SE²A Sustainable and Energy-Efficient Aviation

ScenAIR20250 – Results if the Impact-Uncertainty-Survey

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Content

Preamble

Dear SE²A cluster- and research partners,

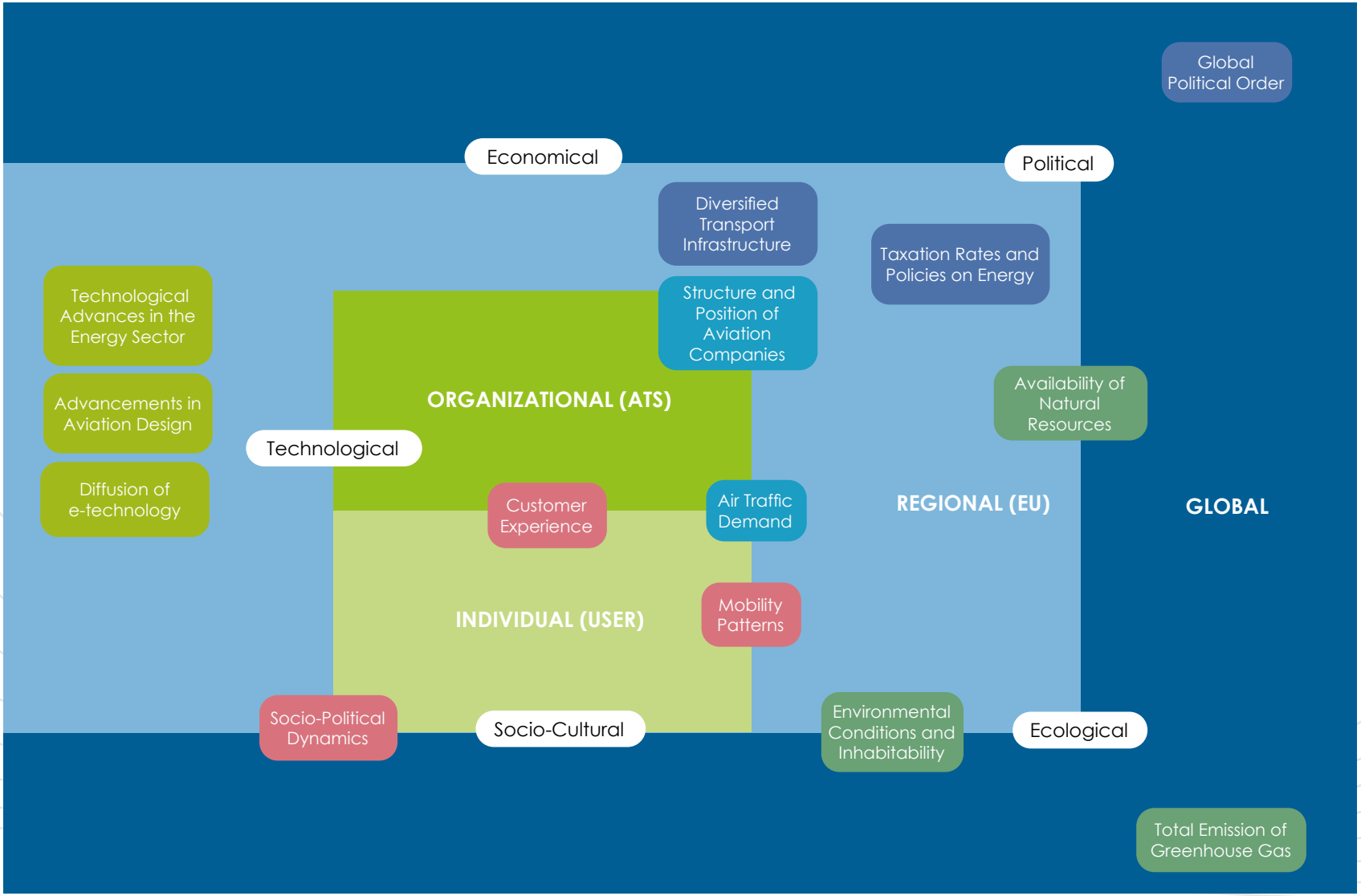
Thank you all who participated in the Impact-Uncertainty surveys we conducted for the project ICA A1.1 ScenAIR 2050 of the SE²A excellence cluster.

The following documentation outlines the main results of the surveys to assess Key Factors for building explorative future scenarios regarding the air transport system by 2050.

The objective of the project ScenAIR2050 is to develop qualitative scenarios for the future of the air transport system (ATS) in 2050. The scenarios aim to provide a multi-criteria decision support for evaluating and optimizing future technologies developed within the SE²A cluster, as well as creating participatory synergies among the cluster members.

The main research question revolves around what possible and plausible developments of a sustainable and energy efficient ATS until the year 2050 should be considered, taking into account not only technological advances but also socio-economic developments.

System Image with Key Factors



Procedure of Impact-Uncertainty Survey 1/2

In a STEEP (PESTE) analysis of the air transport system (ATS) the drivers were sought after. Considering the results from previous projects (Mozuni et al 2019), having an ongoing process of literature research and knowledge exchange with research partners, over 90 factors were identified that also describe the system's boundaries (p. 4).

In order to investigate alternative trajectories in the form of scenarios, in addition to forecastable drivers such as climate change or GDP development, drivers are considered with significant impacts and less predictability. Thereby, offering at least two to four divergent projections.

In a scenario process, these form the key factors and should not exceed the number of 15 to 20. Thus, in the ScenAIR process the number of factors needed to be reduced. This was done with further desk-research and a software-based accumulation process resulting in 69 factors. In the continuous process, to identify the key factors, an Impact-Uncertainty Analysis was planned. Often it is a team effort of experts of the research field and non-experts. The factors are placed on a matrix, where the X-axis indicates the uncertainty of the expected development of a factor and the Y-axis its impact on the system (p. 10). Based on these assessments, the definite key factors exhibit a high impact and a high uncertainty (upper right corner of the matrix)

Procedure of Impact-Uncertainty Survey 2/2

In ScenAIR, we wanted to obtain a greater amount of expert knowledge than would have been possible in a workshop. Therefore, similar to a Delphi survey, we decided to conduct two rounds of Impact-Uncertainty-Analysis surveys and invited experts from the SE²A cluster and external experts from the field of aviation.

For a first Impact-Uncertainty Survey in January 2023 the PhD-candidates of the SE²A cluster were asked to participate (n= 13). They were asked to assess the impact and uncertainty of the 69 STEEP-factors (ordinal scale of 1 to 3). These findings served as the basis for optimising the Impact-Uncertainty Survey.

The final set of factors was a fusion of the abovementioned 69 STEEP factors and resulted in 25 defined factors. This time, 35 experts followed our invitation and gave us the needed insight to evaluate the key-factors that will become the framework for the explorative future scenarios.

This document contains the result of this expert survey, which identified eight definitive and twelve optional key factors, of which fifteen key factors were extracted (p. 4 and further information on p.39).

Surveys' Framework

The survey was setup to be an asynchronized Impact-Uncertainty Analysis where experts in the field of aviation from the SE²A excellence cluster as well as professionals with interest and expertise in the field of aviation were invited via email.

- Participants: SE²A cluster partners and external Experts n=35
- Setup: LimeSurvey licensed for TU Braunschweig.

Foundation: 25 defined driving factors

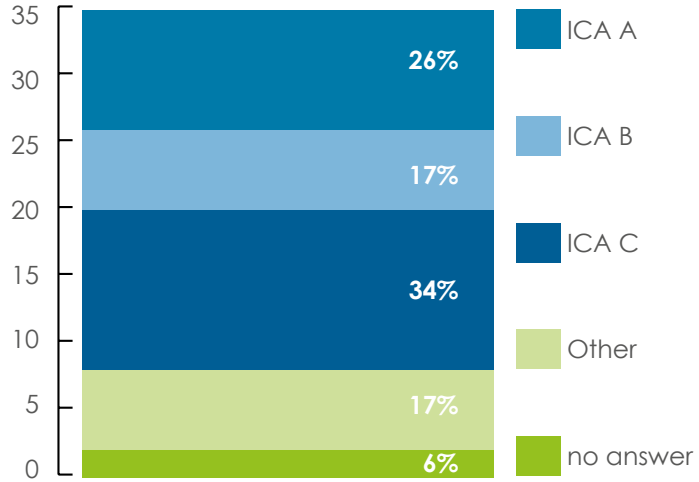
- Assessment on ordinal scale of 1 (lowest) to 5 (highest).
  1. Estimation of the impact of the factor on the system's development
  2. Estimation of the uncertainty of a factor's development
- Ranking according to impact to find 5 main factors
- Demographic question included, discipline, professional status

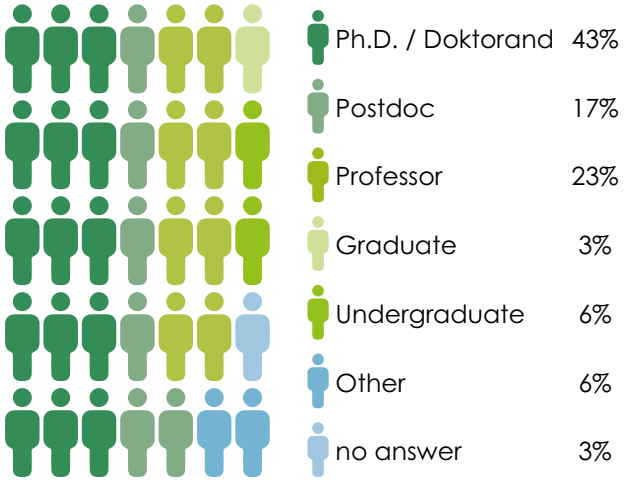
Prior to this a pilot Impact-Uncertainty Survey was held in Dec 2022 to Jan 2023

- 69 Factors based on a STEEP Analysis
- Participants: SE²A excellence cluster PhD candidates n = 13

Survey Demographic Overview

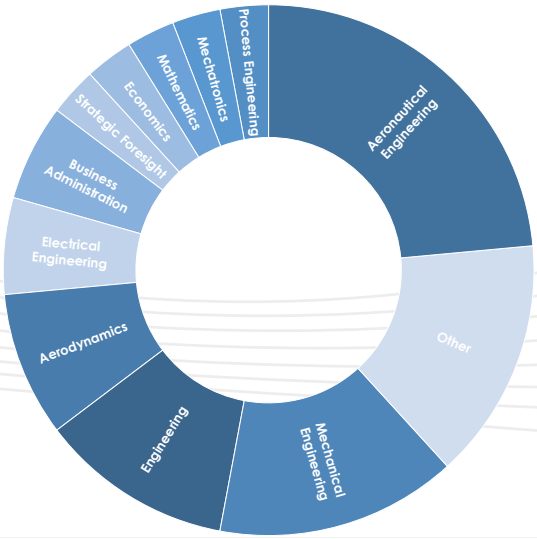
Impact-Uncertainty Survey 2 | May to June 2023 | n = 35

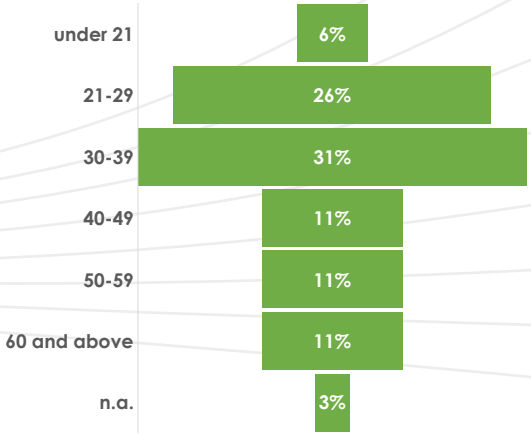




Other:

- Complex systems consulting
- Deutsches Zentrum für Luft- und Raumfahrt e.V. (DLR)
- Foresight (also in transport)
- GA+ mental health
- Glider Pilot
- Gliding club





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Impact-Uncertainty Matrix

Socio-cultural

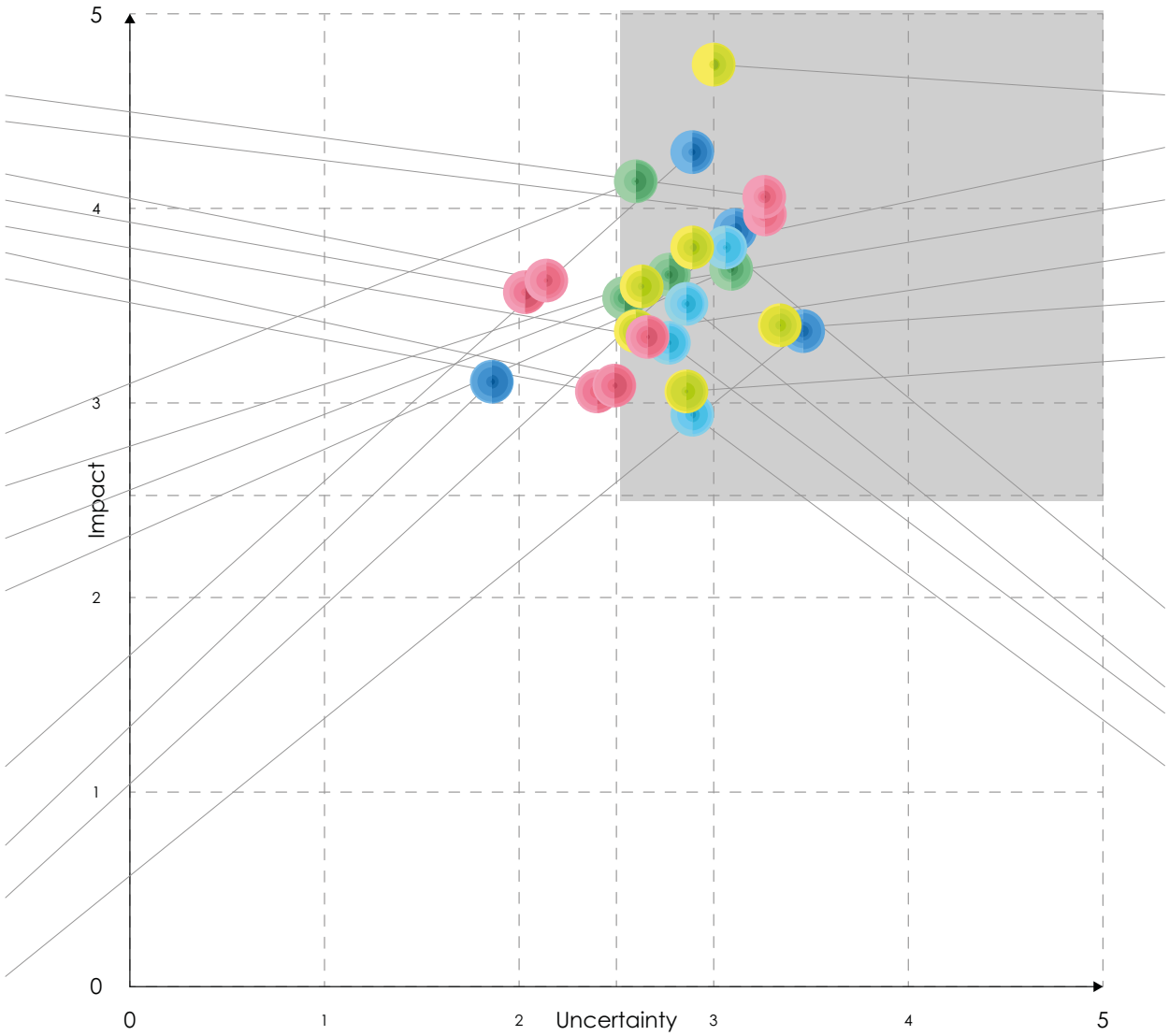
- Socio-Political Dynamics
- Mobility Patterns [change of location incl. virtual & In-Person]
- Societal Values and Education
- Trust in the Safety of Technology
- Rich-Poor Gap
- Flight Experience
- Demographic Development

