958 the Soviet government adopted the law «On use of reed as raw materials for production of cellulose and paper». Reed stocks were concentrated in the delta of the river Dnipro. So it was decided to build a cellulosic plant in Tsiurupinsk, Kherson region. In 1963-1964 the production of bleached cellulose was applied for the first time on the Kherson cellulose plant. In the 1980s reeds were used for animal feeding through grazing of reed land and harvesting for silage.

The use of reed has declined (roofs, crafts) which results in larger fires as a result of higher fuel loads. In the Ukraine burning of reed land is common practice. Reasons may differ, often it is related to hunting practices, which requires open reed land, or burning may drive out animals. Also fisherman (which are usually also the hunters) may acquire easier access to the water after burning. Sometimes, handicrafts are prepared from reed, and burning will improve the quality since more straight reed is growing. Also people may want to just get rid of the reed, to ‘clean’ the area. People are often careless with fire , which can also result in large fires. People can only be prosecuted if they are caught in the offence of setting fire.

3.3.3 Wetland management

In an extensive literature review of reed ecology it was shown that the different management methods have different impacts; however, the results are not straightforward, and may differ based on specifics of the trials that were done, as well as geographical site, substrate, and genotype of reed (Engloner, 2009).

Grazing management in general results in a decline of reed, lower biomass production, less and smaller shoots regrowth. However, grazing over fifteen years by moulting Greylag goose (*Anser anser*) resulted in higher production and increased shoot density, which can be explained by the availability of light, and less litter, depressing regrowth (Engloner, 2009). Grazing however also results in a lower and more open vegetation which can provide important feeding areas for e.g. birds such as bearded tit (Beemster et al., 2010).

Burning in spring and autumn also has positive effects probably as a result of removal of litter, and in combination with mowing biomass production may increase.

Winter cutting is seen as an important management approach to maintain valuable wetland habitats in Poland, Lithuania and Belarus (Wichtmann and Tanneberger, 2009). However, long-term effect of summer mowing results often in an increase in reed density, but a decrease in biomass and height, and smaller shoots which makes it more vulnerable towards mechanical damage (Engloner, 2009). Winter cutting showed no effect on shoot production and biomass, or gave even an increase of biomass as a result of better spring light conditions (Granéli, 1990). Optimal conditions for birds can be maintained by cutting in winter, this prevents the expansion of shrubs and removes dead reed material and litter (Wichtmann and Tanneberger, 2009).

Figure 6 *Current management practices include burning of the reed in winter, which results in intense fires, damage to wildlife, soil and air pollution.*

Hydrological management of wetlands is important. In intensive reed cultures such as in the Netherlands, the hydrology is adjusted depending on the needs for management (Van der Winden et al., 2003). There is currently also a trend of rewetting (drained or degraded) peatlands, to decrease the CO_2 emissions (Daatselaar et al., 2009), an approach which is also called ‘paludiculture’. In some cases this can also involve conversion of grassland into reed land (Grandiek et al., 2007, Daatselaar et al., 2009)

3.4 Description of harvesting areas

Within the ‘Pellets for Power project’ several areas were identified, to test the approach and criteria applied for NTA8080. After establishing local contacts with the villages, field work was done in those areas, to collect baseline data for the area, assess the vulnerability, prepare maps which can eventually form the basis for harvesting.

By May 2012, Phytofuels had signed reed harvesting programs with five villages. Table 4 shows a list of the villages, and the respective hectares of reed land (officially claimed). So far, four areas have been investigated for the biodiversity. By September 2012, the total number of villages had increased to 30, the total village councils to thirteen and the combined reed area had increased to over 8000 hectares. Those areas have not been investigated so far.

The following paragraphs describe those areas the survey focused upon. It is a summary of an extensive report (Rii and Galytska, unpublished report), based on inventory forms which were prepared.

Table 4
Harvesting areas which were identified, where field data was collected and tested.

Villages	Type	Area	Size (ha)	No. of research sites
Malo Pereshepyno Prystantsiine Velyke Boloto	Fen, mire (lowland bog)	Velyke Boloto Male Boloto Veselyi Podil	550	9 7
Postav-Myky Lisova Slobidka			680	
Gorodyshche	Fen, mire (lowland bog)	Gorodyshche	720	4
Kurinka Netrativka			460	
Piski-udalski			470	
SUM			2880	

3.4.1 Velyke boloto

Velyke Boloto is also known as ‘Male Pereshchepyno hydro reserve’, and is located near Mankivka, Mala Pereshchepyna and Rudenkivka villages in Novi Sanzhary district, Poltava region. Velyke Boloto is a plot located in the floodplain of the river Vorskla. There is no direct access to the river.

Almost all of the wetland is covered with reed. Some clusters of *Schoenoplectus, Typha* and *Carex* are along its periphery. There are sedges and Typha in a 5-7 m zone along the bank of the bog. Further inward the vegetation consists entirely of reed. The water depth is at least 70 cm. The depth increases into the bog.

The Reed land is located near the road and power line, bordering the fields of Rudenkivska village council (Figure 8). The area of the bog is not protected and is owned by the local community.
In total nine plots were investigated (M1-M9) for its yield, soil and reed sampling, flora and fauna. Additionally twelve plots were monitored (T1-T12). The total wetland area is 620 ha. The soil type is grey forest soil, alkaline and with low content of NPK and humus. The characteristics are given below.

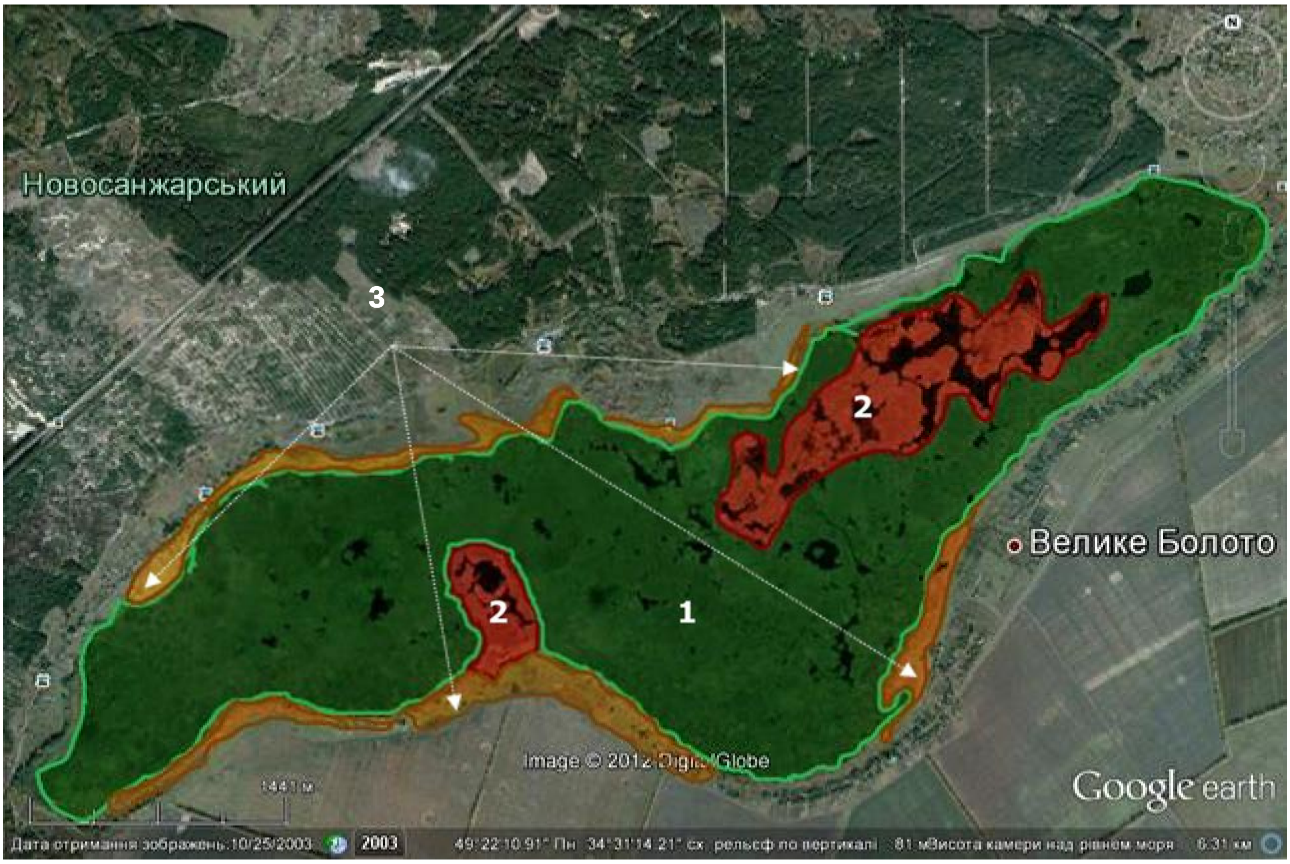


Figure 7 *Land cover map Velyke Boloto. 1 - areas for reed harvesting, 2 - reserve, available open water bodies, left for biodiversity development, 3 - shrubs and sedge /cattail along the perimeter, for development of biodiversity.*

Land use

The reed land is not far from the (former) reed processing plant. Until 1997 the area was used as resource area for reed products. The reeds are small – 1.5 m and stem width is 0.5-0.8 mm, but with a high plant density (287 plants per m2), possibly as a result of intensive harvesting. The territory is used for fishing and hunting Wild boar, Fox, Hare, and waterfowl.

Monitoring

The first time the plot was visited at the end of October-November 2011. Dominant plant species are *Phragmites australis* and *Carex cuspidata. Typha latifolia*, and *Glyceria maxima* are rarely observed. Quite common are groups of willows, including *Salix cinerea, S. Caprea* and *S. aurita*.
During the inventory no animals and birds were observed, but this wetland is habitat for many birds in spring and summer: *Gallinula chloropus, Locustella luscinioides, Acrocephalus schoenobaenus, Circus pygargus, Botaurus stellaris* and others. Two amphibian species were observed: Marsh frog *Pelophylax ridibundus* and Common frog *Rana temporaria*, and from reptiles the Grass snake (*Natrix natrix*).

Recommendations

It is recommended to harvest reed in this area, based on its uniformity, accessibility for harvesting machines (there are dirt roads and asphalt roads for transport and there is also a settlement nearby). Dense reed covers large parts of the bog, thereby out-competing other wetland plants, including those with high environmental value.

Almost all of the plots are covered with reed with high density. The weight of reed is 3,8 kg/m ^{2}. There is a permit for reed harvesting. It is recommended to harvest the proposed areas according to the map (Figure 8 green, marked area).

3.4.2 Male Boloto

Male Boloto is a wetland near Prystantsiine village, Novi Sanzhary district, Poltava region. There is no access to the river, but open water bodies are present (river in the northern-east, three lakes in the west and in the centre of the wetland) (Figure 8). Almost all of the wetland is covered with reed. Open water bodies are not within the wetland, but to the north-east, bordering household plots of villagers. The household plots are separated from the wetland by a dirt road.

The reed is mixed with sedge along the perimeter of the plot. Locally small groups of bushes are present, mainly along the perimeter of the plot. The reed area is uniform. Some clusters of Schoenoplectus, Typha and Carex grow just along its periphery. The wetland area is 560 ha. of which 480 ha. is suitable to be harvested according to previous estimation. It is not a protected area. Male Boloto is owned by the local community.

In total seven plots were investigated in this wetlands. Generally one continuous area was monitored, which was divided into seven sub-plots (Mb1-Mb7). The perimeter is fenced by a narrow line of shrubs, that slightly affect the quality and harvesting of reed, and large areas for grazing and hayfields/meadows. The plot is divided into two equal parts by a road. There is a concrete bridge in the middle of the wetland.

Land use

In the past reed was harvested by people for roofing and bedding, but not intensively or systematically. Burnt areas were not observed. This area is currently used for hunting. Local hunters hunt ducks throughout the year. Sometime wild boar can be seen here. Sometime cattle are grazed and drink here. It is covered by tall standing reed. Reed is uniform by its height and width – 2.10 - 2.80 m, sometime it reaches up to 4.00 m height and almost 2 - 3 cm width. There is a thick and dense layer of litter from 50 till 80 cm. The reed land is quite satisfactory thanks to periodical reed harvesting by local people (for own needs). It has medium hardness.
No household or agricultural wastes were observed.

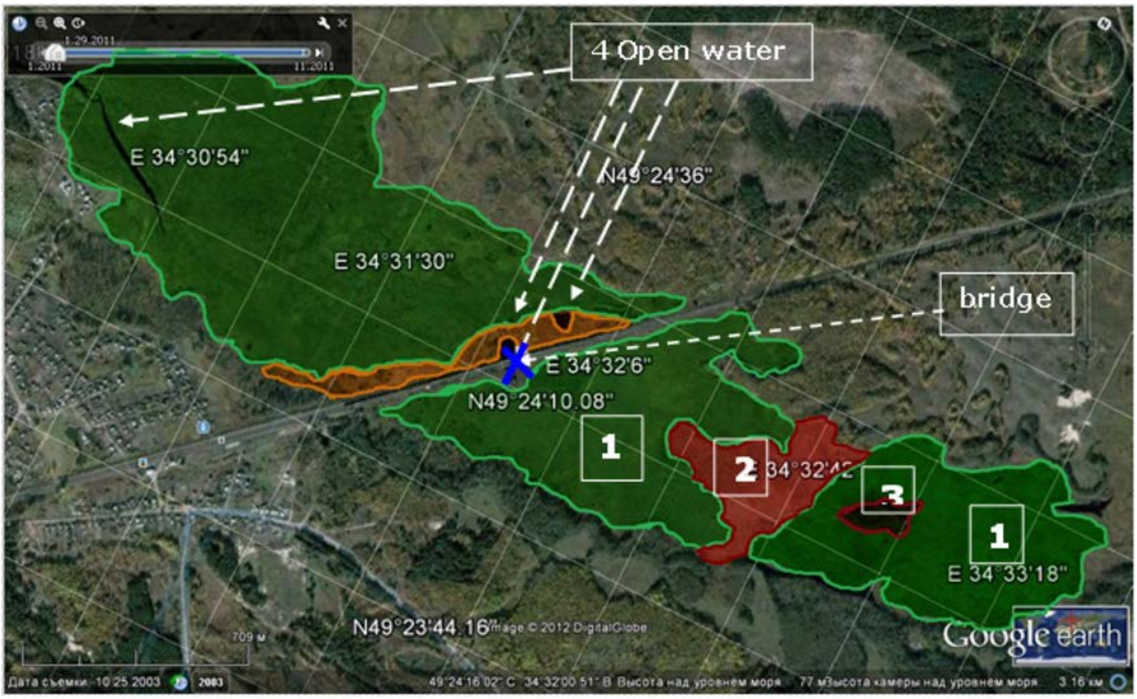


Figure 8 *Land cover map Male boloto. 1 – areas for reed harvesting, 2 - areas for development of biodiversity, 3 - shrubs and sedge/cattail, for development of biodiversity, 4 - marked open water bodies and bridge.*

Monitoring
The plot was visited for the first time at the end of October-November 2011. Dominant plant species are *Phragmites australis* and *Carex cuspidata*. *Typha latifolia* and *Glyceria maxima* are rarely observed. Quite common are groups of willows, including *Salix cinerea, S. Caprea* and *S. aurita*.
No animals and birds were observed during monitoring, but this wetland provides habitat for many birds in spring and summer: *Gallinula chloropus, Locustella luscinioides, Acrocephalus schoenobaenus, Circus pygargus, Botaurus stellaris* and others. Two amphibian species were observed: Marsh frog *Pelophylax ridibundus* and Common frog *Rana temporaria*, and from reptiles the Grass snake *Natrix natrix*.

Recommendations
Based on the extensive uniform reed stands and accessibility for harvesting machines the area of Male Boloto is recommended for harvesting. There is an asphalt road that is good for transport and equipment, allowing for easy transportation of harvested reed.
Indicated plots of shrubs and areas are less suitable for harvesting, and it is recommended to leave them for biodiversity protection.

Figure 9 Reed land at Male Boloto.

3.4.3 Gorodyshche

In total four separate areas were monitored near Gorodyshche; each forms part of the larger wetland area. The monitored area of wetlands is nearly 1200 ha. The areas are located up to 5 km from Gorodyshche village. Access is difficult for some of the areas. Only area 3 and 4 are located near the river Udai. The area is surrounded by grasslands, hay meadows, grazing lands and sparse shrubs. At one kilometre distance there is pine forest.

In general monitored plots are covered with uniform reed, sometimes very high and dense. The territory is covered with perennial reed. The height is nearly 2 - 4 m. There is quite a thick litter layer, up to 50-80 cm, which can form a problem for harvesting machines. The reed is mixed with *Carex* along the perimeter of the bog.

Open water bodies within the reed land are not observed. Above mentioned areas are not protected and belong to the communal territory.

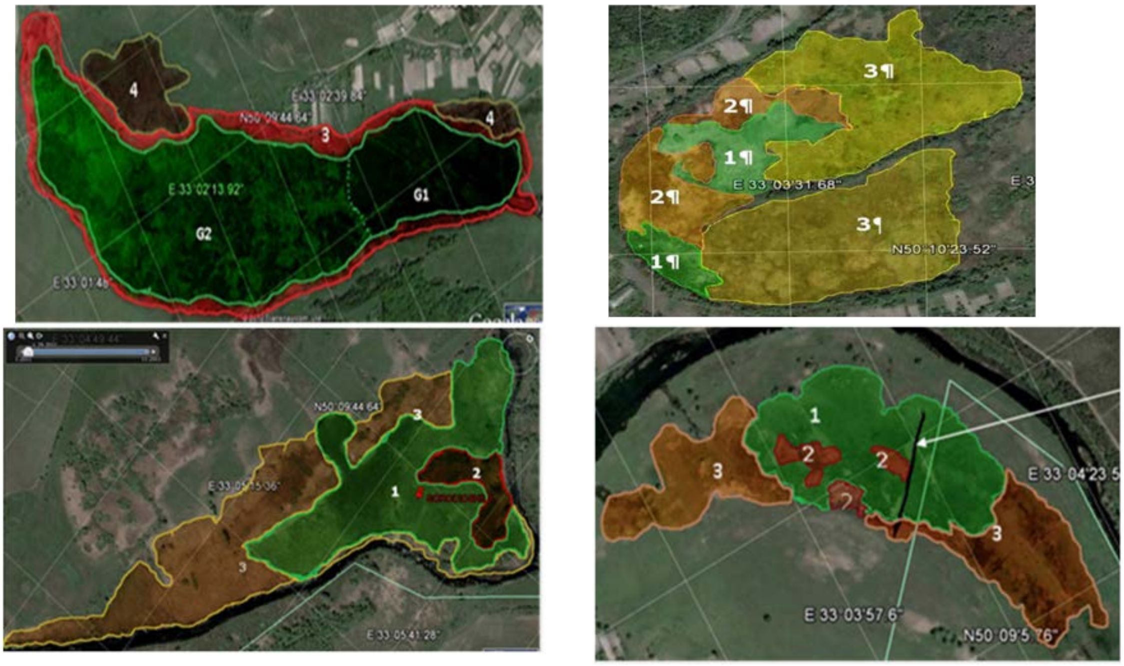


Figure 10 *Land cover map Gorodysche. 1 – areas for reed harvesting, 2 - areas for development of biodiversity, 3 - shrubs and sedge/cattail.*

Land use

The monitored lands are in poor management condition. There is almost no water, most 5-10 cm, and the lowest places are up to 20 cm deep. The height and thickness of the reed is not uniform, the height varies from 2.00-4.00 m and the stems are almost 1.5 - 3 cm thick and of average hardness.

