Kaunas

UNIVERSITY
OF WARMIA AND MAZURY
IN OLSZTYN

FACULTY OF AGRICULTURE
AND FORESTRY

MAIN RESEARCH AREAS –

Bioresources, Bioeconomy, Renewable Energy Sources

Prof. dr hab. inż. Mariusz Jerzy Stolarski

Head of the Department of Genetics, Plant Breeding and Bioresource Engineering

Faculty of Agriculture and Forestry

Head of the Centre for Bioeconomy and Renewable Energies

University of Warmia and Mazury in Olsztyn (UWM)

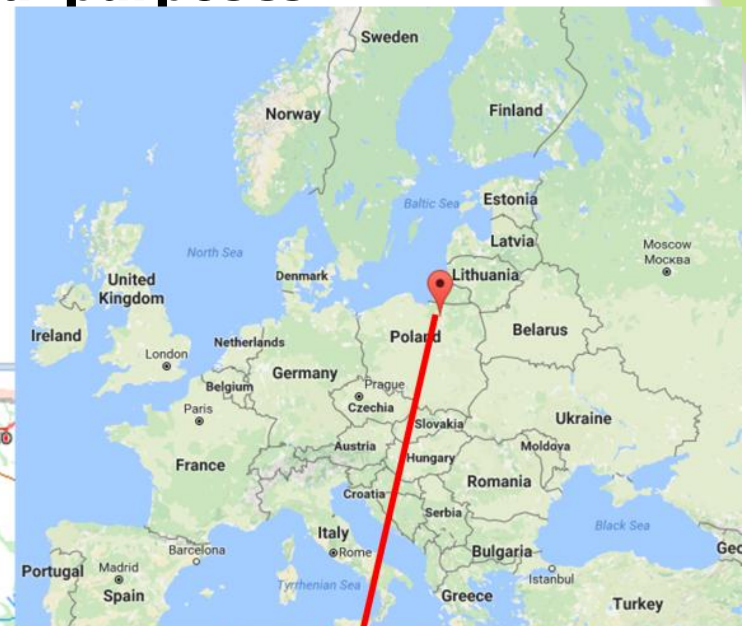
CBEO

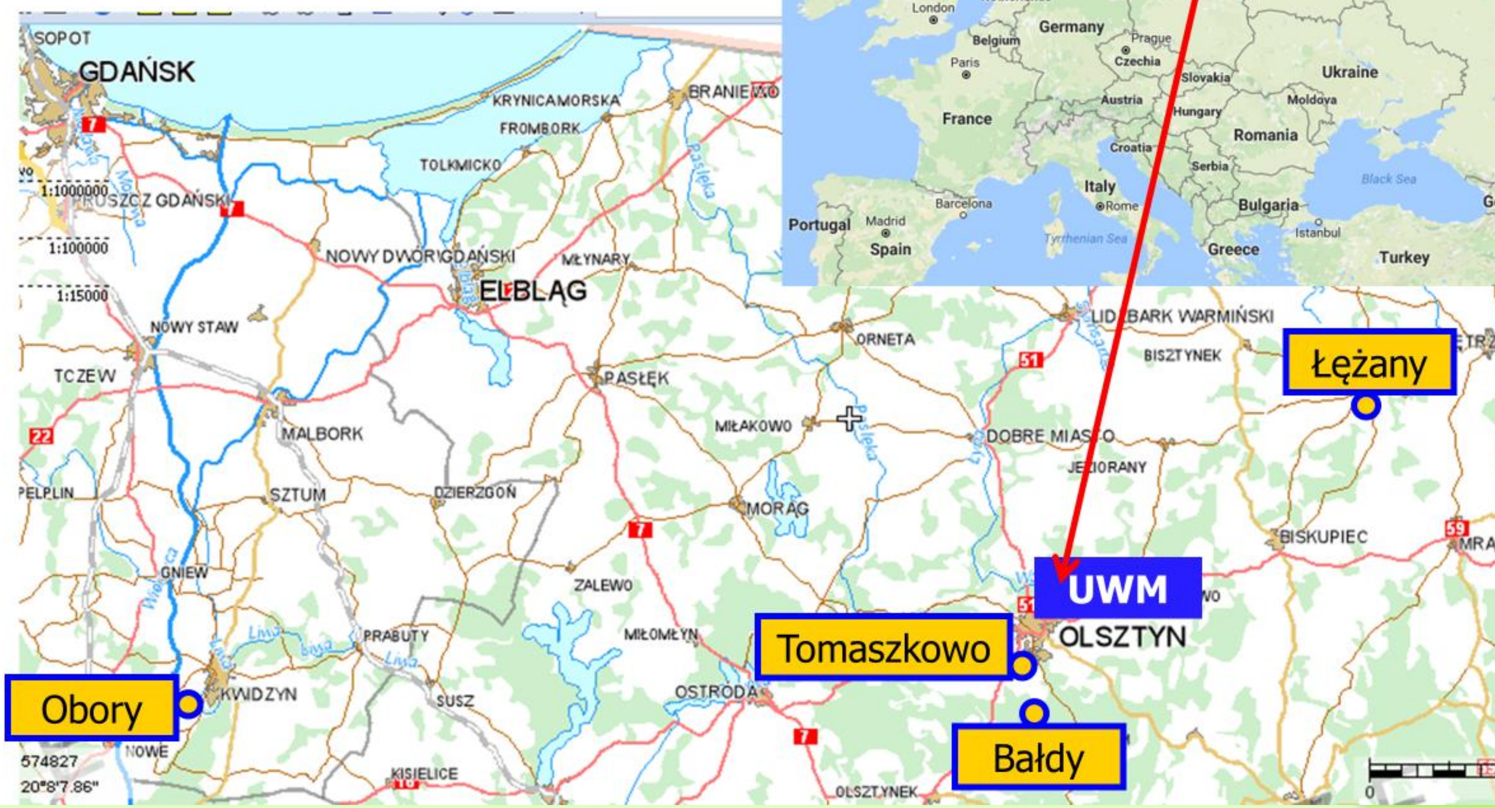
KGHRIB

Field experiments, biomass growing, productivity, quality and the use of perennial and annual alternative crops for energy and industrial purposes

UWM experiments with Perennial Industrial Crops (PIC) since 1992

(Stolarski 2018)





UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

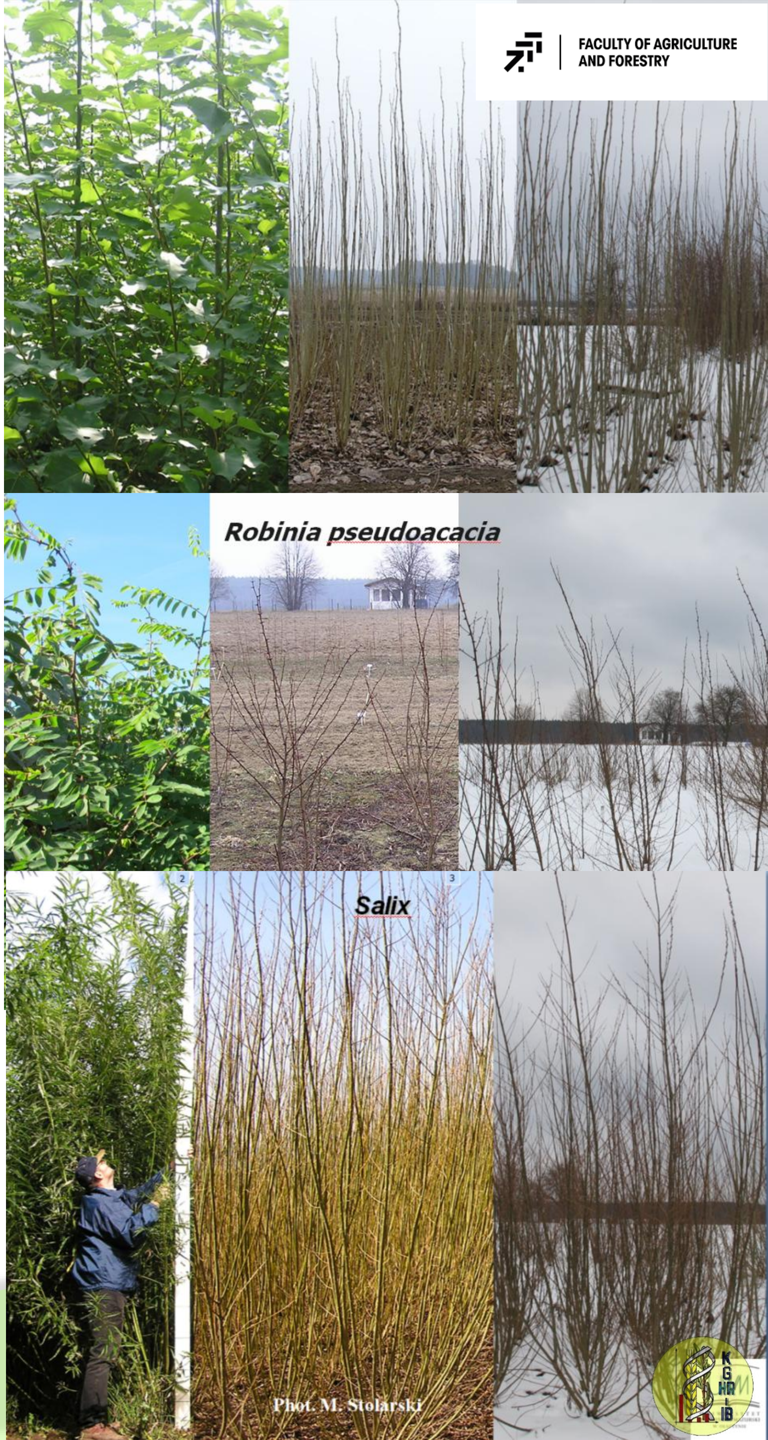
SRC in UWM experiments (woody biomass)

(Stolarski 2018)

- ***14 willow cultivars:*** *Start, Sprint, Turbo (2007); Bona, Kortur, Monotur, Oltur, Tur (2009); Ekotur, Żubr (2015); Aspi, Cortexa, Delta, Viva (2017) and* ***around 150 clones*** *eg.:* clone UWM 195C; *S. viminalis* L., clone UWM 263C; *S. viminalis* L., clone UWM 337C; *S. dasyclados* Willd, clone UWM 155; *S. pentandra* L., clone UWM 035; *S. alba* L., clone UWM 095.

