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Zentrum für Sonnenenergie- und Wasserstoff-Forschung Baden-Württemberg

Indicator system development process

V4InnovatE

Responsible Innovation for the Energy Transition

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30th September 2021, 9:00-12:30 CEST, online, hosted by DIALOGIK

Energy innovation related acceptance problems

- Lithium-ion batteries, an uncontentious technology? Not quite..

- Raw materials: availability and mode of extraction
  - LIBs contain critical metals: cobalt and graphite → supply risk, risk of price increase, competing use
  - The choice of mines is limited (child labor?)

- Protection of the environment and species
  - The recycling rates are still very low
  - Production of lithium: vast amounts of water, environmentally harmful chemicals, evaporation ponds and processing plants consume land and chemical waste is not disposed of in an environmentally friendly manner.
  - Safety risk
- Socio-Economic: Unequal distribution of benefits / burdens, Jobs
  - Job losses in certain industries and regions?
  - Low-wage labor

→ Issues to be taken into consideration (early) in the innovation process.

Target groups - Who will use the indicator system?

- ! Innovation processes are characterized by a high degree of uncertainty ("uncertainty in outcomes").
  - Limits the ability to plan and control the innovation process.
  - It is possible to inform innovation processes as to increase the probability that an innovation will be socially accepted.

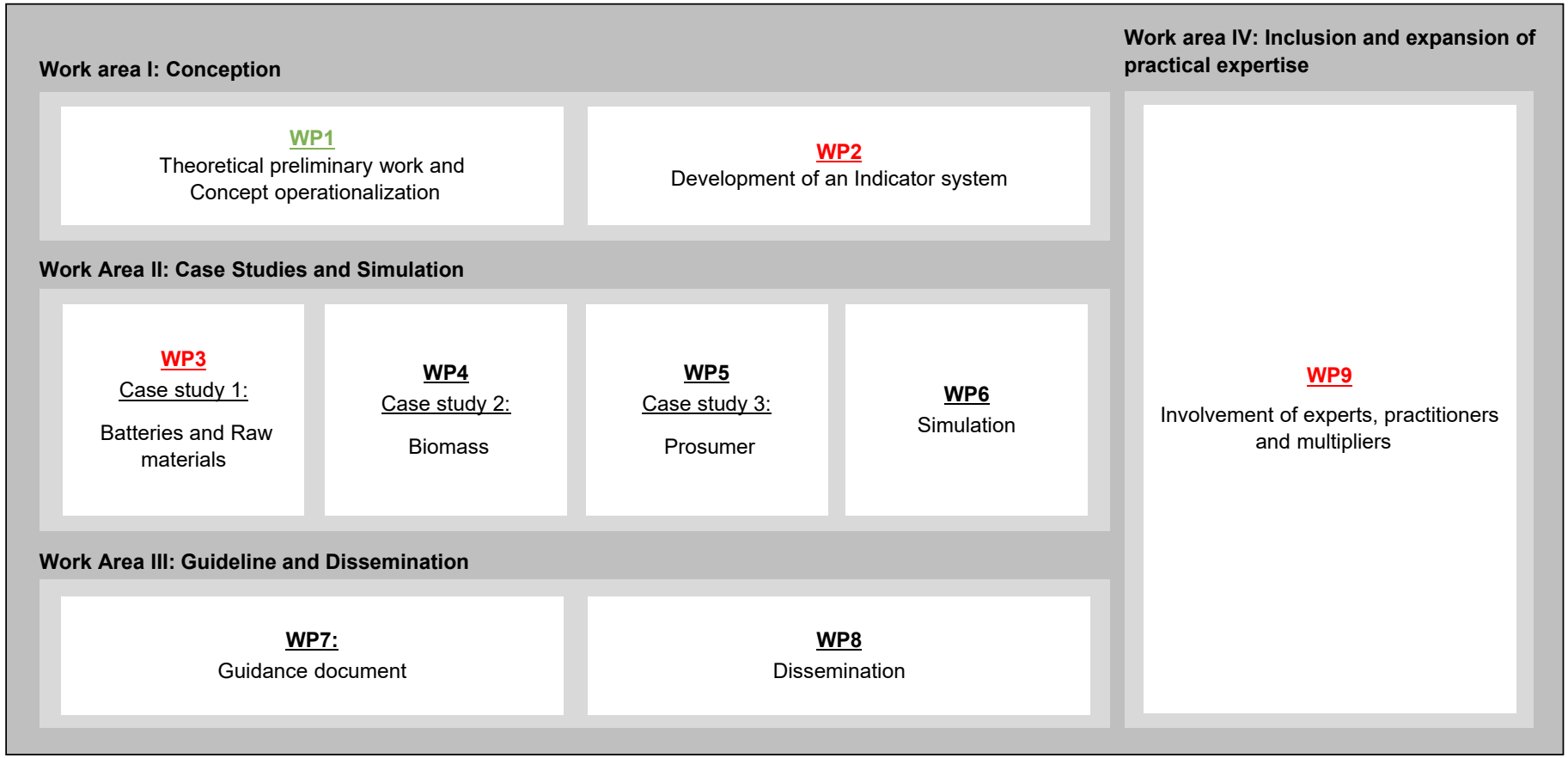
- 2 groups:
  - R&D funding organizations.
  - R&D performing organizations (public and private).