Ecological

- Total Emission of Greenhouse Gas
- Availability of REE as Resources for Aviation Technologies
- Availability of Natural Resources for Europe
- Environmental Conditions and Inhabitability

Political

- Taxation Rates and Policies on Energy in the EU related to pricing
- Role of Regional Airports also through Policies
- Policies and Subsidization for Diversified Transport Infrastructure
- Global Political Order

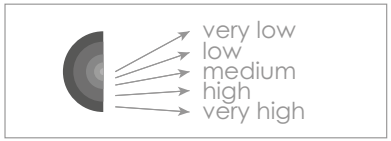


Technological

- Technological Advances in the Energy Sector
- Advancement in Aviation Design
- Certification of Aviation Technology
- Airport Service Experience and Infrastructure
- Diffusion of e-Mobility Technology
- Air Traffic Management [ATM], inlcuding Uncrewed Aerial System [UAS] Advanced Air Mobility [AAM]

Economical

- Air Traffic Demand [in conjunction with mobility options and work models]
- Dominant Economic System
- Structure and Position of Aviation Companies
- Economic Power Distribution and Trade



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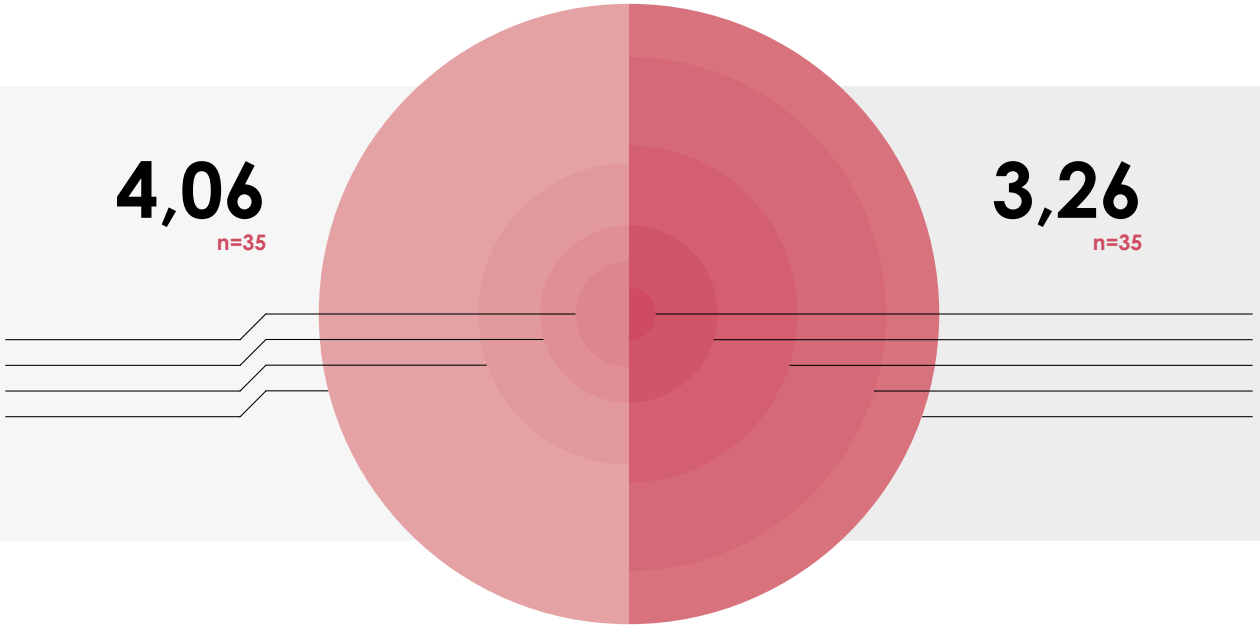
Socio-Political Dynamics

Personal awareness and building of civic movements to act on climate change, as well as climate denial and conspiracies (Terrorism, Social Unrest, Revolutions, mass movements)

Impact
Rating

4,06
n=35

low	(1)	0/n
-	(2)	6/n
medium	(3)	4/n
-	(4)	7/n
high	(5)	18/n

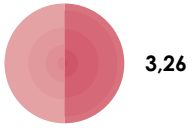


3,26
n=35

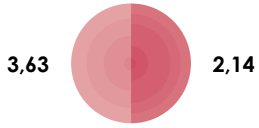
Uncertainty
Rating

low	(1)	3/n
-	(2)	7/n
medium	(3)	9/n
-	(4)	10/n
high	(5)	6/n

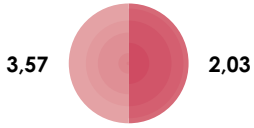
Mobility Patterns



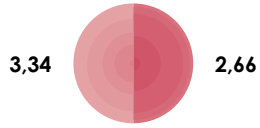
Societal Values and Education



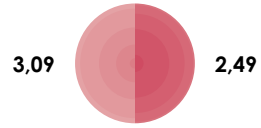
Trust in the Safety of Technology



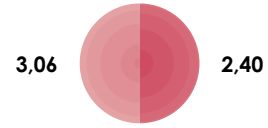
Rich-Poor Gap



Flight Experience

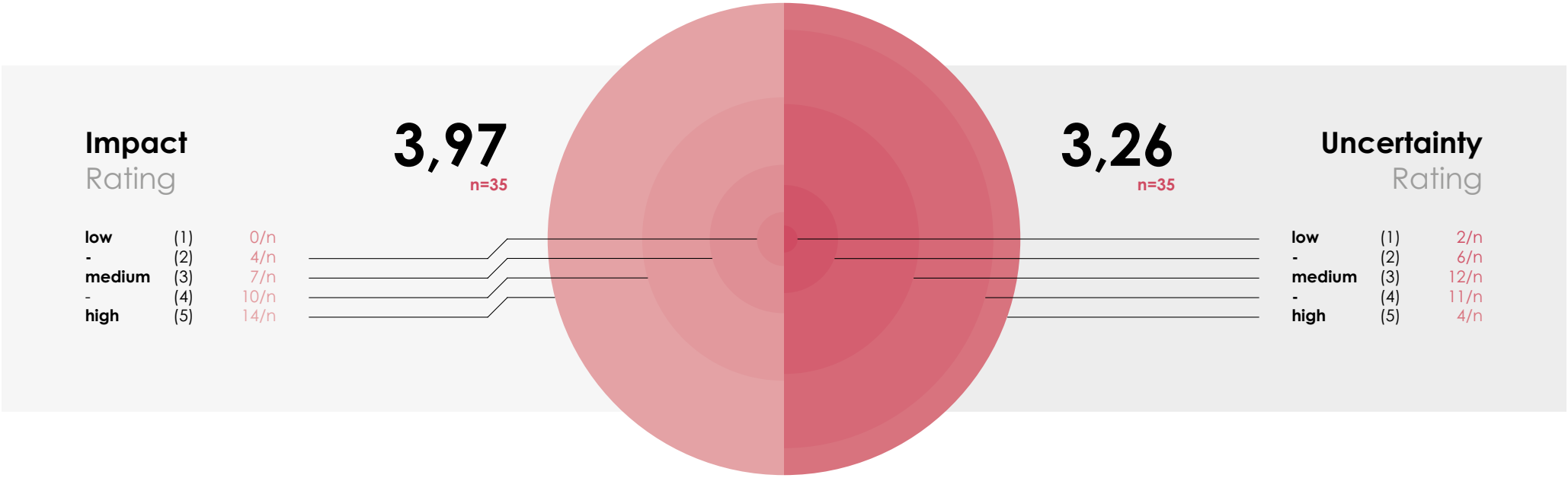


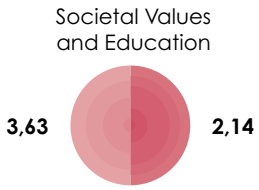
Demographic Development

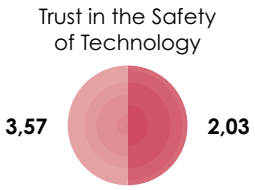


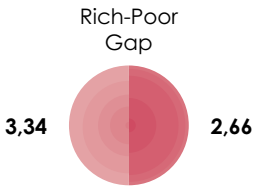
Mobility Patterns

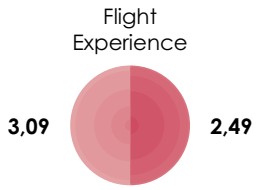
Mobility patterns influenced by work modes, leisure behaviour, and the general social situation

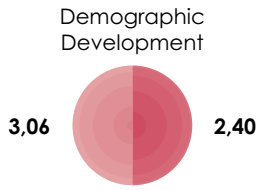


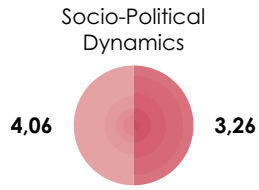






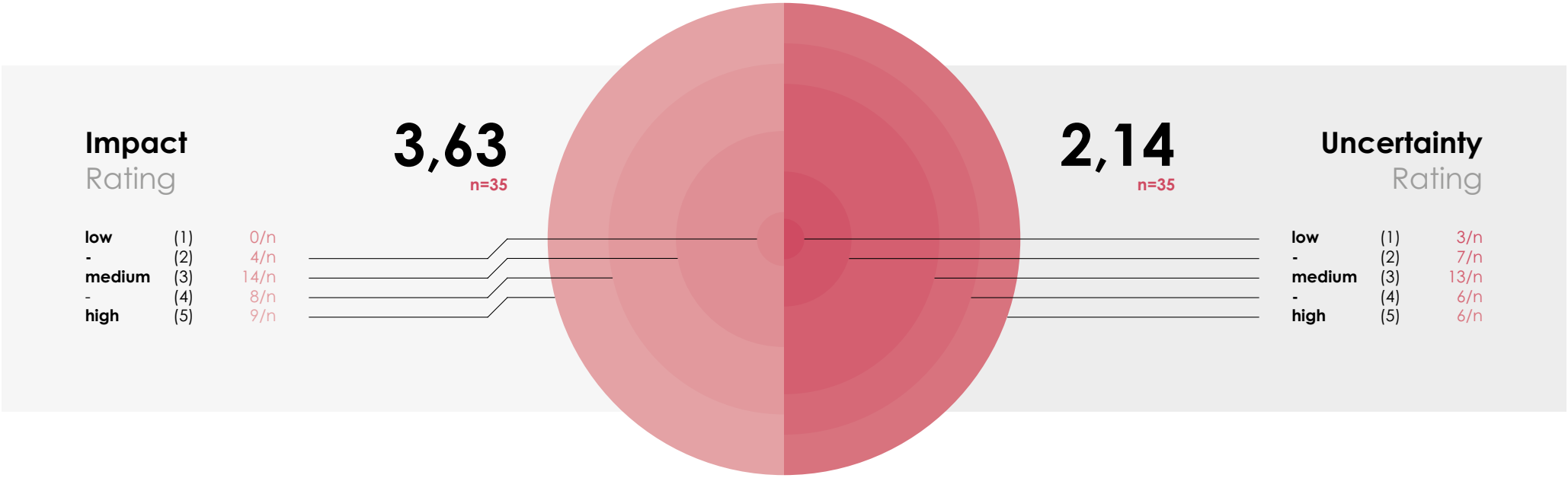


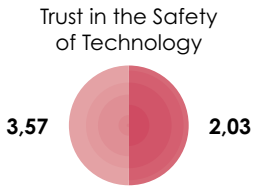


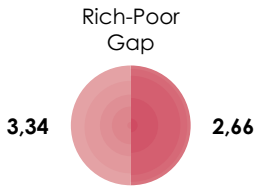


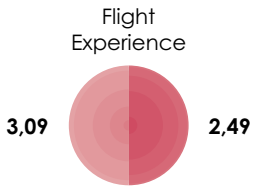
Societal Values and Education

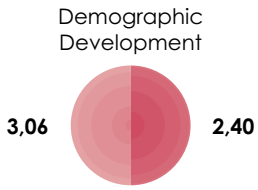
Social behaviours, lifestyles and attitudes of social groups in connection with individual value systems and educational attainment