- *Poplar e.g.: Populus balsamifera* L., clone UWM 2; *P. balsamifera* L., clone UWM 3; *P. nigra* × *P. maximowiczii* Henry cv. Max-5

- *Robinia pseudoacacia* L.



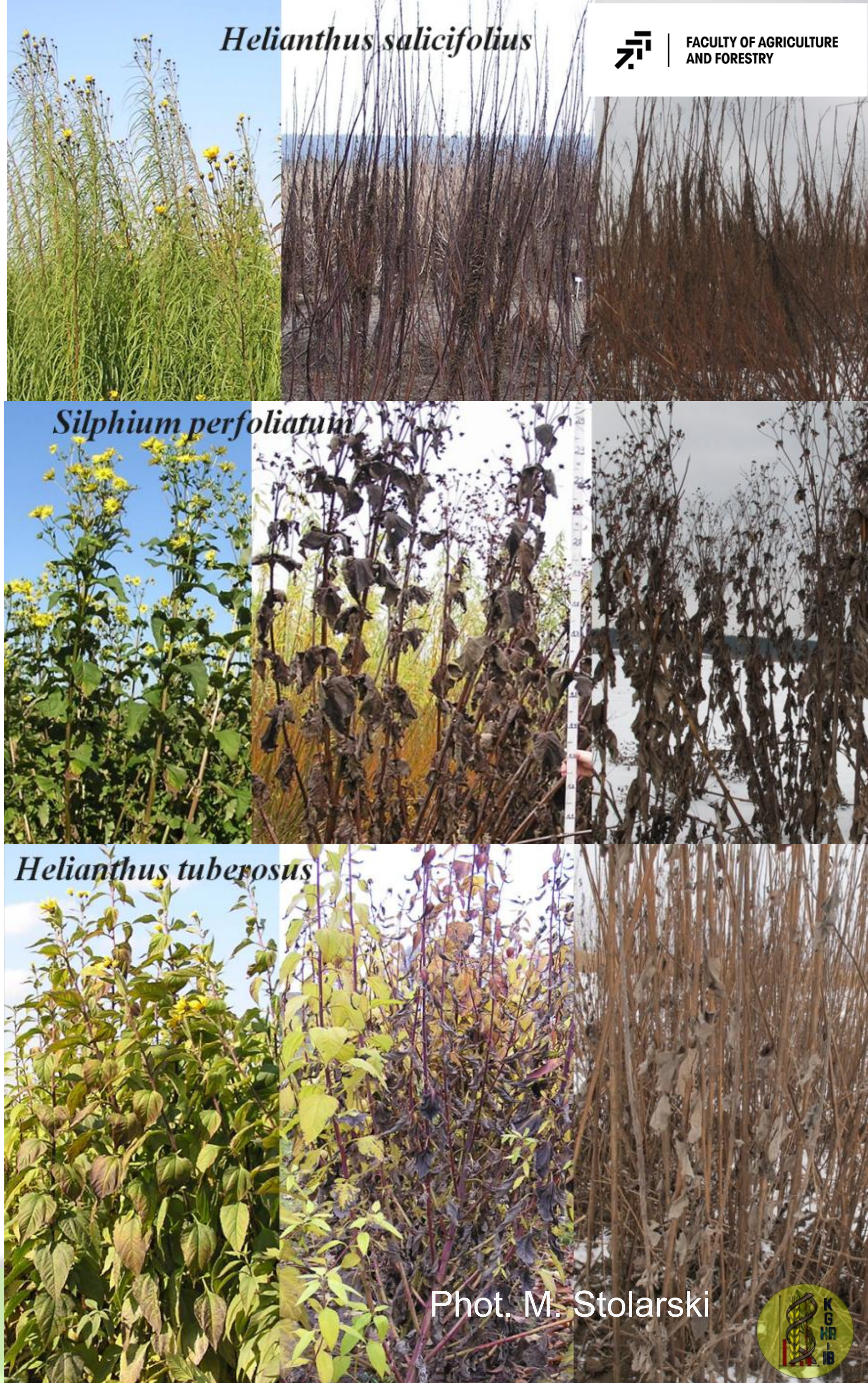
FACULTY OF AGRICULTURE AND FORESTRY

CBEO

Herbaceous crops in UWM experiments (semi-woody biomass)

(Stolarski 2018)

- *Helianthus salicifolius* A.Dietr
- *Sida hermaphrodita* Rusby L.
- *Silphium perfoliatum* L.
- *Reynoutria sachalinensis* Nakai
- *R. japonica* Houtt.
- *Helianthus tuberosus* L.



Grasses in UWM experiments (straw)

(Stolarski 2018)

- *Miscanthus × giganteus* J.M. Greef & M. Deuter
- *M. sacchariflorus* ((Maxim.) Hack.)
- *M. sinensis* ((Thunb.) Andersson)
- *Spartina pectinata* Bosc ex Link
- *Arundo donax* L.

The most popular PIC in Poland

(Stolarski 2018)

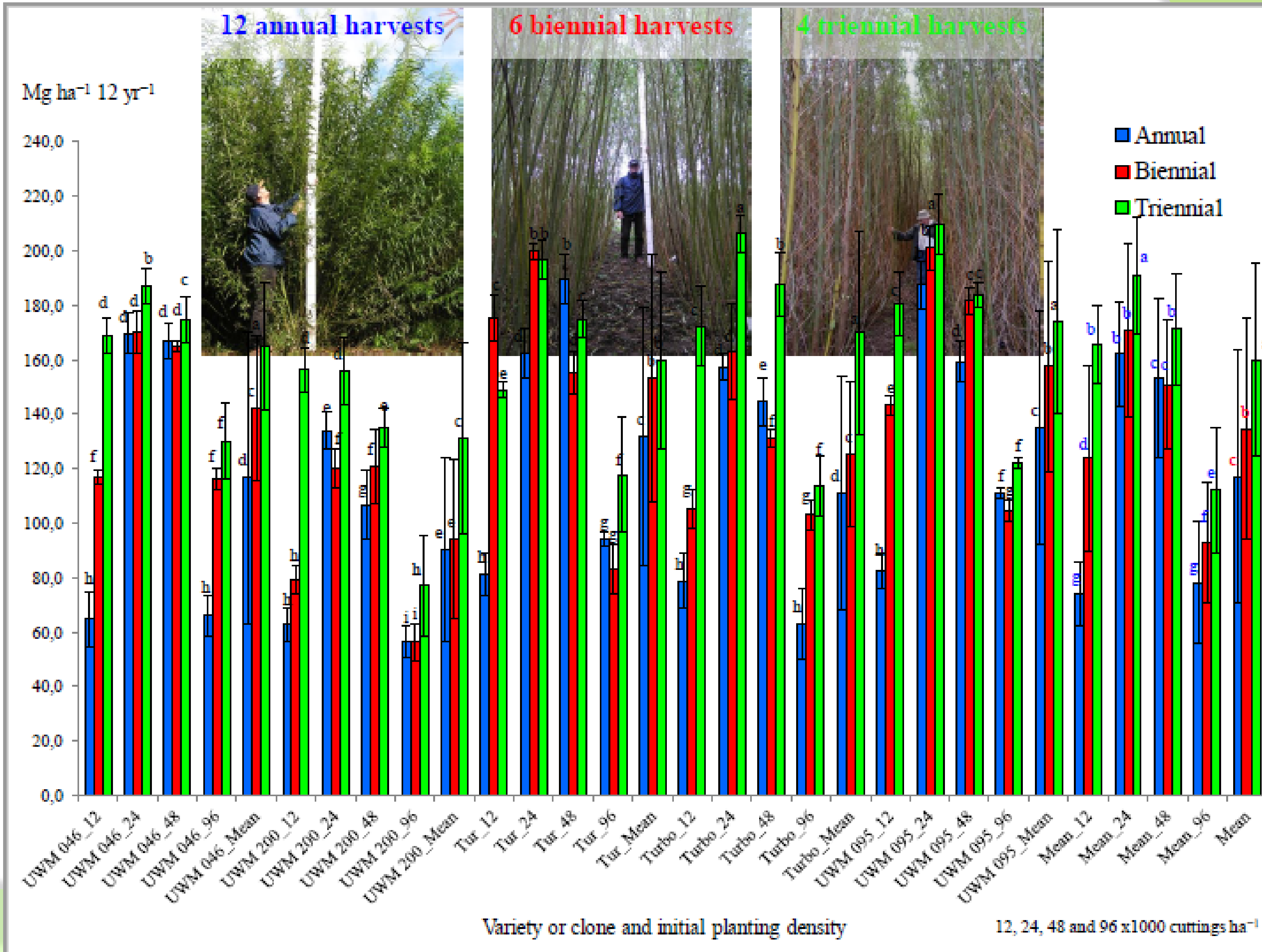
Short rotation coppices - SRC (Salix and Populus)

Herbaceous crops (Sida)

Grasses (Miscanthus)

Willow production during 12 consecutive years —The effects of harvest rotation, planting density and cultivar on dry biomass yield

(Stolarski et al. 2019. GCB Bioenergy. https://doi.org/10.1111/gcbb.12583)



Willow productivity from small- and large-scale experimental plantations in Poland from 2000 to 2017

(Stolarski et al. 2019. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2018.11.034)

annual SRC

bennial SRC

triennial SRC

quadrennial SRC

EcoSalix System

Mean yields of willow biomass in Poland (Mg ha^{-1} $year^{-1}$ d.m.)

