INATECH
DEPARTMENT OF SUSTAINABLE SYSTEMS ENGINEERING

Integrated Sustainability Assessment and Optimization of Energy Systems

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InNOSys Project

Project Partners:

Supported by:

Federal Ministry for Economic Affairs and Energy

on the basis of a decision by the German Bundestag

DLR Deutsches Zentrum für Luft- und Raumfahrt
German Aerospace Center
Institute of Engineering Thermodynamics

GWS SPECIALISTS IN EMPIRICAL ECONOMIC RESEARCH

INEC INSTITUTE FOR INDUSTRIAL ECOLOGY PFORZHEIM

INATECH DEPARTMENT OF SUSTAINABLE SYSTEMS ENGINEERING

ITAS Institute for Technology Assessment and Systems Analysis

zirius Center for Interdisciplinary Risk and Innovation Studies

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Introduction

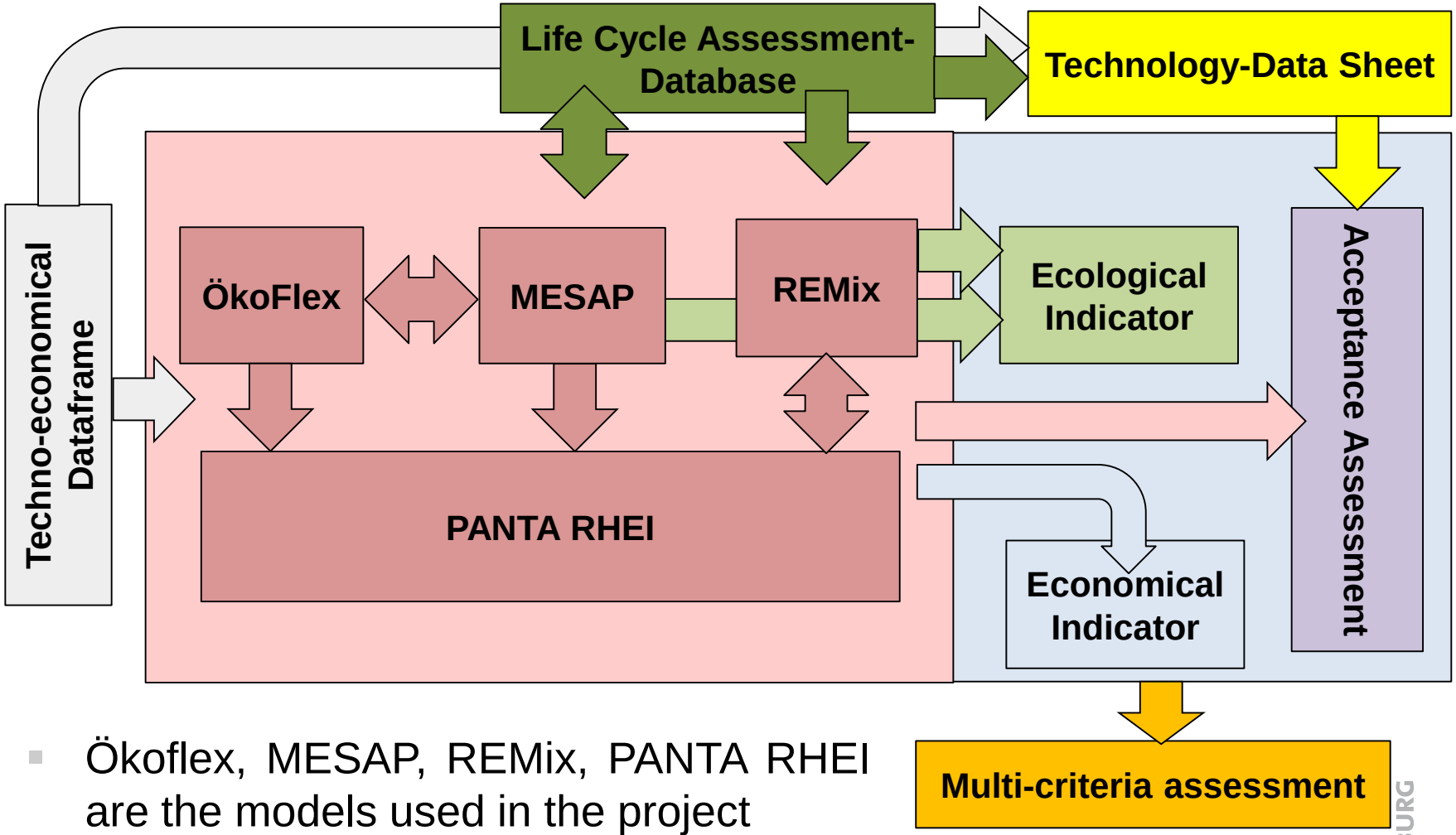
- Energy scenarios studies for sustainable transformation (2050)