Burnt areas were mostly observed along the perimeter of the bog and at the borders of people's gardens (these places serve as dumps for compost, garden waste). Under favourable conditions the dump is set on fire which often leads to burning of adjoining territories with reed). No evidence of fires was observed Currently the territory is used for hunting. Local hunters hunt ducks all-year round. Sometime wild boar were observed.

In the past reed was harvested by people, but not much and not systematically.
The area is sometimes used for cattle grazing and watering. There are three feeders for livestock near the settlement Gorodyshche.

Monitoring

The plot was visited in December 2011. Dominant are *Phragmites australis* and *Carex cuspidata. Typha latifolia* and *Glyceria maxima* are rarely observed. Quite common are groups of willows, including *Salix cinerea, S. Caprea and S. aurita*.

According to Sliusar (ornithologist Poltava State University) common birds are *Gallinula chloropus, Chlidonias nigra, Acrocephalus schoenobaenush, Padiceps cristatus, Podiceps nigricollis, Botaurus stellaris, Ardea purpurea, Circus aeruginosus, Locustella luscinioides, Acrocephalus arundinaceus* and others.
Mammals such as Beaver *Castor fiber*, Muskrat *Ondatra zibethicus* and European otter *Lutra lutra* are very common here. Common amphibian species are Marsh frog *Pelophylax ridibundus* and Fire-bellied toad *Bombina bombina*, and the Grass snake *Natrix natrix*.

Recommendations

At the plot Gorodyshche 1, zone G1, it is not level, there are tussocks, a thick layer of litter, and dense old reed. The possibility to harvest this zone depends on technical characteristics of the harvesting machines.
Productivity of monitored plots is different: Gorodyshche 1 has a high productivity, Gorodyshche 3 and Gorodyshche 4 have average productivity, Gorodyshche 2 has low productivity.

Since Gorodyshche 2 is very variable and has no uniform reed height and density, because of difficult access and problems related to movement of machines (because of large number of bushes) and the limited available space for harvesting, it is recommended to harvest just the areas indicated on the map.

It is recommended to maintain the areas of bushes mixed with reed for biodiversity conservation. Also the areas with carex and typha along the perimeter of the bog should be left for biodiversity development.

4 Reed chain

4.1 General reed chain description

In this Chapter the reed chain is described, step by step. In Table 5, the separate steps are described for an enterprise located at Velyke Boloto, taking into account local circumstances. This is graphically presented in Figure 11 below, and in Annex III.

Table 5
General information about an enterprise at ***Novi Sanzhary district, Male Pereshepyno, Velyke Boloto.***

Characteristic	Description
Harvested area	1200 Ha
Previous land management	20 years ago there was a reed processing plant here Currently local people use reed systematically for fishing, hunting and in agriculture
Reed use by local people	Sometimes used for fencing, roofing, but limited Local craftsmen don't use it for carpets, hats etcetera
Application of fertilizers and pesticides	Not observed Possible release of wastes from production of plastic windows (information has not been confirmed)
Average yield of wet reed	5.0 MT/Ha - minimal 11.24 MT/Ha - average *(see calculation in Annex II)*
Average yield of dry reed	4.0 MT/Ha - minimum 9.0 MT/Ha - average *(see calculation in Annex II)*
Length of reed stem	1.5-3.1m
Distance from a field to storage and place of use	Not more than 10 km
% flooded/not flooded lands	60/40

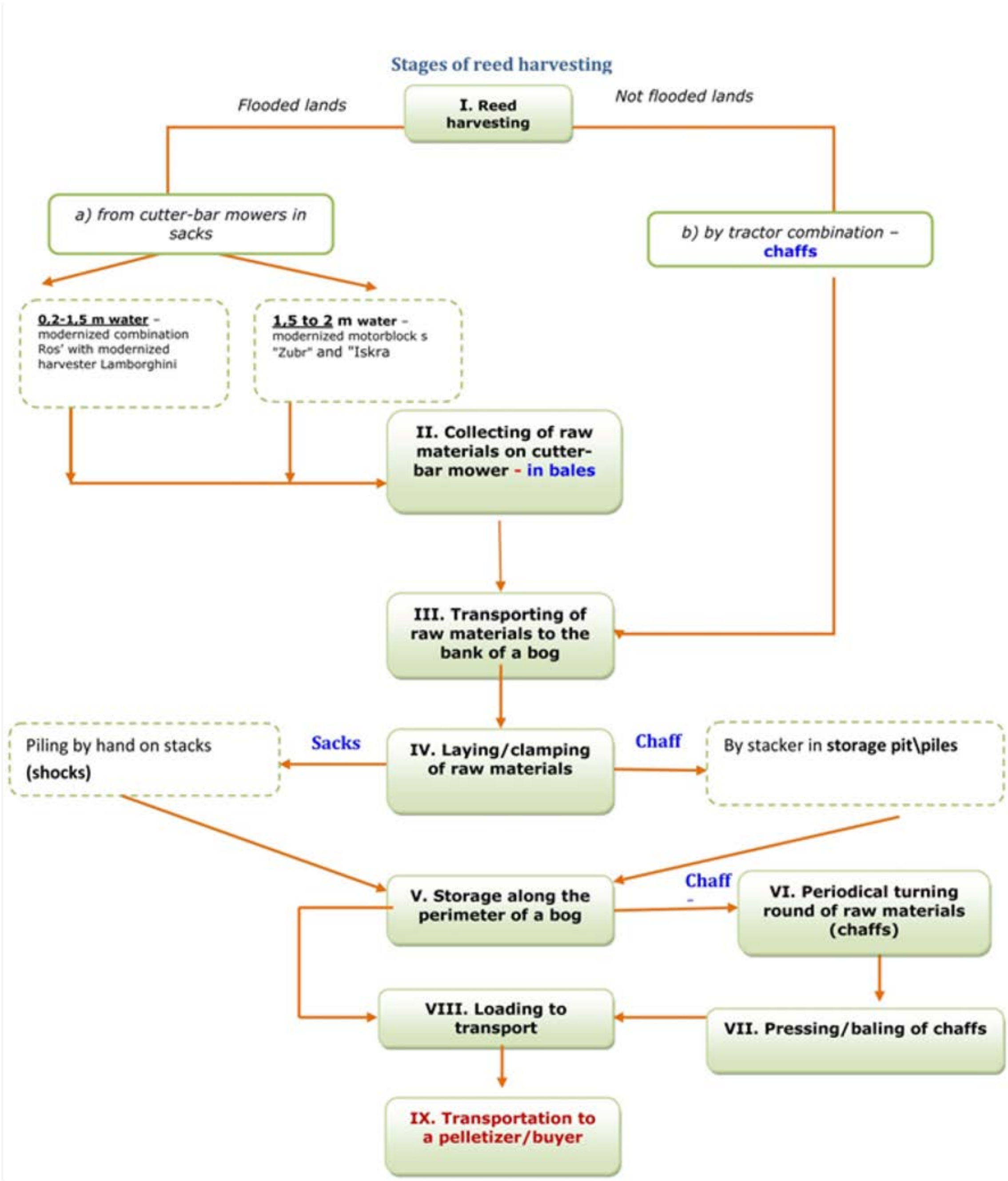


Figure 11 *Graphical representation of the reed chain for Poltava Oblast, based on Velyke Boloto.*

4.2 Reed chain specifications

The reed harvesting process as shown in Figure 11 is described step by step below, with the equipment and technical specifications in the accompanying table below.
A more extensive graphical presentation of the equipment and production figures is provided in Annex III.

I. Reed harvesting
The reed harvesting starts in January when the area should be frozen over. The ice thickness should be at least 10 cm. . Since this is a period of solid ice crust forming and in natural conditions reeds are frozen, this leads to leaching and thus reduction of chemical content (K, Cl, and to some extent S and N).
Depending on the water level of the wetland and the method of reed collection, there are two harvesting processes possible:

A. Not flooded areas:
   Harvesting by aggregate, combined machines: On tussock areas reed is harvested by MT3-80 and connected with it modified harvester Polissya - 1500 and a Tractor tipper trailer for chaffs 2ПТС-4. The trailer capacity is 5.4 m3. The loaded trailer is hauled by another tractor MT3-80 to the bank of a bog (stage III)
   Average productivity of this aggregate is 0.2 ha/hour. Tractor aggregate includes two tractors and two tractor drivers. Reed is harvested, capturing snow and over land surface maximally possibly.
B. Flooded areas (water level exceeds 20 cm) harvesting is done by modified cutter bar mowers. For a water level 1.5-2.0 m – modified cutter bar mowers such as ‘Zubr’ and ‘Iskra’ are used. 3- 4 harvesting cutter bar mowers and 1-2 collecting cutter bar mowers (minimal task), can harvest some 1.0-1.5 ha/hour.
   If the water level is 0.2-1.5 m, reed is harvested by modernized aggregate swamp buggy ‘Rosa’ with modernized ‘Lamborghini’ harvester and trailer. Productivity is 1-1.5 ha.
   Snow depth of harvesting by cutter bar mowers is 15-20 cm, the reed is harvested till the end of March. Above mentioned techniques (aggregates and 10-15 cutter bar mowers with tractors) can harvest 6000-7000 ha in one season.

II. Collecting on cutter bar mowers

A. Reed is harvested by tractor on flooded areas, loaded on a trailer and transported to the bank of the bog.
B. Harvested reeds on flooded areas are collected by hand and piled on stacks, loaded by hands on self-made wooden sledge (as a variant, because of small weight and pressure of loaded sledge on ice, and also costs) or on sledge-trailer, which is attached to collecting cutter bar mowers. Capacity of a sledge is up to 4.5 m3. After loading the sacks are transported to the bank of a bog.

III. Transport of reed to the bank of a bog
First two months to the places of processing

A. Reeds are collected by tractor on not flooded areas (integral dry areas and with relatively much snow, then it is transported to pits/piles by a tractor MT3-80 and tractor tipper trailer for chaffs 2ПТС-4.
B. Reed is collected by cutter bar mowers (from flooded areas). Reed is collected in sacks with 1.0–1.5 m diameter. It is transported by collecting cutter bar mowers and self-made wooden sledge.

IV. Laying/piling of reed material

A. Reeds are collected (not flooded areas), by a tractor with attached loader-stacker СНУ-55. Pits/piles are 5-6 m high and up to 40 m long and 10 m wide. Reed is stored with snow. Plots for piling are selected previously in a range of less than 2 km from harvesting.

B. Reeds, collected by cutter bar mowers, are firstly piled by hand, then by loader-stacker СНУ-550 on stacks from sacks. Plots are selected previously in a radius less than 2 km radius from a place of harvesting.

V-VI. Storage along the edge of the bog, periodical turning of reed

Depending on reed harvesting method (by tractor aggregate or cutter bar mower), reeds are stored:

A. By tractor aggregate on not flooded areas: reeds can be stored till next harvesting season under following conditions

1. Reed should be turned over by a tractor or loader - stacker at least twice a month (March to June).
2. Further turning over - once a month.

These reeds have good properties for pellets production and for export e.g. to the Netherlands, since much of the chemical compounds were removed from the reed by leaching.

B. By cutter bar mowers (bundled in sacks). It has a higher content of chemical elements, compared with reed on piles. Such reed is best used on the domestic market for combustion in bales.

VII-VIII. Pressing/baling of reed stalks. Loading for transport

A. Reed, harvested by tractor aggregate (not flooded areas), goes through modernized bale machine ‘Kyrgyzstan’. The 20 kg bales are loaded on a straw carrier – with trailer-platform PP-12/3b of the brand Kobzarenko, and further transport to the place of processing (biomass-based boilers). Distance to a pelletizer should not be longer than 20 km.

B. Reed, harvested by cutter bar mowers, are loaded by tractor MTZ-80 and modified stacker. The reed is loaded on a trailer ‘Mazhara’. The trailer is transported to the pelletizer by tractor of the type MTZ.

IX. Transport to a pelletizer/buyer

The last stage is transport to the processing place where it is pelletized, or to the buyer.

Figure 12 *Reed harvest with cutter bar mower in Poltava, winter 2011-2012.*

5 Reed production economics

5.1 Introduction

In this section the economic viability of reed harvesting, processing, transport and commercialization is analysed for different logistic scenario's. These scenarios relate to domestic (Ukrainian) markets (scenario 1) and three logistical variants of Dutch biomass markets (scenarios 2 to 4).

Each step in the supply chain is quantified for the delivery costs in Euros per ton biomass pellets and per GJ of pellet calorific value. This is done for all four supply chain configurations. The figures are based on a business case developed by project partner Tuzetka, with an assumed Lower Heating Value of 16 Giga Joule per metric ton of pellets produced and an annual production of 20.000 metric tons of pellets. The scenario's consist of:

- Pellets produced for the domestic heating market (scenario 1)
- Sea transport to Dutch electricity market (scenario 2)
- Pellets transported by train and river barge to Rotterdam (scenario 3)
- Pellets transported by truck to Rotterdam (scenario 4)

5.2 Pellets for the domestic heating market

At this moment the domestic heating market for biomass pellets is highly attractive, given the high domestic price of natural gas, the most common energy source for heating installations in Ukraine. Table 10 provides a cost breakdown of all steps in the supply chain and an overview of prices of alternative fuels. It is clear that reed pellets can easily compete with natural gas over price per GJ of energy. The development of shale gas production could disturb the future of biomass in Ukraine if this brings down the price of natural gas. The main driver for using biomass to replace natural gas is currently its lower price. Ukraine has vast reserves of shale gas.

Table 6
Supply chain costs for scenario 1 and fuel prices.

Scenario 1 Domestic heating market		
Operation	**€ / MT**	**€ / GJ**
Reed harvesting	12	0.75
Reed transport to pelletizer	7	0.44
Pelletizing	57	3.50
Pellet transport to Lubny	4.5	0.28
Total costs	80.5	4.97
Reference prices		
Natural gas		13*
Industrial wood pellets	130	7.8
Coal		2.5
Shale gas		1
Average price domestic market	100	

*Source: NKRE (National Electro-energy agency in Ukraine). http://www2.nerc.gov.ua/

5.3 Sea transport to Dutch electricity market

Scenario 2 involves transporting of biomass pellets from the production site by train to the city of Kherson near the Black Sea and subsequent transport by sea vessel to Rotterdam. As Table 11 shows, this is hardly a viable business case. The supply chain costs are not compensated for by the selling price of industrial wood pellets, that are used for co-firing electricity plants in the Netherlands benefitting from subsidy schemes. Moreover, Ukrainian herbaceous biomass pellets may not possess the same quality (= energy density) as wood pellets, given higher amounts of ash. This should be reflected in an even lower price for non-wood biomass pellets per GJ of energy generated. Unfortunately, reed pellets are not acknowledged today as a commodity (unlike wood pellets) and therefore have no standardized trading price. Based on a Lower Heating Value (LHV) of 16 GJ per ton reed pellets and 19 GJ per ton wood pellets, for comparison sake, the price of reed pellets is assumed to be 16/19 x 130 Euro = 109 Euros per metric ton.

It is hoped that in the longer run much larger volumes of non-wood biomass are produced and supplied to overseas markets. This should reduce the shipment costs significantly, given the large sized ships in use today. For now, however, non-wood biomass is still to conquer a sizeable market and thus relatively small volumes are offered to shipping companies.

This advantage of scale for large volumes will also apply for the other costs, particularly pelletizing, presenting the largest impact on total costs. Current pelletizing costs are based on use of minimills (1.3), processing only small volumes of biomass. There is however large-scaled pelletizing equipment on the market that should significantly reduce pelletizing costs per ton of processed biomass.

Table 7
Supply chain costs for scenario 2 and fuel prices.

Scenario 2 Transport by train + sea vessel to Rotterdam		
Operation	€/MT	€/GJ
Reed harvesting	12	0.75
Reed transport to pelletizer	7	0.44
Pelletizing	56	3.50
Transport pellets to railway 20km	3	0.19
Loading and transport to Kerch	28.6	1.79
Unloading, sent to port, loading	12	0.75
Storage at port	0.7	0.04
Custom clearance	4.5	0.28
Transport to Rotterdam	46.2	2.89
Total costs	170	10.63
Reference prices		
Natural gas		10
Industrial wood pellets	130	7.8
Coal		2.5
Shale gas		1
Average price domestic market	100	

5.4 River barge transport to Dutch electricity market

In market scenario 3 the pellets are transported by train to Izmail and then loaded onto river barges for transport to Rotterdam. This is the most economical of international supply chains, not taking into account any margins of error in the estimations. However, as explained for scenario 1, the current figures are based on delivery of only small volumes. In case more sizeable markets can be secured (several hundreds of thousands of metric tons), it seems probable that scenario 2 is the most economical of international supply chains, given the large sea vessels in use today. For now, like scenario 1, scenario 2 hardly presents a viable business case given that the total supply chain costs are not compensated for by the selling price of pellets. SeeTable 8. For comments on the potential reductions in shipment and pelletizing costs, we refer to scenario 1.

Table 8

Supply chain costs for scenario 3 and fuel prices.

Scenario 3 Train + River barge to Rotterdam		
Operation	**€ / MT**	**€ / GJ**
Reed harvesting	12	0.75
Reed transport to pelletizer	7	0.44
Pelletizing	56	3.50
Transport pellets to railway 20km	3	0.19
Loading and transport to Izmail	28.6	1.79
Unloading, sent to port, loading	12	0.75
Storage at Izmail	0.7	0.04
Loading and river transport to Rotterdam	28	1.75
Custom clearance	4.5	0.28
Canal cost	0.99	0.06
Total costs	165	10.31
Reference prices		
Natural gas		10
Industrial wood pellets	130	7.8
Coal		2.5
Shale gas		1
Average price domestic market	100	

5.5 Truck transport to Dutch electricity market

Apparently, due to the economic crisis, freight companies offer their transport services at minimum prices. See Table 13. This makes pellet transport by truck from Ukraine to the Netherlands relatively economic, with total costs comparable with transport by sea and river. But, it seems unlikely that this method of transport can compete with river and sea transport once the economic crisis has passed. Moreover, as discussed in the previous sections, larger biomass volumes expected will favour large-scaled shipment options and that is going to be offered by sea vessels. For comments and conclusions about current economic feasibility of this transport configuration, we refer to both previous scenarios.

Table 9

Supply chain costs for scenario 4 and fuel prices (fossil reference: natural gas, 9.92 €/GJ).

