INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Industrial Institute of Agricultural Engineering

Starolecka 31, 60-963 Poznan ; tel: +4861 8712222 ; fax: +4861 8793262

Projects: WND-POIG.01.03.01- 00 -164/09 and UOD-DEM-1-145/00

Projects were co-financed by the European Union through the European Regional Development Fund under the Operational Programme Innovative Economy 2007 – 2013

Three phase technology of harvesting and transportation of biomass from wetlands to nearby warehouses

Krzysztof Zembrowski, Adam P. Dubowski, Maciej Polasik

Krzysztof Zembrowski :- Email: zembrowski@pimr.poznan.pl ; Adam P. Dubowski - E-mail : dubowski@pimr.poznan.pl ; Maciej Polasik – E-mail: polasik@pimr.poznan.pl

Background

Many wetlands in Poland require special care to restore and protect them as breeding areas for endangered bird species but

currently, second hand vehicles (*ratracs*), machinery and traditional biomass transport are not so good. They are causing habitat damage and they use mineral oils in power hydraulics, so in the case of equipment failure spillages of the mineral oils are main source of pollution of the surface water and ground.

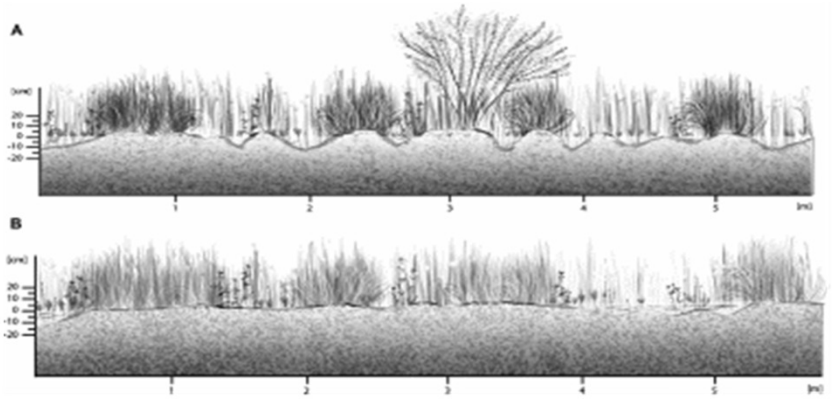
It should be emphasized, however, that in recent years there has been some change in the protection of wetlands: in Biebrza National Park there is regulation that every tracked vehicle should have a sorbent for mineral oil removal action, but on terrains covered by water sorbent is not proper solution to protect environment.

Wheeled tractors alone and when loaded with biomass bale are causing degradation of the peatlands and they **are forming deep ruts 0.4 - 0.6 m**.

Snow groomers (*ratracs*), adapted by farmers to work on wetlands as a tracked mowers, **are destroying the top layer of the vegetation roots**.

The destruction of terrain is also caused by tracked trailers used for transporting biomass bales on wetlands.

Peatland damaged and leveled by ratracs was observed in the Biebrza National Park, **it turned out that ratracs repeated usage during several years was not as environmentally friendly as it was expected.**



(A) Reference area (B) Peatland damaged and leveled by ratracs (mowing proceeded every year within 3–5 years) (Banaszuk et al., 2016)

K. Zembrowski, Logistyka 2014

Peatland after wheeled tractor biomass bale transport, Dubowski et al. 2012

Peatland after ratrac mowers and trailers work in protected wetlands, Dubowski et al. 2014

Ratrac unit is damaging peatland, Krogulec et al. 2013

Strength and load-bearing capacity of the root layer is even smaller than the initial state as it was a few years ago.

An attempt to measure the shear modulus using portable spiked plate (spiked shear vane) design by Ala-Ilomaki J., Finland], failed at the very first try, because plate punctured top root layer and sunk into water up to top of the handle.

Spiked plate (spiked shear vane)

Test was made in the entrance to the wetlands named *Czerwona Lawka* where ratracs were harvesting and transporting biomass for several years**.**

Looks like that ratracs' tracks not only level the ground, but in addition, they are reducing the thickness of peat carrier layer.