Small-scale trials

Large-scale plantations

Production technology and logistics of biofeedstock acquisition and processing to obtain higher added value bioproducts and conversion to solid, liquid and gaseous biofuels

(Stolarski et al. 2021. Energies. https://doi.org/10.3390/en14216877)

Wood chips preparation from various types of wood biomass stored at the Quercus site and the logistics transport to the end consumer

SRC – EXAMPLES OF ONE STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM

(Stolarski 2019)

SRC – EXAMPLES OF TWO STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM

(Stolarski 2019)

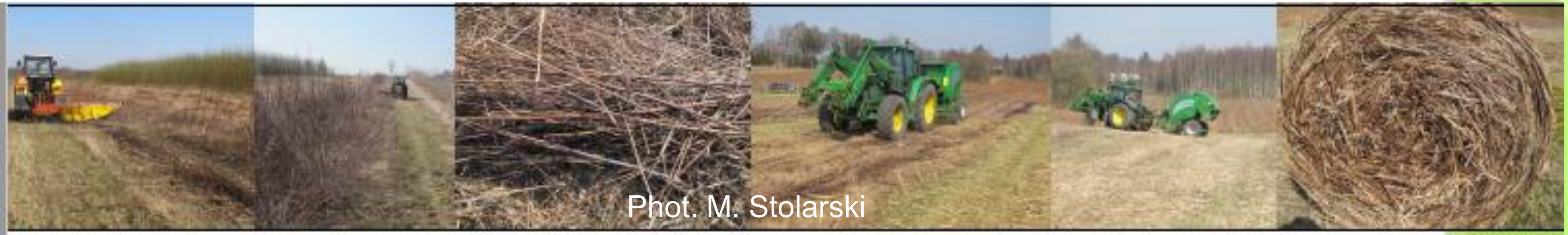
Phot. M. Stolarski

Phot. M. Stolarski

HERBACEOUS CROPS – EXAMPLES OF ONE STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM

(Stolarski 2019)

HERBACEOUS CROPS – EXAMPLES OF TWO STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM



GRASSES – EXAMPLES OF ONE STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM

(Stolarski 2019)

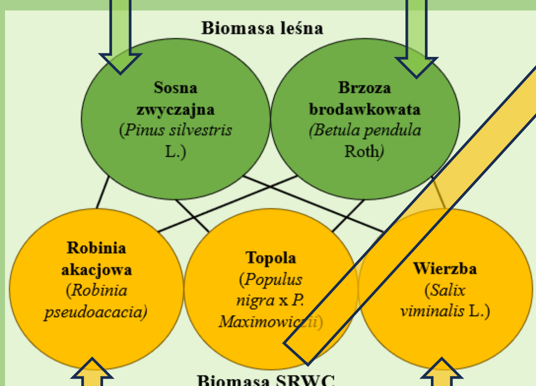
GRASSES – EXAMPLES OF TWO STAGE HARVEST AND BIOMASS LOGISTIC TECHNOLOGIES IN UWM

UNIVERSITY
OF WARMIA AND MAZURY
IN OLSZTYN

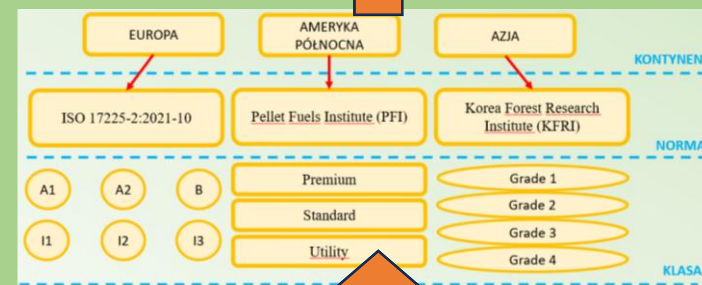
FACULTY OF AGRICULTURE
AND FORESTRY

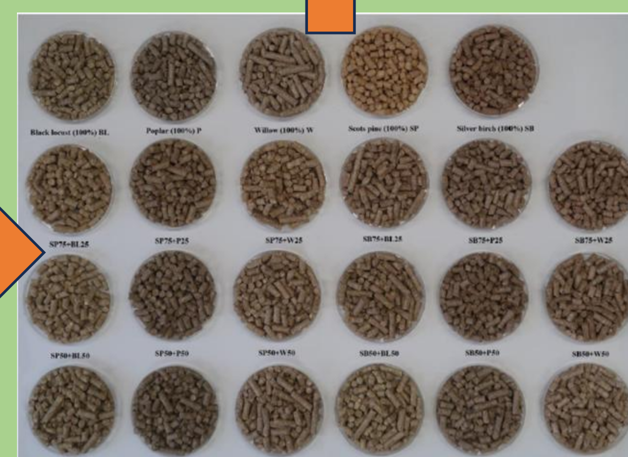
Short rotation woody crops and forest biomass sawdust mixture pellet production

(Stachowicz and Stolarski 2023. Industrial Crops and Products. https://doi.org/10.1016/j.indcrop.2023.116604)



3 types of pellets ≥ A1 (ISO) i Grade 1 (KFRI)
23 types of pellets in at least one class
0 out of class pellets





CBEO

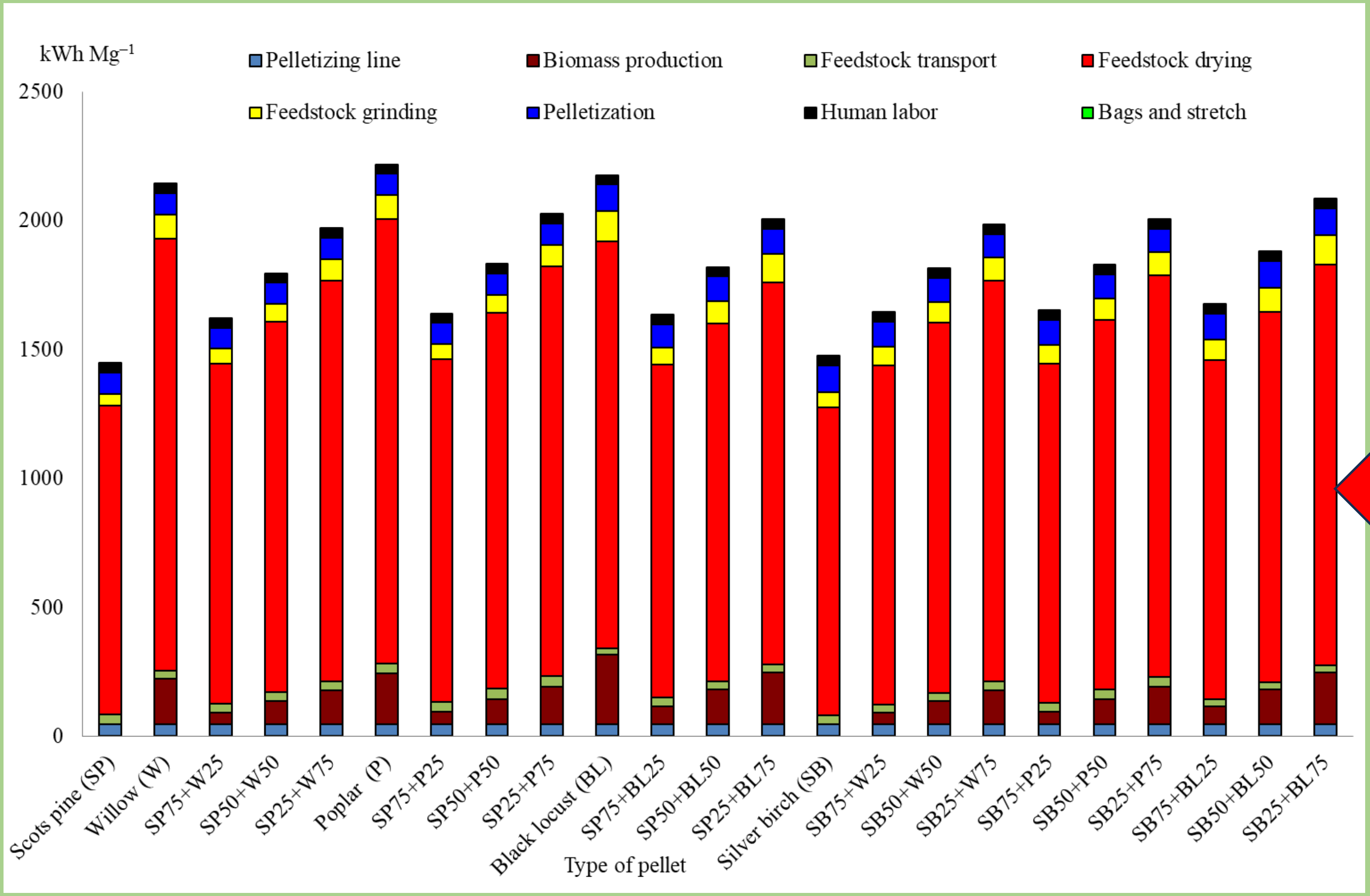
quercus

KGHR IB

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF AGRICULTURE AND FORESTRY

The energy input for pellet production (kWh Mg^{-1}) from selected types of forest and SRC biomass and from their mixtures (Stachowicz and Stolarski 2024. Renewable Energy. https://doi.org/10.1016/j.renene.2024.120250)