Scenario 4 Truck to Rotterdam		
Operation	**€ / MT**	**€ / GJ**
Reed harvesting	12	0.75
Reed transport to pelletizer	7	0.44
Pelletizing	56	3.50
Customs clearing	6	0.38
Truck transport	91	5.69
Total costs	172	10.75
Reference prices		
Natural gas		10
Industrial wood pellets	130	7.8
Coal		2.5
Shale gas		1
Average price domestic market	100	

5.6 Conclusions

For now it is wise to focus on the domestic heating market with regards to the herbaceous biomass pellets produced in Ukraine. The current high gas price (13 €/GJ) easily justifies the harvesting, transport and processing operations. See Table 6 for a breakdown of the supply chain costs and a list of alternative fuel prices. Viability of international supply chains for non-wood biomass will depend on further price increase of fossil fuels. We refer to the Pellet Market report for more detailed information regarding the obstacles and opportunities for herbaceous biomass on domestic, Dutch and EU markets.

Figure 13 *Processed reed pellets (left) and big bags with reed pellets (right).*

6 Legality of reed production

6.1 Introduction

For different NTA 8080 sustainability components - e.g. biodiversity and environmental impact - the biomass producer is required to know relevant laws and regulations that regulate the production, processing, commercialization and use of that particular biomass. Compliance with national laws and regulations (and EU legislation) is the basis for NTA 8080 compliance. National legislation is also considered leading in case it conflicts with NTA 8080 requirements. Legislation is by definition an important aspect of reed based development, because reed is associated with wetlands and other high-value conservation areas that require special protection. More information on the relation between Ukrainian national legislation and NTA 8080 is provided in a separate report (NTA 8080) (Poppens and Hoekstra, 2013).

In this Chapter, the most important national laws of Ukraine are described, which was the fruit of a thorough study by Phytofuels Investments. Phytofuels' role in the project includes the development of sustainable reed production and an important part of that is to acquire reed lands and permits for its sustainable exploitation. However, as it turned out, studying and interpretation of the laws governing reed in Ukraine is not a straightforward exercise. In current legislation there is no clear reference to reed as a particular category of plant, resource or ecosystem. This means that it is not clear even for the authorities on what grounds and by which procedures biomass producers should be granted a permit for reed harvesting. Instead, Phytofuels had to invent these procedures in close interaction with the authorities and with local villages designated by law as rightful owners of reed resources. This process of interacting with authorities and villages - leading up to signing harvesting agreements with villages and issuance of permits by authorities - is described in a separate report: Taking the Law to the People (Poppens et al., 2013a). A summary of that process and its results are written in Chapter 7. In the following section, the laws and regulations are described that emerged in this process as essential for reed production in Ukraine.

6.2 Identifying relevant legislation

According to Ukrainian legislation, the rightful ownership regarding natural resources lies with 'Territorial Communities', i.e. citizens of villages in rural areas of Ukraine. That is why Phytofuels started with identifying villages suitably located and open to signing agreements for joint reed harvesting programs. At the same time authorities were engaged, to find out about any other relevant legislation and permits, e.g. regarding the environment or land use. Eventually, after a long process of trial and error, the regional department of Ecology (Ministry of Ecology) was identified as the authority to issue permits. The role of this authority is based on three laws, described hereafter in separate sub-sections.

6.2.1 Law on Environmental Protection

This law is the most important for obtaining reed harvesting permits and has the following objective: 'To regulate relations in the sphere of protecting nature, utilization and regeneration of natural resources, maintenance of ecological safety, prevention and mitigation of the negative effects of economic and other activity on the environment, conservation of natural resources, the genetic pool of animate nature, landscapes and other natural complexes, unique territories and natural objects related to the historical and cultural heritage'. http://www.elaw.org/node/2659

Article 15 is of particular importance, stating that deputies of local councils bear the responsibility for the condition of the local environment. This article proved pivotal in reaching agreements for 15-year

reed harvesting programs with nine village councils by September 2012. These are three-party agreements, signed between the village council, Phytofuels and the Biomass Institute.
Importantly, Article 15's sub-articles confirm legal compliance of pretty much every single aspect of these agreements, indicating the following duties and rights of village council deputies:

- Ensure the implementation of ecological policy,
- Give consent to the siting of enterprises on their territory,
- Issue and revoke permits for individual utilization of natural resources of local importance,
- Approve local ecological programs,
- Organize the study of the environment,
- When needed, organize necessary ecological examinations by experts,
- Inform the population about the condition of the environment,
- Adopt decisions on organizing territories and objects of nature conservation of local importance and other territories that are subject to special protection,
- Exercise control over compliance with legislation on environmental protection,
- Coordinate the activity of respective authorized state bodies of administration in the field of environmental protection and utilization of natural resources on the territory of the local Council of People's Deputies.

Legislative justification of the Biomass Institute
Article 30 of this law states that ecological examinations referred to above (sixth bullet point from above), shall be carried out by 'independent groups of specialists on the initiative of non-governmental associations as well as local bodies of power at the expense of their own resources or on a voluntary basis. Public ecological examination shall be conducted independently from state ecological examination'.

This article is the justification of the Biomass Institute, as independent research organization, that was established by Phytofuels in cooperation with and based at project partner Poltava State Agrarian Academy. In the frame of this project, the Biomass Institute has operated mainly alongside Phytofuels. But its ambitions are to develop into a true independent research organization, dedicated to developing sustainable biobased development in Ukraine based on NTA 8080.

6.2.2 Law on Flora

This law 'regulates social relations in the sphere of protection, use and restoration of wild and other non-agricultural vascular plants, mosses, algae, lichens, fungi, their communities and habitats'. Two related laws, the Law on Fauna and the Law on Red Book, are also briefly described in this Section.

Article 11 defines the limits of harvesting volumes for above ground and below ground biomass (Table 10). This law allows harvesting of up to 25% of above ground perennial biomass. This includes reed dealt with in the reed harvesting programs.

Article 12 regulates the height of land fees, to be paid to the local communities per ton of biomass. In 2006, this was 5 grivnas (about 0,50 euro) per ton of reed. This money is not directly paid to the community but to the Tax Administration.

Article 40 deals with law enforcement and refers to a separate Codex. District inspectors come to check local producers and make report on any irregularities. Depending on the scale, the producer gets fined or is passed on to the environmental prosecutor. Also the range of fines is defined in the law.

Table 10

Allowed harvesting percentages (Art. 11, Law on Flora 1999).

Allowed harvesting percentages	
Above ground biomass	
Annual crops	50% of biological volume
Perennial crops	25-30 % of biological volume
Below ground biomass	
Grasses	25% of biological volume
Trees, shrubs	10% of biological volume

Law on Fauna

The Ukrainian Law on Fauna is very similar to the Law on Flora, except for its focus on animal life. It also states that biodiversity should be protected and there should be special maps indicating migratory routes of certain animals.

Law on Red Book

This Law deals with the preservation and protection of rare, threatened and endangered species of plants and animals. Ukraine's protected areas such as on state level (zapovednik), for example the ecological reserve in Male Pereshepyno 0) serves to protect Red Book species. The species inventory study described in section 3.4, among other served to identify any Red Book species. However, the law does not forbid harvesting in reed areas with presence of Red Book species. Instead, harvesting volume limitations are defined in the Law on Flora as described above.

6.2.3 Law on Self-governance

This law, in accordance with the Constitution of Ukraine, 'determines the system and guarantees of local self-government of Ukraine, provisions of organization and activity, the legal status and responsibilities of bodies and officials of local self-government'.
Whereas local self-government body is defined as: 'an elected body (council) consisting of deputies and which is granted, in accordance with the law, the right to represent the interests of the territorial community and to adopt decisions on its behalf'.

The law illustrates that local development should really start at the village level. Other articles go deeper into the responsibilities of the village council. For example, ***Article 26*** covers competence of the village council, including approval programs of socio-economic and cultural development.

Article 27 would become the entry point for Phytofuels and the Biomass Institute to develop reed harvesting programs with the villages. This article guarantees the right of village councils to 'prepare socio-economic and cultural development programs of villages, settlements, and cities, and also target programs on other issues of self-government, to submit these programs for the council's approval, and to organize their implementation; to submit to the council reports on the course and results of implementing these programs'.

6.3 Conclusion: can legal reed harvesting become reality in Ukraine?

Phytofuels has shown that in Ukraine a company can make a difference by studying and implementing the law, even with an unclear legal status of reed and facing government officials that are often uninformed or corrupt. With the law on its side, identifying the villages as rightful owners of reed resources, Phytofuels was able to acquire harvesting permits on the basis of 15-year harvesting programs signed with village councils. See the report 'Taking the Law to the People' (Poppens et al., 2013a) for a detailed description of this process, encountered obstacles and its results.

Nevertheless, legal compliance is no guarantee for also complying with NTA 8080. For the NTA 8080 includes requirements that are not covered by the law, so it seems. An example is the mandatory inclusion of a buffer zone covering at least 10% of the surface area of the harvested land. It is likely that Phytofuels needs to make plenty adjustments to its operations first, before aiming at certification in accordance with NTA 8080. This discussion is laid down in another report: Ukrainian biomass sustainability by Poppens and Hoekstra (2013).

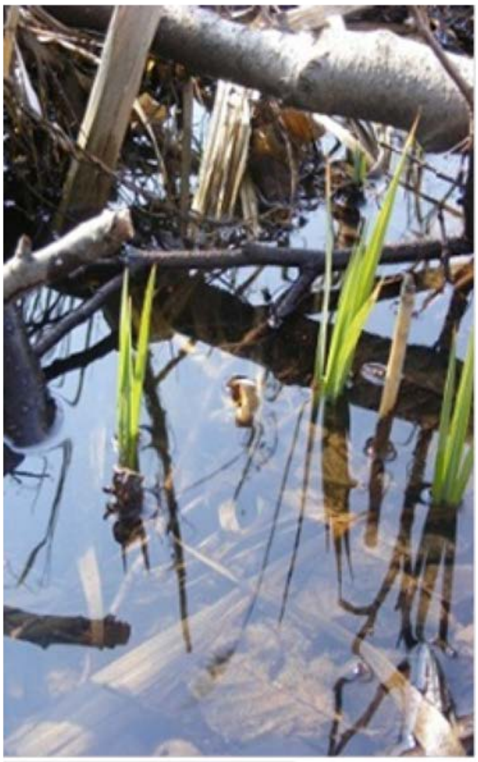


Figure 14 *Emerging reed shoots in spring.*

7 Consultation of stakeholders

7.1 Definition and importance of stakeholder consultations

In accordance with NTA 8080, biomass producers should engage in consultation processes with relevant stakeholders. The following definition of stakeholders is provided in the NTA 8080 standard:

> Definition of stakeholders:
>
> organization and persons, not being the manager and/or owner of the production unit, who have interest in the management of an area, like the local population, indigenous people or organizations representing their interest as well as local or national environmental organizations and labour unions.

Stakeholder consultation is an essential element in developing, implementing and operating a biomass project. It plays a critical role in raising awareness of the project's impacts and helps to achieve agreements on approach, management and operation of the project, whilst maximizing benefits and minimizing negative impacts (www.agentschapnl.nl/node/178155).

Stakeholder consultations are a way of avoiding potential conflicts, arising for example from competing claims over land use. In addition, stakeholders should be consulted for their relevant local and practical knowledge, often filling gaps in scientific knowledge. And given the scarcity of scientific knowledge regarding reed lands in Ukraine, local knowledge was often the only resource available.

Stakeholder consultations proved equally important for Phytofuels and the Biomass Institute in this project and in part were linked with the legislative procedures required for obtaining harvesting permits (Chapter 6). It was through well-planned engagements with communities and authorities that community-based harvesting programs were developed and approved by village councils. And in turn, this process of forging long-term commitments between producer, NGO (Biomass Institute) and village council, provided credibility to the project's sustainability, leading the environmental authorities to issue the required permits. Detailed information on this process is provided in report Taking the Law to the People (Poppens et al., 2013a).

7.2 Stakeholder analysis

According to NTA 8080, direct stakeholders of the primary biomass producer include at least:
a) land owner(s) and land user(s);
b) local residents.

For NTA 8080 compliance it is important that 'producers of primary biomass and the certifying body shall consult the above mentioned stakeholders'. Hereafter, an analysis of direct stakeholders and other stakeholder groups is provided, including a description of their importance and role for biomass projects. It is based on the experiences of Phytofuels and the Biomass Institute with villages and government officials.

7.2.1 Direct stakeholders

Several sub-groups of direct stakeholders were identified, each requiring a different approach discussed hereafter.

Village head and deputies of the village council
This group of stakeholders is important for their decision power. Their backing is necessary for biomass projects to start and run, albeit that deputies can be bypassed sometimes through going directly to the district council ((Poppens et al., 2013a)). Deputies are often leaders in the community and have much influence on public opinion and should therefore be closely involved in biomass programs. It is important to take into account potential conflicts and cross-interests of deputies and administration of the village council. Through continued and well-planned contacts with both village leaders and the general public, Phytofuels and the Biomass Institute have succeeded in building trust among the general population and at the same time reduced the risks of obstruction from individual leaders and corruption of regional and national officials. And with that broad local support, it became possible to promote the program and influence decisions on regional and national levels.

Hunters and fishermen
Several meetings were held with heads of hunting and fishing organizations. Most of them are deputies of village councils and usually they are active people within the community. Hunters are interested in the reed harvesting program because the harvesting sites are attractive for nesting of birds. Previously hunters had to open up reed areas to attract birds, but now the harvesting program would do this for them. Also, patches will prevent too much spreading of reed fires and thus prevent mass killing of wildlife in it. For fishermen, reed harvesting will provide improved access to water. Besides, harvesting in winter will not affect wetlands nor water quality.

Children, schools, orphanages
This group has received special focus by Phytofuels in its contributions to the community. Helping children, schools and orphanages is good for social development at relatively low expenses and it generates a positive image for the project. It gives the possibility to educate children, with potentially positive effects on society in the future and also enables spreading of information about the program. Multiple events were organized in various communities, including lectures about biodiversity and a contest among children making paintings or pictures of local wildlife found in reed lands.

Local families producing hand-made reed objects
In some of the villages there is an old tradition of families producing hand-made reed products, such as sunhats, shoes and bags, mostly for local use. For example, in Gorodyshche village (Chornykhy district), there are fifteen to twenty families using their own patches for that purpose. There is, however, no risk that the program will affect these families in any way, as their patches are in deep water by the river, which are not interesting for the reed harvesting program. These families harvest their reed in December, with the ice just thick enough to support the weight of a person with a hooked knife (tarpan). Phytofuels will harvest later on, on thick ice with machinery, but on land which is dry in summer, thus further away from the river.

Women
In the villages women run the household and take care of livestock, with many also fulfilling additional part time jobs. Women usually play an active role in the community, having positions such as teachers, post deliverers and shop keepers. For Phytofuels women in these roles have been important for passing on information about the program. They may also be involved later in bundling of reed, which was suggested by old ladies in the village, who were themselves once engaged in these activities in Soviet times. Women could also be mobilized as operators of the pelletizer and in management.

7.2.2 Government officials

Local and district officials
State officials dealt with in the project include members of village councils and district councils and administrations on local and district level. For smooth operations and practical results, it is important to have these officials involved in some way. Phytofuels and the Biomass Institutions have aimed at signing memoranda and agreements for long-term cooperation with these officials.
Local officials can sometimes be bypassed by dealing directly with the head of district council.
Regional officials

Regional officials are important as communicators with national officials and for spreading a positive image of the project. Sometimes they are used to inform local officials, and together with public organizations they are controllers of local officials. They also distribute state budget to village level and through them it is possible to regulate the costs for social and ecological programs in territorial communities (i.e. citizens of villages). Regional officials directly dealt with in the project include those working with the Department of Environmental Protection who issue reed harvesting permits.

National officials
According to Phytofuels, contact with national officials should be avoided whenever possible, allegedly for being the most corrupted among all officials. In order to neutralize their potential negative influence on the programs, they are dealt with exclusively through the independent Biomass Institute and with activities focusing on improved legislation.

7.2.3 Non-governmental organizations

For broad public support and credibility toward officials on local, district, regional and national level, it is important for any project to work with civil, independent organizations. This is the reason why the Biomass Institute was established to operate alongside Phytofuels. Such organizations are instrumental in controlling corruption by officials and for generating broad public acceptance of programs. However, there are only few public organizations in Ukraine that are more or less independent and they are working for European projects. One of them is the Ukrainian Association of Ornithologists. Some international NGO's also have an office in Ukraine, for example Birdlife International, with which the Pellets for Power project has had good contacts regarding reed research. However, some national ecological organizations turned out to exist on paper only. Some experts have limited knowledge and resources and 'are willing to write down anything you tell them to write down'. Fact is that the development of non-governmental organizations is still in its infancy in Ukraine. This is another reason why the Biomass Institute was established, to develop its own expertise on reed research with support from the Pellets for Power project.

7.2.4 Biomass producers

Currently there is only a small domestic market for reed biomass, which explains why by May 2012 there were only two or three reed biomass producers known to Phytofuels, producing reed pellets and briquettes for the domestic market. However, this number has been increasing and this is foreseen in the 15-year reed harvesting programs signed with village councils, specifically stating the involvement of (other) local companies. In May 2012, the Biomass Institute prepared guidelines for sustainable reed harvesting for a company called *Nova Energia* which intends to produce on 2500 hectares of reed in Semenivka district. A similar job they did for a private company in the Zaporizhya region. They also help both companies with acquiring permits. Phytofuels is offering these services with a strategic purpose, being well aware that by itself it does not have the leverage to transform the biomass market for compliance with NTA 8080. And with the advantage of scale achieved by pooling small producers, one day also export to the Netherlands and EU may become feasible.

7.2.5 Minorities

There are sometimes groups of wandering gypsy communities in the Poltava region, but by May 2012 none of these groups were present in the villages covered by Phytofuels. Usually these groups enter a village and stay for some time and then move on. It seems unlikely that the reed harvesting programs in any way will interfere in the life of these people and vice versa.

7.2.6 (Future) company employees

A major concern for Phytofuels and any biomass producer is to find qualified and motivated employees in the villages. Both Phytofuels and Tuzetka have experienced cases of theft that is associated with this. Phytofuels had recently experienced how a special connector from the tractor to the reed mower got stolen in a village. They had it investigated by the police and it turned out to be stolen by two tractor drivers in the village. When they were asked why they did it, they simply said they wanted a job as tractor driver, and, '...there are only three tractor drivers in the village, so you have no choice'. Phytofuels did not press charges…

7.3 Stakeholder consultation strategy and methodology

As described before (Poppens et al., 2013a), Phytofuels and the Biomass Institute had to develop their own methodology for acquiring reed lands and permits through engagements with authorities and village people. Three aspects can be distinguished, described hereafter.

7.3.1 Contacting village leaders

They started with identifying village leaders, who were able to influence others and inform the public about the program. This was meant to check the power of individual deputies, who may have personal reasons for backing up the program or not and who may change their minds jeopardizing program continuity. These village leaders could be heads of hunting organizations, heads of agro holdings, teachers, shop owners or anyone else. Information about these people was obtained e.g. by talking to shop owners, visiting fairs and markets, etcetera. At all times it is necessary to maintain good contacts with the village head and the deputies. And it is important to understand the local power balance in villages. For example, in Male Pereshepyno, six deputies were opposing the village leader, the latter who had already agreed with the program. Phytofuels found themselves hostage of the situation, with the six deputies opposing the program just for rivalry reasons. Here, the solution was to bypass the village council, by getting agreements from other important local villagers and with that going to the head of district council who would eventually agree.