PIMR developed new, more eco-friendly **tracked vehicles, machines, tools and technologies for mowing, harvesting and transportation of biomass**, (patents: PCT/PL2011/000065, PL 216591, PL 220683, PL 220296, P.412901, P.412909, P. 420773). **In power hydraulics we use fire-resistant and biodegradable fluid/oil** **(EcoSafe FR, American Chemical Technologies, Inc.)**.

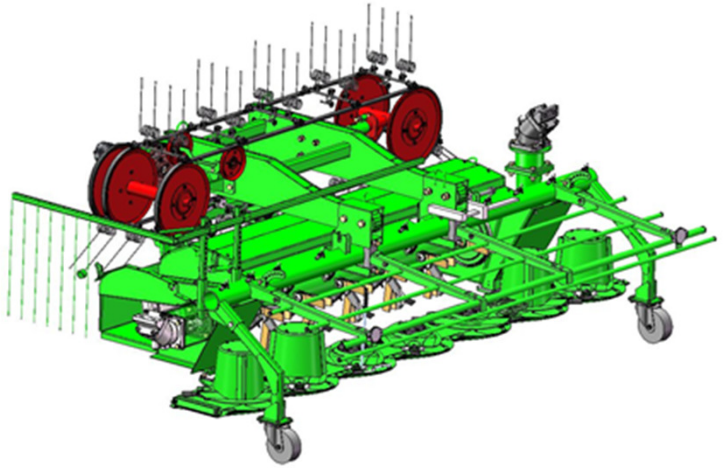
1. The front-mounted mower unit for cutting, conditioning biomass and forming swath

The front-mounted disc mower with rake and tedder was upgraded by PIMR and conditioner with knives and flails was mounted directly behind the disc mower.

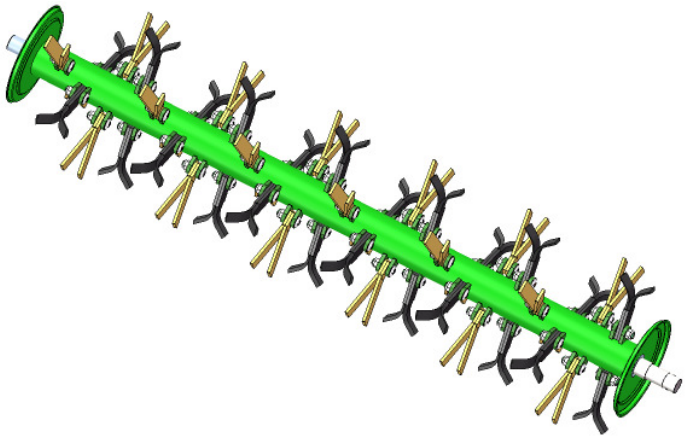
Mowed reed or grass is conditioned - simultaneously is broken and cut into smaller pieces, next biomass is moved in space of the finger-wheel rake and tedder and then swath is laid on the stubble off the track of the vehicle.

Swath is left in the field for about 2-3 weeks - this is needed to secure natural seeding process and to ensure adequate biodiversity in the protected terrains.