- The main objective of InNOSys (Integrated Sustainability Assessment and Optimization of Energy Systems) project is to develop new generic modelling and assessment approaches for energy scenarios, as well as deriving optimized pathways of energy systems in Germany from a sustainability perspective.

Objectives

- To develop interdisciplinary, integrated methods for the **sustainability assessment** of transformation scenarios for (the German) energy systems
- To **optimize** expansion in the power generation capacity under consideration of ecological, economical and social sustainability aspects
- To identify and analyze the **conflicting goals** and trade-offs between different **sustainability indicators**
- To formulate **conclusions for energy policy** and society with respect to alternative courses of action

InNOSys: Basic Concept and Model Coupling



- Ökoflex, MESAP, REMix, PANTA RHEI are the models used in the project

Sustainability Indicators

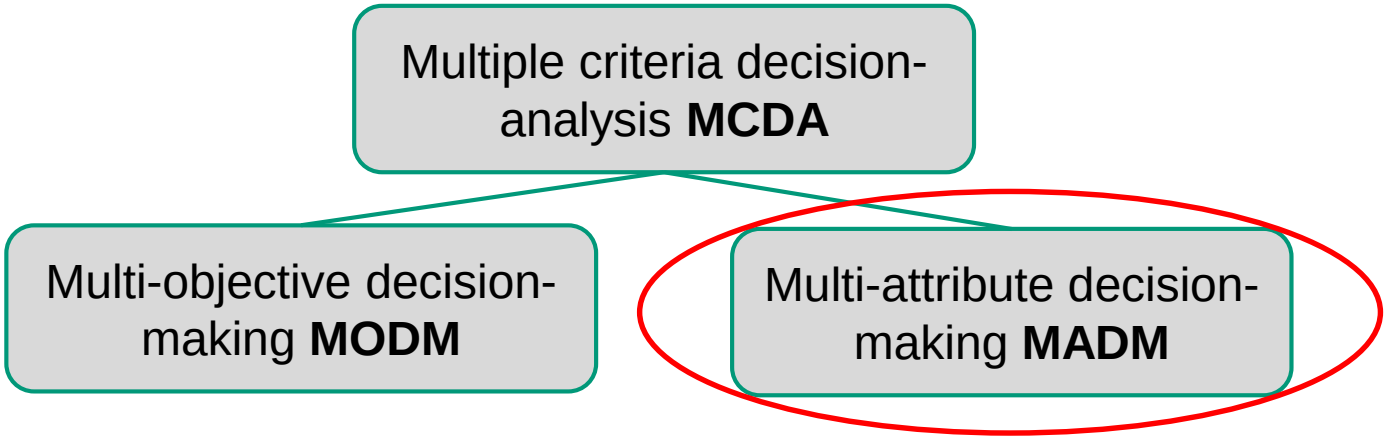
- Sustainability is a triad of ecology, economics and social acceptability [Eizenberg, 2017]

Ecological	Economical	Social/Ethical

- Change in forest area
- Land use
- GHG emissions
  - CO2 emissions
  - SO2 emissions
  - NOx emissions
  - Nuclear waste
  - Fine dust emissions
- Acidification
	- Investment cost
	- O&M Cost
	- Import dependence
	- LCOE
		- Job creation
		- Social acceptance
		- Local manufacturing share
		- Competition to food production