7.3.2 Organizing public meetings and educational events

The next step was to organize public village meetings, usually nearby the local shop for easy access by people. These helped to learn about the public opinion regarding the program, to discuss potential concerns and questions and to identify potential leaders and individuals capable of informing and educating others. Just prior to these meetings, deputies were phoned and asked to come and bring people from their street. Questionnaires were handed out, addressing important issues in the community, serving as starting point for discussions. Political questions were avoided as much as possible and people were not asked to fill in their surnames (confidentiality was guaranteed). In addition to the public meetings, other social and educational events were organized (Section 7.2.1) and articles were written in local newspapers in five villages, informing the public about the program activities.

7.3.3 Bypassing village deputies

In the villages the project partners had to deal with unwilling council deputies on a regular basis. These deputies would try to use the program initiative for their own personal benefits, or perhaps would only support it in return for a bribe. The public meetings, newspaper articles and other interactions with common people helped to neutralize this factor. People were allowed to express their concerns and their wishes should the program become reality. In one village, a deputy asked money from the project to help build a church. But in public meetings it turned out the villagers were more interested in street lighting. This was also the wish of people in three other villages of the Chornukhy district. Subsequently, Phytofuels promised to finance street lighting in these villages, by signing a memorandum with the district council, effectively blocking power of the obstructive village deputies.

7.4 Evaluation of the stakeholder process

So, has the stakeholder approach by Phytofuels and the Biomass Institute been effective and sustainable?

The current financial situation is appalling in most villages, including with underpaid village deputies, making corruption difficult to erase. This also affects the potential for positive change, because cooperation is often dependent on bribes and personal favours and their continuity can thus not be guaranteed. Phytofuels is convinced that there may only be one way of achieving positive changes in the long run: through slow building of trust and cooperation through active and frequent engagements with local communities. These efforts should be translated into socioeconomic programs that work directly with the community, designated by law as the rightful owners of the land and address real concerns, that often go beyond the core business of the company. This is exactly what Phytofuels and the Biomass Institute have been doing, engaging with village people, on the street, in public meetings, by visiting local leaders, through local newspaper articles and educational programs held at schools and other social events. This has resulted in broad support within the community, making the project at the same time less vulnerable to corruption and abuse by individual village council members and officials. By September 2012, long-term reed harvesting programs were signed with thirteen villages. And with each program laying out clear responsibilities for the partners, based on legislation and research conducted in the project, the environmental authorities have issued the required permits.

Whether or not the procedures followed were done in full compliance with NTA 8080, or what adjustments in biomass operations would be required first, is discussed in Poppens and Hoekstra (2013). Yet, some changes in the approach are already proposed by Phytofuels itself. Even more attention should go out to the daily concerns of people in the villages. Instead of starting with activities that are directly linked to the proposed business, such as electrification, it would be much more effective to start with activities focusing on revival of the community as a whole. An example may be preparing flower beds or programs with elderly people to play the harmonica. Such type of activities have great impact on the general well-being of the community, making people 'feel' change instantly. Also the issue of garbage disposal is important in villages and should therefore be addressed by the biomass program. This would trigger people to actively participate, through e.g. placing of garbage bins

Figure 15 *Stakeholder consultation process.*

8 Greenhouse gas emissions and savings

8.1 Assessment rationale

8.1.1 Introduction

One of the main foundations of the European Union (EU) energy policy is the need to reduce greenhouse gas (GHG) emissions in a relatively short period of time to avoid the more extreme consequences of global climate change. The policy has emphasised the important role of renewable energy. Within this context, the extensive use of solid and gaseous biomass, particular for heating, cooling and electricity generation, is regarded as an essential component of the Renewable Energy Directive (2009/28/EC). This has been translated into EU Member State Action Plans as part of the implementation, which requires increasing the share of renewable energy to 20% of EU final energy consumption by 2020.

Greenhouse gas savings are one of the main sustainability criteria of the Renewable Energy Directive and the NTA 8080. In principal the burning of biomass as fuel is carbon neutral as long as the same amount of CO_2 is taken up again by the plants. However, the production, processing and transport of the biomass involves many steps with inputs of energy with subsequent GHG emissions. Therefore the emissions of the entire biomass chain have to be calculated and compared with the fossil fuel reference. According to NTA 8080 biomass operations should lead to maximum reductions of GHG emissions as compared to situation with fossil fuel use, with at least 70% reduction compared to electricity from coal fired power plants.

In this Chapter we first discuss GHG emissions from reed land based on existing literature. Next the used GHG calculation methodology is explained and the assessed reed chains are described. Finally in Chapter 8.4 we discuss the assessment outcomes and recommendations for reduced GHG emissions.

8.1.2 Review GHG emissions from reed land

Many of the reed land in Ukraine are found in wetlands (see Chapter 3). Most of these wetlands are also peatlands with Histosols (organic soils). *Phragmites australis* wetlands act as a sink for greenhouse gases by photosynthetic assimilation of carbon dioxide (CO_2) from the atmosphere and sequestration of the organic matter produced in the wetland soil. However, wetlands also act as a source for greenhouse gases by emission of sediment-produced methane (CH_4) to the atmosphere (Brix et al., 2001). Wetlands can also emit nitrous oxide (N_2O), but this is smaller source, and mostly related to drainage and grazing.

In peatlands decomposition of organic matter is incomplete and peat accumulates. The conservation of peat is caused by waterlogging with its associated low temperatures, anaerobic conditions and small microbial populations. Under anaerobic conditions microbial decomposition does continue, but is slow and done by methane (CH_4) producing microorganisms. Most of the methane in peat columns is derived from recently fixed (young) carbon. The actual amount of methane emitted to the atmosphere depends on the balance between methane production and consumption and the mode of methane transport. The quality and supply of the substrate is the major factor in methane production in peat soils. Only part of the methane produced is emitted to the atmosphere, as considerable amounts are consumed by methanotrophic bacteria. Methane is only emitted at high water levels, at water levels below 20 cm from the surface, hardly any methane is emitted, as it is consumed by the methanotrophic bacteria and oxidised to CO_2 (Couwenberg, 2009). According to Brix et al. (Brix et al., 2001) on an annual basis up to 15% of the net carbon fixed by the wetlands may be released to the atmosphere as CH_4. In that case the wetland becomes a net source of GHG, as the global warming potential of CH_4 is 25 times higher compared to CO_2.

Methane gas can be emitted from the peat to the atmosphere via three main pathways: diffusion, ebullition and plant mediated transport. Many wetland plants possess aerenchymous tissues that allows for transport of oxygen into the root zone as an adaptation to rooting in waterlogged soils. These tissues, however, also allow the transport of methane to the atmosphere, bypassing the aerobic zone. Plant species with this alternative methane emission pathway are referred to as 'shunt species'. Reed *(Phragmites)* is one of these species and this methane pathway can be important. Wahlen (2005) found that the contribution of shunt species to overall methane emissions varies from 25% to as much as 97%. Methane emission is highest during spring and early summer because of high water tables and high availability of labile organic compounds (Brix et al., 2001), see Figure 16. An average methane emission factor for peatlands in temperate zones with water levels higher than -20 cm and with shunt species is 170 kg CH_4/ha/year, which is about 4 ton CO_2-eq/ha/year (Couwenberg, 2009).

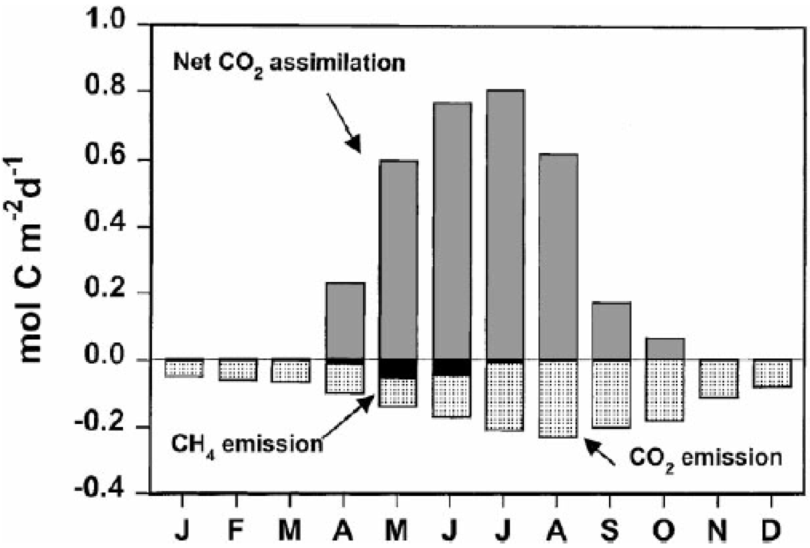


Figure 16 *Estimated seasonal cycle of net CO2 assimilation and CO2 and CH4 emission from a Phragmites australis wetland in Denmark (Brix et al., 2001).*

However, there are few literature sources available about the effect of reed harvesting on the GHG emissions of reed land. However, as most methane is emitted during spring and since plant transport is an important pathway of methane emissions in reed based wetlands, one might expect a reduction in methane emissions after harvesting. The lower input of fresh organic matter will lower the methane production by the methanogenic Archaea. The effect of cutting on the transport of methane via the aerenchymous tissues is not clear. On the other hand the building up of carbon in the peat is lowered, because of the lower biomass input. Jurasinski et al. (2013) showed results for a two year experiment (2011-2013) where GHG emissions from peat land were measures for Phragmites, Typha and Carex, with control sites and sites were the biomass was harvested. The results showed that GHG emissions from the harvested plots were equal or even lower than from the control plots. Also a meta-analysis of several published and unpublished studies by Jurasinski et al. (2013) showed that cutting biomass did not increase GHG emissions from peat soils.

8.2 GHG calculation methodology

The GHG calculation methodology is based on the calculation rules as stated in the Annex V of the Renewable Energy Directive (2009/28/EC). Total emissions of the biomass chain are calculated according to the following formula, which is further explained in Table 11:

$$E = E_{EC} + E_{L} + E_{P} + E_{TD} + E_{U} - E_{SCA} - E_{CCS} - E_{CCR} - E_{EE}$$

Table 11

Explanation of the components of the RED GHG calculation.

Symbol	Description	Relevance for Ukrainian pellet chains
E	Total emissions from the use of the fuel	Expressed in grams of CO2 equivalent per Mega Joule (MJ) of pellet-generated electricity and heat.
EEC	Emissions from the extraction or cultivation of raw materials	Includes harvesting and baling of reed.
EL	Annualized carbon stock changes caused by land use change	Not relevant for reed, as existing reed fields will be used
EP	Emissions from processing	Includes milling, drying, pelletizing and cooling of pellets.
ETD	Emissions from transport and distribution	Separate emission factors are calculated for biomass supply to the pelletizer and pellet distribution to the electricity plant.
EU	Emissions from the fuel in use	Assumed to be zero in accordance with the Renewable Energy Directive.
ESCA	Emission saving from soil carbon accumulation via improved agricultural management	Soil carbon accumulation is not relevant, but in this category we also include the prevented emissions from reed burning, which can be considered as improved agricultural management
ECCS	Emission saving from carbon capture and geological storage	Not applicable, as this technique is not used yet in the Netherlands
ECCR	Emissions saving from carbon capture and replacement	Not taken into consideration due to insufficient data availability.
EEE	Emission saving from excess electricity from co-generation	Not applicable

The GHG emissions savings are calculated as follows:

Saving = $(E_F - E_B)/E_F$

Where E_F is total emissions from the fossil fuel comparator. In the RED Annex V only EF values for biofuels and bioliquids are mentioned. However, the report by the European Commission on sustainability requirements for the use of solid and gaseous biomass sources in electricity, heating and cooling (COM(2010)11) mentions the following values as fossil references: 198 gCO_2eq/MJ electricity, 87 gCO_2eq/MJ heat and 57 gCO_2eq/MJ cooling.

In the Renewable Energy Directive it is stated that the minimum greenhouse gas saving values should be 35%, rising to 50% on 1 January 2017 and to 60% from 1 January 2018 for biofuels and bioliquids produced in installations in which production started on or after 1 January 2017. In COM(2010)11 the Commission recommends the same criteria for solid and gaseous biomass used in electricity, heating and cooling. However, at 17 October 2012 the Commission proposed (COM(2012) 595) to increase the minimum GHG savings to 60% for installations starting operation after 1st July 2014. In the NTA 8080 specific GHG saving requirements are stated for electricity and heat production (Table 12). For biofuels the requirements are the same as in the Renewable Energy Directive.

Table 12

Minimum GHG saving requirements according to NTA 8080.

Installation	Fossil reference	Minimum requirement for net emission reduction of GHG
Co-firing in coal fired power plant	Electricity from coal fired power plant	70%
Co-firing in gas fired power plant	Electricity from gas fired power plant	50%
Other systems	Dutch mixture of electricity production	70%

For the GHG calculation a specific spread sheet was developed, in which the GHG emission and GHG saving of the reed chain is calculated (Figure 17). For each of the relevant components of the GHG calculation (Table 11) the specific steps and related GHG emissions are calculated, based on collected activity data and emission factors. The emissions factors are based on the BioGrace standard values (Biograce, 2012) and IPCC 2006 guidelines (IPCC, 2006). Further information on GHG calculations is provided in the report on 'Herbaceous biomass supply chains' by Poppens et al. (2013b).

Reed burning, although not allowed according to Ukrainian law, is still common practice in Ukraine, as can be observed during road trips. Burning is often done by local people for hunting and fishing purposes. Reed burning in the field not only leads to CO_2 emissions, which can be considered as short cycle emissions, which will be assimilated again by the plant in the subsequent year, but also to non-CO_2 emissions as N_2O and CH_4, due to incomplete combustion of the fuel. Preventing these emissions by reed harvesting can therefore lead to additional GHG savings which can be accounted for under E_{SCA}.

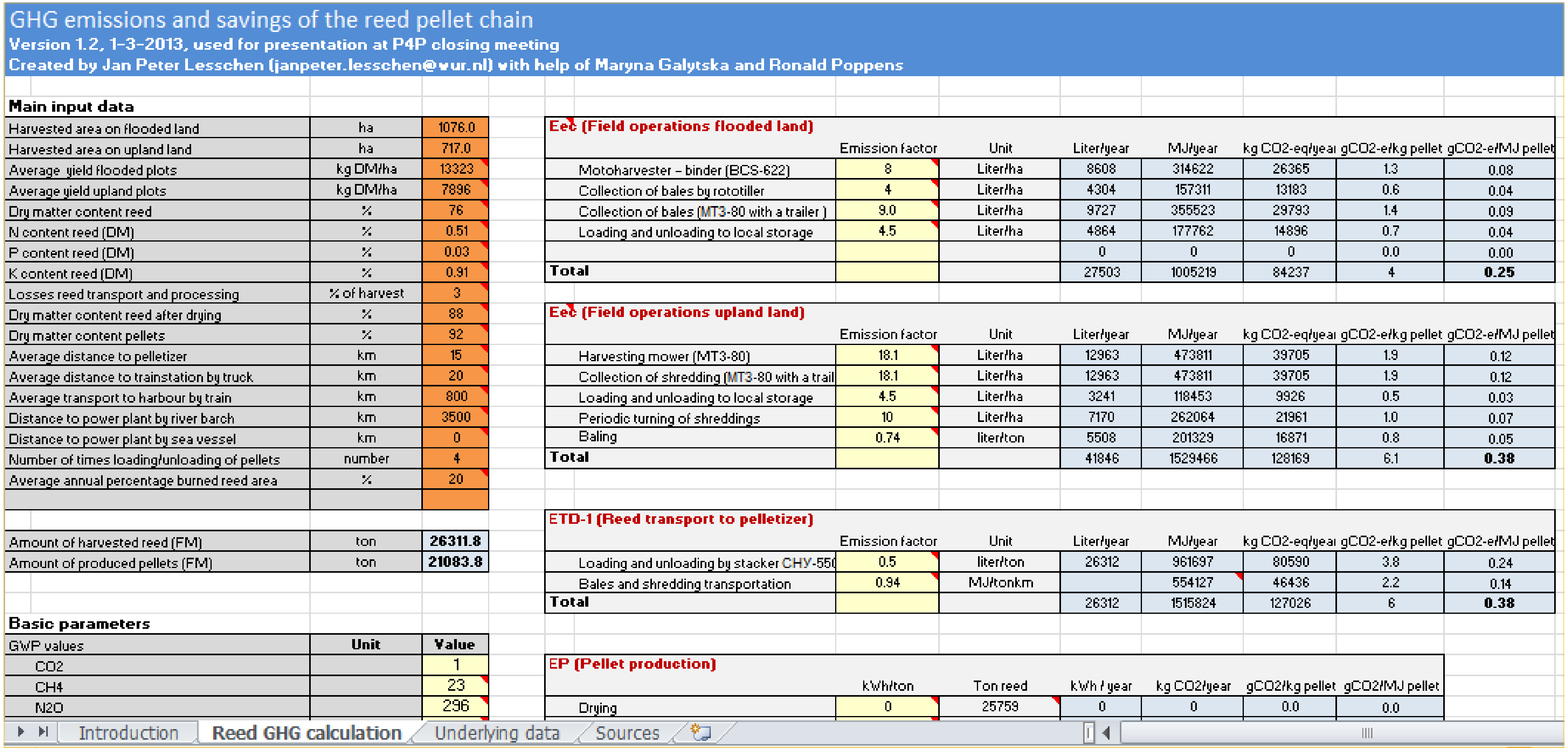
We calculated the emissions of reed burning according to the following formula of the IPCC 2006 guidelines:

$$E_{fire} = A \times M_B \times D_f \times G_{ef} \times 10^{-3}$$

where:

E_{fire} = amount of GHG emissions from fire (ton GHG)
A = area burnt
M_B = mass of fuel available for combustion (ton/ha)
C_f = combustion factor (dimensionless)
G_{ef} = emission factor (g/kg DM burnt)

The combustion factor for reed was set at 0.5 (the value for peatland in the IPCC 2006 guidelines (Table 2.6)) and as emission factors we used the values for savannah and grassland (2.3 g/kg DM burnt for CH_4 and 0.21 g/kg DM burnt for N_2O). Based on observations and interviews with the local people we estimated that the reed on average is burned once in five years (i.e. 20% of reed area is burned annually).