- The indicator system (and guidance document) shall help R&D funding organizations to:
  - Inform the selection of research proposals for funding and take well-grounded funding decisions.
  - Fund anticipatory research on newly emerging energy transition technologies.
  - Identify RRI-relevant research needs and research gaps AND set up corresponding research funding programs.

Target groups - Who will use the indicator system?

- The indicator system and guidance shall help R&D performing organizations to:
  - Design research projects informed by the RRI-philosophy.
  - Invention → Implementation: Provide timely feedback regarding e.g. material selection, energy targets and possible business models (Prosumer?) that may affect acceptance
  - Monitor project alignment with RRI concept

Project overview



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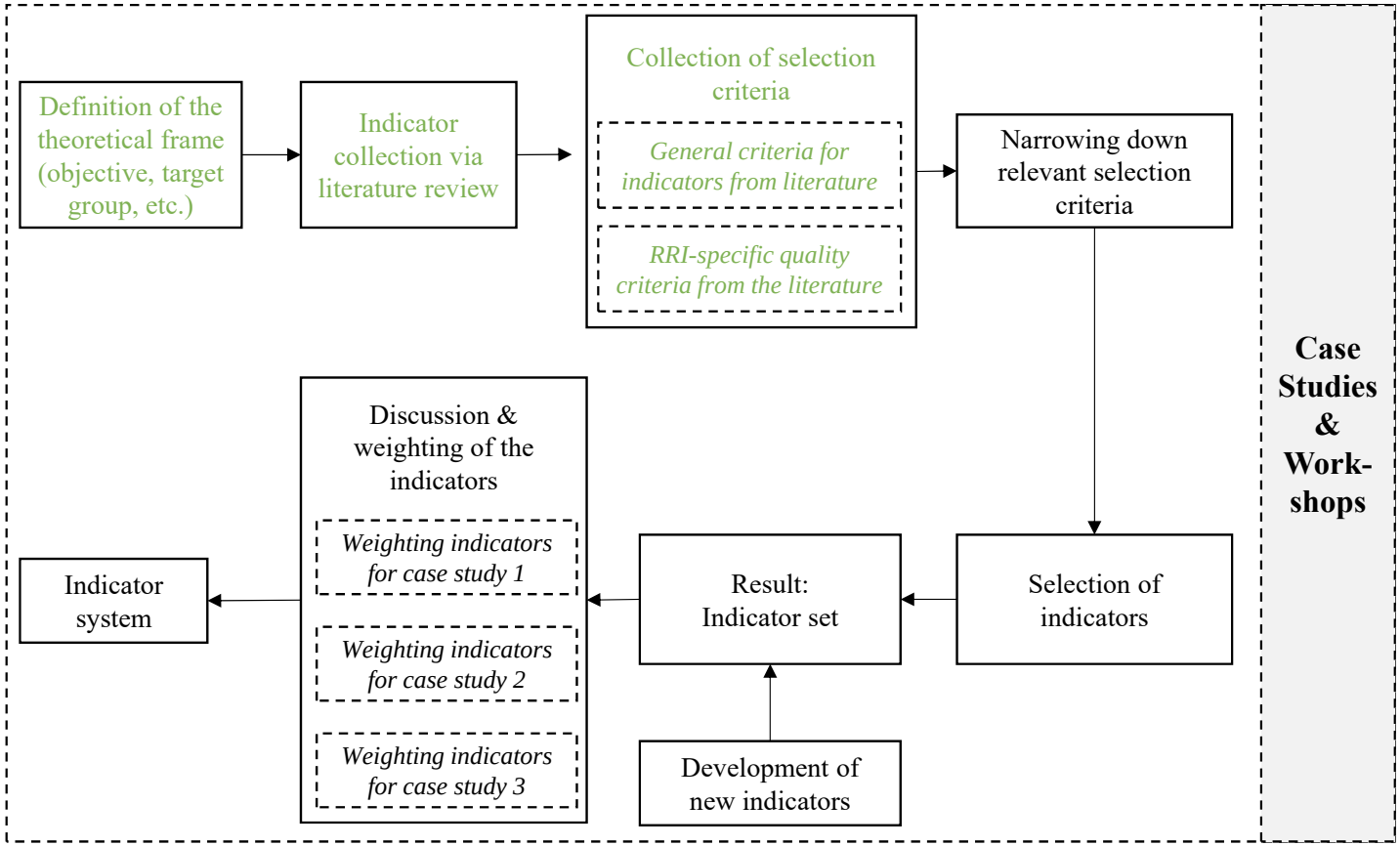
DEVELOPMENT PROCESS

Indicator system development

Overview

- What does the development process look like?
- Clearly defined process, based on the steps found in the literature (see e.g. Meyer, 2004; Lustat, 2012)
- Indicator system development mainly based on (retrospective):
  - A) Extensive literature search
  - B) Case studies in context of energy transition
  - C) Workshops



Indicator system development

A) Literature review of existing RRI indicators

- Collection of existing indicators and indicator concepts from RRI-literature
- However, previous indicator systems