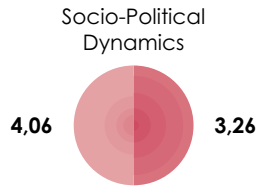


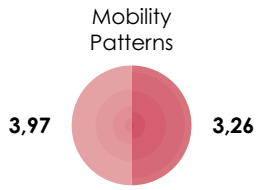












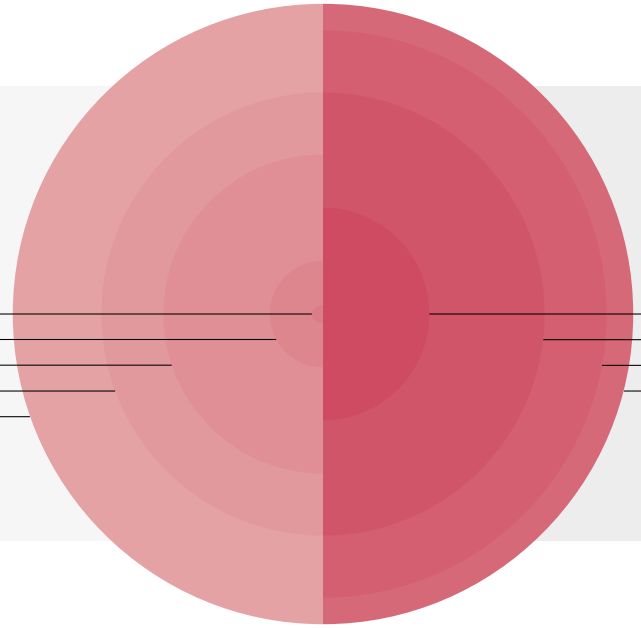
Trust in the Safety of Technology

General trust in technology and infrastructure around aviation

Impact
Rating

3,57
n=35

low	(1)	1/n
-	(2)	5/n
medium	(3)	12/n
-	(4)	7/n
high	(5)	10/n

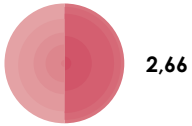


2,03
n=35

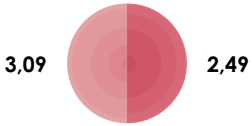
Uncertainty
Rating

low	(1)	12/n
-	(2)	13/n
medium	(3)	7/n
-	(4)	3/n
high	(5)	0/n

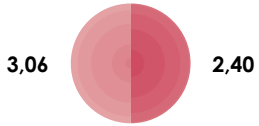
Rich-Poor Gap



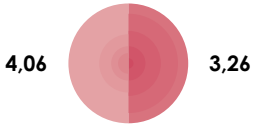
Flight Experience



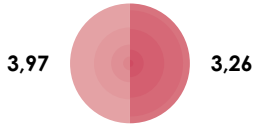
Demographic Development



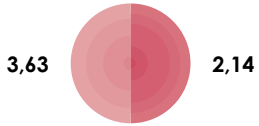
Socio-Political Dynamics



Mobility Patterns

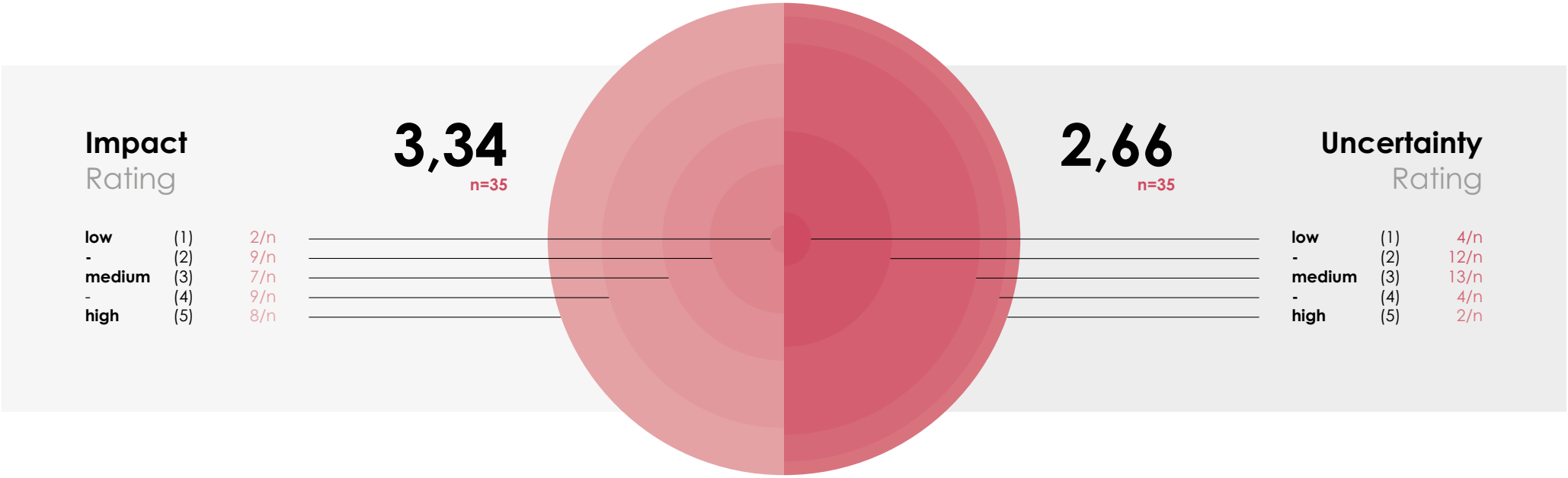


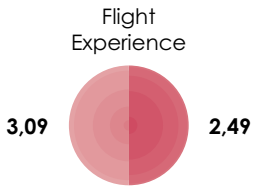
Societal Values and Education

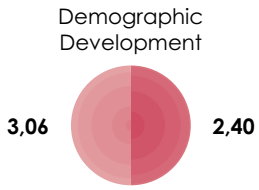


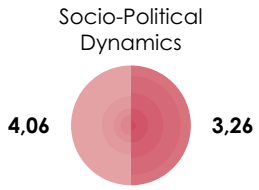
Rich-Poor Gap

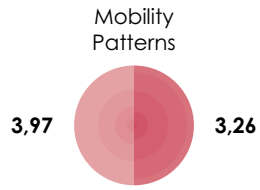
Distribution of financial means in Europe [a] Globally [b]

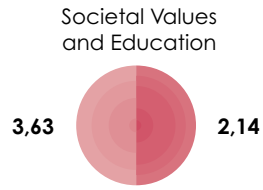


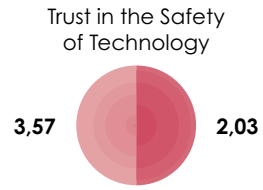












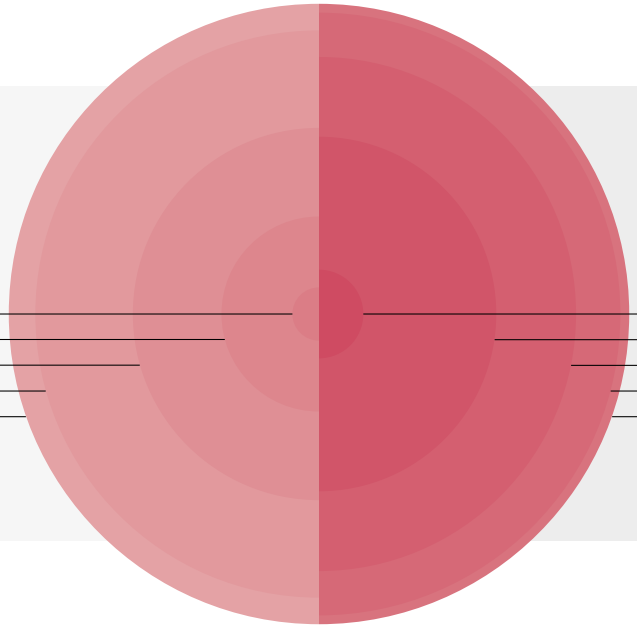
Flight Experience

On-board flight experience (mobility on board, internet, comfort, noise, etc.)

Impact
Rating

3,09
n=35

low	(1)	3/n
-	(2)	8/n
medium	(3)	10/n
-	(4)	11/n
high	(5)	3/n



2,49
n=35

Uncertainty
Rating

low	(1)	5/n
-	(2)	15/n
medium	(3)	9/n
-	(4)	5/n
high	(5)	1/n

Demographic Development
3,06 **2,40**

Socio-Political Dynamics
4,06 **3,26**

Mobility Patterns
3,97 **3,26**

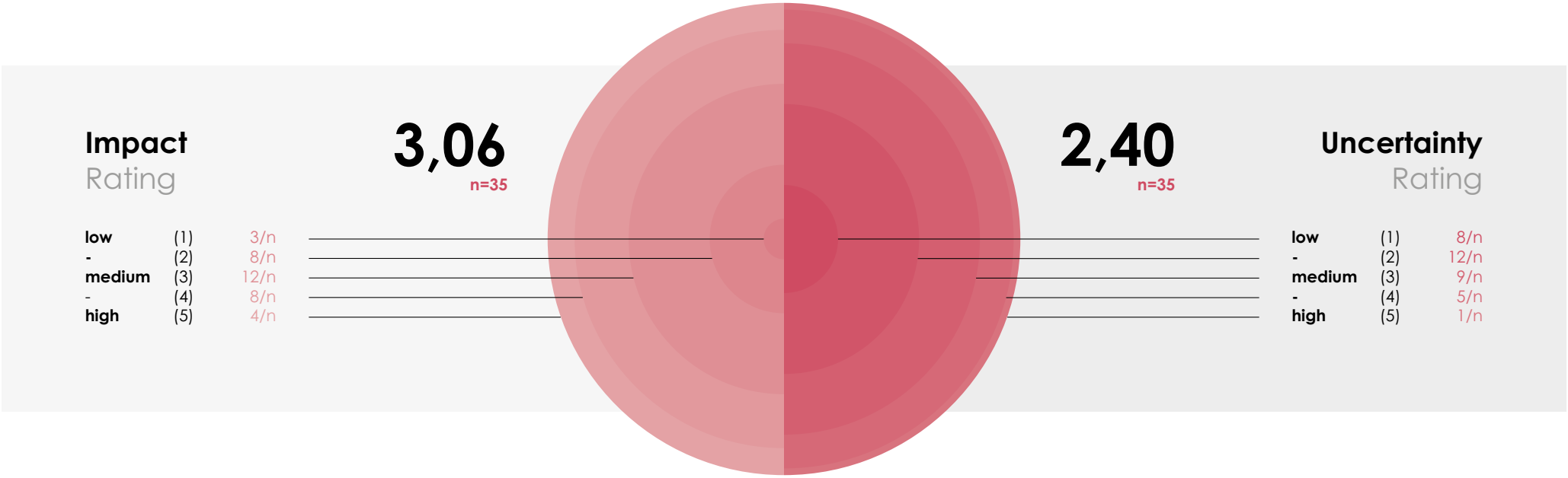
Societal Values and Education
3,63 **2,14**

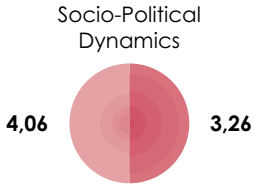
Trust in the Safety of Technology
3,57 **2,03**

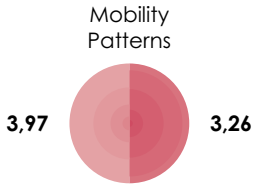
Rich-Poor Gap
3,34 **2,66**

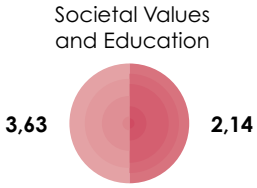
Demographic Development

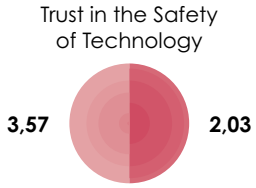
Age distribution with Europe: Population growth in relationship to birth/death rate and migration