75-83%

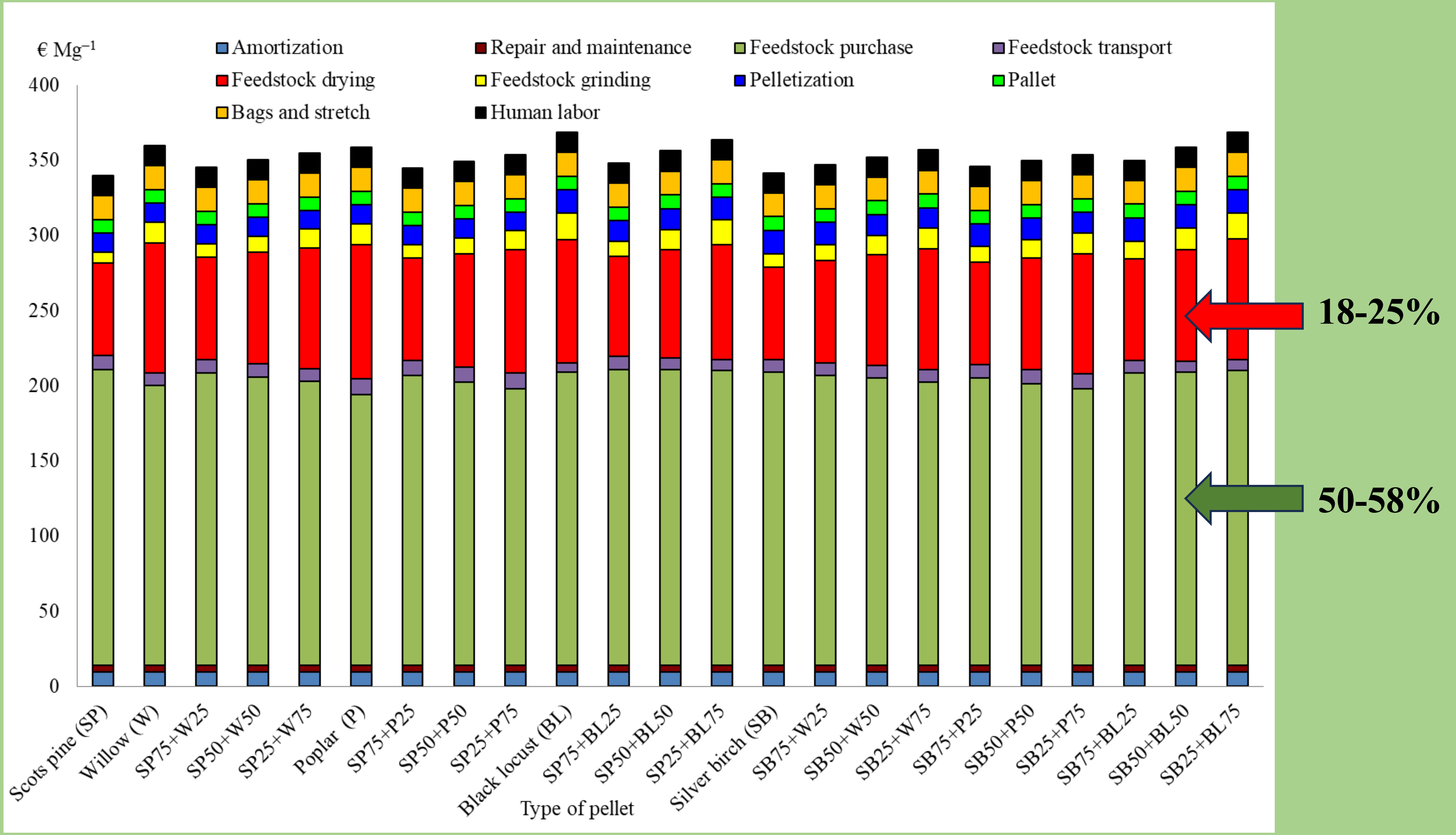
CBEO

quercus

KGHRiB

The cost of pellet production (€ Mg^{-1}) from selected types of forest and SRC biomass and from their mixtures

(Stachowicz and Stolarski 2024. Renewable Energy. https://doi.org/10.1016/j.renene.2024.120250)



UNIVERSITY
OF WARMIA AND MAZURY
IN OLSZTYN

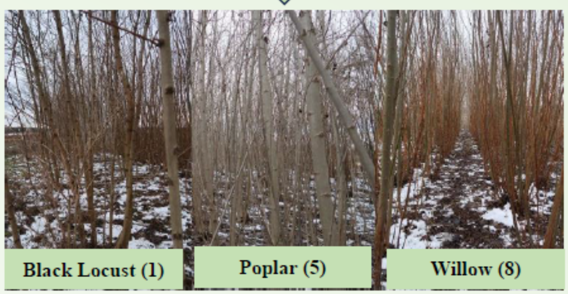
FACULTY OF AGRICULTURE
AND FORESTRY

Cascaded use of various agricultural - and forest- origin biofeedstock types

Wood of one-year-old and four-year-old SRWC shoots as a raw material for multi-purpose use (Stolarski et al. 2024. Energies. https://doi.org/10.3390/en17071535)

Assumptions of the experiment

14 genotypes of short rotation woody crops (SWRC)



Annual and quadrennial harvest cycle

Scope of analysis

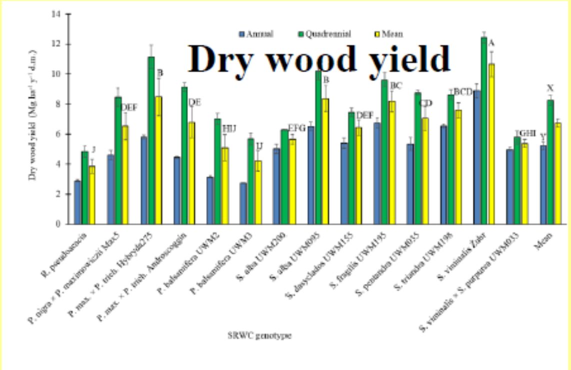
Wood yield
(Mg ha^{-1} y^{-1} d.m.)
Wood energy value
(GJ ha^{-1} y^{-1})

Thermophysical properties
HHV, moisture, ash, fixed carbon, volatile matter

Elemental composition
carbon, hydrogen, nitrogen, sulfur, chlorine

Lignocellulosic composition
soluble substances, hemicellulose, cellulose, lignin

Results



The highest dry wood yield and energy value gave willow (cultivar Żubr) in a quadrennial cycle

Willow and poplar wood contained more cellulose than black locust

Extending harvest rotation increased the content of cellulose lignin, carbon, HHV and decrease ash moisture and N, S content

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

BIOmagic project (Stolarski et al. 2017-2021)

FACULTY OF AGRICULTURE AND FORESTRY

Uniwersytet Warmińsko-Mazurski w Olsztynie (UWM) - Lider

ChemProf Doradztwo Chemiczne s.c. Michał Łuczyński, Katarzyna Łuczyńska ChemProf sp. z o.o (CP)

Quercus sp. z o.o (Qs)

Sieć Badawcza Łukasiewicz - Instytut Nowych Syntez Chemicznych (INS)

Instytut Uprawy Nawożenia i Gleboznawstwa Państwowy Instytut Badawczy (IUNG)

Instytut Technologiczno-Przyrodniczy (ITP)