  - Lack of context-based indicators as a main weakness of existing indicator systems (Monsonís-Payá et al., 2017)
  - Currently no set of indicators in context of energy transition

Reference	Unit of assessment	Assessor	Aim of assessment	Indicators	Type of measurement
Ravn, Nielsen and Mejlgaard (2015)	Country	Independent assessor	Monitoring; comparison	36	Quantitative
Strand et al. (2015)	RRI initiatives	Independent assessor	Monitor and assess the impacts of RRI initiatives	83	Quantitative
Flipse et al. (2015)	Project (within a company)	Self- assessment	Monitoring; decision support for managers	30	Qualitative
Stahl et al. (2017)	Company	RRI researchers; Self-assessment	Assessing RRI level, monitoring	14	Qualitative
Heras & Ruiz-Mallén (2017)	Research/Teaching Institutes	Self- assessment	Monitoring; comparison	86	Qualitative
Otero-Hermida & García-Melón (2018)	Research Institutes	Self- assessment; Independent assessor	Monitoring	23	Quantitative
Tharani et al. (2019)	Company	Self- assessment	Learning	43	Qualitative
Verburg, Rook, and Pesch (2019)	Employee (in a company)	Self- assessment	Assessing RRI level	7	Qualitative
Yaghmaei et al. (2019)	Project	Self- assessment	Monitoring	43	Qualitative
Nazarko (2020)	Company	Self- assessment	Monitoring; decision support for managers	53	Qualitative/ Quantitative
V4InnovatE	R&D funding programmes R&D projects	Self- assessment; Independent assessor	Improving (RRI-oriented) design/performance of renewable energy innovations; decision support for research funders and researchers	x	Qualitative/ (Quantitative)