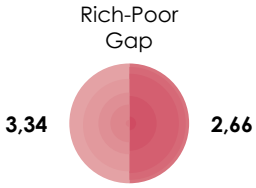


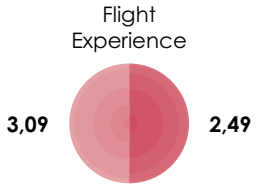






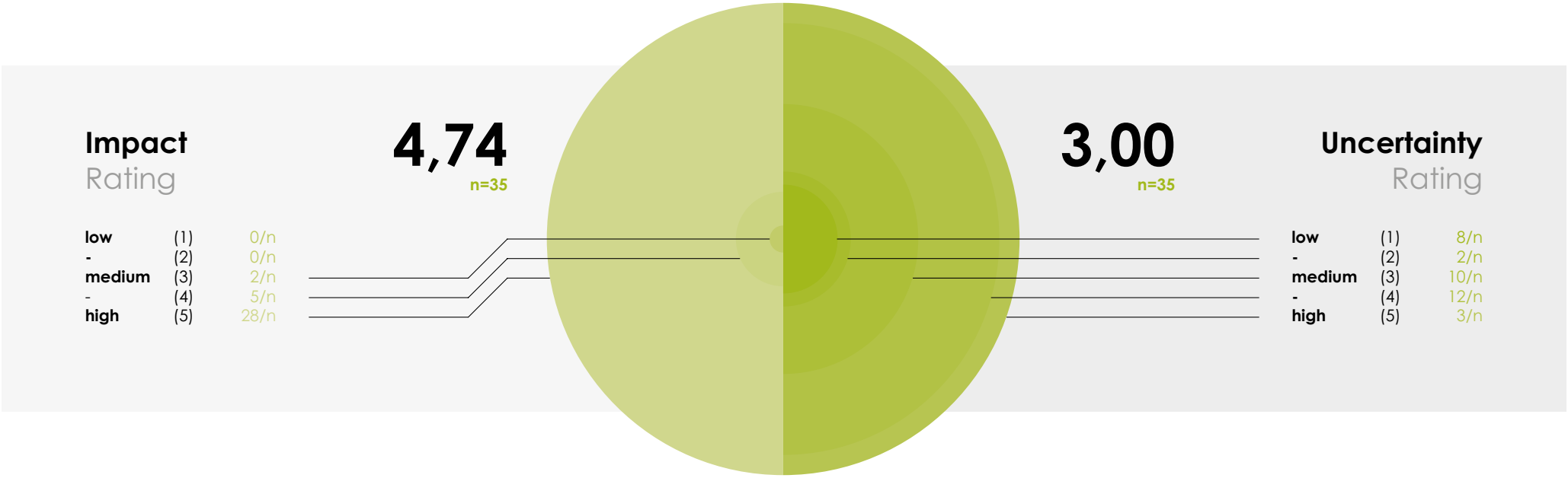


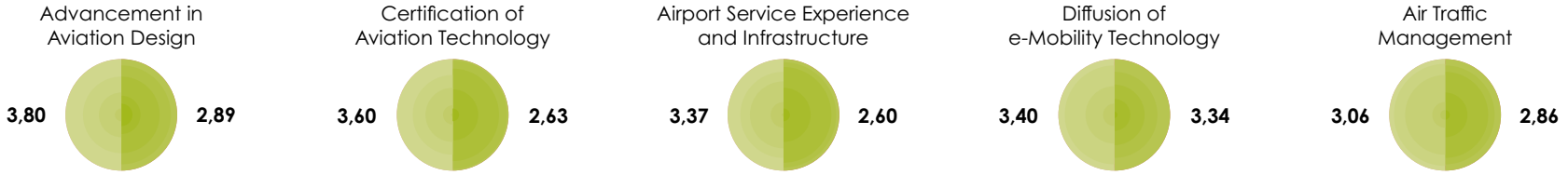




Technological Advances in the Energy Sector

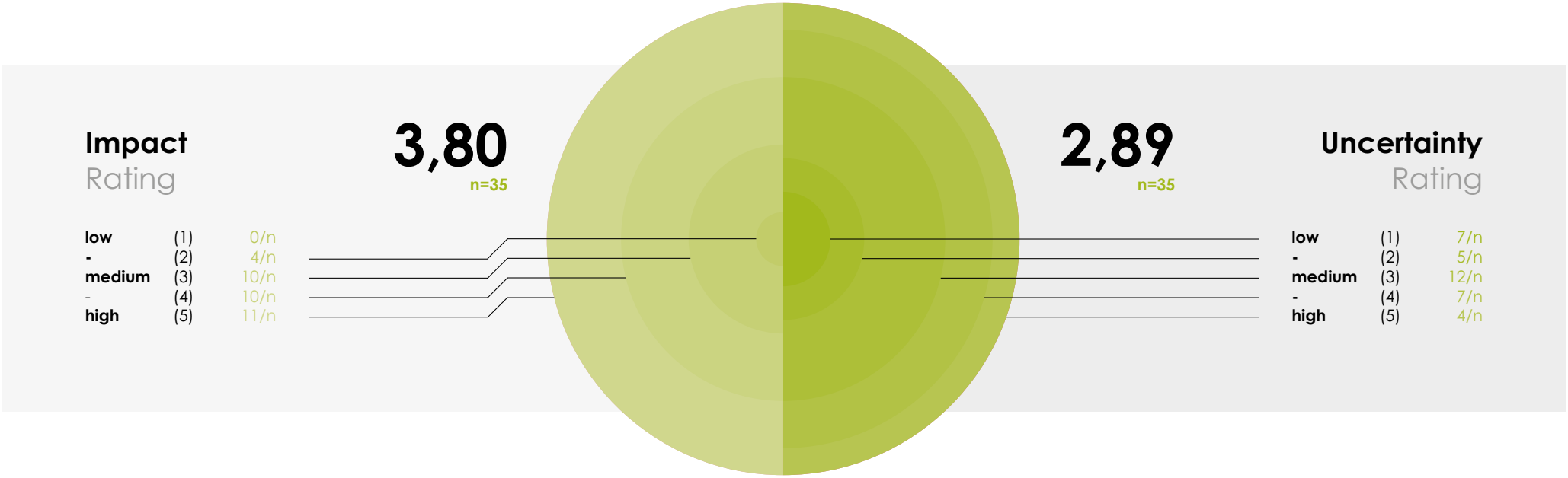
Depending on power storage solutions for aviation, the innovations producing sustainable aviation fuels and the effect of advancements in propulsion technologies on the energy mix for aviation

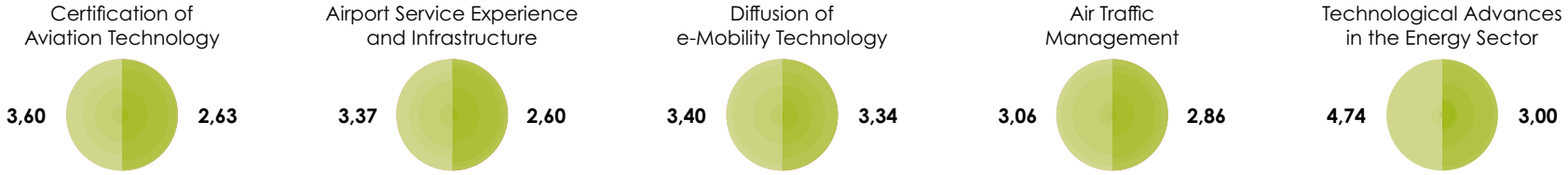




Advancement in Aviation Design

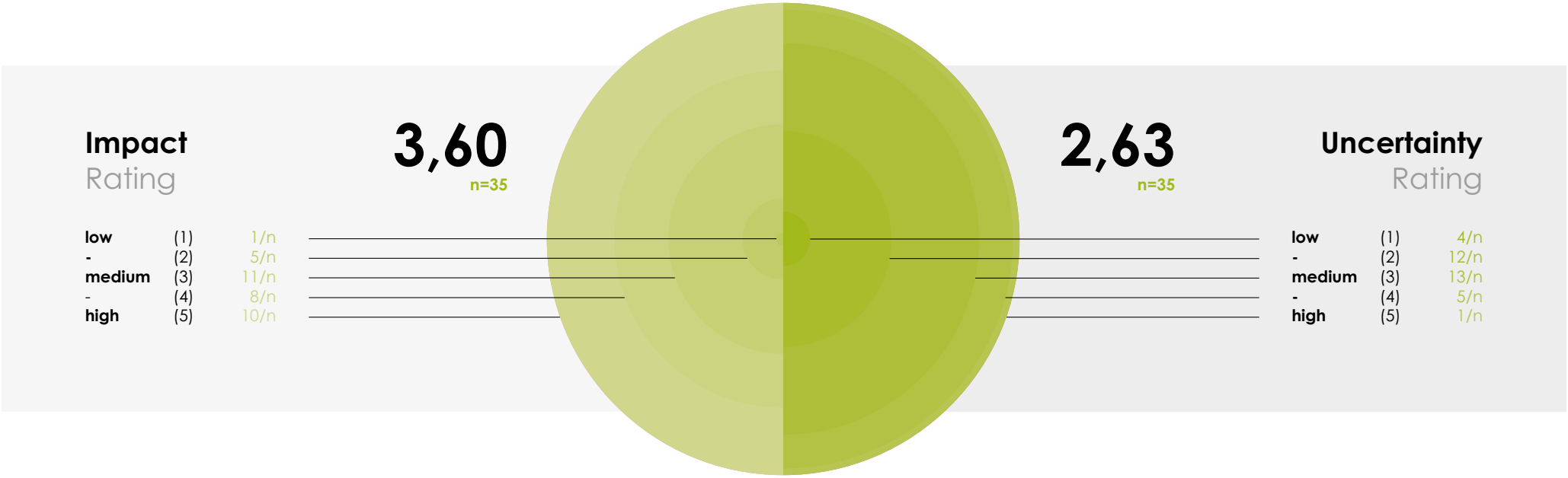
Penetration rate and acceptance of e-mobility, particularly in Europe's air transport sector

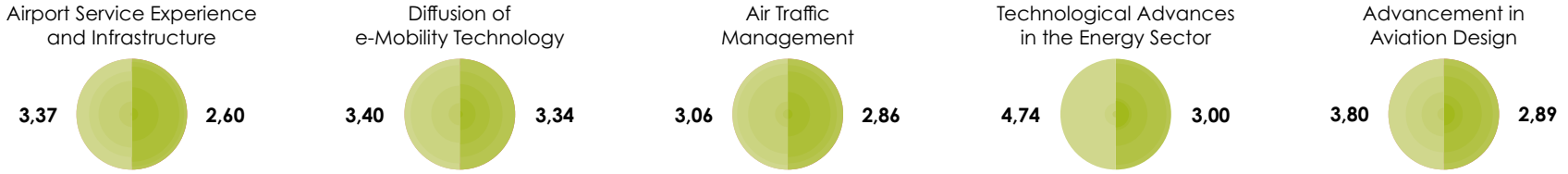




Certification of Aviation Technology

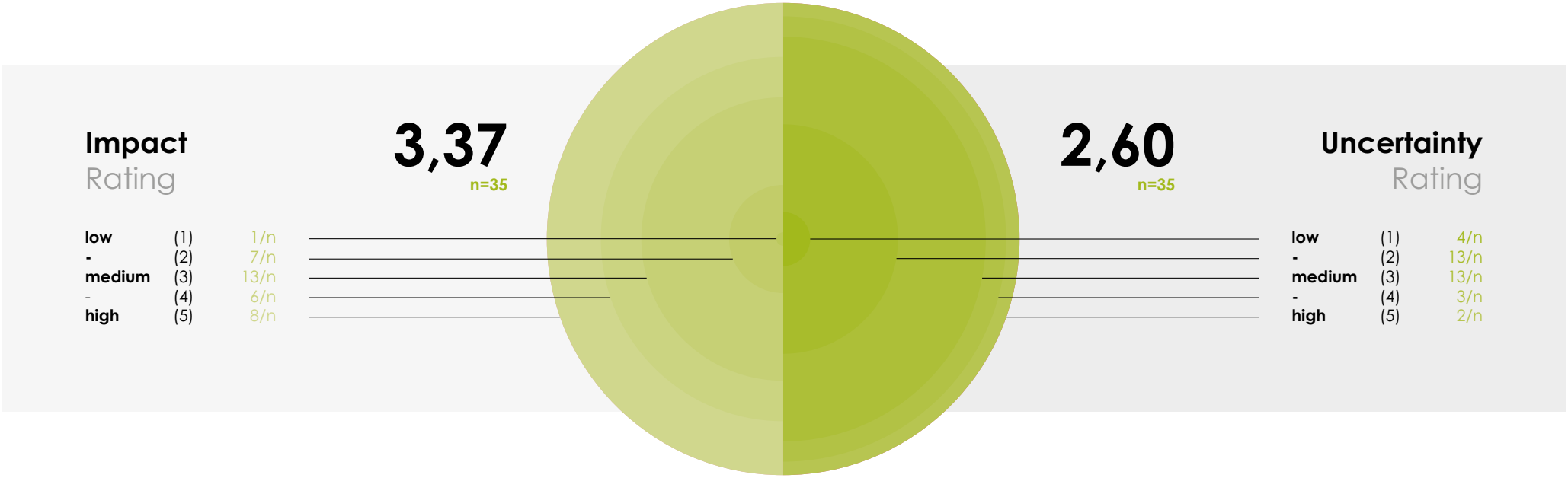
Certification of aviation technologies with regard to safety regulations and measures

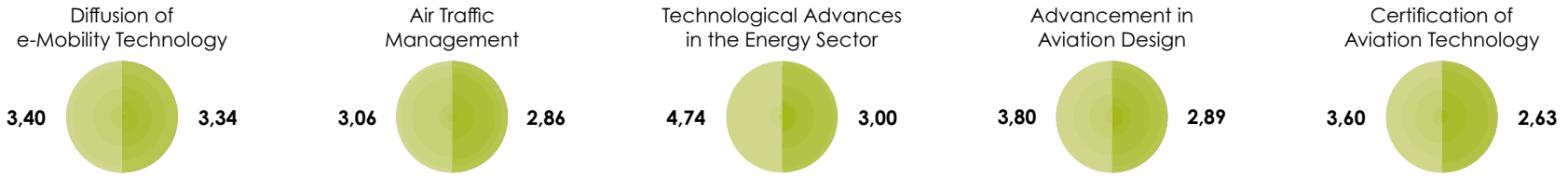




Airport Service Experience and Infrastructure

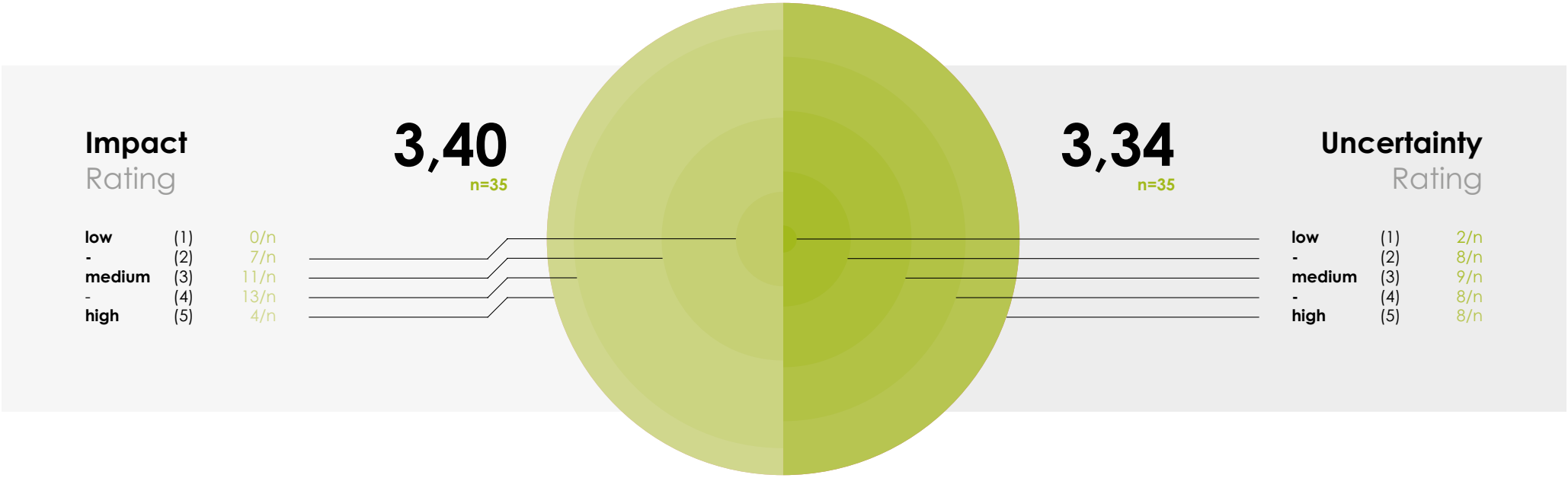
Airport service experience for both passengers and cargo along with supporting Infrastructure