GHG emissions and savings of the reed pellet chain
Version 1.2, 1-3-2013, used for presentation at P4P closing meeting
Created by Jan Peter Lesschen (janpeter.lesschen@wur.nl) with help of Maryna Galytska and Ronald Poppens

Main input data

Harvested area on flooded land	ha	1076.0
Harvested area on upland land	ha	717.0
Average yield flooded plots	kg DM/ha	13323
Average yield upland plots	kg DM/ha	7896
Dry matter content reed	%	76
N content reed (DM)	%	0.51
P content reed (DM)	%	0.03
K content reed (DM)	%	0.91
Losses reed transport and processing	% of harvest	3
Dry matter content reed after drying	%	88
Dry matter content pellets	%	92
Average distance to pelletizer	km	15
Average distance to trainstation by truck	km	20
Average transport to harbour by train	km	800
Distance to power plant by river barch	km	3500
Distance to power plant by sea vessel	km	0
Number of times loading/unloading of pellets	number	4
Average annual percentage burned reed area	%	20
Amount of harvested reed (FM)	ton	**26311.8**
Amount of produced pellets (FM)	ton	**21083.8**

Basic parameters

GWP values	Unit	Value
CO2		1
CH4		23
N2O		296

Eec (Field operations flooded land)

	Emission factor	Unit	Liter/year	MJ/year	kg CO2-eq/year	gCO2-e/kg pellet	gCO2-e/MJ pellet
Motoharvester – binder (BCS-622)	8	Liter/ha	8608	314622	26365	1.3	0.08
Collection of bales by rototiller	4	Liter/ha	4304	157311	13183	0.6	0.04
Collection of bales (MT3-80 with a trailer)	9.0	Liter/ha	9727	355523	29793	1.4	0.09
Loading and unloading to local storage	4.5	Liter/ha	4864	177762	14896	0.7	0.04
			0	0	0	0.0	0.00
Total			27503	1005219	84237	4	**0.25**

Eec (Field operations upland land)

	Emission factor	Unit	Liter/year	MJ/year	kg CO2-eq/year	gCO2-e/kg pellet	gCO2-e/MJ pellet
Harvesting mower (MT3-80)	18.1	Liter/ha	12963	473811	39705	1.9	0.12
Collection of shredding (MT3-80 with a trail	18.1	Liter/ha	12963	473811	39705	1.9	0.12
Loading and unloading to local storage	4.5	Liter/ha	3241	118453	9926	0.5	0.03
Periodic turning of shreddings	10	Liter/ha	7170	262064	21961	1.0	0.07
Baling	0.74	liter/ton	5508	201329	16871	0.8	0.05
Total			41846	1529466	128169	6.1	**0.38**

ETD-1 (Reed transport to pelletizer)

	Emission factor	Unit	Liter/year	MJ/year	kg CO2-eq/year	gCO2-e/kg pellet	gCO2-e/MJ pellet
Loading and unloading by stacker CHY-55(	0.5	liter/ton	26312	961697	80590	3.8	0.24
Bales and shredding transportation	0.94	MJ/tonkm		554127	46436	2.2	0.14
Total			26312	1515824	127026	6	**0.38**

EP (Pellet production)

	kWh/ton	Ton reed	kWh / year	kg CO2/year	gCO2/kg pellet	gCO2/MJ pellet
Drying	0	25759	0	0	0.0	0.0

Introduction | Reed GHG calculation | Underlying data | Sources

Figure 17 *Screen shot of the GHG calculation excel file.*

8.3 Description of the assessed reed chains

For this report we have assessed the following two reed chains:

1. Reed pellets for export to the Netherlands for electricity generation,
2. Reed pellets for domestic use in heating boilers in Lubny.

The upstream part of the reed chain, i.e. harvesting and processing, is the same for both chains. The downstream part (transport and end use) is different. In the text below the main assumptions for the upstream and downstream parts of the reed chain are described. Further details are also provided in Chapter 4.

Reed harvesting (upstream part of the reed chain)
Two different reed systems are distinguished, reed from flooded land (water level > 20 cm) and reed from upland (dry) land (water level < 20 cm). This distinction is made because the reed yield differs between these two systems and also the harvesting and collection techniques are different. For the calculations we assumed that 60% of the reed land is flooded reed and 40% of the reed land is upland reed.

Based on measurements from 20 m^2 plots from the reed fields in Velyke Boloto, see also Annex II, we calculated an average yield of 13.3 ton DM / ha for the flooded reed and 7.8 ton DM / ha for the upland reed. As these plots were not harvested or burned during previous years the yield might be overestimated compared to a reed from areas that are harvested annually. However, since the emissions from reed harvesting are relatively small, see results in Chapter 8.4, the effect of the reed yield on the GHG emissions is limited. Nevertheless, from an economic point of view the effect of reed yield might be more important.

For flooded reed cutter bar-based harvesters and reed is bundled manually. The bundles are then transported to a local storage location, from where they will be transported to the pelletizer (see Chapter 4). The upland reed is harvested by a tractor with a harvesting machine that shreds the reed. Another tractor is connected to a trailer that collects the shredding and transports this to a nearby storage location, where it is stored in a pile. This pile has to be turned periodically to prevent rotting and improve drying and leaching of the minerals. Finally the shredding is baled and transported to the pelletizer (see Chapter 4).

Pelletizing reed
After transport from the storage location the reed shredding or bundles might have to be dried additionally. In the GHG assessment we assumed that further active drying was not needed. Before pelletizing the moisture content of the biomass should be less than 15%. In case active drying is needed, it will be based on burning of the reed biomass itself. This can be calculated as well, based on the assumption that 1 kWh is needed to evaporate 1 litre of water. This would not lead to additional GHG emissions, but it would lower the amount of pellets that can be produced, and in that way the overall GHG balance. The reed shredding or bundles are further shredded and milled, which has an electricity usage of 60 kWh/ton. Then the shredded and milled biomass is converted to pellets in the pelletizer (Figure 18). This process has an electricity consumption of 90 kWh/ton.


Figure 18 *The pelletizing process.*

Reed pellets for export to the Netherlands for electricity generation
For the export to the Netherlands the transport by train and river barge has been assessed (Chapter 5), which seems from economic point the most cost-effective option. The pellets are first transported by truck from the pelletizer location to the nearby railway station (distance 20 km). From there the pellets are transported by train to the port of Izmail (distance about 800 km). From Izmail the transport will continue by river barge over the Danube and Rhine to Rotterdam. In Krems (Austria) the pellets are overloaded to another ship. Total distance is estimated at 3500 km (Izmail to Krems 2000 km and Krems to Rotterdam 1500 km). For the generation of electricity we assume that the pellets will replace fossil coal. For the efficiency of the electricity generation we used 40%, which is an average value for fossil coal based power plants. The average efficiency in the Netherlands is somewhat higher because of the natural gas based power plants.

Reed pellets for domestic use in heating boilers in Lubny
Lubny, a small town in the province of Poltava, has plans to build heating boilers based on biomass, which will produce heat for a new neighbourhood. The pellets will be transported by truck to Lubny over a distance of about 30 km. These heating boilers have an efficiency of about 90%. The fossil fuel reference in this case is the use of natural gas for heating. See Chapter 9 for an analysis of the combustion quality issues when using reed pellets for heating purposes.

8.4 Assessment outcomes and recommendations for reduced GHG emissions

GHG assessment reed chains
Figure 19 shows the results of the GHG assessment of both reed chains. The results are expressed in gCO_2-eq per MJ pellet, in accordance to the RED. The largest emissions are due to the processing, as the pelletizing process requires relatively large electricity inputs, in addition electricity use in Ukraine has a high CO_2-emission due to the large scale use of fossil coal. For the export reed chain the emissions from transport are also large, which is not unexpected, considering the large distance and the need for different transport types (i.e. by road, train and ship). The GHG emission from the field operations, i.e. the reed harvesting, is only 0.6 g CO_2-eq per MJ. The emissions of harvesting are lower for flooded reed, as this is harvested with small machine and put manually in bundles, also the yield of the flooded reed is higher. For the upland reed larger machines are used and energy is also needed to turn the shredding. However, at the end the quality of this reed is better due to the natural leaching, which reduces Cl and K content leading to better combustion quality (see Chapter 9). The GHG savings from the prevention of reed field burning is limited with -0.7 g CO_2-eq per MJ.

The total GHG emission of the reed chain for export to the Netherlands for electricity production is 19.5 g CO_2-eq per MJ pellet, which is 48.8 g CO_2-eq per MJ electricity based on an (conservative) efficiency of 40% (for conversion to electricity in coal co-combustion). Compared to the fossil fuel reference of 198 g CO_2-eq per MJ electricity, the GHG savings of the entire chain are 75%, which is above the 70% minimum GHG saving as stated in the NTA 8080. For the domestic reed chain for heat production the total GHG emission is 11.0 g CO_2-eq per MJ pellet, which is 12.2 g CO_2-eq per MJ heat, based on an efficiency (of conversion to useful heat) of 90%. Compared to the fossil fuel reference of 87 g CO_2-eq per MJ heat, the GHG savings of the entire chain are 86%, which is higher than the other chain.

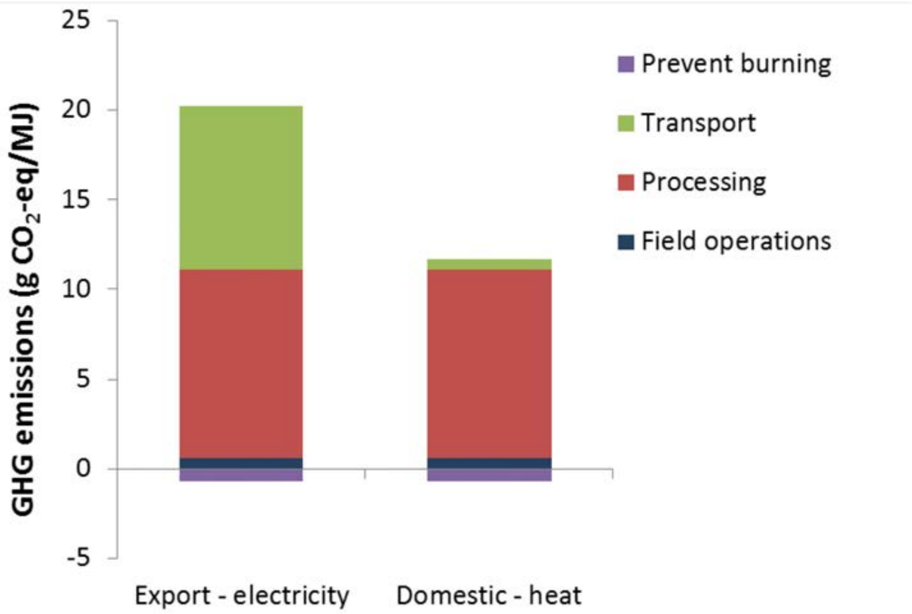


Figure 19 *GHG emissions for both reed chains.*

Recommendations for reduced GHG emissions
Although both chains have already high GHG savings, there are still possibilities for further improvements. Especially in the pelletizing process improvements might be achieved, via technical improvements that increase the efficiency and/or via the use of renewable electricity which could be produced via a combined heating and power installation based on the reed biomass. Regarding the transport emissions, these could be lowered if transport to the Netherlands would occur via sea vessel. However, this requires large volumes of biomass and still the reduction in GHG emissions is limited (see also Poppens et al., 2013b), since the transport route via the Mediterranean Sea is relatively long (about 8000 km). From a global climate change point of view it would be marginally more efficient to use biomass in Ukraine itself for heat production, instead of exporting it to the Netherlands, which would cause additional emissions.

Conclusions
The overall reed biomass chain has a highly positive GHG balance with 75% savings in case of export to the Netherlands for electricity production and 86% for domestic heat production. The GHG savings comply with the minimum requirements as stated in the NTA 8080. Emissions from the extraction of the reed biomass are relatively low, while emissions from processing, i.e. the pelletizing process, form the highest contribution. Transport emissions are also important in case of export to the Netherlands. From a global climate change point of view it would be marginally more efficient to use the biomass in Ukraine itself for energy production, instead of exporting it to the Netherlands, which would cause additional emissions. However, since the potential for large scale biomass production in the Netherlands is very limited, the import of reed biomass from the Ukraine is still an alternative which would comply with the sustainability criteria of the RED and NTA 8080. And it is one of the only options to reduce GHG emissions on the short term.

Figure 21 *Reed storage in Poltava.*

9 Reed thermal conversion analysis and pellet combustion test

9.1 Biomass thermal conversion quality analysis

In the Pellets for Power project the main application envisioned for reed pellets has been thermal conversion into heat and electricity[2]. This market is very large in the EU 27. We estimate at least 400 million tons (DM) by 2020. Most of the biomass used for this purpose is wood. Still a considerable amount of non-wood biomass will also have to be used for this purpose. The quality of this biomass is a very important issue.

Biomass quality for thermal conversion is determined by a mix of factors including the ash content (lower is better), ash melting temperature (higher is better) and risk of corrosion. The composition of the biomass determines these factors. Based on the composition of the biomass an indication of the quality can be obtained. Still the components also interact. Therefore real tests in which corrosiveness and ash melting behaviour is measured are also necessary to know the exact quality/behaviour of the biomass.

Most thermal conversion systems have been designed for woody biomass. Compared to woody biomass all herbaceous biomass (such as reed and straw) will generally have higher ash contents, and higher alkali (K, Na) contents. Higher alkali contents and especially a high alkali to Ca+Mg ratio in the ash will lead to lower ash melting points. This will lead to slag formation and downtime of the combustion system. Chlorine content, which contributes to corrosiveness, is also always higher than in wood.

The composition of herbaceous biomass is also highly variable throughout the year and is strongly influenced by the type of plant (C3 grasses have more ash then C4 grasses), the plant part (leaves contain more ash than the stems), the plant variety and also the soil type and availability of inorganic compounds in the soil (Si, K, Cl, N, Ca, Mg, etc.).

Other quality aspects that have to be considered are the moisture-content at harvest. This should be as low as possible to reduce the cost of transport and increase the energy content per volume. For herbaceous biomass it is also important that the biomass can be stored without the need for drying. Herbaceous biomass can be stored without the risk of self-ignition if the moisture content is at least below 20% and preferably below 15%.

When reed is used for thermal conversion the reed will generally be harvested in winter to reduce the impact on wildlife. This also assures that the reed has a low moisture content and has lower content of ash and other inorganic compounds. The effect of harvesting reed in fall, winter and early spring, is shown in Table 13. The Table shows the composition of reed between November 2011 and March of 2012 at Male Pereshchepyno (Velyke Boloto), Novi Sanzhary district in Ukraine. As may be expected the ash content is reduced due to loss of leaves and tops over time. These plant parts generally contain more ash than the stems. Especially the compounds that are easily dissolved in water are reduced. For example chloride content is reduced from 0.189 to 0.056 % of DM in four months during winter. The potassium (K) content is reduced from 4,56 to 1.01 % K_2O in the ash. It may therefore be expected that later harvesting has reduced the corrosion problems and has increased ash melting point.

[2] Other uses of the reed pellets may include second generation fuels and chemicals which have other quality requirements

Table 13

Reed biomass composition development after the end of the growing season at different intervals at Male Pereshchepyno (Velyke Boloto), Novi Sanzhary district in Ukraine, fall of 2011 and winter of 2012.

	November 2011	December 2011	January 2012	February 2012	March 2012
Ash %	7,07	9,77	3,32	5,05	3,91
S %	0,14	0,14	0,09	0,08	0,08
Cl %	0,189	0,156	0,052	0,081	0,056
N %	0,53	0,66	0,54	0,56	0,43
P %	0,03	0,03	0,01	0,02	0,02
SiO_2 % in ash	86,51	91,3	79,9	90,57	87,51
Al_2O_3 % in ash	0,9	0,94	0,94	0,94	1,88
CaO % in ash	1,76	1,51	3,77	1,51	4,02
K_2O % in ash	4,56	2,03	0,82	2,42	1,01
Na_2O % in ash	2,11	0,67	0,77	1,28	1,06
LHV MJ/kg	15,2	15,3	16,5	16,1	16,0
HHV MJ/kg	18,9	19,7	19,6	19,7	19,3

9.2 Combustion test at the Marum biomass heating plant

The Marum biomass (Bio Forte Marum b.v.) heating plant in The Netherlands was commissioned in May 2012 and it uses locally produced wood chips to provide heat and warm water to nine buildings and the swimming pool in the municipality of Marum. The plant has a total capacity is 500 kW. Starting in spring, when heat demand for heating is reduced, the local open air swimming pool is supplied with warm water until fall, when the swimming pool is closed and heat demand for other buildings increases. This way the heat demand is spread out evenly over the year. The plant consists of a moving grate/inclined grate combustion system with a hydraulic feed-in system.

To test the viability of using reed pellets as a biofuel for heating purposes the whole system from harvest, making pellets, transport to the Netherlands and combustion in the Netherlands was executed in winter and spring of 2013. Reed was harvested from reed fields near Gorodyshche (Ukraine) in January and pelleted and stored in big bags until transported. The pellets were tested for thermal conversion quality at SGS (Berlin). The results of the pellet analysis are summarised in Table 14. Detailed analysis is shown in Annex IV. In Figure 22 the whole chain from harvest to combustion testing is illustrated. Before transport to The Netherlands the main fuel analysis results were evaluated by the plant manager. The system has been designed for wood chips and operates at combustion temperatures up to about 850°C. It is equipped with flue gas recirculation and can thereby cool the furnace to approx. 600°C in order to cool the grate and to reduce NO_x emissions. Due to the lower moisture content of pellets compared to wood chips (typically 30-50% moisture) the flue gas recirculation would have to be maximized to prevent overheating. The plant manager set an acceptance limit for the ash melting temperature at 1000°C (DT, deformation temperature). A Cl content of below 0.4 % (DM) was required and an ash content of less than 7% was preferred. For wood chips currently the ash content varies between 1 and 3 %. A high ash content is undesirable because it does not provide a (energy) value and still has to be transported. Most combustion systems cannot handle high ash amounts leading to clogging of the ash removal system. After combustion, the ash has to be disposed of, often at a considerable cost. In the Netherlands the total cost of transportation and dumping ash (current legislation forbids its use as fertilizer) is approximately € 80,- per tonne (Personal communication Koppejan, 2013). The biomass ash does not (yet?) have an outlet like coal fly ash which is used in cement production and which has a much lower cost of disposal.

As we can see in Table 14 the ash melting temperature (DT) was 1350°C, well above the limit set. The Cl content of 0.2% (DM) was also below the 0.4% limit. The ash content of the pellets was 8.55% which was high compared to the content of other samples collected from the same area. Still, the ash content was seen as less critical and the test went ahead. See Figure 22 for an illustration of the whole process chain.

Table 14

Reed biomass analysis for thermal quality from two sites in Ukraine (Reni and Gorodyshche) harvested in early 2013. In both cases the soil was mainly clay. Perennial means the biomass was harvested from reed that has not been harvested in the previous year. 'Dry' means the reed was from an upland site that was not or hardly flooded. For comparison the analysis of Reed Canary Grass (RCG), Miscanthus and switchgrass harvested from a heavy clay soil in March was added.