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Indicator system development

B) Case Studies

- Aim: Adaption to energy context → broad coverage

- Three main types of innovation processes:
  - (1) Innovation based on "analytic knowledge"
    - In this case, the knowledge is primarily gained in formalized processes in laboratory environments.
    - E.g. batteries
  - (2) Innovation based on "synthetic knowledge"
    - Consists to a greater extent of empirical knowledge from engineering activities
    - E.g. biomass
  - (3) Technology-based services
    - Developed to a large extent through direct interaction with users
    - E.g. prosumer services

Indicator system development

C) Workshops

- Accompanying workshops for discussion and implementation of feedback loops
- Workshops:
  - (1) Review workshop on the preliminary concept of the indicator system (Today)
    - Informing participants about project objectives, methodology, indicator system development and goals
    - Reflect and discuss the preliminary concept of the indicator system with experts from RRI, Innovation research and Energy research
  - (2) Review workshops with practitioners on the case studies.
    - Three workshops with experts regarding the case studies (Battery technologies, biomass technologies, prosumer services)
    - The aim is to discuss the indicator system in the context of the case studies and to gain additional input for the indicator system → Feedback loop for the development of the indicator system
  - (3) Transfer workshop
    - Practice-science dialogue with representatives from research funding, science and practice

Indicator system development

Quality criteria

- **RRI quality criteria** provide an overview of aspects that "*'good' science and 'responsible' research and innovation should entail*" (Wickson & Carew, 2014, p. 261)
- Quality criteria should always be adapted to the respective project or the respective evaluation task (Wickson & Carew, 2014)!

	Quality Criteria	Sub-criteria/ Components
Kupper et al. (2015)	Engaging a variety of stakeholder groups	4
	Variety of means of stakeholder engagement	3
	Engagement of public(s)	3
	Institutional diversity	2
	Attention for appropriate R&I models and methods	2
	Honest and clear (re)presentation of the practice details	5
	Open and clear communication about the processes of deliberation and decision-making	2
	Open and clear communication about the results of the practice	3
	Appropriate means and content of communication and education per actor	2
	Openness to critical scrutiny from all stakeholders	1
	Analysis of the background, current situation and context of the (planned) research or innovation	5
	Envisioning of plausible futures	3
	Variety of impacts	5
	Facilitating deliberation on values, perceptions, needs, interests, choices and definition of the problem at issue in the practice	2
	Addressing roles in RI trajectories	2
	Structure for seeking and incorporating feedback	2
	Flexible process management	4
	Development and implementation of evaluation strategies	5
	Flexible attitudes to revise views and actions	2
	Changing responsibilities	2
	Application of results	2
Wickson & Carew (2014)	Socially relevant and Solution oriented	2
	Sustainability centered and Future scanning	3
	Diverse and Deliberative	3
	Reflexive and Responsive	4
	Rigorous and Robust	3
	Creative and Elegant	3
	Honest and Accountable	5

Indicator system development

Indicator selection and clustering

Selection

- Selection of relevant quality criteria and specification of indicators
  - Three case studies inform the selection of quality criteria and indicators for the indicator system adapted to context of energy technology innovations
  - Adaptation of existing or development of new indicators

Clustering

- Clustering of the selected indicators
- Kupper et al. (2015) already assign possible RRI-dimensions to the quality criteria which we will adopt
  - Based on an adapted version of the AIRR-Dimensions (Stilgoe et al., 2013) created in the RRI-Tools Project