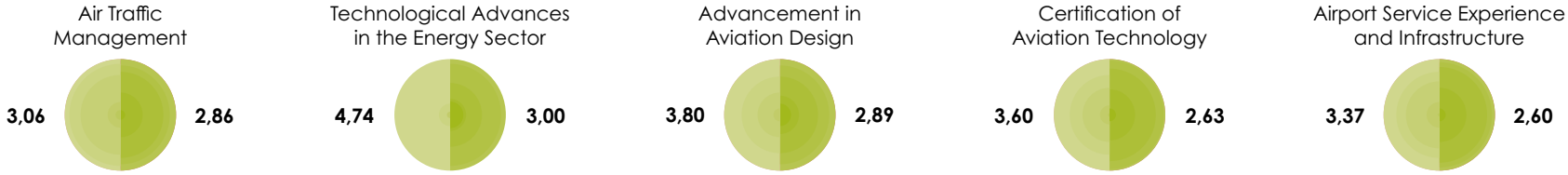




Diffusion of e-Mobility Technology

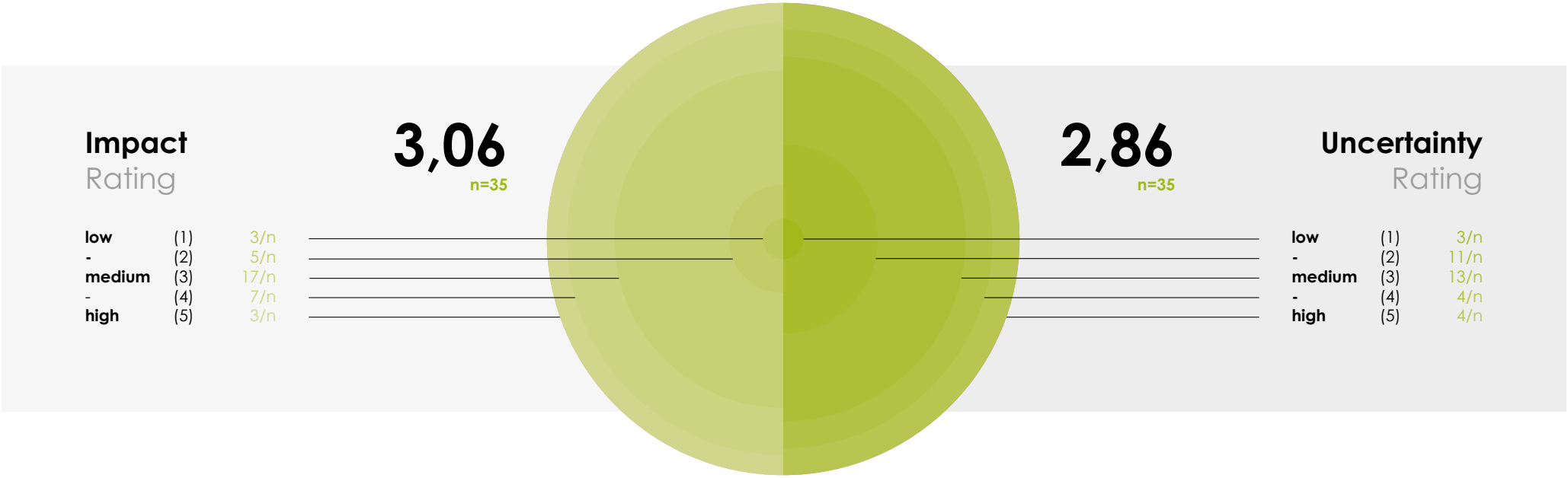
Penetration rate and acceptance of e-mobility, particularly in Europe's air transport sector

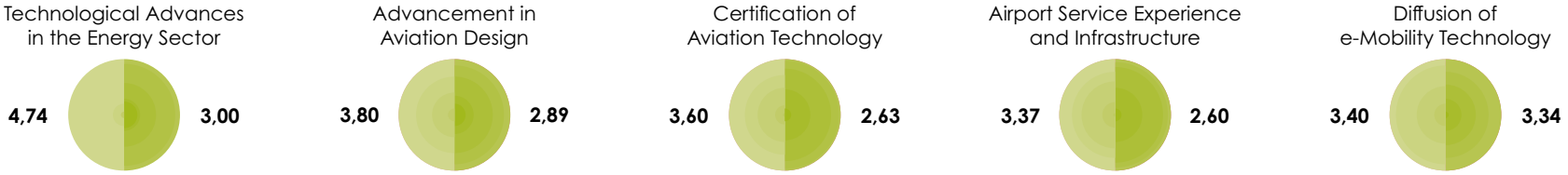




Air Traffic Management

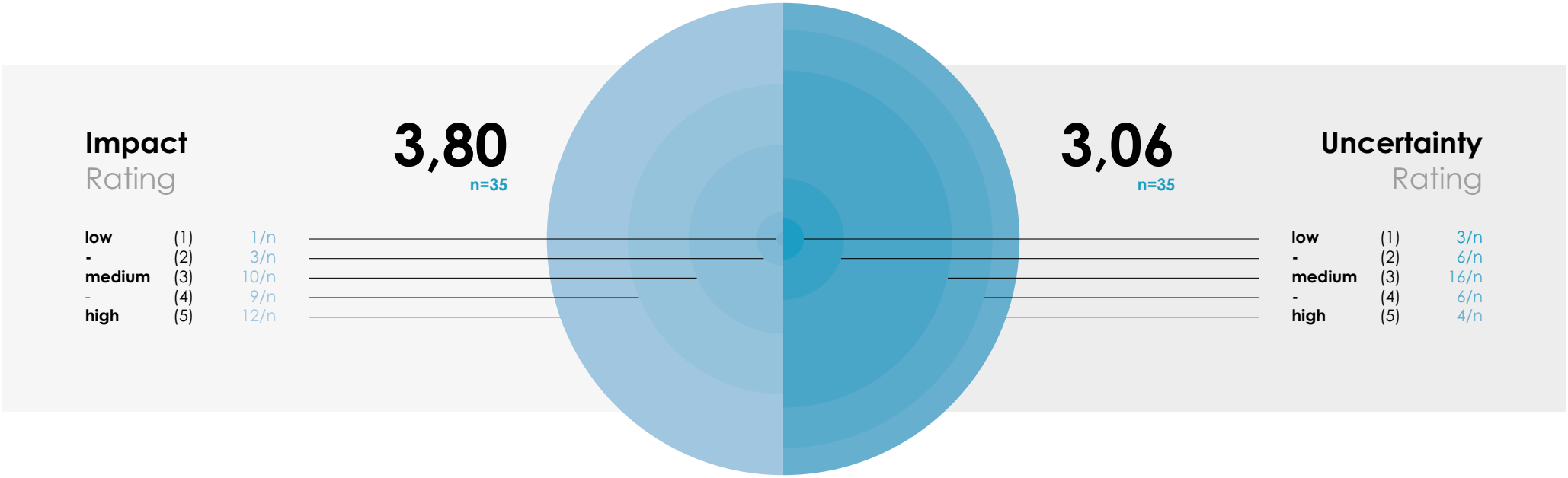
Computational development and international cooperation for efficient and secure Air Traffic Management (ATM), including Uncrewed Aerial System (UAS) and Advanced Air Mobility (AAM)

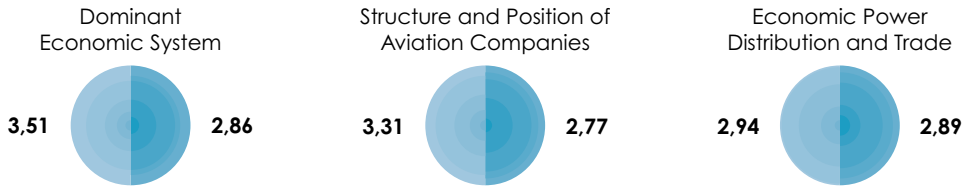




Air Traffic Demand (ATD)

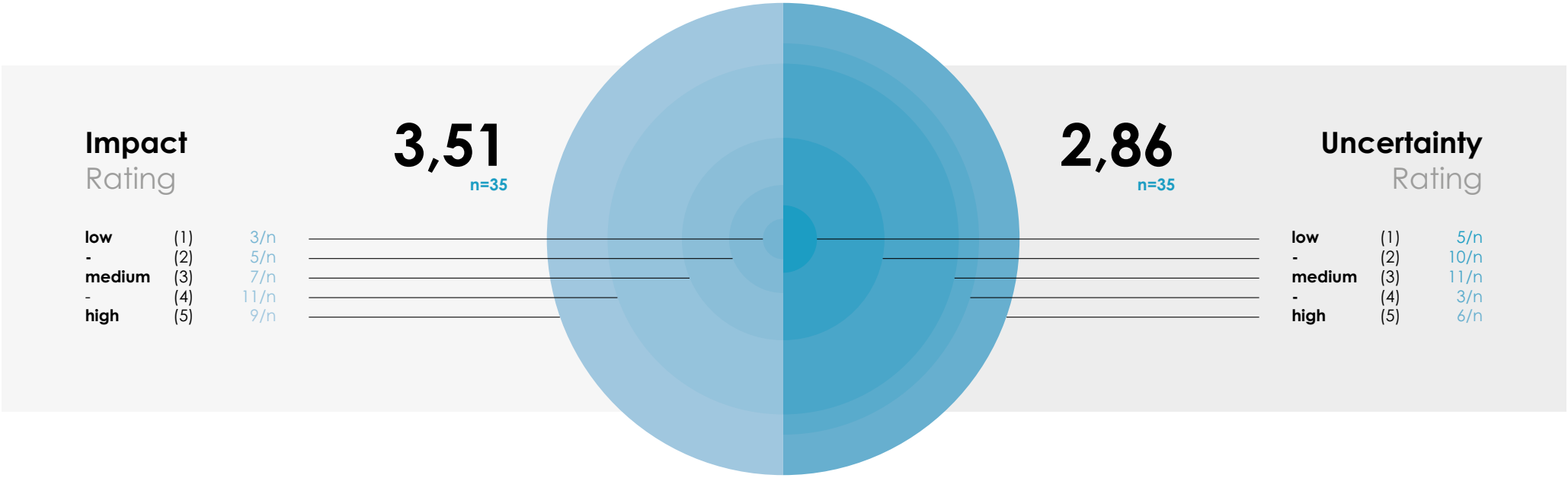
In conjunction mobility options and work models. The demand for air travel in response to the primacy of labour models, modes of business communication and the options available for inter-modular travel

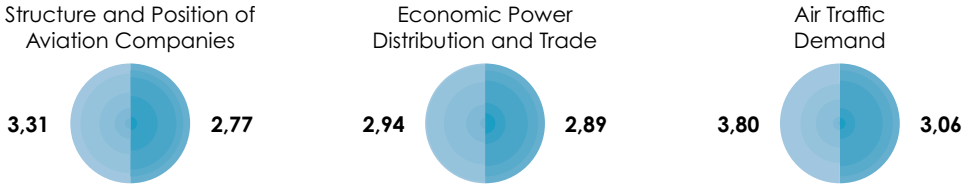




Dominant Economic System

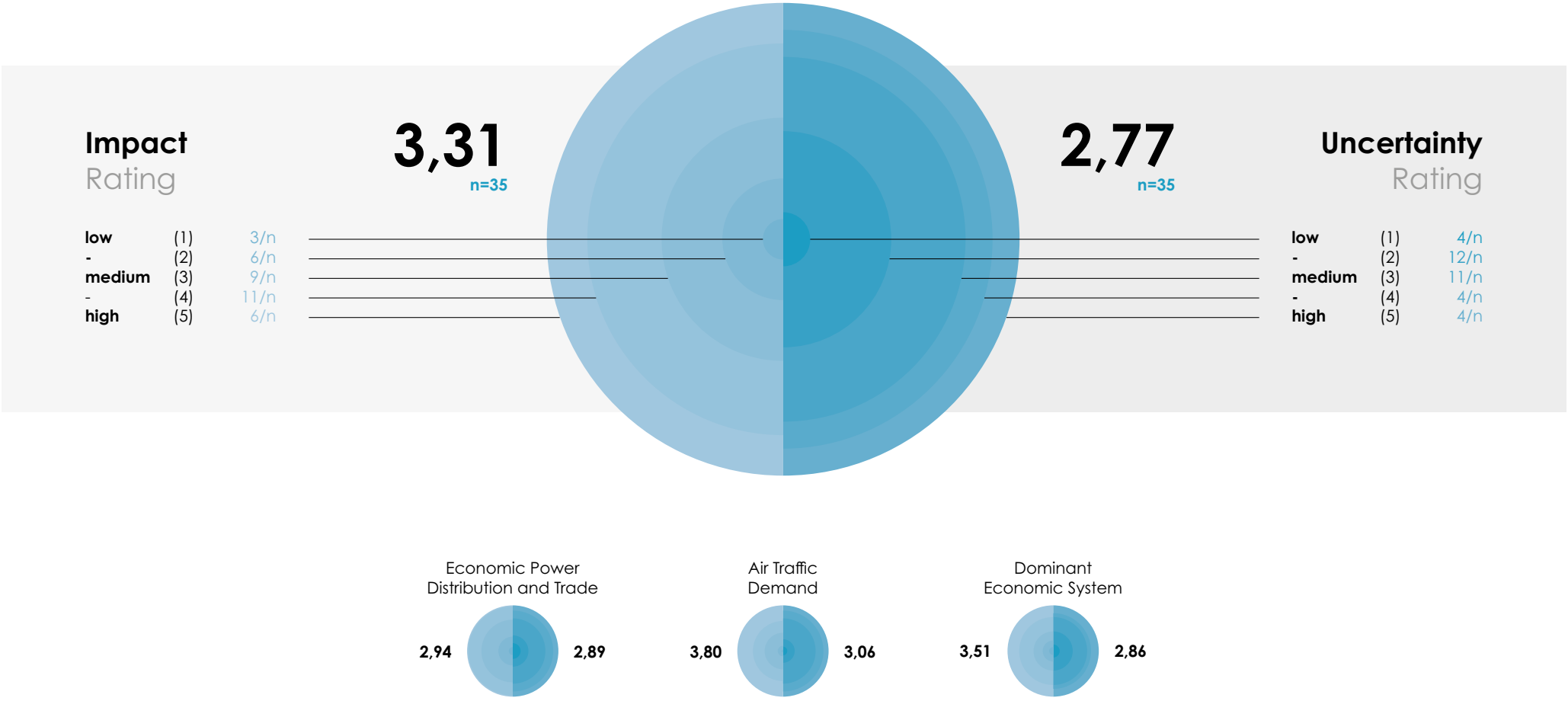
Prevailing economic logic and resulting economic system (liberal capitalism, social market economy, socialist market economy, etc.)