		Reni	--------- Gorodische, January 2013 -----------					---- Groningen, The Netherlands ---		
		Pellet	Pellet	Perennial flooded	Perennial dry	Annual flooded	Annual dry	Switchgrass	Miscanthus	RCG
Ash 550	% DM	6.22	8.55	3.68	4.21	7.50	3.19	3.64	4.53	7.13
N	% DM	0.38	0.66	0.37	0.58	0.58	0.48	0.56	0.57	1.46
P	% DM	0.018	0.053	0.017	0.028	0.036	0.021	0.07	0.05	0.18
K	% DM	0.15	0.18	0.07	0.04	0.12	0.06	0.11	0.46	0.13
Cl	% DM	0.24	0.20	0.017	0.05	0.16	0.04	0.25	0.47	0.23
Ash melting:										
Shrinkage start °C		850	830	820	830	1400	830	770	660	890
Deformation start °C		1370	1350	1420	1470	> 1500	1360	1140	670	970
Hemisphere start °C		> 1500	> 1500	> 1500	> 1500	> 1500	> 1500	1400	1080	>1500
Flow Temperature °C		> 1500	> 1500	> 1500	> 1500	> 1500	> 1500	1430	1160	>1500
Ash composition:										
SiO_2	% mass	85.1	86.8	89.4	90.4	92.5	84.9	80.2	70.9	77.1
Al_2O_3	% mass	0.42	0.43	0.39	0.37	0.21	0.58	0.74	0.36	1.73
TiO_2	% mass	0.027	0.013	0.01	0.0037	0.034	0.029	0.041	0.0091	0.13
P_2O_5	% mass	0.82	1.27	1.06	1.12	1.04	1.52	3.12	2.5	4.95
SO3	% mass	1.47	1.4	0.9	0.54	0.55	1.42	0.58	1.68	0.83
Fe_2O_3	% mass	0.27	0.29	0.23	0.17	0.3	0.41	0.3	0.13	0.8
CaO	% mass	2.42	3.07	2.36	2.82	1.96	4.16	5.3	2.14	5.08
MgO	% mass	3.71	1.95	1.56	1.9	0.43	2.12	3.15	3.98	3.96
Na_2O	% mass	2.1	1.6	1.61	1.32	0.82	2.17	2.59	4.57	2.77
K_2O	% mass	2.9	2.52	2.14	1.18	1.86	2.37	3.74	12.3	2.25
Mn_3O_4	% mass	0.037	0.17	0.14	0.035	0.14	0.18	0.018	0.022	0.21

It was observed that the pellets contained much fines which led to some dust problems. The Marum plant does not allow to take direct measurements but observations could be made. The temperature did increase when pellets were burned. A higher rate of flue gas recirculation helped to contain this. The main problem encountered was an accumulation of ash after approximately six hours form the start of using 100% reed pellets. Apparently the ash did not fall through the ash pit grate and accumulated, leading to a shutdown. This is illustrated in Figure 23. After the system was changed to a mix of approximately 50% wood chips and 50% reed pellets the plant could operate again though the ash accumulation had to be monitored and additional furnace cleaning needed to be performed.

The explanation for the ash accumulation lies in the high ash content of 8.5% measured (and likely more) and also in some sintering of the ash which prevented the ash from falling through the grate. The measurements (Table 14) were conducted on clean pellets (excluding fines), though the big bags contained a high amount of fines too, so it was observed. Fines are known to contain more ash.

It was concluded that the system could use the reed pellets if another furnace would be used that was from the start designed to cope with the higher ash content. This would involve adding an 'ash breaker' and including a water cooled fuel grate. The extra investment cost of the total plant would be marginal (Personal communication Jaap Koppejan). On top of this the extra cost of ash disposal and possible more maintenance cost should be considered. Even more important the quality of the reed pellets should, and we believe, can be improved.

Figure 22 *Reed harvested at Gorodische (Ukraine) was pelleted and 10 tons were transported in Big Bags to Marum (The Netherlands) for use in the local wood chip municipal heating plant. At that moment of testing the heat was mainly used for heating the local swimming pool.*

Figure 23 *Boiler of the Marum biomass plant at the start of the test run and after approximately six hours when ash accumulation on the ash removal grate led to a shutdown.*

Overall the test showed that reed pellets can be used for local heat production though it will be necessary to better control the pellet production process and thus reduce the ash content while maintaining the high ash melting temperature and low Cl content. With respect to the pellet production a range of improvements should be possible to increase the pellet quality. This includes selecting reed from sites with sandy or organic soil, making sure that soil contamination is avoided during harvesting, transport and palletisation. Furthermore the pelleting process could be optimised to make sure less breakage occurs and the pellets should be sieved before transport.

10 Competition with food and alternative uses

10.1 Introduction

Internationally, using agricultural land for the production of bio-energy crops has been subject to criticism. Food prices may go up, as less agricultural land becomes available for food production. This results in extra demand for land to be taken into production. This effect of Indirect Land Use Changes (ILUC) has negative consequences for sustainability. Increased demand for land is leading to increased forest destruction, wetland drainage and release of greenhouse gasses worldwide. In fact, in some cases the ILUC effect may even outweigh the direct effects of bioenergy production, in terms of its impact on the climate and overall sustainability (Fritsche et al., 2010).

At this moment ILUC is not yet included in international legislation, nor in international sustainability standards such as the Dutch NTA 8080. Yet, its inclusion seems just a matter of time. Without a measure for ILUC effects, the fight against global warming and other sustainability initiatives cannot be truly successful. One way to address the problem is by taking degraded and marginalized land back into production for biomass. This solution is discussed in the switchgrass cultivation report (Elbersen and Kulik, 2013) and the Supply Chain report (Poppens et al., 2013b). Another solution is by using agricultural by-products such as straw, also discussed in the Supply Chain report. Countries like Ukraine have plenty of abandoned and marginal lands, as well as millions of hectares of grain production (straw). Reed belongs to the first category, as it grows in wetland areas not used (currently) for agriculture. However, also the current reed uses must be taken into consideration. In case biomass production competes with current reed use, extra reed demand may lead to exploitation of new areas with potentially negative effects on people, climate and the environment.

10.2 Reed production in wetlands

Reed is harvested in wetland areas, not on lands dedicated to agricultural production. This would make reed harvesting safe from competing with food production. On the other hand, in Ukraine much of today's reed is growing on abandoned land that was formerly in use as agricultural land, particularly for grazing but it is not known how ILUC effects - if any- should be quantified. Ecofys (2013) applies a criterion of surplus abandoned land to assess whether or not a specific biomass producing site generates ILUC effects. However, it is not clear if this also applies to reed.

10.3 Current and potential local reed use

Currently, there is hardly any use of reed in the project area. Local studies revealed that in one reed owning community about 20 families manage a small plot of reed for production of handicrafts (hats among other items). The only other users of reed land is by hunters, who are interested not in the reed itself but in the birds it harbours (Poppens et al., 2013a). In fact, reed is commonly burned by local people, despite laws against it. This is done apparently to provide access to fishing grounds and hunting birds. Reed burning was witnessed by the project team on a regular basis during field trips in the project area.

Commercial reed harvesting for thatching purposes does not occur currently in the project area. Though this could be a potential profit generating activity for the reed communities, most of the reed does not comply with the high quality demands for this market. According to a Dutch company importing reed from the Ukrainian Danube area, perhaps only 30% of reed in the Danube delta would qualify. Reed of sufficient quality measures 1,6 to 1,7 meters in length, has a tapered shape and a greasy feel to it. The remaining 70% is too long and too thick or perhaps too salty to be of use in thatching.

Though we have no information about whether reed from the project area would qualify as thatching material, there is no reason to suggest that reed harvesting for biomass purposes would outcompete this potential activity. Future operations could focus on the high quality reed for roofing markets, yielding maximum added value for the communities. The remaining lower quality reed could then be harvested for other biomass purposes. This would be a good example of biomass cascading, where maximum added value is obtained. And especially in times of economic crisis, with a reed roofing market under much pressure, this could be the answer for current and future reed producing enterprises.

Figure 24 *Harvesting reed in the Wieden, the Netherlands: ILUC free?*

10.4 Is ILUC free reed harvesting possible?

The answer to the question above seems affirmative. Reed in the project area is harvested on land not used currently for agricultural purposes. And even in case of reed occupying land that was formerly used for agriculture, this still refers to 'abandoned land' and thus there is no competition for food of reed production.

Also the risk of displacement seems to be low, with no current or planned alternative reed uses of any scale. And even if commercial reed harvesting for roofing purposes would take off, biomass harvesting would still be a viable option for most of the reed not complying with high quality standards for roofing.

Without present methodologies in place for accurate quantification of ILUC effects of reed harvesting on wetlands, the ILUC effects are considered 'neutral' by the project unless proven otherwise.

Figure 25 *Reed land in Pereshepyno village.*

11 Biodiversity and environmental impacts of reed harvesting

11.1 Introduction

The management of reed land defines biodiversity. As a requirement for NTA8080 the biodiversity impact of reed harvesting should be minimal, or should have a positive effect on biodiversity. This is summarised in the following principles and criteria (NEN Netherlands Standardization Institute, 2009):

Principle 4: Biomass production does not affect protected or vulnerable biodiversity and will, where possible, strengthen biodiversity.
Criterion 4.1: No violation of national laws and regulations that are applicable to biomass production and the production area.
Criterion 4.2: In new or recent planning, no deterioration of biodiversity by biomass production in protected areas.
Criterion 4.3: In new or recent planning, no deterioration of biodiversity in other areas with high biodiversity value, vulnerability or high agrarian, nature and/or cultural values,
Criterion 4.4: In new or recent planning, maintenance or recovery of biodiversity within biomass production units.
Criterion 4.5: Strengthening of biodiversity where this is possible, during planning and by the management of existing production units.

It is therefore important to develop a strategy which minimizes the impact on biodiversity. Three key issues that should be addressed in any biodiversity risk-mitigation strategy: conservation of areas of significant biodiversity value; mitigation of negative effects related to indirect land-use change; and promotion of agricultural practices with few negative impacts on biodiversity (Hennenberg et al., 2010).

To answer these key issues we used different sources: published literature on (the impact of) wetland management), expert opinions, and agreed guidelines for wetland management - which are usually also based on 'expert opinion'.

11.2 Literature review

Biomass harvesting from wetlands has several effects directly relevant to biodiversity conservation (Wichtmann and Tanneberger, 2009):
- Reduction of the thickness of the litter layer and of old standing vegetation
- Depletion of excess nutrients from top soil mineralization and atmospheric deposition;
- in case of early summer mowing weakening of reed and favouring of sedge vegetation (Asaeda et al., 2006);
- Reduction of the encroachment of bushes (e.g. willows) and of successional afforestation
- Increased water levels reduce the share of reed areas, with an increased dominance of Typha and Phragmites, and reduced water levels may result in forming of saline-grassland vegetation.

Among the various possible management regimes, winter reed cutting for thatching has probably the longest tradition and its effects on biodiversity are best studied. With regard to plant conservation, winter cutting can maintain (Güsewell and Le Nédic, 2004) or increase species diversity as it substantially reduces the ruderal and nitrophilous character of the vegetation (Gryseels, 1989) and benefits shorter and more species-rich vegetation (Cowie et al., 1992). Winter harvesting increases the shoot height and shoot density, but no difference was seen in Sweden in wetland productivity as a result of winter mowing (Björndahl, 1985).

However, (early) summer mowing decreases the rhizomes and biomass production of reed, and gives way to a more open vegetation of sedges and rushes (Asaeda et al., 2006).

Monitoring in the Danube Delta, at Reni, (Southern Ukraine) showed an overall positive impact on the bird populations: the site supports some 35 species of wetland birds, and around 80 birds overall. These include globally threatened species like ferruginous duck and pygmy cormorant, heron colonies and the largest population of moustached warblers in Ukraine (Goriup, 2013).

For typical reedbed birds, Kube and Probst (1999) showed low population densities e.g. of bearded tits *(Panurus biarmicus)* in brackish reed beds in Northeast Germany up to three years after cutting. In contrast, Hawke and José (1996) describe that the same species preferred recently cut brackish reed beds (with rapid litter accumulation) in Southwest England above areas that had not been cut. Other characteristic reed species such as sedge warbler *(Acrocephalus schoenobaenus)* are apparently also able to rapidly recolonise cut areas (Hawke and José, 1996). Also owl species benefit from mowing due to the easier access to mouse species (Den Boer, 2001). Bibby and Lunn (1982) see generally little conflict between harvesting activities and ornithological interests, as long as patches of uncut reed remain. Often, the reduced abundance of potential prey for passerine birds is used as an argument against reed cutting, but reliable data to support this are not available. Also the aquatic warbler seems to benefit from reed cutting, reed cutting stops the vegetation succession into shrubland (Kloskowski and Krogulec, 1999). However, contrary to this, mowing also opens up reed lands for predator species such as the fox or marten (Den Boer, 2001).

Although invertebrates wintering in reed stems and litter-dwelling species are likely to suffer from cutting, other groups (e.g. entomofauna) benefit from fresh shoots. A study in Rozwarowo Marshes (Poland) could not find differences in total biomass of potential prey for passerine birds between the regularly winter cut Rozwarowo breeding sites and other Pomeranian breeding sites (Tanneberger et al., 2008). Differences between cut and uncut sites were only observed in few invertebrate families, and this effect declined over time after cutting. After one year, no soil invertebrates and only a few families of above-ground invertebrates showed any significant effects (Ditlhogo et al., 1992). Also other authors show that appropriate management for invertebrate conservation in reed beds and fen meadows should include rotational burning or cutting, with parts of the bed left unmanaged, forming a mosaic of ages and allowing recolonisation of invertebrates which are sensitive to cutting (Schmidt et al., 2008).

In the case of harvesting for thatch, annual harvesting of the complete reed bed would be preferred. From a biodiversity point of view, rotational cutting with approx. 10-15% of the site being uncut would be preferred (Wichtmann and Tanneberger, 2009). In the UK the mowing cycle is seven years (Hawke and José, 1996). The most productive commercial reed beds in the UK are harvested each year in winter (single wale), but most beds are cut on a two year rotation (double wale): two years of accumulated growth harvested together in a single operation (White, 2009). Plant diversity in single wale system is generally low as annual cutting favours reed dominance. Double wale cutting (as compared to single wale) is better for conservation and diversity as the standing crop left in alternate years provides overwintering habitat and shelter for wildlife.

Landscape diversity is an important aspect of biomass production impact (Firbank, 2007). A mosaic pattern will stimulate biodiversity of bird species. In particular if also habitat diversity is allowed, with water, unbroken reed, some shrubs, damp grassland, and sludge shores alternating. Therefore the management should aim at a mosaic structure in the use of reed beds (Ikonen and Hagelberg, 2007).

Figure 26 *Reed land inventory, spring 2011.*

11.3 Expert opinions on harvesting

Several regional experts (8) were interviewed for the purpose of this project on reed management and biodiversity. The Ukrainian experts could not provide a clear cut answer how reed harvesting affects biodiversity: it depends on the area and its history of use, but also the volume and intensity of harvesting. Much of today's reed grows on former flooded meadows and elsewhere much mineralisation has occurred (even in natural reed lands such as Danube Delta). However, the following comments were noted in the interviews that were taken (unpublished report, M. Galytska)

Impact of harvesting on biodiversity
Certainly, it will change the bird population density, nesting in the reed land biotope (N.O. Stetsiuk). It will also affect the bird populations that live on nearby meadows and pastures (M.V. Sliusar).

Correct harvesting (not below 15 cm from the soil surface) has a positive impact on development of the reed: increases biomass by 48,7% and density of new sprouts – by 35% (V.M. Samorodov, N.O. Stetsyuk). However, Mykytiuk mentions: Reed is best harvested as low to the ground as possible, so as not to hinder birds.

Decreased leaves and stem litter at harvested plots results in better water quality (E. Zhmud, http://awsassets.panda.org/downloads/zhmud_elena.pdf). There is a better development of aquatic flora and fauna, due to increased penetration sunlight, and thus to warmer water (M.V. Sliusar)

Method of harvesting
Mosaic harvesting (or zig-zag) is important for biodiversity protection or even improvement. It benefits insects, and thus birds, by creating more reed edges. Also a buffer of at least 3 to 10 meters should be maintained between land reed and flooded reed. Up to 70% could be harvestable in this way without affecting biodiversity (O. Mykytiuk, Birdlife Ukraine). Rotational reed harvesting can lead to repopulation of bird populations in 2 - 3 years (M.V. Sliusar). The width of harvested strips should not exceed 50 m.

Increasing the reed edges improves the conditions for insects, birds and aquatic fauna (V.V. Popelniukh, M.V. Sliusar and O. Mykytiuk).

Winter harvesting is best for biodiversity. The optimal cycle of reed harvesting without adverse effects on biodiversity is considered seven years, i.e. with reed patches up to seven years old (Personal communication O. Mykytiuk).

Recommendations of the Ukrainian experts on optimal wetlands management:

- To protect the aquatic vegetation and its regeneration ability, at most 75 % of designated plots should be mown, in a mosaic pattern. Mown plots should not be larger than 200 m long and 50 m wide,
- Absolutely no reed harvesting within a radius 500 m from colonies of herons, Eurasian Spoonbill, Glossy Ibis, Pygmy Cormorant and other rare colonial and nesting species of birds,
- No harvesting at the edge of the reed land, along the water body. These reeds are important for protection of the river bank and as biofilter, and form also important habitat for birds.

Harvesting in the Netherlands takes place based on opinions of organisations involved in reed land management and e.g. bird societies. This is partly based on expert opinion, partly fact-based information from research. Current management in the Netherlands is that 31% of reed in core wetland areas is mown and sold. Most is cut, often just 1% is left of edges and shrubs. Some conservation organisations require 10% of reed to remain for wildlife refuge and water birds. Research showed that leaving 15% of reed generally has the same positive impact on biodiversity as leaving 50-100%. Saving 20-25% of reed is considered optimal for biodiversity, mostly edges along the water, which are protected for 3-5 years (Van der Winden et al., 2003). This can be explained by the preference of birds for the edges, where foraging takes place along reed land edges, and areas with weeds and shrubs (Van der Winden et al., 2003). Harvesting should stop at the beginning of the breeding season, which is in the Netherlands on the 1st of March. Moreover, if 20% of the wetlands is included in the protected areas network, including extensive wetlands for colony birds, the situation for Dutch wetlands could markedly improve by allowing establishment of core populations of wetland birds (Van der Winden et al., 2003).

Recommendations from the Dutch Bird protection society for ‘optimal wetland management’ are (Van der Winden et al., 2003):

- Phased mowing, harvesting 10-20% in a 5-10 year cycle,
- 10% open water of at least 1-2 ha shallow water,
- Natural water table fluctuations,
- Long wetland edge,
- Variety of open, low wetlands vegetation, reed land as well as older reed stands with dense old plant material.

11.4 Environmental impacts

11.4.1 Assessment rationale

According to NTA 8080 biomass operations should not harm the environment. The sustainability requirements related to environment are mentioned in Chapter 5.5 of the NTA 8080 and include soil, ground and surface water and air. This is summarised in the following principles and criteria:

Principle 5: In the production and conversion of biomass, the soil and soil quality are retained or even improved.
Criterion 5.1: No violation of national laws and regulations that are applicable to soil management.
Criterion 5.2: In the production and conversion of biomass best practices are applied to retain or improve the soil and soil quality.
Criterion 5.3: The use of residual products is not at variance with other local functions for the conservation of the soil.
Principle 6: In the production and conversion of biomass, ground and surface water are not depleted and the water quality is maintained or improved.
Criterion 6.1: No violation of national laws and regulations that are applicable to water management.
Criterion 6.2: In the production and conversion of biomass best practices are applied to restrict the use of water and to retain or improve ground and surface water quality.
Criterion 6.3: In the production and conversion of biomass water from non-renewable sources is not used.
Principle 7: In the production and conversion of biomass, the air quality is maintained or improved.