Indicator system development

Example for a resulting set of indicators

- RRI quality criteria and assigned RRI indicators (identified as relevant in the energy transition context)
- Resulting set of indicators enables evaluation of relevant RRI-aspects
- Possible extension with an RRI rubric to facilitate evaluation (as used by e.g. Wickson & Carew, 2014 or Yaghmaei, 2018)

Criteria	
Fully met	100
Well met	75
Halfway met	50
Barely met	25
Not met	0

Dimension	ID	Quality Criteria	Possible Indicator (qualitative)	Value
Diversity and Inclusion	DI1	Engaging a variety of stakeholder groups	Engagement of relevant stakeholders in the innovation process (civil society organizations, local government, education community, customers, patients, Families, etc.)	
	DI2	Variety of means of stakeholder engagement	Within this project we use a systematic approach (specified how, when, and why) from the beginning to include various stakeholder viewpoints on a wide set of values (technical, social, ethical, legal, etc.)	
Openness and Transparency	OT1	Open and clear communication about the results of the practice	We organise science communication/education activities aimed at educating citizens and generating awareness of aspects/issues of the innovations we are working on	
	OT2	Openness to critical scrutiny from all stakeholders	Within our project we use tools and mechanisms for organising dialogue with stakeholders on appraisal/ethical acceptability	
Anticipation and Reflection	AR1	Variety of impacts (Society)	Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	
	AR2	Variety of impacts (Ethics)	We use ongoing, continuous monitoring of ethical aspects in this project	
	AR3	Variety of impacts (Environment)	This project provides substantial environmental benefits to society compared to available alternatives	
	AR4	Envisioning of plausible futures	We continuously consult other researchers and research projects to signal new and future technological trends	
Responsiveness and Adaptive Change	RAC1	Structure for seeking and incorporating feedback	Within our project we use tools and mechanisms for organising dialogue with stakeholders on appraisal/ethical acceptability	
	RAC1	Flexible process management	Within this project we adopt a learning approach to adapt the research programme according to the viewpoints and ideas of other stakeholders.	

Indicator system development

Indicator weighting

- Central weakness of existing measurement concepts: lack of hierarchical ordering (Monsonís-Payá et al., 2017)
- Use of Analytical Hierarchy Process (AHP), introduced by Saaty (1990)
  - Multi-criteria analysis method for prioritizing RRI indicators
- Weighting specific to the three technologies (three expert workshops)
  - Allows the estimation of indicator relevance for the three different cases

Possible weighting for the dimension "Anticipation and Reflection"

From Your Point of View, Which Indicator Is More Important in the Context of the Case Study										
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR2:** We use ongoing, continuous monitoring of ethical aspects in this project
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR3:** This project provides substantial environmental benefits to society compared to available alternatives
AR1: Societal values (privacy, safety, health, security, data ownership, etc.) are actively included in the design process of this project	9	7	5	3	1	3	5	7	9	**AR4:** We continuously consult other researchers and research projects to signal new and future technological trends
AR2: We use ongoing, continuous monitoring of ethical aspects in this project	9	7	5	3	1	3	5	7	9	**AR3:** This project provides substantial environmental benefits to society compared to available alternatives
AR2: We use ongoing, continuous monitoring of ethical aspects in this project	9	7	5	3	1	3	5	7	9	**AR4:** We continuously consult other researchers and research projects to signal new and future technological trends
AR3: This project provides substantial environmental benefits to society compared to available alternatives	9	7	5	3	1	3	5	7	9	**AR4:** We continuously consult other researchers and research projects to signal new and future technological trends

Exemplary evaluation				
	AR1	**AR2**	**AR3**	**AR4**
AR1	1	1/7	5	1/3
AR2	7	1	1	1
AR3	1/5	1	1	5
AR4	3	1	1/5	1

→

Resulting Weights
22%
30%
29%
19%

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Example

Possible Application

- Final indicator system that
  - covers the essential RRI aspects in the energy transition context
  - combines the individual indicators within the dimensions by means of weighting
  - allows an assessment of the degree of alignment with regard to the different RRI dimensions

- The exemplary application is supplemented by a guidance document, which explains the indicators and the indicator system as well as their application in more detail.