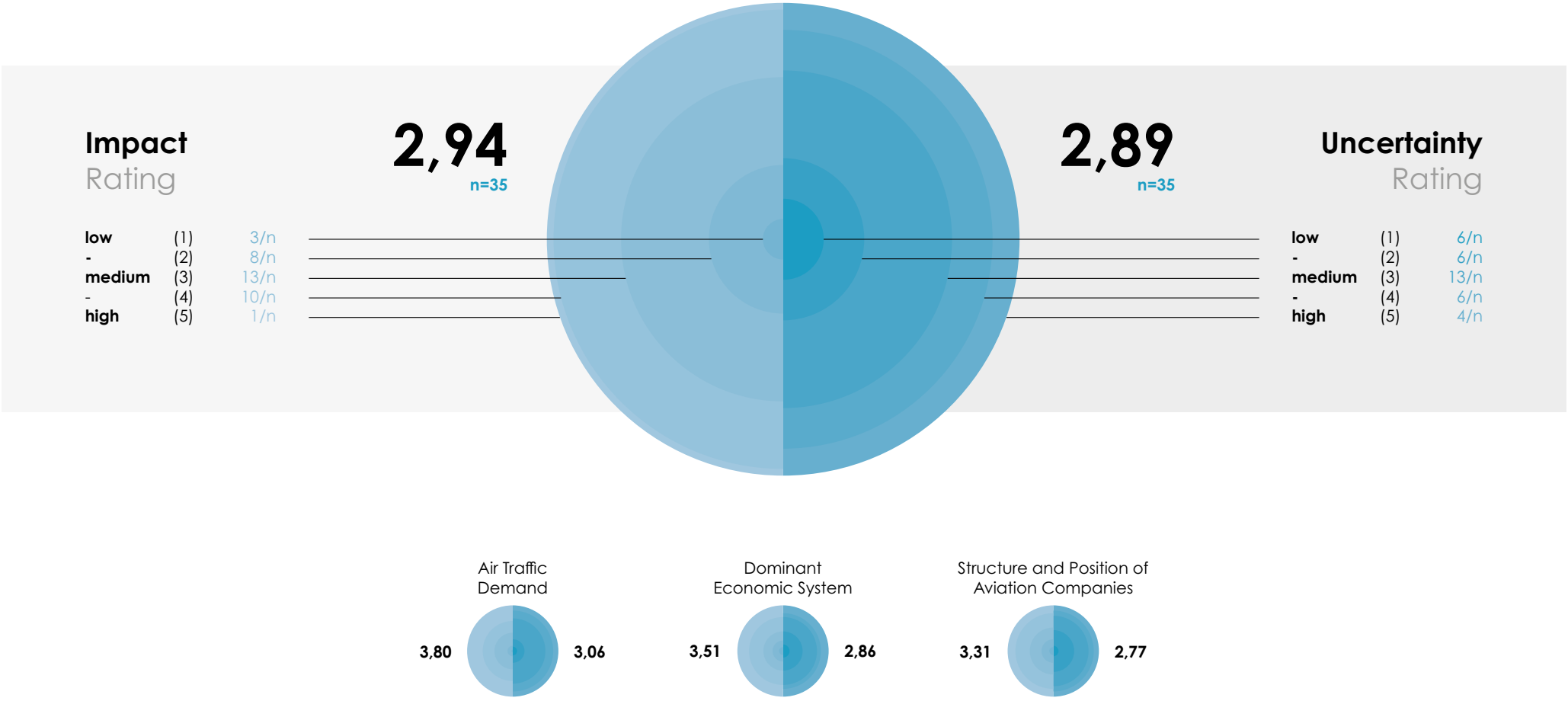
Structure and Position of Aviation Companies

Market division and dynamics (incumbents/start-ups) and political influence (Lobbyism) of aviation companies (manufacturers, airlines) in the EU (i.e. the European market)



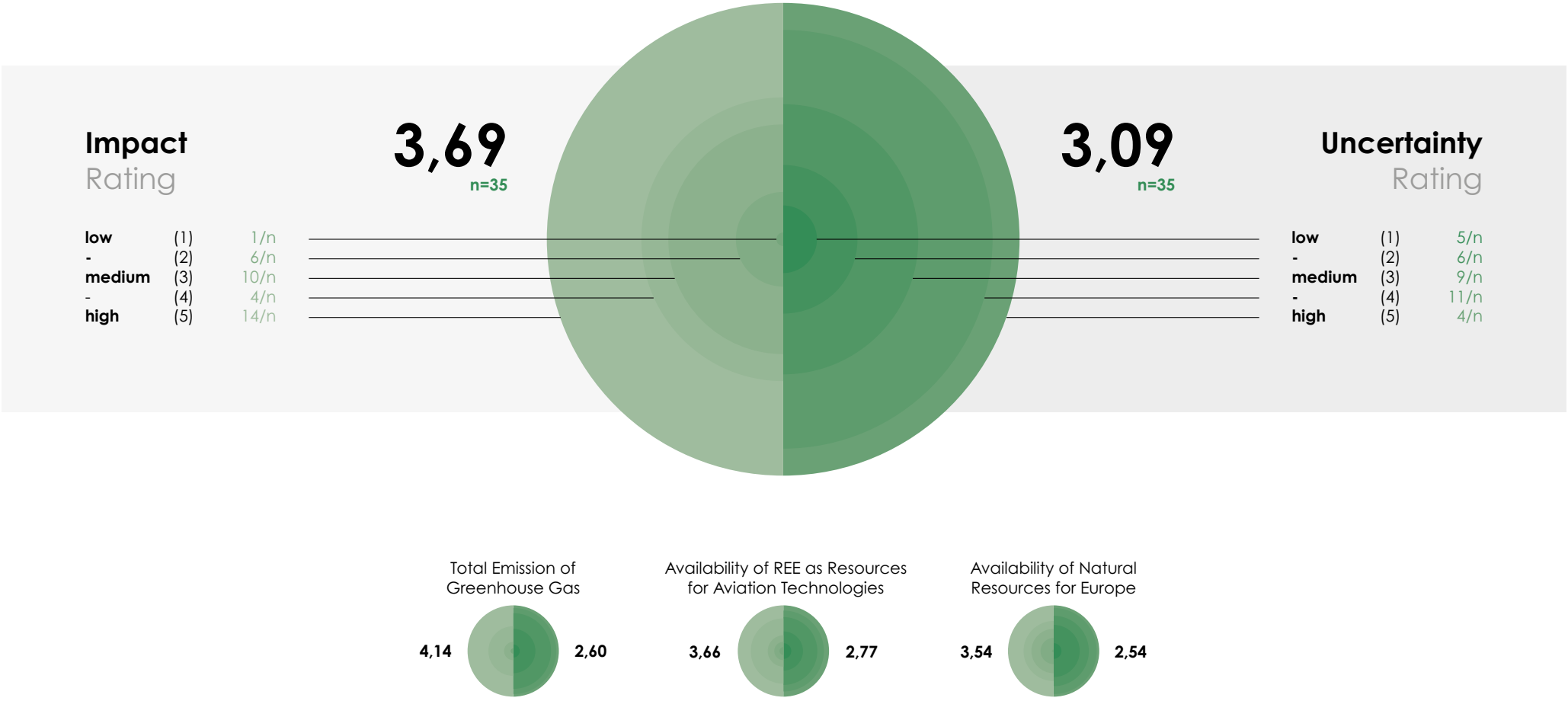
Economic Power Distribution and Trade

Economic position and power of individual states based on trade agreements and the potency of both their exports and imports



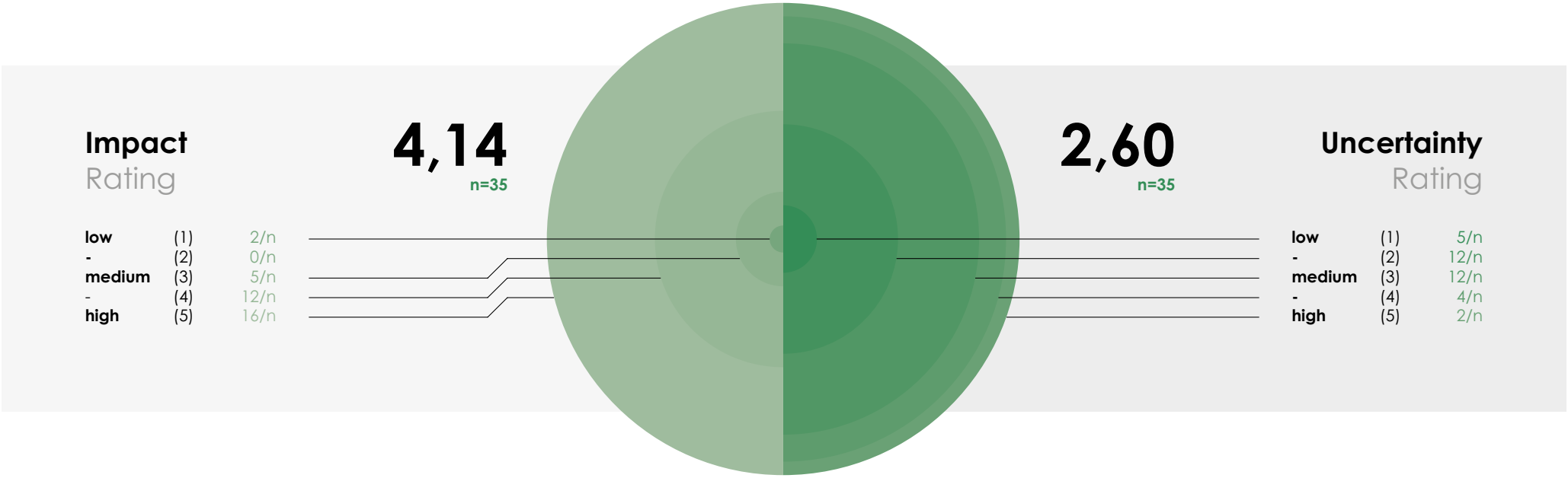
Environmental Conditions and Inhabitability

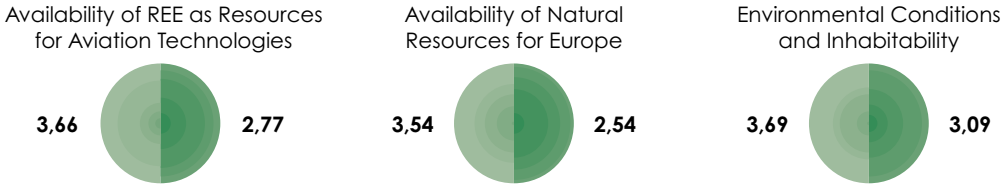
Impact of climate change on air transport and living conditions. This includes the measure to restrict areas that will be prohibited for habitation, as well as no-fly zones



Total Emission of Greenhouse Gas

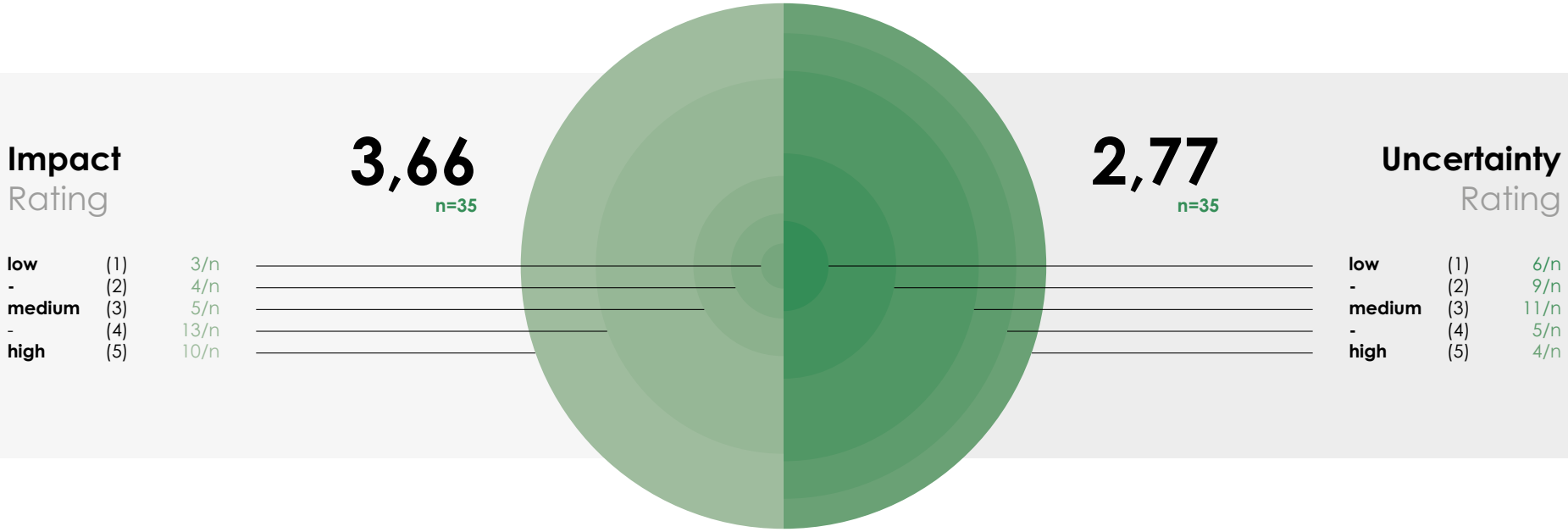
Projected total emissions of Greenhouse Gas in relation to the manageability/mitigation of their consequence

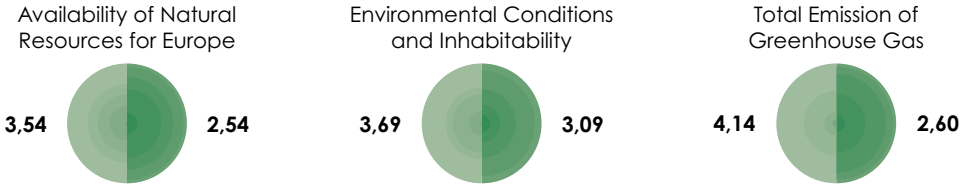




Availability of REE as Resources for Aviation Technologies

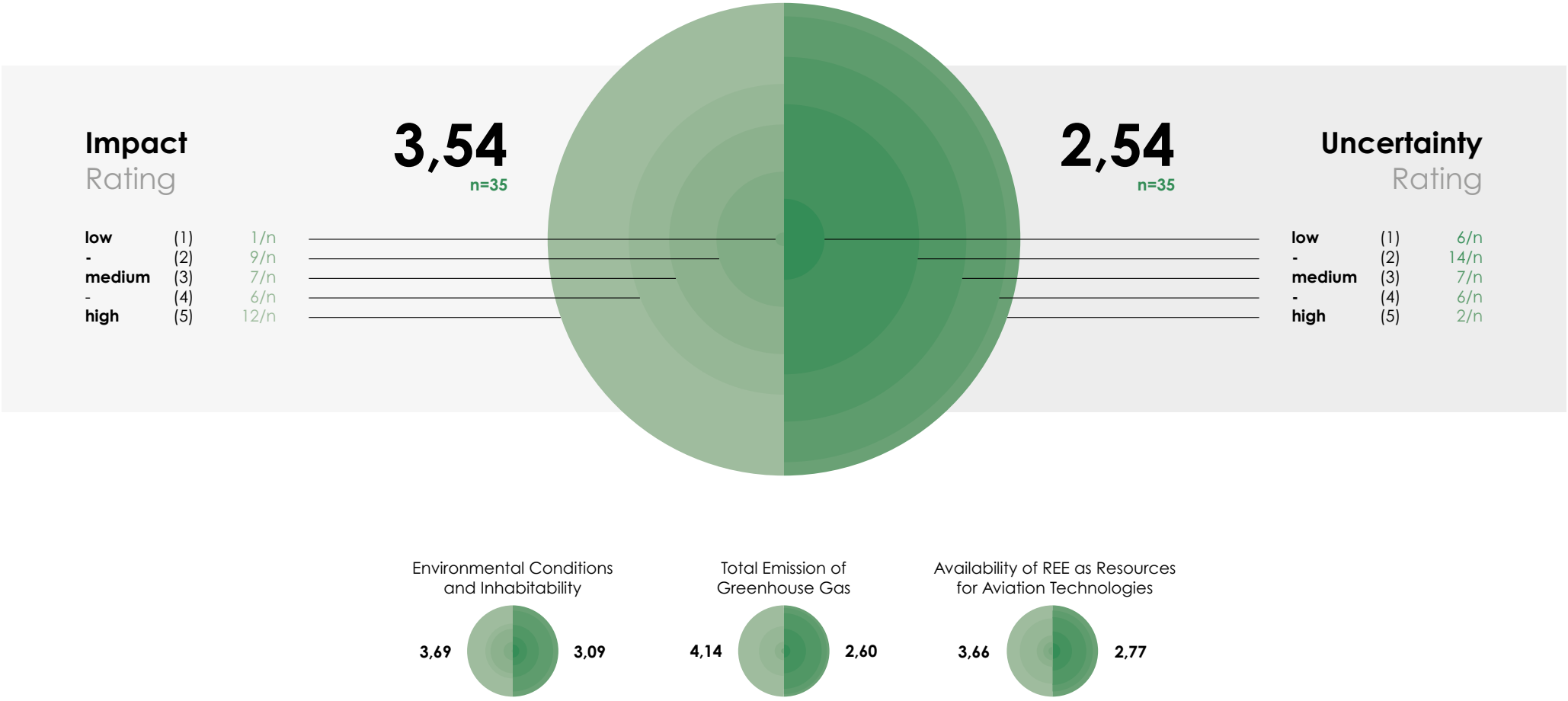
The availability of rare earth elements (REE) for the European market depending on the demand for these elements for the optimisation of aviation technologies such as propulsion