Mower unit - disk mower and finger-wheel rake and tedder



Virtual model of the innovative mower unit with biomass conditioner



Virtual model of the biomass conditioner with knives and flails

Real model of biomass conditioner with knives and flails

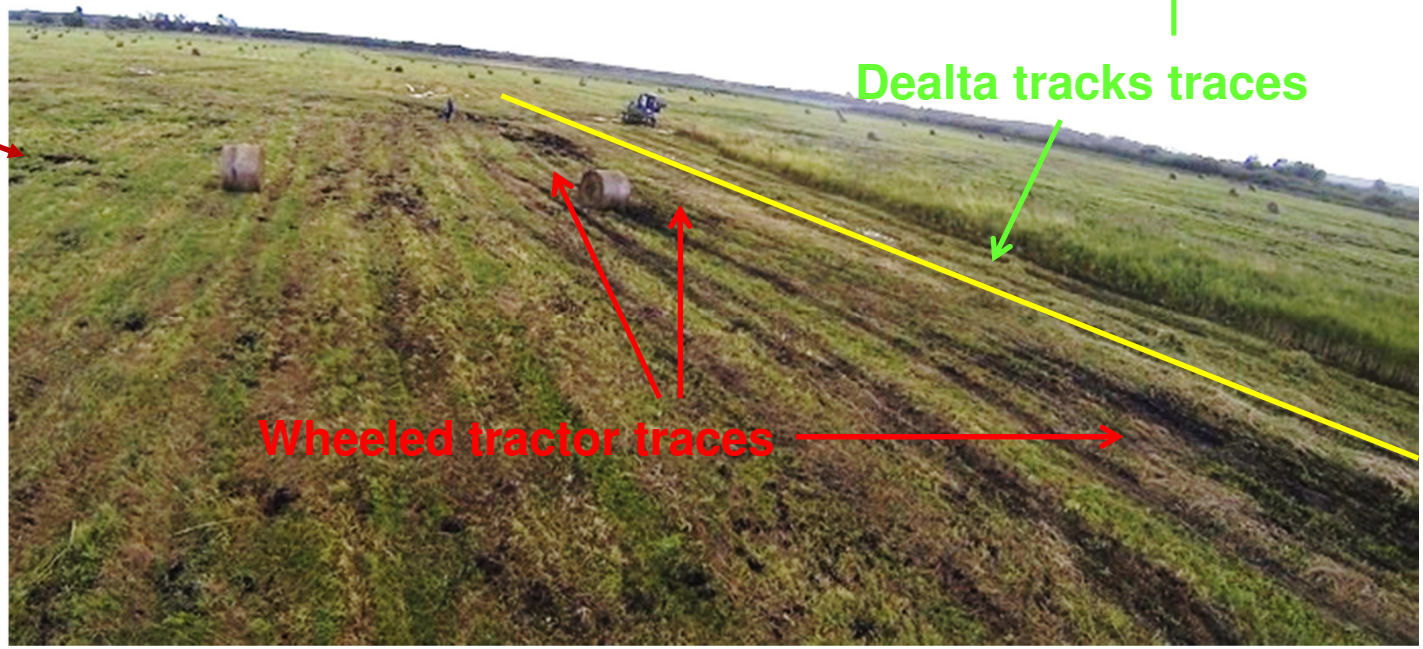
Mower unit with conditioner was working better than without it. Biomass was generally cut into pieces (ca. 30-50 cm of length). Unit should be improved and verified in the future field tests – for example shape of knives should be redesigned because 5- 20 % mass of biomass was not cut into pieces but all stems were broken in few points.

Delta tracks developed by PIMR have practically no impact on the surface of the terrain

Delta tracks - no leveling of the ground

Iveco 4x4 traces

No any traces of my Subaru Outback



Wheeled tractor, Iveco truck and tracked vehicle traces in the field near Biala village near Trzcianka, September 15, 2017

2. Non-stop swath collecting and forming round bales system

Non-stop swath collecting unit consists of a **swath pick-up attachment** and two **belt conveyors** mounted on the tracked tractor , **unit for forming bales** is constructed on the tracked trailer - it consists of spacious **feeding hopper** and **round-bale press** (patent P. 412901) **.**

Tracked vehicles unit for non-stop swath collecting and forming round bales, Biala village near Trzcianka, 2015

Unit has won awards for innovation:

- Gold medal - Brussels Eureka! ,
- XVIII Polish Future Product Competition 2015 – Winner in the category R&D Institute for „The new generation of the multi-modules machine for wetlands protection”.

3. Biomass-train technology

developed in PIMR is an innovative alternative for transporting biomass to warehouses located outside protected wetlands.