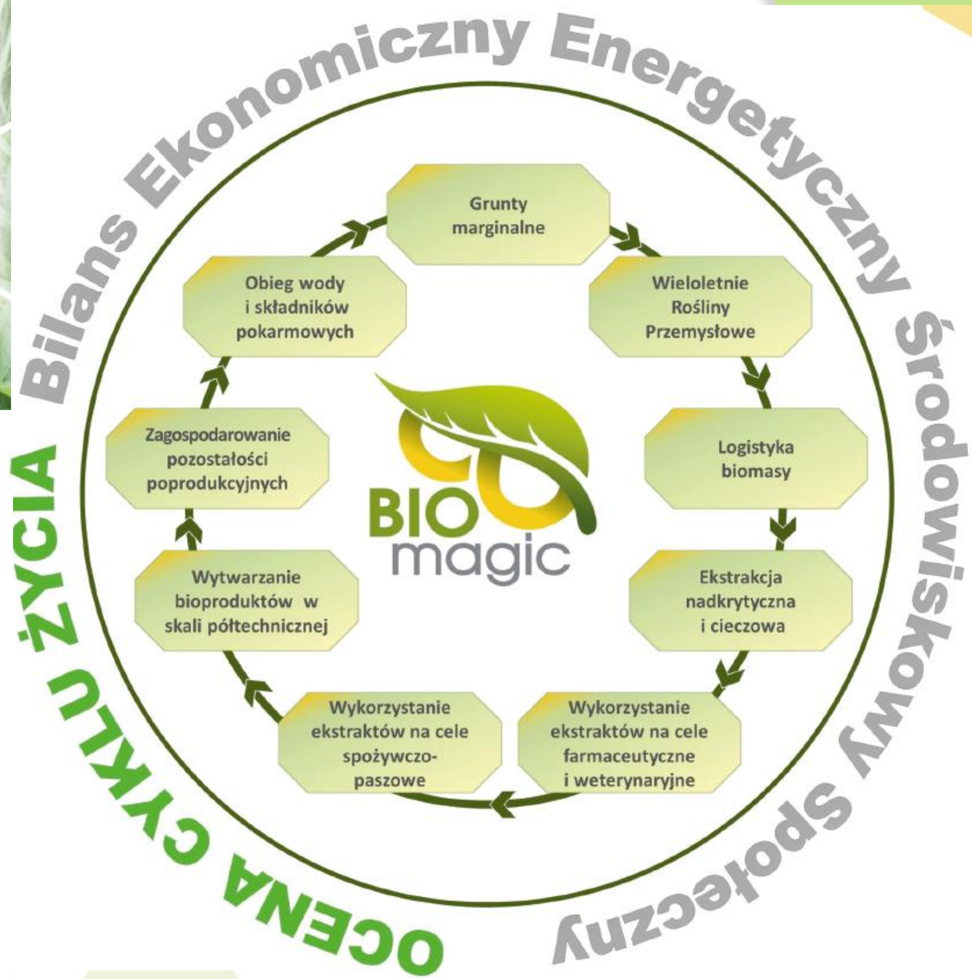
Uniwersytet Medyczny w Lublinie (UMLUB)

BIO magic

Narodowe Centrum Badań i Rozwoju

BIO magic

Narodowe Centrum Badań i Rozwoju



CBEO

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF AGRICULTURE AND FORESTRY

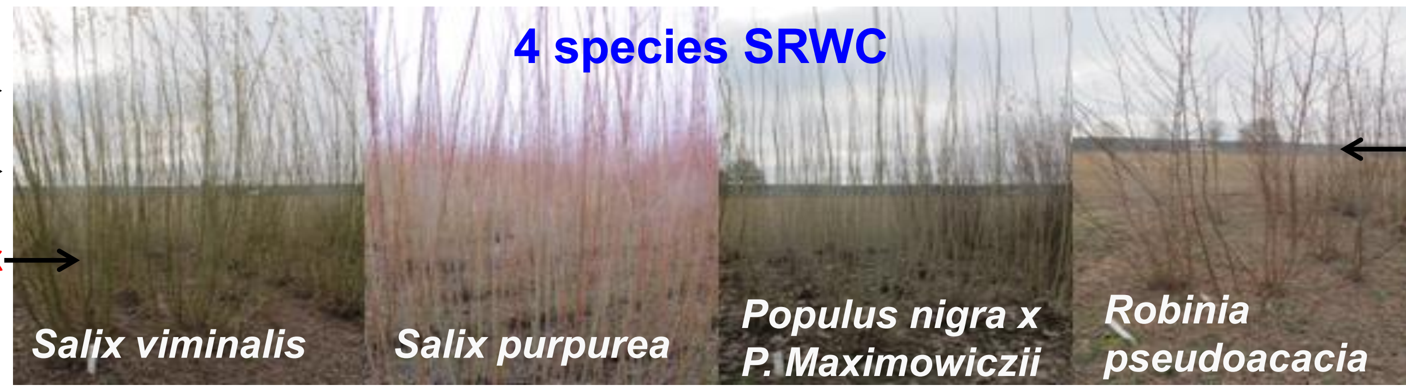
Sustainable technologies for cultivation of Perennial Industrial Crops (Stolarski et al. 2017-2021)

- The objective of this task is to evaluate factors which affect the productivity and thermophysical and chemical properties of biomass **of 11 PIC species,** generating biomass in the form of **wood, semiwood and straw**, in the context of sustainable biomass production. Elaboration of **optimal PIC cultivation technologies** on marginal land, and delivery of biomass, satisfying the quality requirements, to the project's partners.

bark →

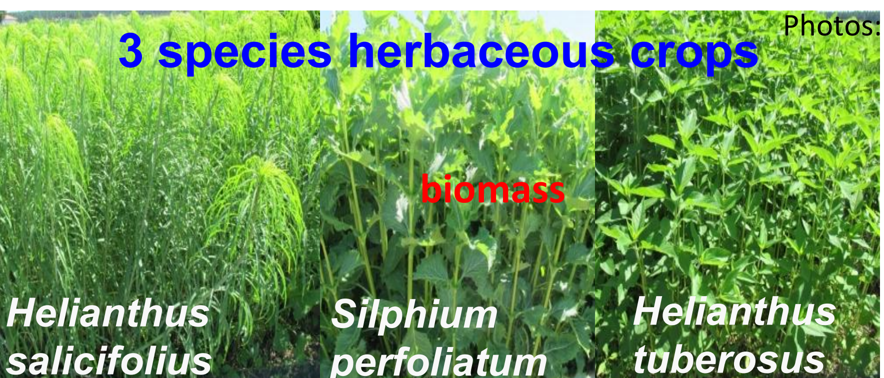
wood →

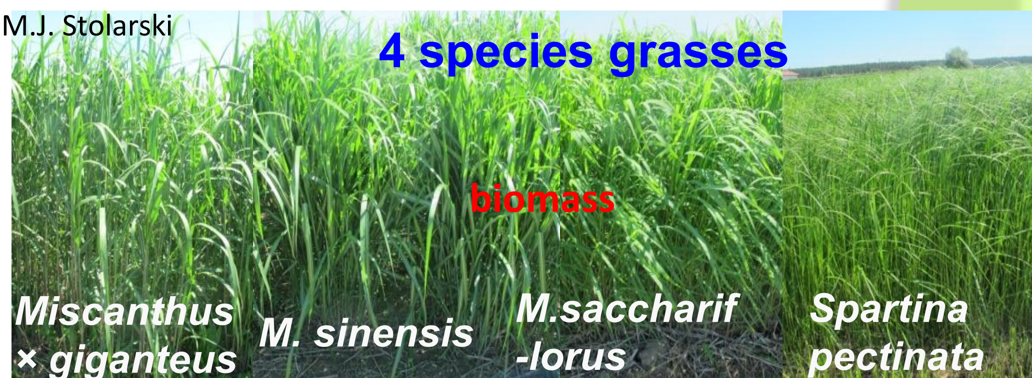
wood+bark →



← Harvest time: February/March

Photos: M.J. Stolarski





Harvest time: (i) February/March, (ii) June, (iii) October

CBEO

Plant extracts from supercritical extraction and management of post-extraction biomass

(Stolarski et al. 2017-2021)

PIC lignocellulosic biomass

source: UWM

Supercritical extraction

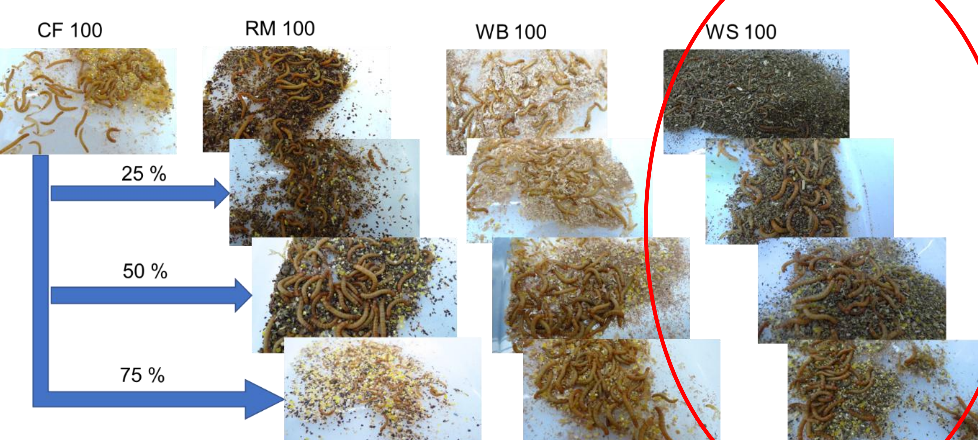
source: INS

Extracts

source: INS

Post-extraction biomass

in yellow mealworm rearing



Bordiean et al. 2022. Insects. https://doi.org/10.3390/insects13090810

for pellet production

Stolarski et al. 2022. Industrial Crops and Products. https://doi.org/10.1016/j.indcrop.2022.115104

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF AGRICULTURE AND FORESTRY

BIOmagic final bioproduct - Veterinary bioproduct - cow udder care gel

(Stolarski et al. 2017-2021)

Narodowe Centrum Badań i Rozwoju

ChemProf

MINT-HERB

BIO magic

Skład: ekstrakt z szałwii, woda, etocas, olejek miętowy, karboksymetyloceluloza, gliceryna, ekstrakt SFE z topoli, paraben

Właściwości: Preparat pielęgnacyjny do wymion zawierający innowacyjny ekstrakt SFE z topoli do pielęgnacji i łagodzenia podrażnień skóry wymienia.