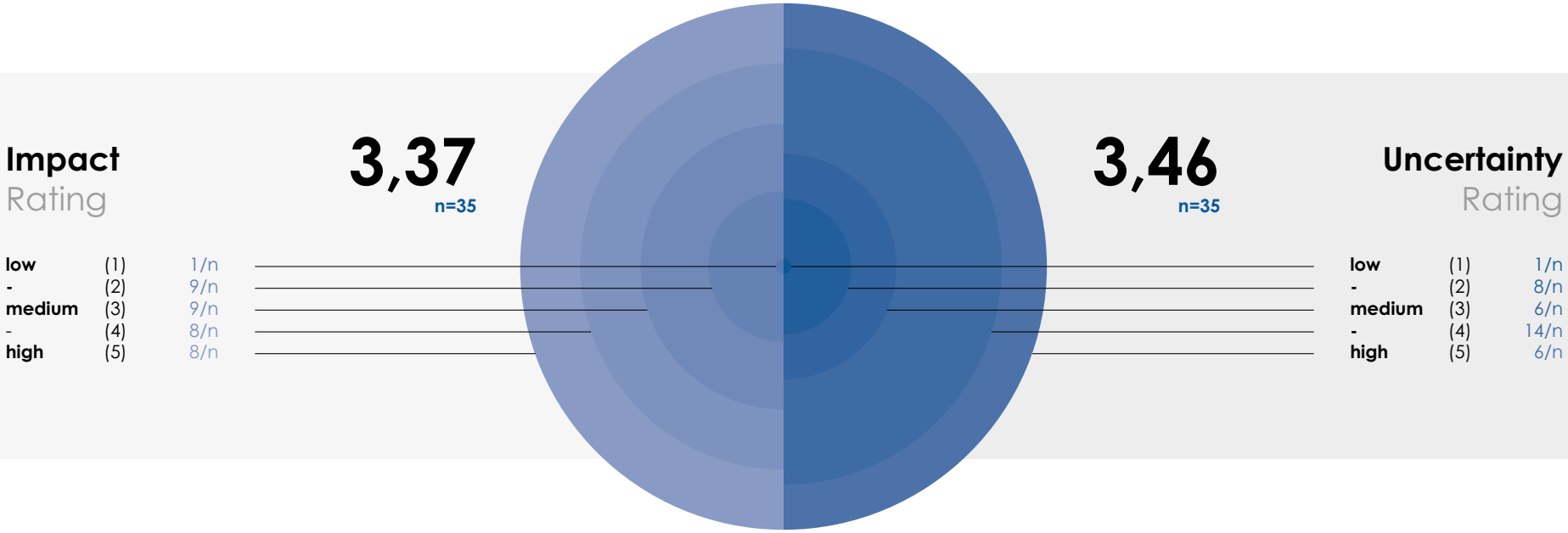
Availability of Natural Resources for Europe

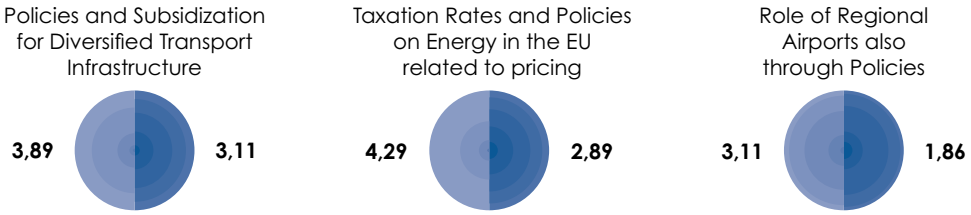
Ability to produce and/or import natural resources (Water, fertile Land, Gas, Minerals, Wood, Sand, etc.)



Global Political Order

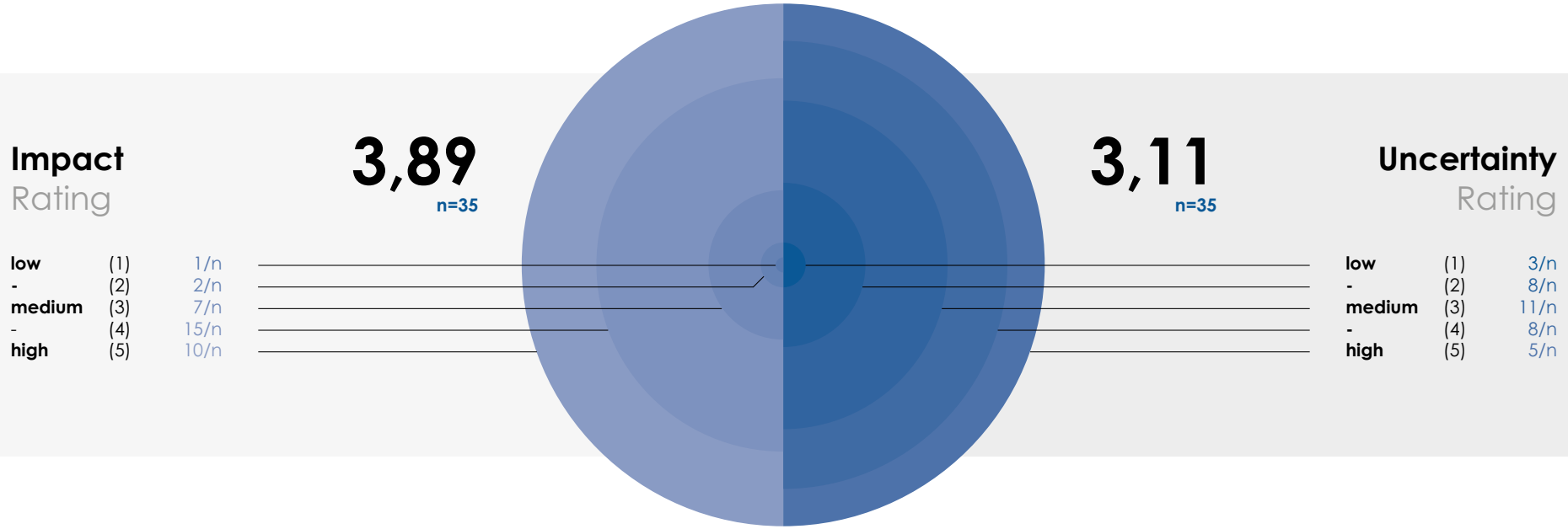
Development of public policies for subsidization and regulation of inter-modular (diversified) transportation structure, in conjunction with environmental protection laws

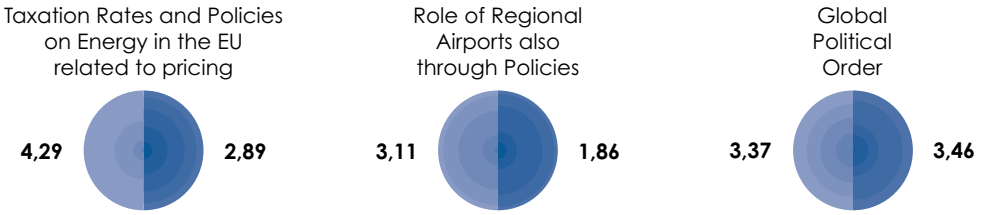




Policies and Subsidization for Diversified Transport Infrastructure

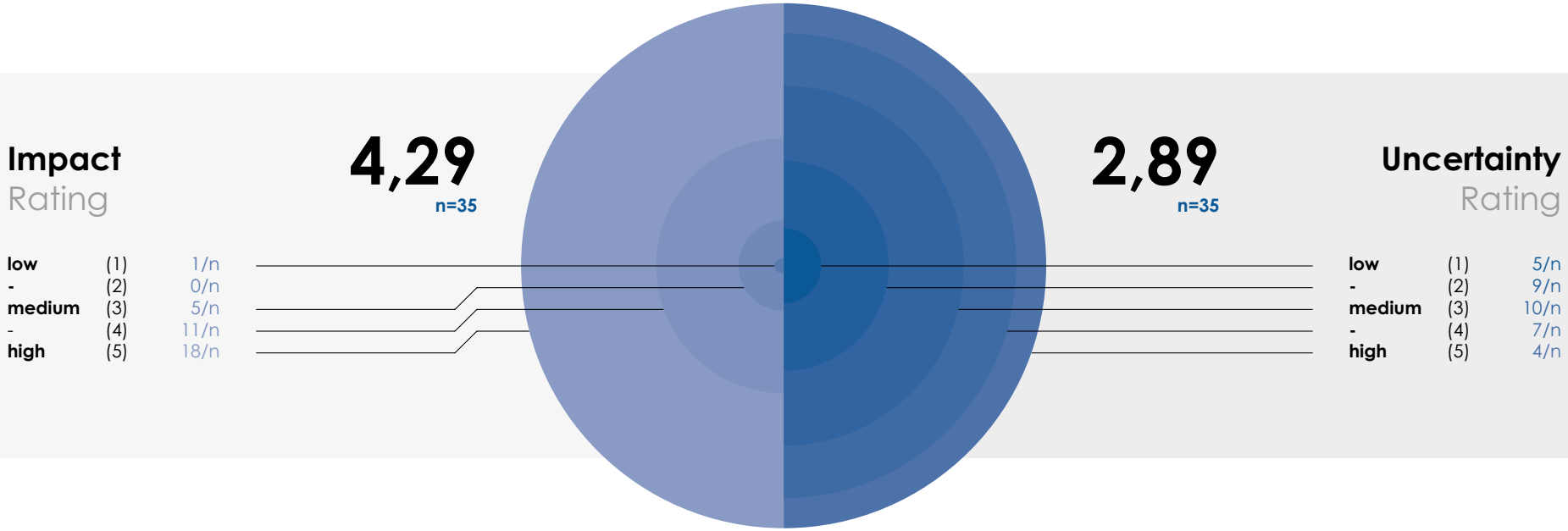
Development of public policies for subsidization and regulation of inter-modular (diversified) transportation structure, in conjunction with environmental protection laws

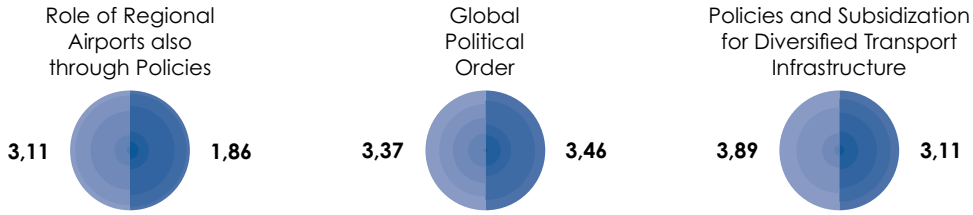




Taxation Rates and Policies on Energy in the EU related to pricing

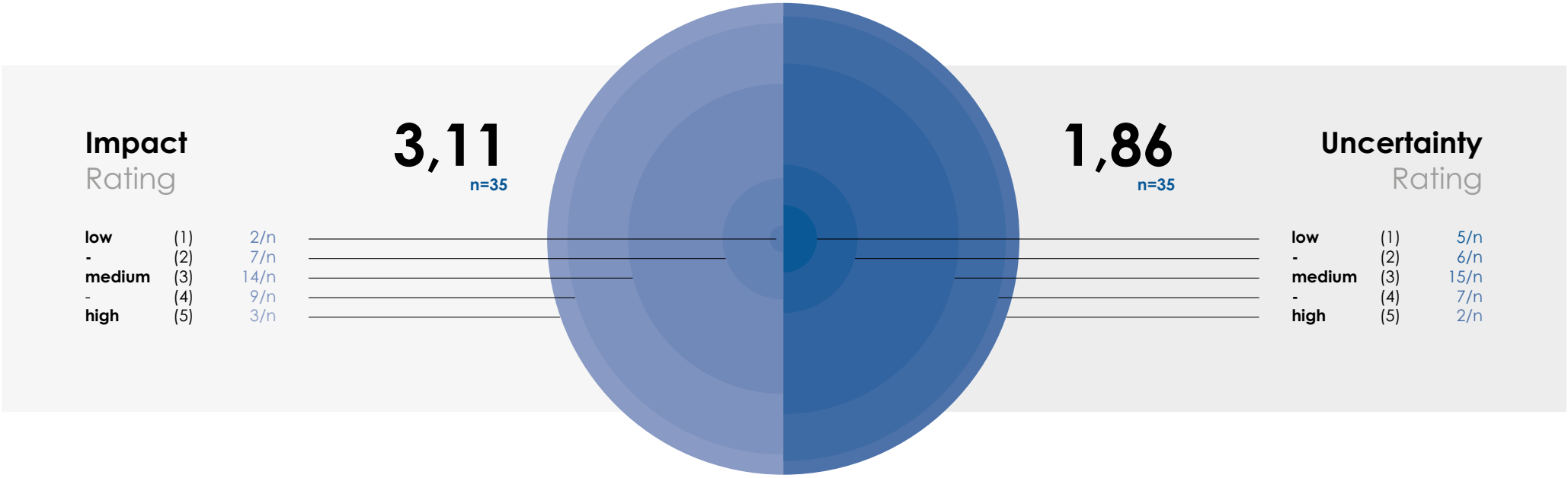
Policies to regulate the taxation of aviation fuels in conjunction with the development of energy prices in Europe based on the pricing of electricity, gas and fuels from renewable sources