The system is based on special adapters that are **used to form a biomass-train** of the round bales and transport it, **with the bales rolling on the ground**, **behind towing vehicle** such as an farm tractor with wheels and/or medium size trucks and pickups equipped with delta track modules and/or wheels. **A biomass-train should reduce the cost of biomass transport** as it should be possible to tow four or more bales without any negative impact on the ground, **making it a very efficient and environmentally friendly technology on peatlands**, especially in national parks and Nature 2000 sites in Europe as well as in the other regions of the world.

Farm tractor rolling on bales on peatland near Notec river, Byszewice village

The Prowler - wheeled side by side all-terrain vehicle (ATV)

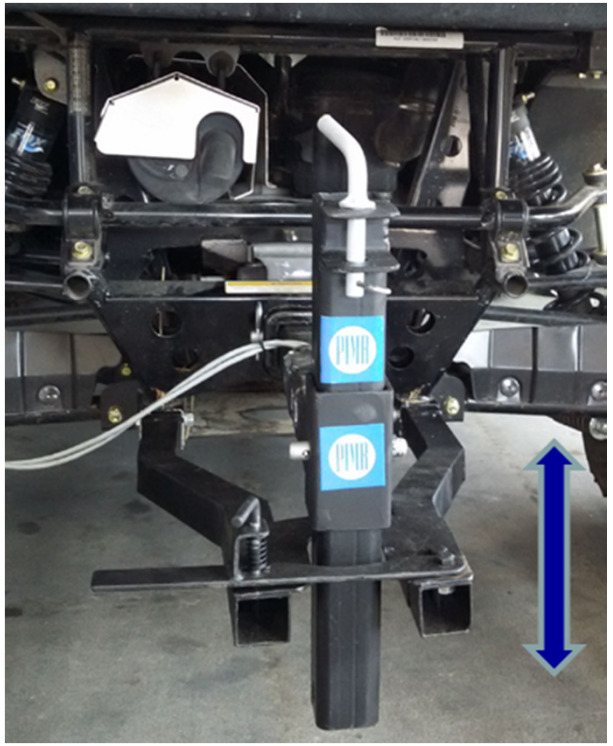
In 2014, the Prowler 700HDX, made by Arctic Cat, Canada, was bought by PIMR thanks funds of the R&D project No. UOD-DEM-1-145/00.

After preliminary traction field tests **it was rebuild by PIMR into the tracked ATV and a mini-tractor as well**, by installing **light rubber tracks** and **rigid cabin**. In addition, **on the loading floor** of the vehicle box **was mounted the aluminum frame** of the **stand for the adapters for the biomass bales**.
The **clevis pin hitch** was constructed in PIMR, wherein **on its main beam a load cell was mounted** in order to measure the biomass bales towing forces. Prowler with adapters and tools can be easily transported on a car's trailer

Wheeled ATV

Tracked ATV – mini-tractor of biomass train

The Prowler was equipped with special clevis pin hitch with a strain gauge bridge for the evaluation of the Prowler's towing capability. Changes of the voltage of the bridge are measured using NI CompactDAQ with NI 9205 module and LabVIEW software (National Instruments).



The older version of the hitch (0.6 m) for 1.2 m dia. bales - on left side,
and the new one (0.6 & 0.8 m) for 1.2 &1.6 m dia. bales - on right side

ATV - preliminary field tests

In February 2015 at Notec river meadows near Byszewice village, were conducted the first field tests of the Prowler.
Field trials were carried out in a sunny day, with an air temperature of a few degrees, the meadow was partly thawed to a depth of 1-2 cm. In shady places, the ground was covered with frost and shallow pools of water were frozen.

