

Clean energy from biomass

Harvest of Energy

EMIL NALBORCZYK
Polish Academy of Sciences
emil.nalborczyk@pan.pl



Where should we look for renewable, environment-friendly sources of energy? The answer is simple: try to understand the term „green energy” literally.

Professor Emil Nalborczyk, Vice-President of the PAN, has for many years been investigating the photosynthetic efficiency of plants and the adaptation of new and alternative plant species into agricultural practice

Whenever we are confronted with more reports of fuel price hikes or further global warming, it becomes clear that the consumption of petroleum and coal cannot be a good long-term strategy. We need to tap into renewable energy sources, as well as sources that will enable emissions of greenhouse gasses to be gradually curbed. Indeed, such new sources should ideally have both of these properties.

Renewable energy now accounts for some 6% of all energy consumed in the EU. By 2010, however, this percentage is slated to

increase twofold. Poland itself has an equally ambitious goal: to derive 7.5% of all its energy from renewable sources in 2010. While this is less than the planned EU average, at present the figure in Poland is now below 3%. How can such a significant increase be achieved? Polish scientists know the answer.

Ecological strategy

Already now, plant biomass (meaning the energy stored in plant tissues) represents one of the fundamental sources of renewable energy. Almost all of the renewable energy in Poland is presently derived from this source. But this has not exhausted the potential of agriculture, the largest potential biomass producer. This is why research on specific aspects involved in the efficient harnessing of energy from plants is now underway at more than a dozen Polish scientific institutions: institutes of the Polish Academy of Sciences, R&D centers, and institutions of higher education. These endeavors all form part of an extensive research project on solid biofuels, authored by the Division of Agricultural, Forestry, and Veterinary Sciences of the Polish Academy of Sciences. This project is currently waiting to be adopted by the government as a strategic program. International cooperation will help contribute to the successful realization of the project. Potential program implementers are now or will in the future be participating in the following programs: the Global Change - International Geosphere-Biosphere Programme, the World Climate Change Programme, the International Human Dimension Programme, and the Global Carbon Cycle Joint Project.

Cultivating plants to be used for energy purposes in Poland will enable us to harness the arable lands that are now standing fallow (currently 1.5 million ha) as well as soils that have been polluted by industry and transport (some 1.8 million ha). Assuming that we can put 1/4 of this area to use for energy crops, each year we would be able

Every hectare planted with *Miscanthus giganteus* grass can produce as much energy as 15-20 tons of coal!



Szarlat



Amaranthus is a multi-purpose plant species. Its seeds, rich in nutritious substances, are attracting the interest of the food industry, while the remainder of the plant might be used in producing energy

to produce biomass quantities corresponding to some 15-20 million tons of coal! Agriculture would thus become a significant energy sector on the nationwide scale.

But that's not the limit. Most agricultural producers would be relatively rapidly able to change over and specialize in producing crops for energy purposes. And this would entail an improvement in the rural population's socioeconomic condition.

Botanical power stations

In the second half of the 20th century, the science of plant cultivation was oriented towards increasing the agricultural yield. The aim was to obtain strains that utilized the environmental conditions most effectively, and to develop the agricultural technology for maximizing those plant organs that are useful to mankind (i.e. the grains of cereal crops, the roots of the sugar beet, the fruit of the tomato, etc.). The most spectacular example of was perhaps Norman Borlaug's development of a new type of wheat whose grains accounted for up to 50% of the overall plant biomass. This achievement, combined with other favorable traits in such varieties, touched off a so-called "green revolution," which earned its author a Nobel peace prize. Nevertheless, despite such great progress, the percentage of biomass in other plant organs remains high. That is why more fre-

quent attempts are now being made to obtain this portion of the biological yield, as a renewable source of energy and as a renewable raw material for industry.

However, because we live in an era of specialization, harnessing plant biomass energy is also best performed though the



Willow plantations are not just a source of cheap, renewable energy. These plants can also be used to biologically clean up contaminated areas

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cultivation of special high-yield cultivars of cereals. In the case of liquid fuels, varieties of rapeseed with genetically modified fatty acid content may prove to be the most promising. Strains of grain intended for producing ethanol as a gasoline additive, in turn, should be characterized by a high content of starch-dissolving enzymes. For fuel purposes, perennial crops whose aboveground portions yield yearly harvests of 20-35 tons of dry mass per hectare should be cultivated in plantations. Our project has been testing the common willow (*Salix viminalis*), giant silver grass (*Miscanthus giganteus*), Virginia mallow (*Sida hermaphrodita*), Sakhalin knotweed (*Polygonum sachalinensis*), and prairie cordgrass (*Spartina pectinata*), as well as other species of plants that exhibit exceptionally high biomass production under the habitat conditions present in Poland.