Zastosowanie: Preparat stosować w celu utrzymania fizjologicznych funkcji skóry wymienia.

Uwagi: Tylko do użytku zewnętrznego.
Nie stosować na otwarte rany.

Sposób użycia: Preparat wcierać w skórę wymienia.
Profilaktycznie smarować skórę wymienia raz lub dwa razy w tygodniu.

Producent: ChemProf Doradztwo Chemiczne s.c.
Michał Łuczyński, Katarzyna Łuczyńska i Chemprof Sp. z o.o.
ul. Gutkowo 54B, 11-041 Olsztyn

Zakład produkcyjny: ul. Pasymska 23, 12-120 Dźwierzuty

Numer weterynaryjny: α PL 2817002p

Najlepiej wykorzystać przed:

Data produkcji/Numer partii:

Warunki przechowywania:
Przechowywać w temperaturze pokojowej, w zamkniętym opakowaniu.

Pojemność: 1kg

source: CP

CBEO

K G HR IB

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF AGRICULTURE AND FORESTRY

Assessment of economic, energetic and environmental effectiveness of cultivation, production, logistics and processing of biomaterials

BIO magic

Narodowe Centrum Badań i Rozwoju

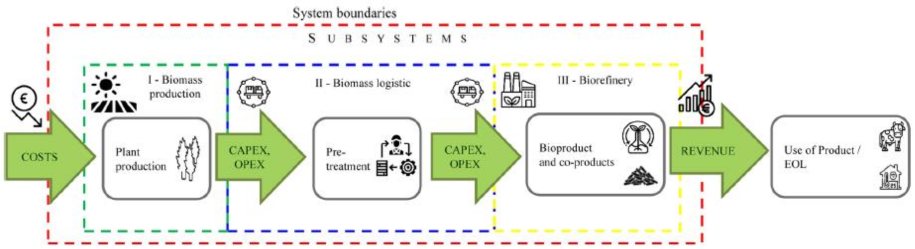
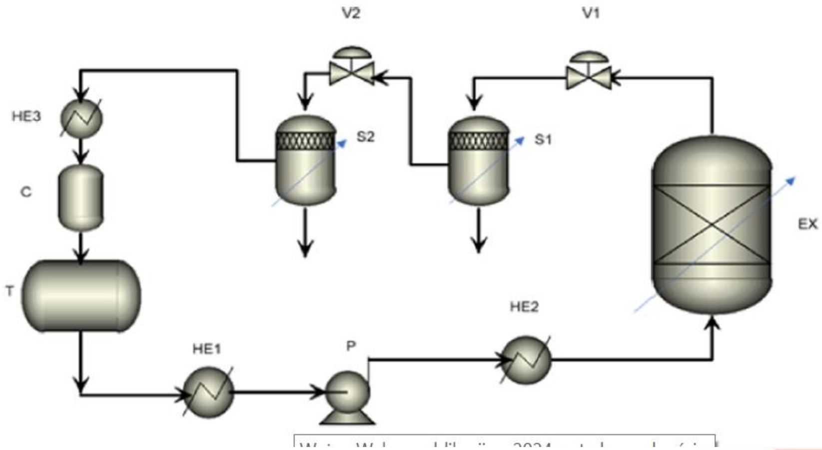
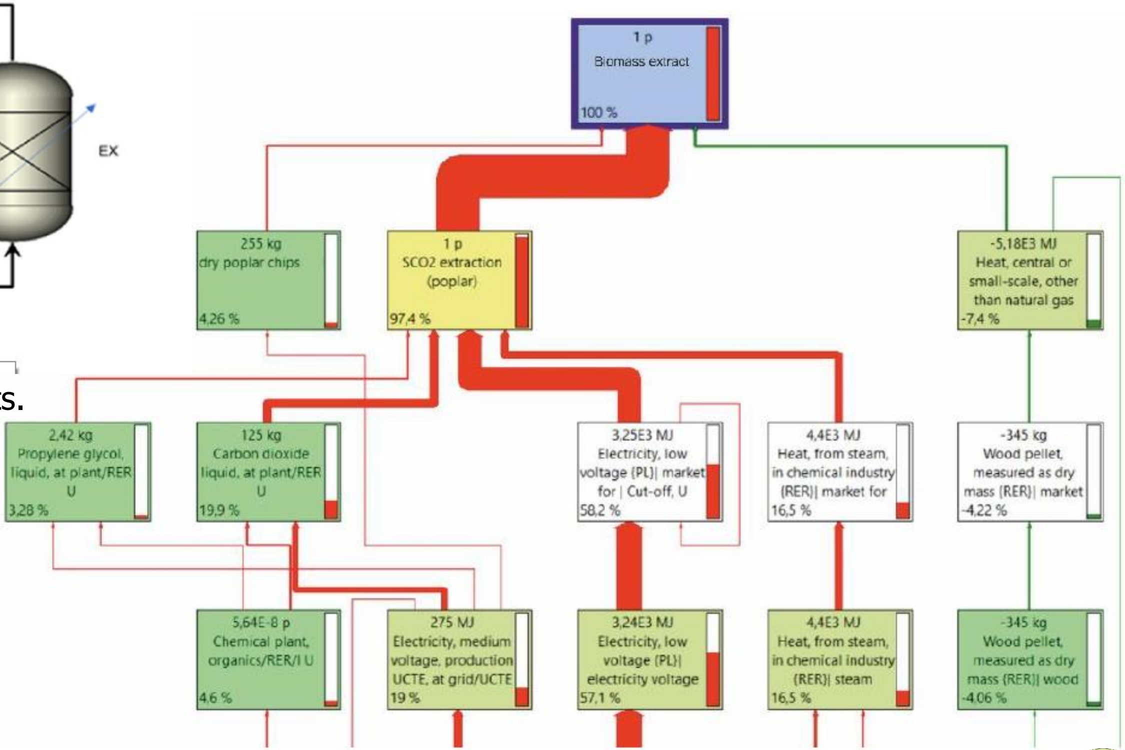


Fig. 1. System boundaries for the economic analysis (CAPEX – capital expenditures, OPEX – operational expenditures).

Economic and environmental analysis of poplar extract production



(Olba-Zięty et al. 2022. Industrial Crops and Products. https://doi.org/10.1016/j.indcrop.2022.115094)

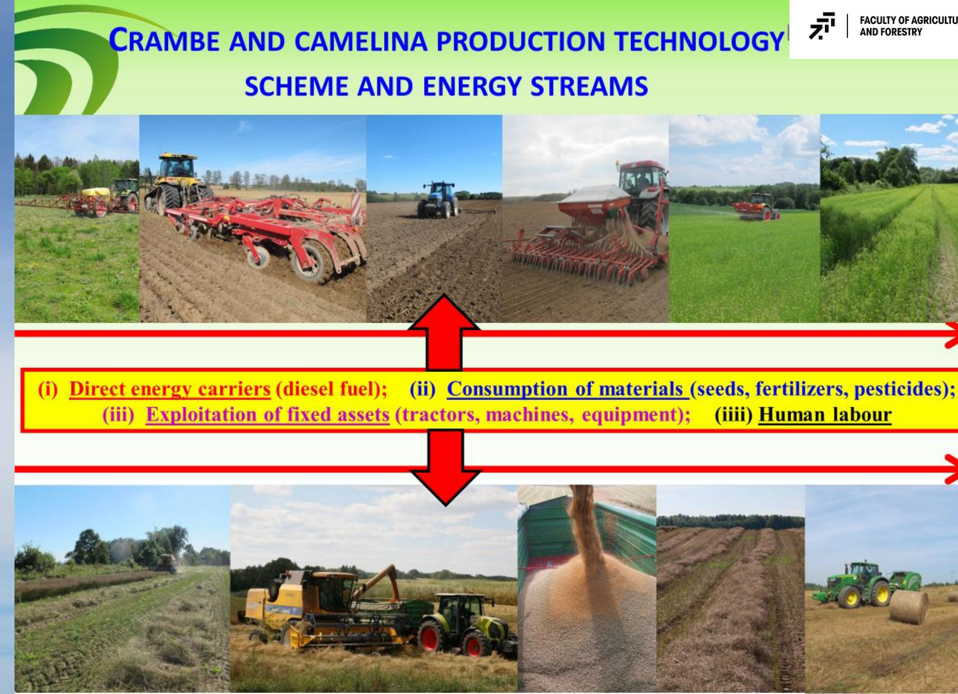


(Krzyżaniak et al. 2023. Energies. https://doi.org/10.3390/en16217287)

CBEO

KGHR IB

Assessment of economic, energetic and environmental effectiveness of cultivation, production, logistics and processing of biomaterials



Indices of economic efficiency of camelina and crambe production, average for three years