Criterion 7.1: No violation of national laws and regulations that are applicable to emissions and air quality.
Criterion 7.2: In the production and conversion of biomass best practices are applied to reduce emissions and air pollution.
Criterion 7.3: No burning as part of the planning or management of biomass production units.

In the following section we will discuss the criteria that are relevant for the reed chain. This assessment mainly deals with some recommendations of best practices related to the reed harvesting.

11.4.2 Assessment outcomes and recommendations for minimal environmental impact

The legal requirements regarding no violation of national laws and regulations that are applicable to soil management, water management and emissions and air quality, have been discussed, where relevant in Chapter 6. In this Section we will discuss the other criteria related to soil, water and air quality.

Soil
For the preservation and improvement of the soil quality there are two main aspects, soil organic matter should not decline and the nutrient balance should not be negative, i.e. more nutrients are removed than supplied to the soil. Therefore the organisation should carry out measurements yearly and record the results in relation with the soil losses in tons of soil per hectare per year, the soil organic matter (SOM) and pH in the top layer and the nutrient balance as far as nitrogen (N), phosphorus (P) and potassium (K) is concerned. In addition, the organisation should take measures, which are needed to ensure that the experiences applied in the operational management are aimed at the prevention and control of erosion, maintenance of the nutrient balance, maintenance of the soil organic matter (SOM) and the prevention of soil becoming brackish. The risk on soil quality decline is limited, since the reed lands can be considered as more or less natural systems, which are not managed, except the harvesting.

In Table 15 an overview of the nutrient content of reed (pellets) samples is presented, most of these samples were collected in Ukraine during this project, and all samples were analysed in the same laboratory (SGS Institut Fresenius in Germany). Based on an average dry matter yield of 9 ton/ha, which is already quite high, a total amount of 44 kg nitrogen (N), 3 kg phosphorus (P) and 15 kg potassium (K) is removed. Compared to an agricultural system these amounts of removed nutrients are not very high, and on flooded soils one can expect that these amounts of nutrients are compensated by sedimentation. However, if reed will be harvested annually on non-flooded soils there is certainly a risk on nutrient depletion. In that case the reed system should be considered as agricultural system, and fertilization would be required, as otherwise reed yields would decrease. This will reduce the GHG savings of the reed chain due to emissions of fertilizer application and production.

The risk on decline of soil organic matter is limited in reed fields, as reed is a perennial plant of which at least the roots and stubbles remain in the soil. Late harvesting in winter is in this case beneficial for soil organic matter, as the leaf biomass will remain on the field. Natural reed systems have often a high build-up of soil organic matter, which in case of high (ground) water levels results in the formation of peat soils. This process can be disturbed by the harvesting of reed, but we do not expect that there will be a negative soil carbon balance because of the perennial rooting system. However, there is no data to support this statement, as this would require long term soil sampling or modelling of the carbon flows. A variety of soil organic carbon models exists, but these are mainly aimed at agricultural systems and have, as far as we know, not been parameterised or applied for reed.

Table 15

Nutrient analysis results of reed samples harvested in winter (expressed in % of DM).

Sample	N	P	K
Reed pellets Gorodysche 2013	0.66	0.053	0.18
Reed pellets Reni 2013	0.38	0.018	0.15
Reed Gorodysche flooded perennial	0.37	0.017	0.06
Reed Gorodysche not flooded perennial	0.58	0.028	0.04
Reed Gorodysche flooded annual	0.58	0.033	0.11
Reed Gorodysche not flooded annual	0.48	0.021	0.06
Reed Mayaki (Ukraine) 2012	0.48	0.030	0.11
Reed Vilkova (Ukriane) 2012	0.35	0.030	0.13
Reed pellets 2011	0.49	0.047	0.64
Average	0.49	0.031	0.17

Many of the reed lands in Ukraine are found in wetlands (see Chapter 3). Most of these wetlands are also peatlands with Histosols (organic soils). These peat soils have a very low bulk density and therefore a low carrying capacity. This is of importance for the reed harvesting. With heavy machinery there is a high risk on destruction of the peat soils, with related high CO_2- and N_2O-emissions. Therefore machines should have low pressure tyres to reduce the impact on the soil or harvesting should occur during periods when the soil is frozen and stable enough to drive with heavy machinery.

Ground and surface water

Reed harvesting for biomass has only minor relevance for the preservation and improvement of water quality. Since reed is grown naturally, there is no use of fertilizers nor pesticides or other agro-chemicals, with the risk of leaching to ground and surface water. Furthermore irrigation and water extraction is not occurring in these reed systems. The only risk is of some pollution during the harvesting, e.g. oil leakage. With reliable machinery this risk should be minimized.

Air

The risk on air pollution is low in the reed chain, as no use is made of any chemicals. The main risk is the emission of particulate matter during the pelletizing. Although this process produces quite some dust, most of this probably consists of larger particles and not the harmful fine particles (e.g. PM2.5). A recommendation is the use of dust caps by the workers and to prevent dust emissions outside the pelletizer unit.

One of the criteria in the NTA 8080 is that no burning will occur during planning or management of the biomass production unit. In this case the harvesting of the reed for biomass use is beneficial for air quality, as reed burning is traditionally occurring when the reed is not harvested. This is done by local people often for fishing or hunting purposes, although according to the national law the burning is officially not allowed. The prevention of burning has also a positive effect on the GHG balance (see Chapter 8).

11.4.3 Recommendations to minimize environmental impact

To prevent nutrient depletion and a negative soil carbon balance we recommend not to harvest all reed area every year, but to reduce the harvesting frequency to once every two years. In this way there is more time for input of nutrients via natural sources, i.e. deposition and flooding, which reduces the risk on nutrient depletion. This might also be beneficial to the reed yield, as the yield of perennial reed is somewhat higher compared to annual reed. This might also be beneficial for reed pellet quality, as the analysis results seem to indicate a lower ash and nutrient content for perennial reed. In addition, this would have benefits for biodiversity, see previous Chapter and par. 11.5. Also late harvesting is recommended, as this reduces the nutrient content in the reed biomass, especially for potassium, and thus the nutrient removal.

Another soil related recommendation is the use of harvesting machines with low pressure tyres to reduce the impact on the soil. Best would be to harvest at late winter when the soil or water is well frozen. In this case there is no or only a very minor risk on destruction of the soil surface. For ground and surface water quality there is no specific recommendation, except the prevention of pollution, e.g. oil leakage, during the reed harvesting. Regarding air quality, a recommendation is the use of dust caps by the workers and to prevent dust emissions outside the pelletizer unit.

11.5 Best practices for reed harvesting

Based on the available literature, as well as the guidelines which are used in different countries, the following is recommended as 'best practice' for harvesting with regard to conserving biodiversity:

Site selection:
- Avoid all areas where protected species, Red List species, or otherwise rare species are present. No harvesting should take place here, and a buffer of at least 100 m should be maintained around breeding sites, and 500 m for colony breeders of rare species (such as herons, Eurasian Spoonbill, Glossy Ibis, Pygmy Cormorant),
- Potential sites should be investigated beforehand to identify important species. The inventory should be done by qualified experts, in particular ornithologists, fauna specialists, herpetologists. Based on this inventory should be decided if reed harvesting is possible, and whether specific methods and measures are required,
- Exclude strictly protected sites (zapovedniks or zakazniks),
- In the case of Ramsar sites or International Bird Areas (IBAs) experts, ornithologist should provide advice on possible harvesting before any measures are taken.

Harvesting recommendations:
- Harvesting of reed should take place in winter, which improves the combustion quality of the biomass, but also the quantity of biomass, which also results in the least impact on flora and fauna. In addition harvesting on a frozen soil prevents damage and compaction to organic soils, which have a low bulk density,
- Exclude (at least) 25% of old stands of reed (up to 10 years old), shrubs, and pools as refuge for species,
- Aim for a diverse pattern: strip-harvesting, or 'chess-pattern',
- Leave the edges of reed land since these are most important for biodiversity,
- Aim for diverse reed land, including old stands (up to ten years),
- Leave pockets with shrubs, trees, sedges etcetera,
- Maintain open water in reed land.

Reed land management:
- No draining, no digging, or otherwise altering the abiotic conditions of the reed land,
- Maintain the natural river dynamics (also pertaining upstream measures in the water catchment!),
- Avoid pollution, from domestic or agricultural waste,
- Careful planning around wetlands is essential, in particular to maintain buffer zones around the wetland with regard to industrial activities and expansion of villages.

External management factors:
- Ensure cooperation with local communities and local hunters and fisherman, in protecting reed land and biodiversity,
- Ensure that reed land is not burnt, or if this is necessary, only localized controlled burning should take place,
- Hunting and fishing is only allowed in accordance with the legislation.

Monitoring:
- Regular monitoring is required in the case of biomass harvesting (i.e. at least every three years),
- Monitoring should be done according to a monitoring protocol (such as developed for this project) and standard monitoring form (see Annex III),

- Monitoring should be repeated in the same period of the year,
- Monitoring should be specific for species groups: for birds, amphibians, mammals, aquatic fauna etcetera,
- Indicator species, if well chosen, can be a good representative for a specific taxonomic group (e.g. for birds those species which are exclusively found in reed land habitats: the Bittern, Bearded tit, Eurasian reed warbler, Great reed warbler and Water rail (Ikonen and Hagelberg, 2007)),
- Monitoring should also take into account physical parameters of the wetlands (see example Annex III),
- Based on monitoring results, the harvesting methods may be adjusted over time (adaptive management).

If these 'Best practices' are followed, biomass harvesting, even from valuable wetlands, will not compromise biodiversity, or better, it can be beneficial for biodiversity since it will regulate other (negative) activities and protect the important values of wetlands, and increase habitat diversity. Biomass from wetlands provides sustainable alternatives for fossil energy.

Figure 27 *Monitoring is crucial, such as with protected species (fauna law and Bern convention) as the Fire-bellied toad (Bombina bombina), left, and Common spadefoot (Pelobates fuscus), right.*

12 Contribution to prosperity and social wellbeing

12.1 Introduction

At this moment there are no continuous biomass operations in the project area. It was therefore not possible to implement a thorough social impact study. For lack of data, in this Chapter the social impact components of (contributions to) prosperity and social well-being - two separate components in the NTA 8080 standard - are combined.

Some issues regarding social well-being have been addressed already, such as interactions with stakeholders and compliance with legislation. Project activities and outcomes regarding these aspects are extensively described in Poppens et al. (2013a). Also the Ukrainian biomass sustainability report (Poppens and Hoekstra, 2013) is referred to, which analyses the level of project compliance with sustainability criteria described in the NTA 8080 standard.

12.2 Full time job creation

Here, only the generation of full time jobs is discussed, which is a prominent aspect of a project's contribution to prosperity. Related social well-being issues, such as labour division and contractual arrangements are not discussed here for lack of running operations to base our information on. As a general rule, project partner Tuzetka estimates that biomass based businesses generate one full time job (fte) per 1000 tons of biomass. More specifically, seventeen people may be employed in local production and processing of biomass. This number is based on actual Tuzetka managed operations and does not include people employed further down the supply chain. What is more, this figure is based on the context of Western Europe; in Ukraine, given its low salary costs, more fte's could be generated per amount of biomass output (expressed in GJ). Figures above come down to 62,5 full-time jobs per Petajoule of biomass.

This figure is comparable to data published by the World Bank (Table 16). Here for alternative energy technologies an estimation is provided of the amount of job years (fte's) per GWh generated. In the adjacent column these figures are recalculated in job years per Petajoule (1015 Joule). The figures show that biomass generates almost twice as many job years per PJ in comparison with coal and natural gas, though less than other 'alternative' energy technologies such as geothermal and landfill gas. It is not clear however, to what extent jobs created throughout the supply chain are included and thus to what extend the real case figure by Tuzetka (62.5) can be compared to these.
The authors point out though that real figures are much dependent on the plant life and this may vary greatly among technologies and among actual cases.

Table 16

Job creation in energy production (Ref: World Bank).

Job creation per energy technology in the United States			
Technology	Plant duration (years)	Average job years per GWh	Average job years per PJ
Biomass	40	0.21	58,3
Geothermal	40	0.25	69.4
Landfill gas	40	0.72	199.9
Small hydro	40	0.27	75.0
Solar PV	25	0.87	241.7
Solar thermal	25	0.23	63.9
Wind	25	0.17	47.2
Carbon capture and storage	40	0.18	50.0
Nuclear	40	0.14	38.9
Coal	40	0.11	30.6
Natural gas	40	0.11	30.6
Energy efficiency	20	0.38	105.7

Table 17 shows World Bank estimations of the number of jobs generated for different energy technologies, per million US dollars of spending. For fair comparison with Table 16, it is not clear whether the direct jobs or total jobs generated should be taken into account. But still, the figures show the relative differences in job creation among the available energy technologies. Of all alternatives, biomass seems to generate most full time jobs per million US dollar of spending. Moreover, the total jobs created (17.4) is somewhat comparable to the actual figure provided by Tuzetka, regarding people employed upstream in the supply chain (17-20), as this is based on 20,000 tons of biomass production per year and an investment of approximately one million Euros.

Table 17

Job creation related to investments

Job creation per million US dollars of spending				
Technology	Direct jobs	Indirect jobs	Induced jobs	Total jobs
Oil and Natural gas	0.8	2.9	2.3	5.2
Coal	1.9	3.0	3.9	6.9
Wind	4.6	4.9	8.4	13.3
Solar	5.4	4.4	9.3	13.7
Biomass	7.4	5.0	12.4	17.4

Figure 28 *Local farmers can play a role in harvesting operations, which results in increased income opportunities and prosperity.*

13 Conclusions and recommendations

13.1 Can reed be harvested sustainably (certifiable)?

For NTA 8080 certification the biomass producer is required to know relevant **laws and regulations** that regulate the production, processing, commercialization and use of that particular biomass. Compliance with national laws and regulations (and EU legislation) is the basis for NTA 8080 compliance. Legislation is by definition an important aspect of reed based development, because reed is associated with wetlands and other high-value conservation areas that require special protection. See also the separate report on legislation and NTA 8080 (Poppens and Hoekstra, 2013).

Phytofuels has shown that in Ukraine a company can make a difference by studying and implementing the law, even with an unclear legal status of reed. With the law on its side, identifying the villages as rightful owners of reed resources, Phytofuels was able to acquire harvesting permits on the basis of 15-year harvesting programs. See Chapter 6 and Poppens et al. (2013a) for a detailed description of this process, encountered obstacles and its results.

In accordance with NTA 8080, biomass producers should engage in **consultation processes** with relevant stakeholders. The following definition of stakeholders is provided in the NTA 8080 standard. According to NTA 8080, direct stakeholders of the primary biomass producer include at least landowner(s) and land user(s), and local residents. Whether or not the procedures followed were done in full compliance with NTA 8080, or what adjustments in biomass operations would be required first, is discussed in Poppens and Hoekstra (2013).

Stakeholder consultation is an essential element in developing, implementing and operating a biomass project. It plays a critical role in raising awareness of the project's impacts and helps to achieve agreements on approach, management and operation of the project, whilst maximizing benefits and minimizing negative impacts (www.agentschapnl.nl/node/178155).

Stakeholder consultations are a way of avoiding potential conflicts. In addition, stakeholders should be consulted for their relevant local and practical knowledge, often filling gaps in scientific knowledge. And in Ukraine local knowledge was often the only resource available.

Stakeholder consultations proved equally important for Phytofuels and the Biomass Institute (NGO, research organization) in this project and in part were linked with the legislative procedures required for obtaining harvesting permits (Chapter 6). Yet, some changes in the approach are already proposed by Phytofuels itself. Even more attention should go out to the daily concerns of people in the villages. Instead of starting with activities that are directly linked to the proposed business, such as electrification, it would be much more effective to start with activities focusing on revival of the community as a whole.

According to NTA 8080 biomass operations should lead to minimal reductions of **GHG emissions** as compared to fossil fuel use, with at least 70% reduction compared to electricity from coal fired power plants. The overall reed biomass chain has a highly positive GHG balance with 75% savings in case of export to the Netherlands for electricity production (replacing coal) and 86% for domestic heat production in Ukraine (replacing natural gas). The GHG savings comply with the minimum requirements as stated in the NTA 8080. Emissions from the extraction of the reed biomass are relatively low, while emissions from processing, i.e. the pelletizing process, form the highest contribution. Transport emissions are also relevant in case of export to the Netherlands. From a global climate change point of view it should be marginally more efficient to use the biomass in Ukraine itself for heat production, compared to exporting it to the Netherlands (using it for co-firing), which would cause additional emissions. However, since the potential for large scale biomass production in the

Netherlands are very limited. The import of reed biomass from the Ukraine is an alternative which would comply with the sustainability criteria of the RED and NTA 8080.

At this moment Indirect **Land Use Change (ILUC)** is not yet included in international legislation, nor in international sustainability standards such as the Dutch NTA 8080. Yet, its inclusion seems just a matter of time, and general discourse indicates that ILUC effects have to be taken into account. Reed in the project area is harvested on land not used currently for agricultural purposes. And even in case of reed occupying land that was formerly used for agriculture, this still refers to 'abandoned land' and thus not competing for food production.

Also the risk of displacement seems to be low, with no current or planned alternative reed uses of any scale. And even if commercial reed harvesting for roofing purposes would take off, biomass harvesting would still be a viable option for most of the reed not complying with high quality standards for roofing.

Without present methodologies in place for accurate quantification of ILUC effects of reed harvesting on wetlands, the ILUC effects are considered 'neutral' by the project unless proven otherwise. Whether or not this conclusion complies with NTA 8080 is discussed in Poppens and Hoekstra (2013).. Land use in true reed land is at most fishing and hunting, which is facilitated through proper reed land management as proposed in this study.

NTA 8080 biomass operations should be beneficial for **biodiversity**. As we show in Chapter 11.2, the literature review, harvesting - provided it is done in the right season and with care - is positive for most species. Setting back succession and withdrawing nutrients will result in sustaining optimal habitat for most reed land species, often also critical bird species. In particular old reed areas, important for many marsh birds, will be better protected. Moreover, also the conditions for insects and amphibian species will be improved. In particular if we consider current management, which results in frequent burning of reed land, thereby destroying areas, possibly killing animals and resulting in ash, smoke and dust. The agreements with the communities will lead to abandonment of burning, and better regulated hunting and fishing practices, which are beneficial for biodiversity.

According to NTA 8080 biomass operations should not harm the **environment**. The sustainability requirements related to environment are mentioned in Chapter 5.5 of the NTA 8080 and include soil, ground and surface water and air.

The risk on soil quality decline is limited, since the reed lands can be considered as more or less natural systems, which are not managed, except the harvesting. Compared to an agricultural system these amounts of removed nutrients are not very high, and on flooded soils one can expect that these amounts of nutrients are compensated by sedimentation.

Reed harvesting has only minor relevance for the water quality. Since reed is grown naturally, there is no use of fertilizers nor pesticides or other agro-chemicals, with the risk of leaching to ground and surface water.