From seedling choice to social analysis

The development of an "agricultural energy industry" must rest firmly upon the precise analysis of all the elements of the future system: from studying the demand for "green energy" in various regions in the country, inspecting soil quality and climatic conditions, through selecting the most high-yield species and strains of plants and methods of cultivation, and finally developing techniques for processing such plants and ac energy from them. In order to cope with these

project issues in detail, the project has been subdivided into six thematic subprograms:

1. Investigating the current and future potential for using land to cultivate plants for non-food purposes, and developing the technology for cultivating plants as an energy source,
2. Raising the biomass yield obtained from energy plantations,
3. Producing and using wood as an energy source,
4. Integrating technologies for producing and utilizing biomass with systems for utilizing it as energy,
5. Optimizing biomass processing chains in view of economic, environmental, and social factors,
6. Studying the technical circumstances behind the harnessing of biomass to produce energy.

Research work has been planned under the above subprograms, including selecting, cultivating, and seeking the genotypes of new plants useful for the production of biomass as an energy source. These plants should be characterized by a high dry mass yield, lower fertilizer demands, and low susceptibility to illness and pests (as a result of which the use of chemicals can be reduced). Moreover, an assessment of waste wood resources and their potential to be used as an energy source will be performed. Project also calls for energy plant gene banks to be set up,



Sakhalin knotweed (*Polygonum sachalinensis*) is a promising biomass producer analyzed under the project set up by the Division of Agricultural, Forestry, and Veterinary Sciences of the Polish Academy of Sciences

Emil Nalborczyk

and for reproduction methods to be adapted to suit our habitat conditions.

First off, work will concentrate on optimizing biomass production under various conditions. Particular attention will be paid to improving the economic and energy efficiency of production, minimizing the negative ecological impact, and assessing the socioeconomic benefits. In parallel, methods will be sought for more effective biomass use in processes of combustion, co-combustion, or potentially methane production. This research will be carried out in full cycles, encompassing the production of biomass, its processing, and its use for the production of energy.

In view of the scope of the planned production of such fuels in Poland, the consequences of such production will be investigated with respect to the macroeconomic aspects, the country's food balance, changes in the use of land, socioeconomic transformations, and environmental protection aspects.

The project also evaluates land resources that could be useful in the production of biomass for solid fuels, to set up for plantations reproduction of such plants, to assess their productivity in various habitats (especially on land that is not suitable for cultivating typical agricultural crops), to expand research on the techniques and technology of producing alternative plants with high biomass yield, to analyze the effectiveness of their production, and to assess the environmental and social impact such production might exert.

A win-win project

The above subprograms and range of additional research would be participated in by a total of seven Polish Academy of Sciences establishments: the Institute of Plant Genetics, the Mineral and Energy Economy Research Institute, the Institute of Plant Physiology, the Institute of Rural and Agricultural Development, the Research Center for Agricultural and Forest Environment, the Botanical Garden - Center for Biological Diversity Conservation, and the Systems Research Institute. Other research institutions, including universities and R&D centers, will also participate in the project.

This research program devoted to biomass as a source of energy will help concentrate our national research potential (specialists and equipment) on solving issues of great



import for the national economy. It will also increase Polish specialists' opportunities to participate in the European Research Area (ERA). The European dimension of this program cannot be overestimated: it will make it easier for Poland to make good on its commitments under EU directives on agriculture, the energy industry, and environmental protection. It will also fit in well with EU research priorities, such as those expressed in the 6th EU Framework Programme, especially under the "Sustainable Development, Global Change and Ecosystems" priority. Of course, even national and European strategies are not the limit. In closing, we should also point out that "botanical factories" not only supply energy, they also significantly limit emissions of greenhouse gasses into the atmosphere. Achieving this goal is a global-scale priority, as expressed in the recently ratified Kyoto Protocol. ■

Sosnowski's hogweed (*Heracleum sosnowskyi*) was brought to Poland from the Caucasus in the 1950s. It did not live up to the hopes placed in it as a potential fodder plant, becoming instead a health-threatening weed. Now, thanks to their impressive growth rate, varieties with decreased levels of irritating compounds might be able to vindicate themselves an energy crop

Further reading

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