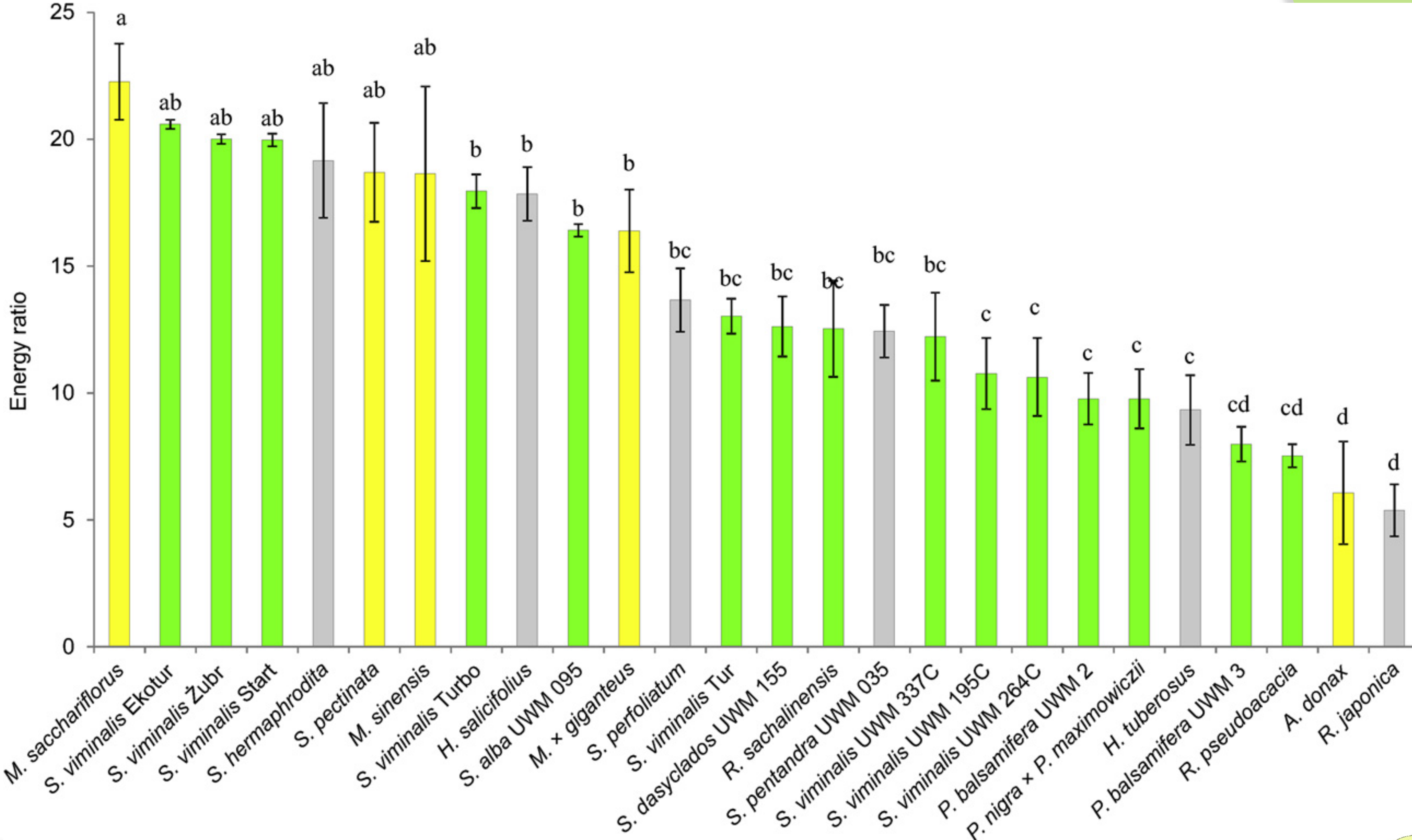
(Stolarski et al. 2018)

Item	Camelina	Crambe
Income from seeds (€ ha^{-1})	876.3	773.7
Income from straw (€ ha^{-1})	120.6	118.6
Total income (€ ha^{-1})	996.9	892.3
Cost of seed production (€ Mg^{-1})	455.5	464.9
Cost of straw production (€ Mg^{-1})	220.1	230.7
Cost of production regarding to the oil content (€ Mg^{-1})	1235.0	1383.5
Revenue from seeds (€ ha^{-1})	**312.0**	**199.6**
Total revenue, from seeds and straw (€ ha^{-1})	**432.6**	**318.2**

(Stolarski et al. 2018. Energy. https://doi.org/10.1016/j.energy.2018.03.021)

Energy ratio for the production of 26 perennial industrial crops genotypes in six consecutive annual harvest rotations (2012–2017)

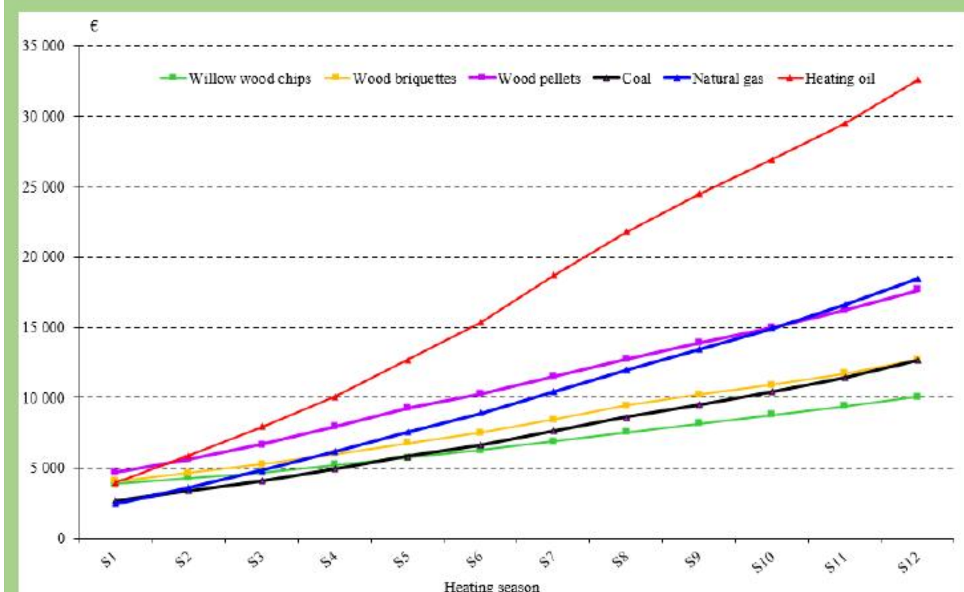
(Stolarski et al. 2019; Industrial Crops and Products. https://doi.org/10.1016/j.indcrop.2019.04.022)

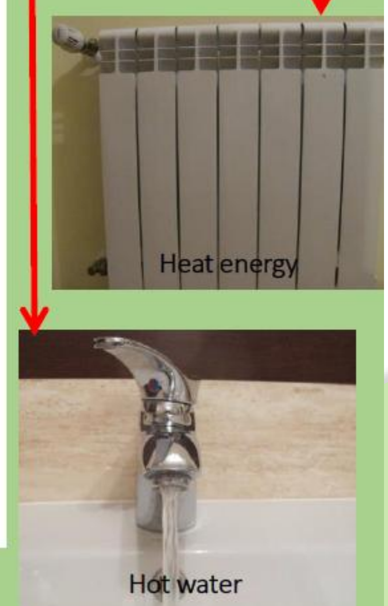


CBEO

Characterisation and assessment of biomass and other RES usability on an individual, local, regional, national and international level

Is heating a detached house with solid biomass for 12 years cheaper than heating with fossil fuels?



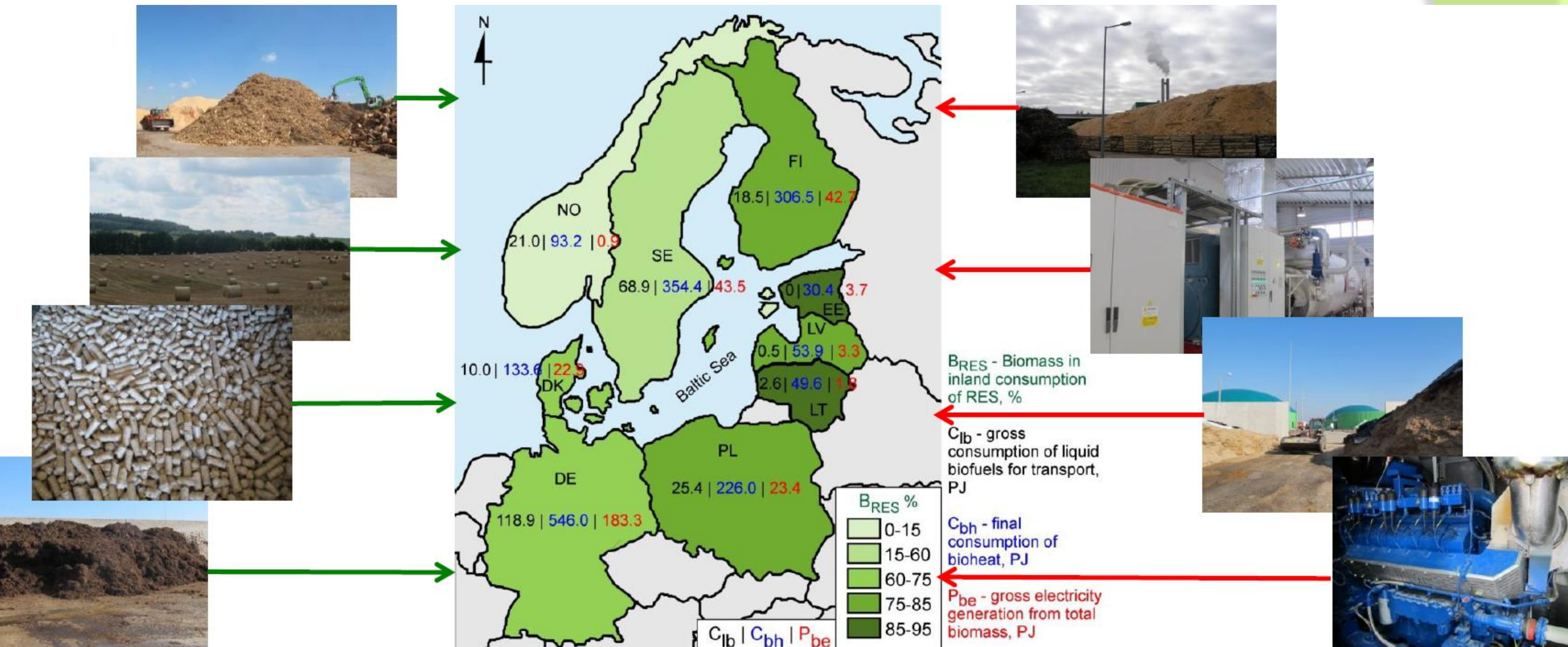


The financial flows related to operation of a briquette-fired boiler compared to the other fuels during the 12 heating seasons

