

Project description for the general public

What the project will achieve?

The project will develop methods for decision-making support applicable to a wide range of problems, in particular in planning and managing sustainable development, i.e., harmonized advancements of economy, human well-being, and environment. Rational decision-making in this context requires integrated analysis of the relations between decisions (e.g., selection of technologies, locations of power plants, setting various regulations, taxes) and consequences of their implementation measured by the corresponding criteria (e.g., investment and operational costs, indicators of environmental and health impacts, availability of energy and water, use of resources). The knowledge about such relations is represented by mathematical models, which typically have infinite number of solutions (composed of the decisions and the corresponding criteria values).

The key challenge of rational decision-making is to find solutions fitting best the preferences (expressed through the desired criteria values) of the stakeholders. Rational decisions are Pareto-efficient, i.e., there is no other solution having better value of a criterion and at least equally good values of all other criteria. However, there are very different efficient solutions (e.g., *cheap and dirty* or *expensive and clean* or *balanced*). Different stakeholders have different preferences, e.g., either reaching possibly best values of some criteria and accept bad achievements of the other criteria, or reaching balanced achievements of all (or most of) criteria.

The preferences are defined by sovereign decision-makers. The role of science is to provide methods for effective and transparent representation of any preferences in order to compute the corresponding efficient solution. Such a support is best provided by various methods of the Multi-Criteria Analysis (MCA). Despite much progress in MCA methods, some elements of the MCA still inadequately support problem analysis, which results in oversimplifications of the analysis, and thus hampers the effectiveness of the decision-making support.

The project will, by filling the gaps in the MCA methods, not only provide effective methods for solving problems in sustainable development but also improve the basis for further development of the decision-making support science.

What research will be carried out?

The project research will advance the following classes of the MCA methods, and verify the developed methods through applications to models of real-life complex problems:

- Fairness. Build into the MCA methods minimizing inequalities in representing interests of diverse stakeholders. Verify the approach on multi-level supply chain in the China energy system model.
- Robust portfolios. Develop effective methods for handling uncertain factors of technological advancement and market prices. Verify the methods on technology portfolios with China's energy systems.
- Pareto set analysis. Develop methods for representing efficient-solutions' subsets fitting diverse preferences. Verify the methods on the China's model focused on decarbonization of energy-intensive industries.
- Post-interactive analysis. Develop methods for supporting users in effective selection of manageable subsets of Pareto-solutions that fit best diverse user preferences on attainable goals for competing criteria. Verify the approach on the China's energy system models.

Why the research is important?

The importance and diversity of the sustainable development problems is well illustrated by the 17 global goals (called SDGs) set by the well-known United Nations Development Programme. Similar sustainability goals are set not only by the national and regional governments but also by the industry and various organizations. Both China and Poland face challenges of sustainable development. On one hand, each country needs to sustain economic growth, improve efficiency of the industry, provide the societies with all goods and services assuring well-being. On the other hand, both countries cope with problems of environment quality and international requirements for decarbonization.

Rational decision-making, especially related to sustainable development, requires consistent consideration of societal and industrial problems that are increasingly complex and involve analysis of conflicts and synergies between diverse attainable goals for the criteria measuring the development, such as various types costs and key elements of human well-being (e.g., availability of energy, clean water, as well as health impacts, quality of environment). To support finding rational decisions that are fair for all stakeholders and robust against inherent uncertainties, effective and efficient MCA methods are indispensable.