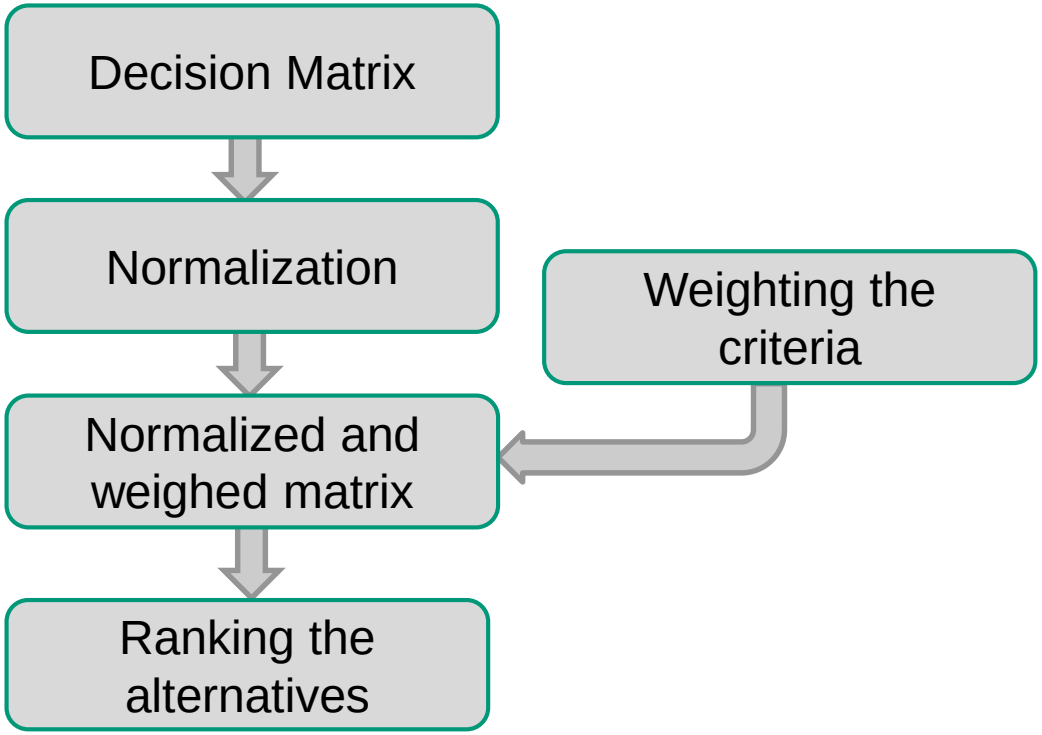
Multi-Criteria Decision Analysis (MCDA)

- Multi-criteria decision analysis (MCDA) is a formal, structured and transparent decision making methodology. It aims to assist groups or individual decision makers to explore their decisions in the case of **complex situations** with **multiple criteria**.



Multi-Attribute Decision Making (MADM)

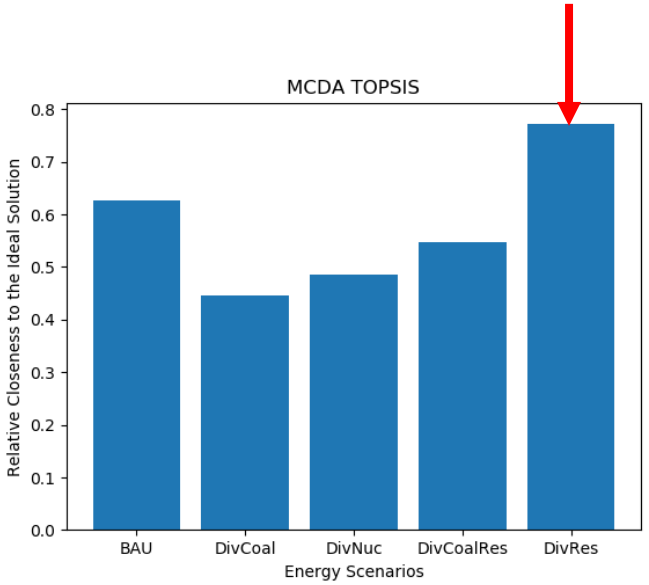
- MADM: Multi-attribute utility functions
  - → Aim: Make a choice among several alternatives
- General idea:



Case Study for Sustainability Assessment

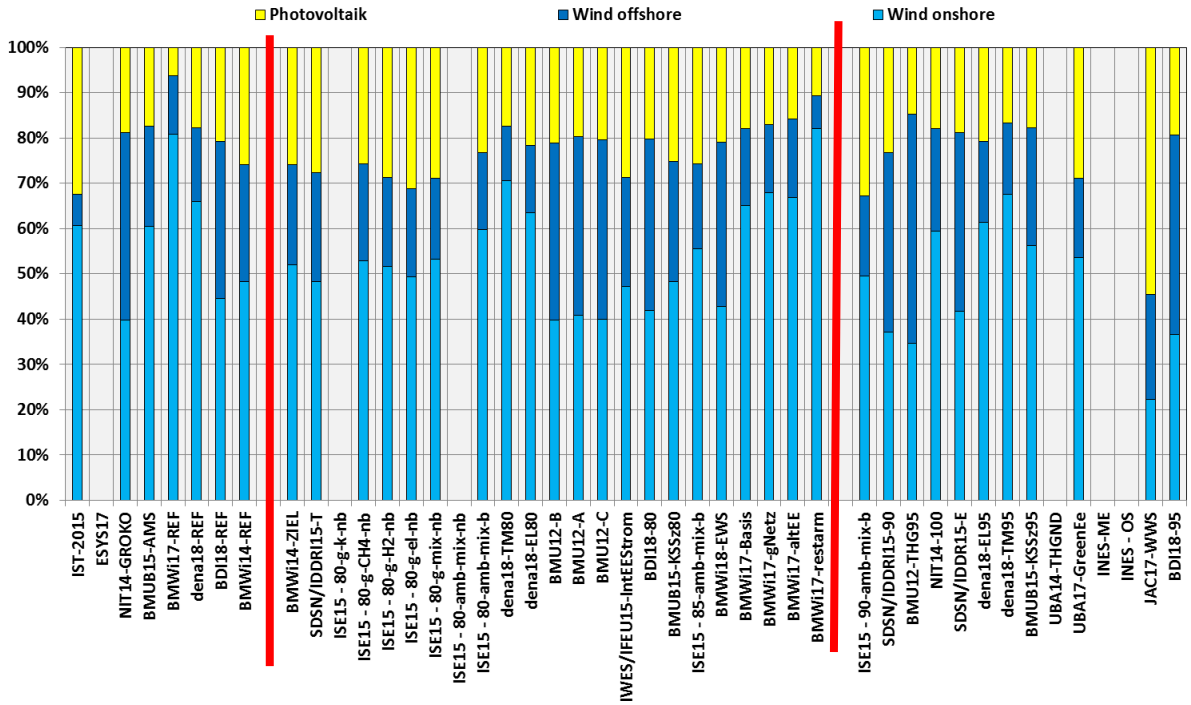
	Scenario *j*					
	1	2	3	4	5	
	BAU	DivCoal	DivNuc	DivCoalRes	DivRes	
Criteria *i*	Performance x_{ij} of criteria *i* in scenario *j*					Unit
1	13.9	13.1	13.7	13.6	14.4	billion €
2	69.9	64.4	68.1	67.0	72.4	€/MWh
3	1.63	1.36	1.53	1.20	1.13	point [-2...2]
4	2822	1846	2447	1831	2424	PJ
5	-1.85	-1.55	-1.85	-1.39	-1.36	point [-2...2]
6	21.7	21.4	18.9	24.7	29.5	%
7	0.75	0.42	0.53	0.81	1.08	point [-2...2]
8	3650	5690	5460	7360	8890	jobs
9	167	226	144	206	143	Mt CO_2
10	0	22	0	18	0	kt SO_2
11	19	48	16	42	16	kt NO_x
12	0	0	149	0	0	t nuc. waste
13	0	2150	0	1800	0	t fine dust

[Brand, 2014]