(Stolarski et al. 2020. Energy. https://doi.org/10.1016/j.energy.2020.117952)

Characterisation and assessment of biomass and other RES usability on an individual, local, regional, national and international level

Bioenergy technologies and biomass potential vary in northern European countries



(Stolarski et al. 2020. Renewable and Sustainable Energy Reviews. https://doi.org/10.1016/j.rser.2020.110238)

Bioconversion of various types of biomass residues by insects

UWM - VALUE CHAIN BASED ON INSECT REARING

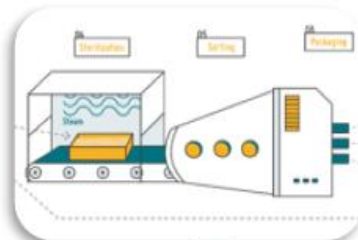
Substrates for insect rearing based on by-products and residues

Dry residues :
- cereal brans
- cakes and meals from oil extraction
- 2nd gade seeds from seed cleaning

Wet residues :
- industrial grade vegetables and fruits
- pomace
- expired food

Insect rearing

Insect processing



Products

- Insect meal
- Insect oil
- Insect protein
- Fertiliser
- Chitosan

Interreg
CENTRAL EUROPE
Co-funded by
the European Union
TeBiCE

References

Stolarski M.J., Krzyżaniak M., Kwiatkowski J., Tworkowski J., Szczukowski S. 2018. Energy and economic efficiency of camelina and crambe biomass production on a large-scale farm in north-eastern Poland. Energy 150: 770–780. https://doi.org/10.1016/j.energy.2018.03.021.

Stolarski M.J., Szczukowski S., Tworkowski J., Krzyżaniak M. 2019. Extensive willow biomass production on marginal land. Polish Journal of Environmental Studies, 28(6): 1–9. https://doi.org/10.15244/pjoes/94812.

Stolarski M.J., Warmiński K., Krzyżaniak M. 2020. Energy value of yield and biomass quality of poplar grown in two consecutive 4-year harvest rotations in the north-east of Poland. Energies, 13, 1495. doi:10.3390/en13061495.

Stolarski M.J., Krzyżaniak M., Załuski D., Tworkowski J., Szczukowski S. 2020. Effects of site, genotype and subsequent harvest rotation on willow productivity. Agriculture, 10, 0412; doi:10.3390/agriculture10090412.

Stolarski M.J., Warmiński K., Krzyżaniak M., Tyśkiewicz K., Olba–Zięty E., Graban Ł., Lajszner W., Załuski D., Wiejak R., Kamiński P., Rój E. 2020. How does extraction of biologically active substances with supercritical carbon dioxide affect lignocellulosic biomass properties?. Wood Science and Technology, 54: 519–546. https://doi.org/10.1007/s00226-020-01182-5.

Stolarski M.J., Krzyżaniak M., Warmiński K., Załuski D., Olba–Zięty E. 2020. Willow biomass as energy feedstock: the effect of habitat, genotype and harvest rotation on thermophysical properties and elemental composition. Energies, 13, 4130; doi:10.3390/en13164130.

Bordiean A., Krzyżaniak M., Stolarski M.J. 2022. Bioconversion potential of agro-industrial byproducts by Tenebrio molitor - long-term results. Insects 13, 810. https://doi.org/10.3390/insects13090810.

Krzyżaniak M., Stolarski M.J., Warmiński K 2019. Life cycle assessment of poplar production: Environmental impact of different soil enrichment methods. Journal of Cleaner Production, 206: 785-796. https://doi.org/10.1016/j.jclepro.2018.09.180.

Olba–Zięty E., Stolarski M.J., Krzyżaniak M., Gołaszewski J. 2020. Environmental external cost of poplar wood chips sustainable production. Journal of Cleaner Production 252: 119854. https://doi.org/10.1016/j.jclepro.2019.119854.

Stolarski M.J., Szczukowski S., Tworkowski J., Krzyżaniak M., Załuski D. 2019. Willow production during 12 consecutive years—The effects of harvest rotation, planting density and cultivar on biomass yield. GCB Bioenergy, 11: 635–656. https://doi.org/10.1111/gcbb.12583 DOI: 10.1111/gcbb.12583.

Stolarski M.J., Niksa D., Krzyżaniak M., Tworkowski J., Szczukowski S. 2019. Willow productivity from small- and large-scale experimental plantations in Poland from 2000 to 2017. Renewable and Sustainable Energy Reviews, 101: 461–475. https://doi.org/10.1016/j.rser.2018.11.034.

Stolarski M.J., Stachowicz P., Sieniawski W., Krzyżaniak M., Olba-Zięty E. 2021. Quality and delivery costs of wood chips by railway vs. road transport. Energies, 14, 6877. https://doi.org/10.3390/en14216877.

Stolarski M.J., Gil, Ł., Krzyżaniak M., Olba-Zięty E., Wu A.-M. 2024. Willow, poplar, and black locust debarked wood as feedstock for energy and other purposes. Energies, 17, 1535. https://doi.org/10.3390/en17071535.

Stachowicz P., Stolarski M.J. 2023. Short rotation woody crops and forest biomass sawdust mixture pellet quality. Industrial Crops and Products, 197, 116604, https://doi.org/10.1016/j.indcrop.2023.116604.

Stolarski M.J., Śnieg M., Krzyżaniak M., Tworkowski J., Szczukowski S., Graban Ł., Lajszner W. 2018. Short rotation coppices, grasses and other herbaceous crops: Biomass properties versus 26 genotypes and harvest time. Industrial Crops and Products: 119: 22–32. https://doi.org/10.1016/j.indcrop.2018.03.064.

Krzyżaniak M., Stolarski, M.J., Warmiński K., Rój E., Tyśkiewicz K., Olba-Zięty E. 2023. Life Cycle Assessment of Poplar Biomass for High Value Products and Energy. Energies, 16, 7287. https://doi.org/10.3390/en16217287.

Olba-Zięty E., Stolarski M.J., Krzyżaniak M., Rój E., Tyśkiewicz K., Łuczyński M.K. 2022. Supercritical production of extract from poplar containing bioactive substances – An economic analysis. Industrial Crops and Products, 184, 115094. https://doi.org/10.1016/j.indcrop.2022.115094.

Stolarski M.J., Krzyżaniak M., Warmiński K., Olba–Zięty E., Penni D., Bordiean A., 2019. Energy efficiency indices for lignocellulosic biomass production: Short rotation coppices versus grasses and other herbaceous crops. Industrial Crops and Products, 135: 10-20. https://doi.org/10.1016/j.indcrop.2019.04.022.

Stachowicz P., Stolarski M.J. 2024. Pellets from mixtures of short rotation coppice with forest-derived biomass: Production costs and energy intensity. Renewable Energy 225, 120250. https://doi.org/10.1016/j.renene.2024.120250.

Stolarski M.J., Warmiński K., Krzyżaniak M., Olba–Zięty E., Stachowicz P. 2020. Energy consumption and heating costs for a detached house over a 12-year period – Renewable fuels versus fossil fuels. Energy, 204, 117952. https://doi.org/10.1016/j.energy.2020.117952.

Stolarski M.J., Warmiński K., Krzyżaniak M., Olba–Zięty E., Akincza M. 2020. Bioenergy technologies and biomass potential vary in northern European countries. Renewable and Sustainable Energy Reviews, 133, 110238, https://doi.org/10.1016/j.rser.2020.110238.

Stolarski M.J., Warmiński K., Krzyżaniak M., Olba-Zięty E. 2022. Cascaded use of perennial industrial crop biomass: The effect of biomass type and pre-treatment method on pellet properties. Industrial Crops and Products, 185, 115104. https://doi.org/10.1016/j.indcrop.2022.115104.

Stachowicz P., Stolarski M.J. 2024. Pellets from mixtures of short rotation coppice with forest-derived biomass: Production costs and energy intensity. Renewable Energy 225, 120250. https://doi.org/10.1016/j.renene.2024.120250.

UNIVERSITY OF WARMIA AND MAZURY IN OLSZTYN

FACULTY OF AGRICULTURE AND FORESTRY

THANK YOU FOR YOUR ATTENTION

Professor Mariusz Jerzy Stolarski, PhD, Eng.

University of Warmia and Mazury in Olsztyn, Poland

mariusz.stolarski@uwm.edu.pl

http://www.uwm.edu.pl; http://wril.uwm.edu.pl; http://wril.uwm.edu.pl/kghb

CBEO