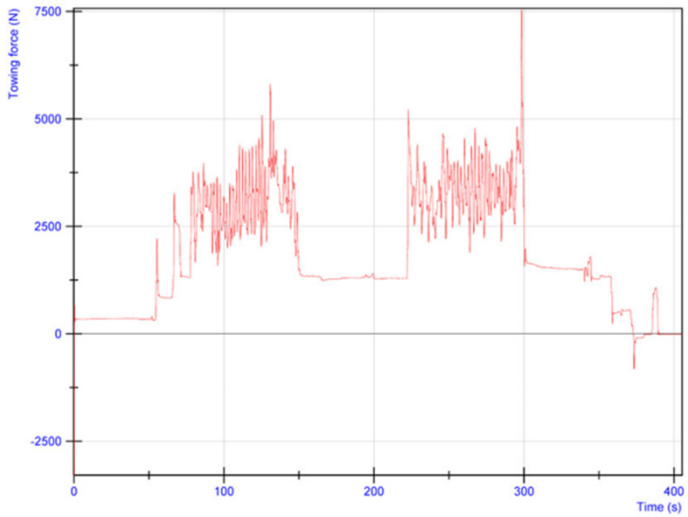
Some difficulty was that the biomass bales for a longer period (from September to February) were left in the meadow. The bales were partly dry out and deformed at the point of contact with the ground after several months of leaving bales in the meadow. Bales were firmly adhered to the ground and every biomass bale had to be separated from the frozen ground by hand pushing bales by several people .



Recorded routes of the Prowler's biomass train showed on the Google Earth satellite photo fully confirm the ability of the Prowler to work as mini-tractor of the biomass train. During field tests **14 biomass bales were transported** from the field to the edge of the road. **Prowler was able to tow 2-3 bales using the drive on two tracks** and for towing **4-5 bales - using 4x4 drive**. At a speed of approx. 4 kmph, the five bales biomass-train towing forces ranged between 2 and 4 kN. Light-ATV can significantly **reduce transport costs** of the biomass bales on wetlands and to improve environmental protection.

ATV - autumn field tests

In October 2015, repeated attempts to tow the biomass bales (dia. 1.2m) on Notec River's meadows near Biala village, Poland.



For a biomass-train: Prowler and five biomass bales - measured forces are in the range 2.5-4.5 kN.

Summary of the three phase technology developed by PIMR

1. PIMR's **tracked vehicles and tools proofed to be eco-friendly**. **Vehicles are much safer** for top root layer of vegetation than farm tractors, snow grooming vehicles and tracked trailers.

2. **Mower unit with conditioner was working better - than without it** - generally, biomass was cut into pieces ca. 30-50 cm of length.

3. **Vehicles unit for non-stop biomass swath harvesting and forming it into the round bales looks promising** – it is able to collect whole swath from the ground and it makes round biomass bales without any stops of vehicles unit.

4. Prowler 700HDX- **ATV can serve as the tracked mini-tractor of the biomass train**. **It can reduce transport costs of biomass bales on wetlands** to nearby warehouses.

5. **EcoSafe FR – fire-resistant and biodegradable oil** used for power hydraulics, **delta tracks** and **rolled on the ground biomass bales** have no any negative impact on the top root layer of vegetation.

6. **Tracked vehicle** and its tools modules **can be transported on light road units** *(Gross Vehicles Weight – 12000kgs)*, e.g. Iveco Daily 4x4 truck coupled with gooseneck trailer.

INNOVATIVE ECONOMY
NATIONAL COHESION STRATEGY

EUROPEAN UNION
EUROPEAN REGIONAL DEVELOPMENT FUND

Industrial Institute of Agricultural Engineering
Starolecka 31, 60-963 Poznan ; tel: +48 61 8712222 ; fax: +48 61 8793262

Three phase technology of harvesting and transportation of biomass from wetlands to nearby warehouses

Thank you for your attention but we have short annex with information on new tracked vehicle developed in R&D project conducted by PIMR

Adam P. Dubowski - Mobile:+48 601453602 ; E-mail : dubowski@pimr.poznan.pl ; Krzysztof Zembrowski – Mobile: +48602385216 ; Email: zembrowski@pimr.poznan.pl

ANNEX

Autonomous Tracked Vehicle for the biomass transport

Research test field was located near Trzcianka in Wapniarnia village. July, 2017

Project PBS2/B8/11/2013 is co-financed by the National Centre for Research and Development under the Applied Research Programme

Thank you once again