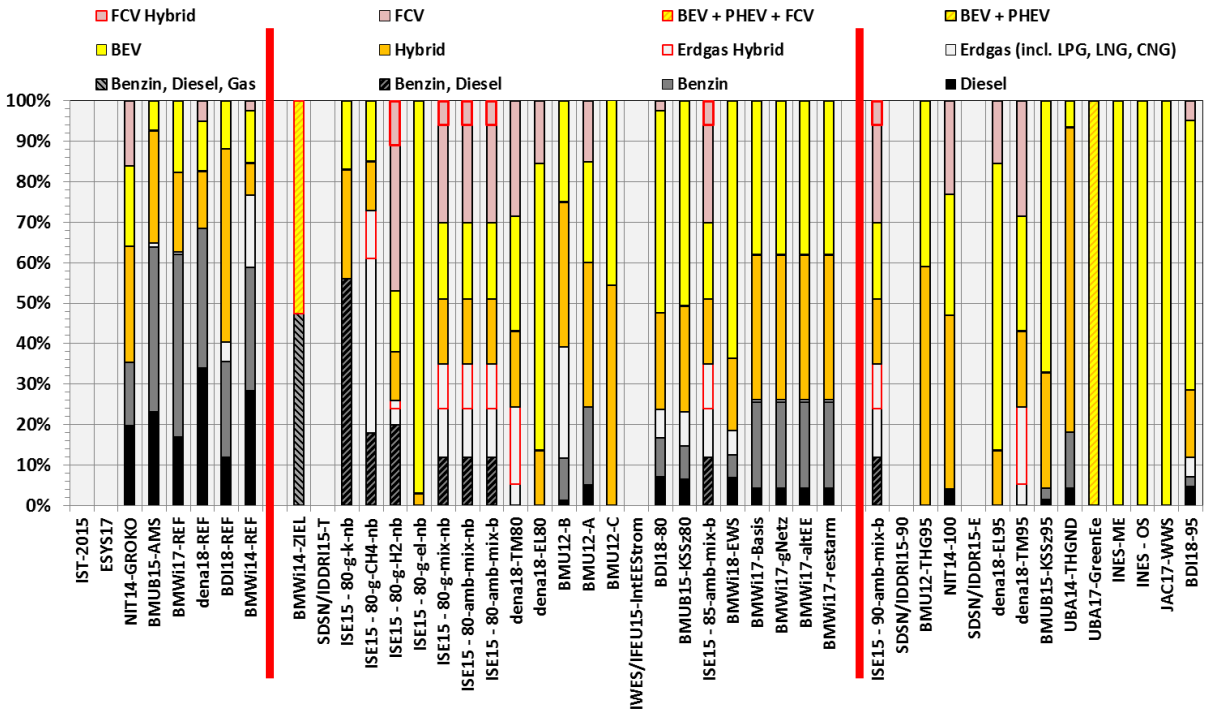
- Case study for sustainability assessment in Tunisia
- Five energy scenarios and 13 sustainability criterias
- TOPSIS method: DivRes

Intermediate Result: Energy Scenarios



- Two classifications: 80%-90% and 90% CO2 emission reduction target
- Share of electricity generation from wind offshore, wind onshore, PV (average from the scenarios):
  - Reference year: 61% wind onshore, 7% wind offshore, 32% PV
  - Moderate amb: 54% wind onshore, 23% wind offshore, 23% PV
  - Very ambitious: 48% wind onshore, 29% wind offshore, 23% PV

Intermediate Result: Energy Scenarios



- Personal vehicle: electric vehicles will dominate mobility sector in 2050
- Moderate amb: electric vehicles, hybrid with biofuels, fuel cell vehicles, natural gas engines
- Very ambitious: electric vehicles, hybrid with synthetic fuels, fuel cell vehicles, no natural gas and fuel based on mineral oil

Intermediate Results: Sustainability Indicator

- Three sustainability indicators sets were decided to be defined:
  - Elaborate: all indicators those could be calculated from the models
  - MCDA Input
  - Input for focus groups

(www.abnamro.com)

Intermediate Results: MCDA

- Three MCDA methods which have been selected are:
  - AHP (Analytic Hierarchy Process)
  - TOPSIS (Technique of Order Preference by Similarity of Ideal Solution)
  - PROMETHEE (Preference Ranking Organization Methods for Enrichment Evaluation)

(www.marketing91.com)

Conclusion

- The main purpose of the InNOSys project is sustainability assessment of energy scenarios
- Energy scenarios for 2050 were compared and analysed
  - For different sectors (electricity, heat, mobility)
  - Classified into two categories (moderate ambitious and very ambitious)
- Several scenarios with varying “technical storylines” will be selected and recreated
- Three sustainability indicators sets (economical, ecological and social indicators) which were decided to be defined are elaborate set, MCDA input set and focus groups input set
- Multi-criteria assessment method which were selected are AHP, TOPSIS, PROMETHEE

www.innosys-projekt.de

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Thank You!

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