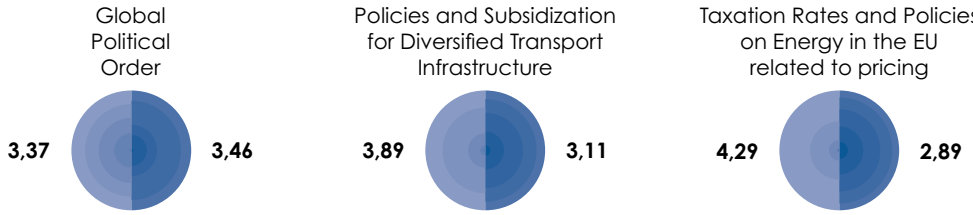




Role of Regional Airports also through Policies

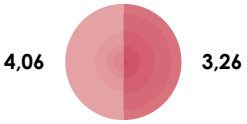
Their role within a region's mobility and economic infrastructure supported by policy measures including resident protection



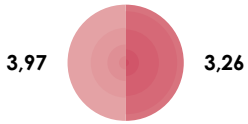


Overview of Resulting 8 defined Key Factors

Socio-Political Dynamics



Mobility Patterns

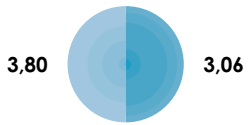


Technological Advances in the Energy Sector

Diffusion of e-Mobility Technology

Environmental Conditions and Inhabitability

Air Traffic Demand

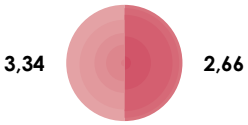


Global Political Order

Policies and Subsidization for Diversified Transport Infrastructure

Overview of Resulting 12 optional Key Factors

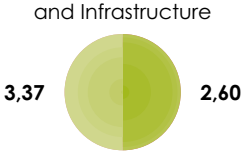
Rich-Poor Gap



Certification of Aviation Technology

Advancement in Aviation Design

Airport Service Experience and Infrastructure



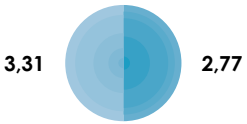
Availability of REE as Resources for Aviation Technologies

Total Emission of Greenhouse Gas

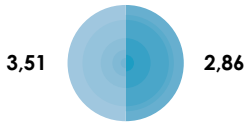
Availability of Natural Resources for Europe

Air Traffic Management

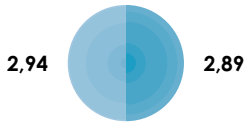
Structure and Position of Aviation Companies



Dominant Economic System



Economic Power Distribution and Trade



Taxation Rates and Policies on Energy in the EU related to pricing

Not considered Factors

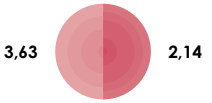
Flight Experience

Trust in the Safety of Technology

Role of Regional Airports also through Policies

Demographic Development

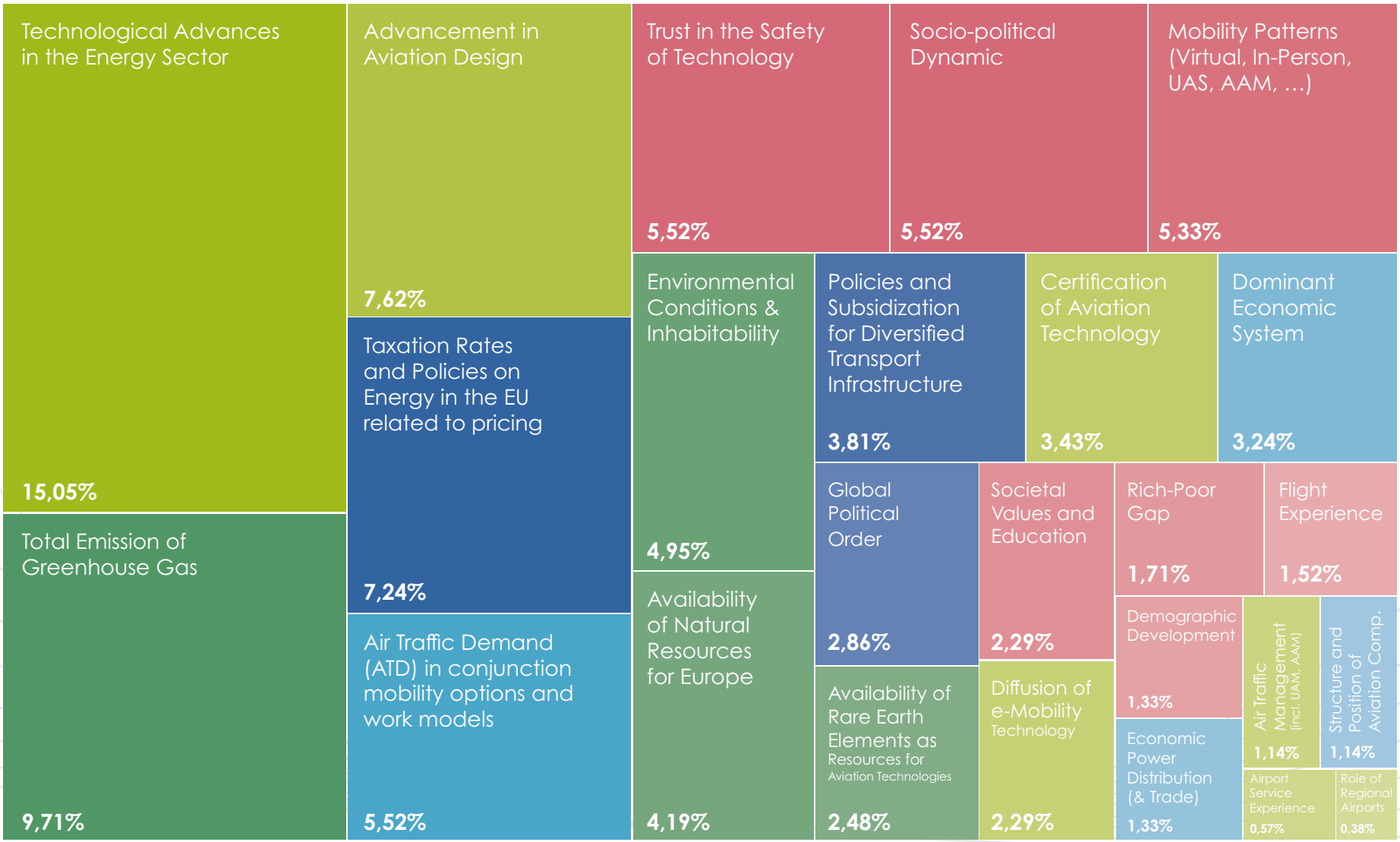
Societal Values and Education



Braunschweig University of Art
Hochschule für Bildende Künste Braunschweig
INSTITUT für DESIGN FORSCHUNG

Ranking of the 25 Factors

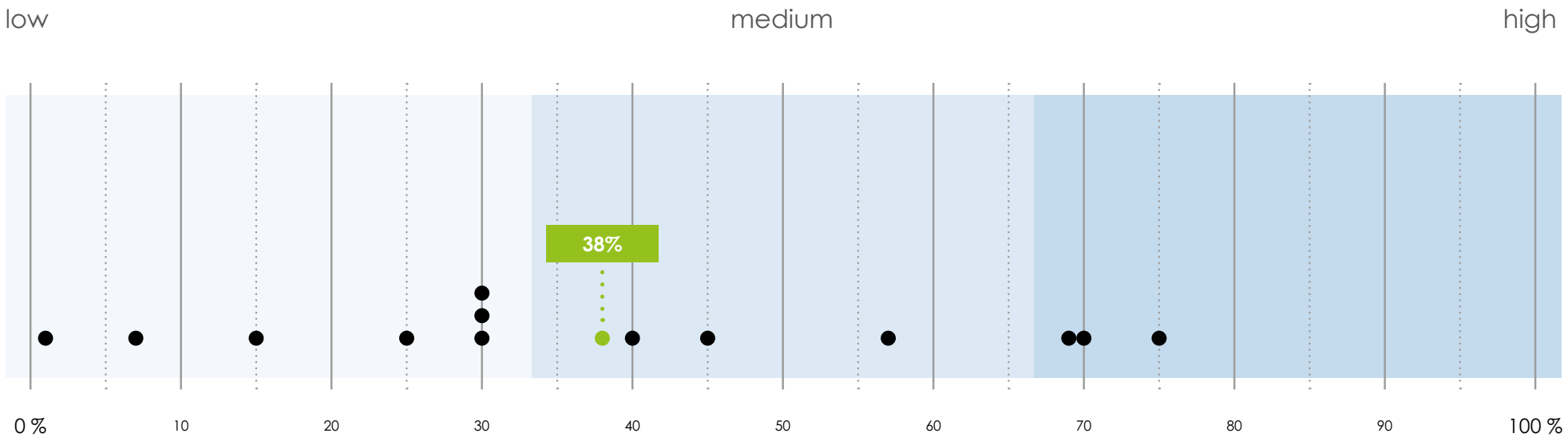
Accumulated Ranking through 35 Participants (n=35)



Evaluation of ATS Transformation 1/2

How high is your expectation that the air transport system in Europe will reach the goal of ”net zero” by 2050?

Survey no. 1 – Estimation through 13 Participants (n=13)



Average rating

Individual rating

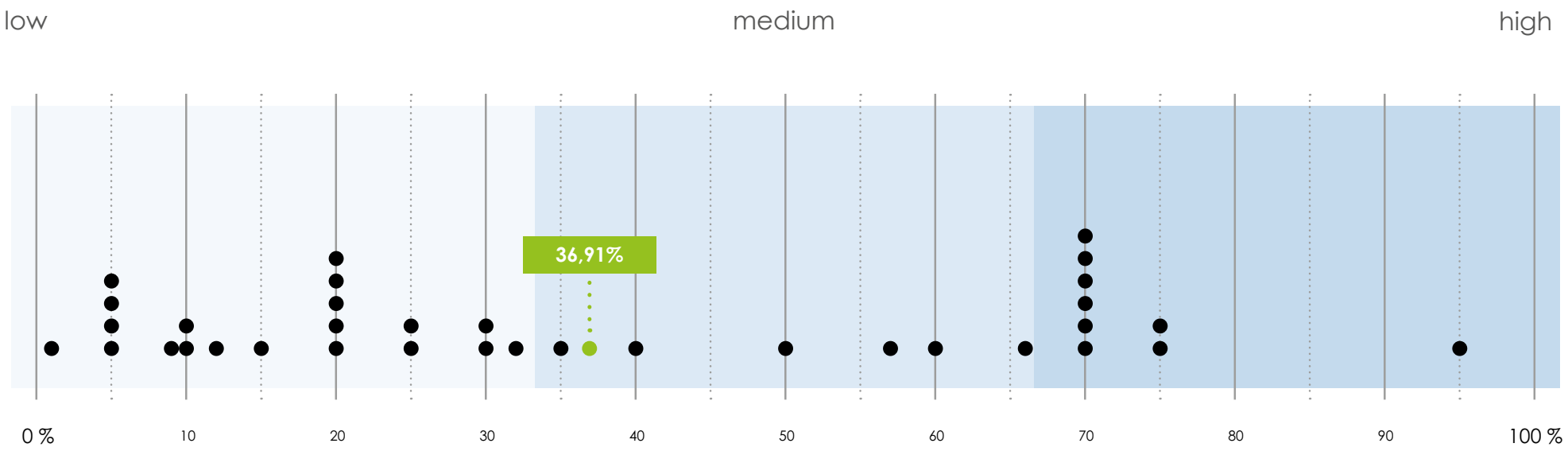
23% of the participants have a high expectation towards the „net zero“ target by 2050. However about **54%** of all participants have given a lower rating.

The average rating for the achievement of the „net zero“ target by 2050 is **38%**.

Evaluation of ATS Transformation 2/2

By what percentage do you estimate that the air transport system in Europe will achieve the “net zero” target by 2050?

Survey no. 2 – Estimation through 35 Participants (n=35)



Average rating

Individual rating

23% of the participants have a high expectation towards the „net zero“ target by 2050. However about **54%** of all participants have given a lower rating.

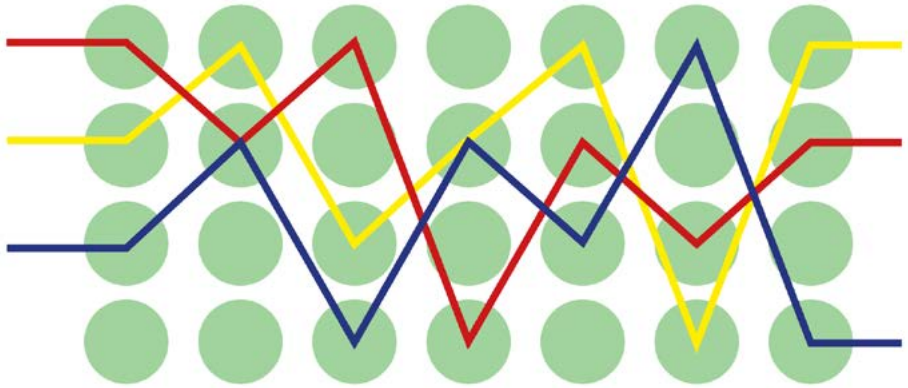
The average rating for the achievement of the „net zero“ target by 2050 is **38%**.

Result Evaluation and next steps

The survey results were 8 defined and 12 optional key factors. All can be understood as active drivers impacting the ATS's future development but less predictable to allow for two to four divergent projections.

As mentioned, the participants were mainly engineers from the SE2A excellence cluster, which may have led to the high emphasis on technological factors when asked to rank (p. 36). The ScenAIR team additionally conducted an active/passive mapping to explore its perspective on the 25 factors. Taking the above into account combined with the objective of the ScenAIR project focussing on users and socio-economic factors, the final number of key factors extracted is now 15 (p. 4). Those, will be the foundation of the explorative scenario work.

In two online expert-workshops the results of the survey were used to develop first projections (qualitative descriptions of the key factors' possible developments). This was done for seven of the key factors, for the remaining the projections are being developed to build a morphological box. In a next step a consistency analysis is conducted to assess the congruence of projections with each other. The values are needed to perform a conclusive morphological analysis. Those calculation will be done via a scenario-software to receive distinct (raw) scenarios (expected results end of 2023).



Thanks for your help in building sustainable futures!

If you have questions, please contact the ScenAIR2050 HBK Braunschweig team at: se2a-scenair.idf@hbk-bs.de

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