The risk on air pollution is low in the reed chain, as no use is made of any chemicals. The main risk is the emission of particulate matter during the pelletizing. Although this process produces quite some dust, most of this probably consists of larger particles and not the harmful fine particles (e.g. PM2.5).

At this moment there are no continuous biomass operations in the project area. It was therefore not possible to implement a thorough **social impact** study. A first calculation showed that 62.5 people may be full-time employed in Ukraine for processing of 1000 tons of biomass. Also World Bank figures underline that biomass generates most jobs per investment.

13.2 Is sustainable reed harvesting economically viable?

In the marketing and transport scenario's (Chapter 5) the potential costs are calculated for reed processing. The scenarios consist of pellets produced for the domestic heating market, or transported by various means to the harbour of Rotterdam in the Netherlands. Our research shows that it is best to focus on the domestic heating market with regard to the herbaceous biomass pellets produced in Ukraine. The current high gas price easily justifies the harvesting, transport and processing operations (see Table 6 for a breakdown of the supply chain costs and a list of alternative fuel prices). Viability of international supply chains for non-wood biomass will depend on lowering the cost of supply and/or higher cost of fossil fuels. We refer to the Pellet Market report (Jamblinne et al., 2013) for more detailed information.

At this moment the domestic heating market for biomass pellets is highly attractive, given the high price of natural gas, the most common energy source for heating installations in Ukraine. The development of shale gas production could disturb the future of biomass in Ukraine if this drives down the price of natural gas. This does not take into account the environmental costs, which are likely to be quite negative.

13.3 Recommendations for improved economics and sustainability of reed production in Ukraine

To prevent nutrient depletion and a negative soil carbon balance we recommend not to harvest all reed area every year, but to reduce the harvesting frequency to once every two years. In this way there is more time for input of nutrients via natural sources, i.e. deposition and flooding, which reduces the risk on nutrient depletion. This might also be beneficial for the reed yield, as the yield of perennial reed is somewhat higher compared to annual reed. This might also be beneficial for reed pellet quality, as the analysis results seem to indicate a lower ash and nutrient content for perennial reed. In addition, this would have benefits for biodiversity, see Chapter 11. Also late harvesting is recommended, as this reduces the nutrient content in the reed biomass, especially for potassium, and thus the nutrient removal.

Another soil related recommendation is the use of harvesting machines with low pressure tyres to reduce the impact on the soil. Best would be to harvest at late winter when the soil or water is well frozen. In this case there is no or only a very minor risk on destruction of the soil surface. For ground and surface water quality there is no specific recommendation, except the prevention of pollution, e.g. oil leakage, during the reed harvesting. Regarding air quality, a recommendation is the use of dust caps by the workers and to prevent dust emissions outside the pelletizer unit.

Specific recommendations are given regarding biodiversity aspects of biomass harvesting:

- Ensure that no important bird, plant or amphibian species are present (Red List, protected etcetera),
- Exclude Ramsar sites, IBAs,
- Exclude sites with species of conservation interest, OR:
- Include such sites if species of conservation interest benefits from harvesting (rejuvenation of habitat),
- Harvest (late) winter (January-March),
- Exclude 25% of old stands of reed (up to ten years old), shrubs, and pools as refuge for species,
- Harvest reed at fifteen cm height (for insects),
- Protect reed on shores and edges,
- Avoid modification of terrain (e.g. soil compaction, roads, drainage),
- Regulate other activities (e.g. burning, hunting).

Baseline inventories regarding biodiversity are crucial. A monitoring protocol is required for this survey. Once it has been decided to harvest biomass, it is important that developments are monitored. A specific inventory form is included in the report (Annex III).

- Perform a baseline survey in the area before harvest (reed land),
- Continue monitoring, regular repeat visit, to observe development and changes,
- Focus on birds, amphibians, flora (mammals indirect). Amphibians and birds are important indicators for sustainable biodiversity of wetlands.

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Annex I List of Abbreviations

AES	Agri-environmental scheme
cm	Centimetre
CV	Caloric value = LHV
DBI	Sustainable Biomass Import Programme
DM	Dry matter
GHG	Greenhouse gas
GJ	Gigajoule
ha	Hectare
LHV	Lower heating value
MJ	Megajoule
P4P	Pellets for Power project
PJ	Petajoule
RCG	Reed canary grass *(Phalaris arundinacea)*
SD	Standard deviation
TJ	Terajoule

Annex II Calculation yields

Calculation of yield from received data about perennial reed yield *(November 2011-March 2012)*

Number plot	water level	type of plot	Area of research plot	Yield of 20 m2	Yield kg/ m2 wet	Yield kg/ ha wet	Yield t/ ha wet reed	Moisture reed	Yield of 20 m2 DRY	Yield kg/ m2 dry reed	Yield kg/ ha dry reed	Yield t/ ha dry reed
			m2	kg wet	kg/m2 wet	kg/Ha wet	MT/Ha wet	%	kg dry	kg dry	kg/Ha dry	MT/Ha dry
D8	0-5 cm	Not flooded	2x10 m	9,85	0,5	4925,0	4,9	18,3	8,05	0,40	4023,7	4,02
D6	0-10 cm	Not flooded	2x10 m	16	0,8	8000,0	8,0	19,4	12,90	0,64	6448,0	6,45
D7	0-10 cm	Not flooded	2x10 m	14,5	0,7	7250,0	7,3	18,5	11,82	0,59	5908,8	5,91
D10	0-5 cm	Not flooded	2x10 m	22,5	1,1	11250,0	11,3	18,7	18,30	0,92	9151,9	9,15
D1	20-50 cm	Averagely flooded	2x10 m	18	0,9	9000,0	9,0	18,48	14,67	0,73	7336,8	7,34
D2	30-50 cm	Averagely flooded	2x10 m	18,5	0,9	9250,0	9,3	18,67	15,05	0,75	7523,0	7,52
D5	30-50 cm	Averagely flooded	2x10 m	15	0,8	7500,0	7,5	18,60	12,21	0,61	6105,0	6,11
M4	20-50 cm	Averagely flooded	2x10 m	24,5	1,2	12250,0	12,3	19,40	19,75	0,99	9873,5	9,87
D3	100-150 cm	Flooded	2x10 m	26,5	1,3	13250,0	13,3	19,6	21,30	1,1	10651,7	10,65
D4	100-150 cm	Flooded	2x10 m	25,5	1,3	12750,0	12,8	19,4	20,54	1,0	10271,4	10,27
M9	80-150 cm	Flooded	2x10 m	37,5	1,9	18750,0	18,8	19,4	30,23	1,5	15112,5	15,11
D9	80-150 cm	Flooded	2x10 m	41,3	2,1	20650,0	20,7	19,1	33,41	1,7	16705,9	16,71
Mean				22,47	1,12	11235,42	11,24	18,96	18,19	0,91	9092,68	9,09

Annex III Technical specifications of equipment in reed harvesting process

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
I. Reed harvesting							
Not flooded areas		MT3-80	3	55 hp (40 kW)	0,2 Ha/hour or 12 MT/hour	8.5 l\Ha During harvesting	
		Trailer dumping *2ПТС-*			Volume 5,4 m^3		
Flooded areas	 	Modificated cross-country vehicle *ROSA -400* or *ROSA-600*	2	70 hp. 52 kW	2 Ha\hour	0,15 - 0,22 l/Ha	

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
		Harvester	2	-	-	--	
		Modified cutter bar mower Zubr with attached harvester	2	6 hp	1-1,5 Ha\hour	1,4 l/hour or 2 l/Ha	
		Modernized cutter-bar mower ISKRA with attached harvester	2	8,0 ph / 5,88 kW	-1,5 Ha \hour	1,4 l/hour or 2 l/Ha	

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
II. -III. Collecting on cutter bar mower and Transport of reed material to the bank of a bog							
Not flooded areas:		Tractor MT3-80	1	55 hp (40 kW)	0,2 Ha/hour or 12 MT/hour	? To be calculated	Fuel consumption is 2 l/hour during loading or transportation
		Tractor tipper trailer *2ПТС-4.*	1		Volume 5,4 m^3		
Flooded areas		Modernized harvesting cutter bar ISKRA with attached trailer-sledge	2	8,0 ph/ 5,88 kW	-1,5 Ha\hour	1,4 l/hour or 2 l/Ha	
		Trailer-sledge	2				Given as a variant for discussion. We look for alternative

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
IV.-V. Laying/piling of reed material and storage							
Not flooded	pile/pit  	Tractor MT3-80	1	55 ph (40 kW)		2 l/hour During loading	
		Loader/stacker СНУ-550	1				

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
Flooded	 	Tractor MT3-80	1	55 hp (40 kW)		2 l/hour During loading and turning out	
		Loader-stacker CHY-550	1				

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
VI. Periodical turning over of reed materials							
Not flooded areas		Tractor MT3-80	1	55 hp (40 kW)		2 l/hour During loading and turning out	
		Loader/stacker CHY-550	1				

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
VII.-VIII. Pressing/baling of reeds. Loading for transport							
Not flooded areas		Kyrgyzstan ППП-Ф-16 baling machine	1		18 MT/hour		Volume of a bale is 1 m^3 Weight is 300 kg
		Tractor MT3-80	1	55 hp (40 kW)	-	3,8 l/hour during baling 16 l/hour during transportatio n	-
		Trailer-platform ПП-12/3	2	Tonnage capacity 16 MT Capacity – nearly 50 bales			

Step	Activity	Type of machine	Number	Capacity	Productivity	Fuel consumpt. l/Ha	Note
Flooded (sacks)		Tractor MT3-80	2 (1 with stacker + 1 for Mozhara)			4 l/hour during loading on Mozhara 16 l/hour during transportatio n	
		Loader –stacker СНУ-550	1	-	-	-	
		trailer 2ПТС1 4 type Mozhara	2		Capacity 5, 4 m3 Tonnage capacity is 6 MT		

Annex IV Chemical analysis of Reed pellets

Combustion quality analysis (SGS, Berlin) of reed pellets used in combustion test at Marum May 2013.

Sample description				Sample 1 Region: Gorodyshche, Ukraine Content: Reed pellets Origin: P4P project				
Parameter	**Unit**	**LOQ (d)**	**Method**	**Amount (ar)**	**Amount (ad)**	**Amount (d)**	**Amount (daf)[1]**	**Amount in ash**
Dry mass	mass-%	0.1	DIN EN 14774-1	83.0	97.4	--	--	--
Moisture	mass-%	0.1	DIN EN 14774-1	17.0	2.6	--	--	--
Ash (550°C)	mass-%	0.1	DIN EN 14775	7.10	8.33	8.55	--	--
Ash (815°C)	mass-%	0.1	sim. to DIN EN 14775	7.01	8.23	8.45	--	--
Volatile matter incl. moisture	mass-%	0.1	DIN EN 15148	--	76.7	--	--	--
Volatile matter	mass-%	0.1	DIN EN 15148	63.2	74.1	76.1	83.1	--
Fixed Carbon	mass-%	0.1	DIN 51734	12.8	15.0	15.5	16.9	--
Sulphur	mass-%	0.01	DIN EN 15289	0.068	0.080	0.082	0.090	--
Chlorine	mass-%	0.01	DIN EN 15289	0.17	0.19	0.20	0.22	--
Fluorine	mass-%	0.005	DIN EN 15289	< 0,004	< 0,005	< 0,005	< 0,005	--
Phosphorus	mass-%	0.001	DIN EN 15290	0.044	0.052	0.053	0.058	--
Carbon	mass-%	0.1	DIN EN 15104	37.5	44.0	45.2	49.4	--
Hydrogen	mass-%	0.1	DIN EN 15104	4.64	5.44	5.59	6.11	--
Nitrogen	mass-%	0.1	DIN EN 15104	0.55	0.64	0.66	0.72	--
Oxygen	mass-%	0.1	DIN EN 15296	33.0	38.8	39.8	43.5	--
Gross calorific value Ho, v	GJ/t	0.5	DIN EN 14918	15.40	18.07	18.55	20.26	--
Net calorific value Hu, p	GJ/t	0.5	DIN EN 14918	13.97	16.82	17.33	18.93	--
Gross calorific value Ho, v	kcal/kg	120	DIN EN 14918	3680	4320	4430	4840	--
Net calorific value Hu, p	kcal/kg	120	DIN EN 14918	3340	4020	4140	4520	--
Gross calorific value Ho, v	MWh/t	0.14	DIN EN 14918	4.28	5.02	5.15	5.63	--
Net calorific value Hu, p	MWh/t	0.14	DIN EN 14918	3.88	4.67	4.81	5.26	--
Gross calorific value Ho, v	BTU/Lb	210	DIN EN 14918	6620	7770	7980	8710	--
Net calorific value Hu, p	BTU/Lb	210	DIN EN 14918	6010	7230	7450	8140	--
Antimony	mg/kg	6	DIN EN 15297	< 5	< 6	< 6	< 7	--
Arsenic	mg/kg	1	DIN EN 15297	< 1	< 1	< 1	< 1	--
Beryllium	mg/kg	0.2	DIN EN 15297	< 0,2	< 0,2	< 0,2	< 0,2	--
Lead	mg/kg	3	DIN EN 15297	< 2	< 3	< 3	< 3	--
Cadmium	mg/kg	0.3	DIN EN 15297	< 0,2	< 0,3	< 0,3	< 0,3	--
Chromium	mg/kg	1	DIN EN 15297	2	3	3	3	--
Cobalt	mg/kg	1	DIN EN 15297	< 1	< 1	< 1	< 1	--
Copper	mg/kg	2	DIN EN 15297	5	6	6	7	--
Nickel	mg/kg	1	DIN EN 15297	1	1	1	1	--
Mercury	mg/kg	0.05	DIN EN 15297	< 0,04	< 0,05	< 0,05	< 0,05	--
Vanadium	mg/kg	1	DIN EN 15297	< 1	< 1	< 1	< 1	--
Zinc	mg/kg	1	DIN EN 15297	30	35	36	39	--
Thallium	mg/kg	0.4	DIN EN 15297	< 0,3	< 0,4	< 0,4	< 0,4	--
Aluminium	mg/kg	100	DIN EN 15290	< 83	< 97	< 100	< 110	--
Tin	mg/kg	10	DIN EN ISO 11885	< 8	< 10	< 10	< 11	--

Total EF	t CO_2/TJ	1	calculated	98	96	96	96	--
Ash melting behaviour (oxidising atmosphere) (ash fusion temperatures) (Ash produced at 550°C):								
Shrinkage starting temperature SST	°C		DIN CEN/TS 15370-1	--	--	--	--	830
Deformation temperature DT	°C		DIN CEN/TS 15370-1	--	--	--	--	1350
Hemisphere temperature HT	°C		DIN CEN/TS 15370-1	--	--	--	--	> 1500
Flow temperature FT	°C		DIN CEN/TS 15370-1	--	--	--	--	> 1500
Ash analysis (Ash produced at 550°C):								
SiO_2	mass-%	--	SN EN 15309	--	--	--	--	86.8
Al_2O_3	mass-%	--	SN EN 15309	--	--	--	--	0.43
TiO_2	mass-%	--	SN EN 15309	--	--	--	--	0.013
P_2O_5	mass-%	--	SN EN 15309	--	--	--	--	1.27
SO_3	mass-%	--	SN EN 15309	--	--	--	--	1.4
Fe_2O_3	mass-%	--	SN EN 15309	--	--	--	--	0.29
CaO	mass-%	--	SN EN 15309	--	--	--	--	3.07
MgO	mass-%	--	SN EN 15309	--	--	--	--	1.95
Na_2O	mass-%	--	SN EN 15309	--	--	--	--	1.6
K_2O	mass-%	--	SN EN 15309	--	--	--	--	2.52
Mn_3O_4	mass-%	--	SN EN 15309	--	--	--	--	0.17
ar - result calc. to 'as received' state	d - result calc. to 'bone dry' state							
ad - result calc. to 'air dry' state	daf - result calc. to 'dry and ash free' state							
-- not ordered / not applicable	LOQ - Limit of quantitation							

1) calculation base is the ash amount at 815°C

Annex V Inventory form biodiversity

Inventory form for baseline survey and monitoring Poltava

Biodiversity Baseline survey - Poltava Biofuel project

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General site characteristicsзагальні характеристики ділянки

1	Number of observation site/номер ділянки		--
2	Authors/виконавець	Natasha / Anna / Oleksei / Maksim /......	
3	Date of site description/ дата опису ділянки		.../. .. / 20..
4	Size of observation site/розмір ділянки		...... X ..... M.
5	Geografical location/геграфічне	Latitude/Longitude - GIS coord./Широта/Довгота-Гіс координати	
	E	N	
6	Elevation (m. above sea level)/висота над рівнем моря		
7	Description location/опис розташування		
8	Distance from river or lake (m)/Відстань до річки чи озера (м)		
9	Site status (protection)/ Статус ділянки (природоохоронність)		
10	Type of reedland/ тип заболочених земель		

Land Use /Використання земель

11	Land use /використання земель			
12	History of land use/історія використання земель			
13	Intensity land use (if any)/інтенсивність використання земель(якщо наявна)			
14	Last burned (years ago)/Останнє спалювання(років тому)			
15	Proximity to other reedbeds (from maps)/близькість до інших ділянок очерету (з карти)			
16	Presence wildlife protected species/наявність захищених видів дикої фауни			
18	Presence botanical protected species/Наявність захищених видів флори			
19	Depth of groundwater (dm)/глибина залягання грунтових вод (дм)			
20	Soil type/тип грунту			
21	Relief/рельєф			
22	Drainage/дренаж	yes / no (так/ні)	describe/опис:	
23	Depth of litter (cm)/глибина підстилки(см)			
24	Code of Soil sample bags/номер проби грунту			
25	Water Quality/якість води	pH		
		EC (mS)/електропровідність		
		temp °		
26	Description water colour/опис кольору води			
27	Fluctuation of water table (dm)/коливання водяного стовба(дм)			

Quality of Reed/якість очерету

28	Height, average (m)/висота, середнє значення (м)		maximum	
29	Density (no/m2)/густота(к-ть/м2)			
30	Stem thickness (Ø cm)/товщинаь стебла(d см)			
31	Reed hardness/твердість очерету			
32	Weight of reed sample/вага зразка очерету			

Name site:/назва ділянки	

Sketch location site/ескіз ділянки

17 Reported animal species by hunters
види тварин помічені мисливцями

Vegetation Cover/рослин покрив:

33	Reed /очерет,%	
34	other helophytes/інші болотні рослини (%)	
35	herb vegetation/лікар. рослин %	
36	shrub vegetation,кущі %	
37	tree vegetation,дерева %	

Biodiversity observations/моніторинг біорізноманіття:

38	Soil fauna in A-horizont/грунтова фауна в А-горизонті :	a. Type/тип	
		Abundance/поширеність	
39	Bird observations/ моніторинг птахів		
40	Plants/рослини	Typha latifolia	
		Carex	
		Scirpus	
		Convolvulus	
		Solanum dulcamara	
41	Fish/риби		
42	Mammals/ссавці		
43	Amphibians/амфібії		
44	Reptiles/рептилії		
45	Insects/комахи		
46	Photo number/номер фото		
47	Additional remarks/додаткові помітки		

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