Criteria	Fully met	100
	Well met	75
	Halfway met	50
	Barely met	25
	Not met	0

Dimension	ID	Quality Criteria	Value	Weight	Result
Diversity and Inclusion	DI1	Engaging a variety of stakeholder groups	100	0,5	0,625
	DI2	Variety of means of stakeholder engagement	25	0,5	
Openness and Transparency	OT1	Open and clear communication about the results of the practice	50	0,5	0,375
	OT2	Openness to critical scrutiny from all stakeholders	25	0,5	
Anticipation and Reflection	AR1	Variety of impacts (Society)	50	0,22	0,573
	AR2	Variety of impacts (Ethics)	50	0,3	
	AR3	Variety of impacts (Environment)	75	0,29	
	AR4	Envisioning of plausible futures	50	0,19	
Responsiveness and Adaptive Channge	RAC1	Structure for seeking and incorporating feedback	100	0,5	0,75
	RAC1	Flexible process management	50	0,5	

Example

Possible Application

- Final indicator system that
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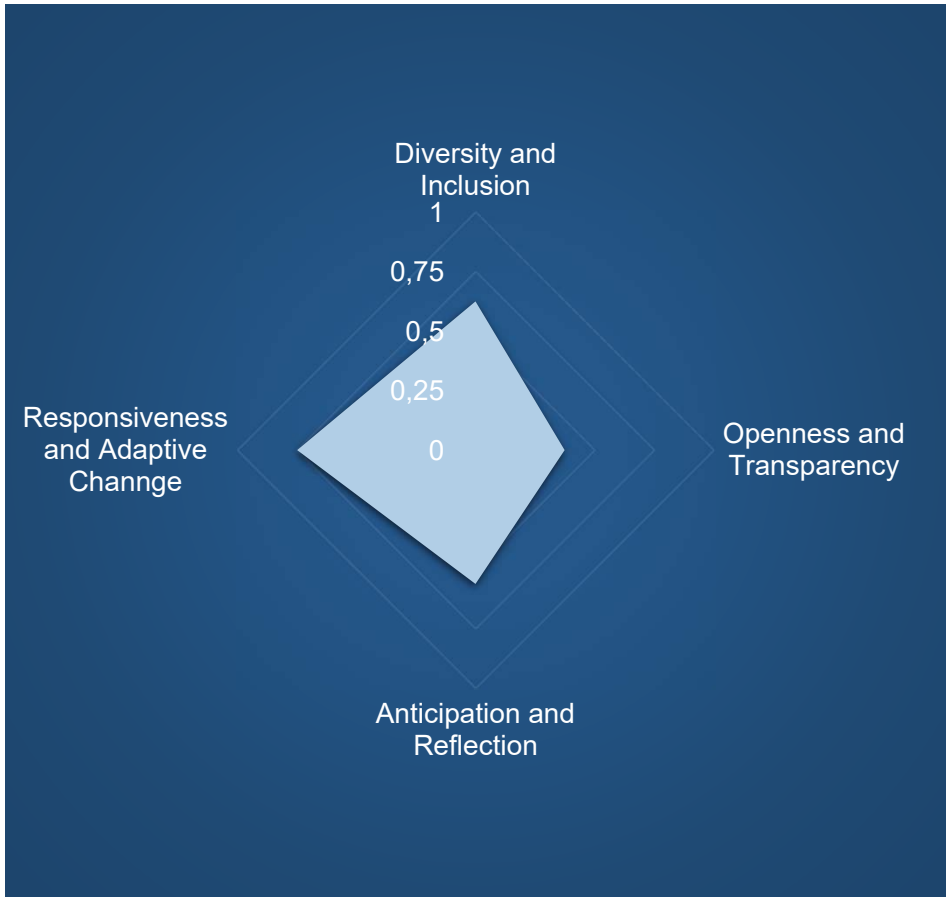

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