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Indicators for sustainable energy development: An Icelandic case study

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ABSTRACT

Sustainable energy development is a complex and global policy objective. What needs to be emphasized to reach the objective, varies based on context corresponding to different energy-related challenges. A robust set of context-specific indicators is needed to measure progress towards sustainable energy development. Sustainability indicators enable the monitoring of progress towards policy goals and can inform actions and decision-making. Indicators often reflect the critical issues or challenges that lie ahead. In this study, an iterative stakeholder approach to indicator development is implemented within Iceland. The approach highlights the importance of stakeholder engagement for indicator selection and that indicators need to be context specific. The product of this is a set of indicators for sustainable energy development of the Icelandic energy system. These indicators, based on stakeholder input, reflect national priorities for energy development. Multiple products with policy implications come out of the process; indicators, analysis of stakeholders and their views, a definition of sustainable energy development in the context, a roadmap towards it, and identification of linkages between indicators. Thus, the process can provide a base for energy policy, an action plan towards sustainable energy development that is supported by stakeholders.

1. Introduction

The purpose of energy systems is to provide (energy) services that improve human well-being and promote economic growth and social development (UNDP et al., 2000). Consequently, energy plays a fundamental role in making sustainable development possible. This role is often referred to as sustainable energy development (SED) and was recognized with the introduction of the UN's Sustainable Development Goal (SDG) 7 on affordable and clean energy (United Nations General Assembly, 2015). The concept of SED has evolved from being focused narrowly on energy security and the role of energy in reducing emissions to becoming a cross-cutting policy objective. Currently, SED is connected to some of the major environmental, social, and economic challenges facing the world (Gunnarsdottir et al., 2021a; Johnston et al., 2007; United Nations General Assembly, 2015). Consideration of environmental, social, and economic impacts is necessary for SED to be realized (United Nations Development Programme et al., 2000). SED is a complex and contested concept, and actions towards it vary corresponding to diverse energy-related problems facing energy systems or countries (Cherp and Jewell, 2014; Gallie, 1956; Taylor et al., 2017). Therefore, tailored actions towards SED are necessary.

Sustainability indicators can monitor progress towards policy goals and inform actions and decision-making. Indicators often reflect the critical issues or challenges that lie ahead. In a data-driven world, the usefulness of indicators is generally acknowledged. Numerous criteria for indicator selection have been developed; nonetheless, no standardized approach to indicator selection exists (Taylor et al., 2017). Multiple efforts have been made to create indicators for SED or parts of it (Gunnarsdottir et al., 2020; Narula and Reddy, 2015; Shortall and Davidsdottir, 2017; Taylor et al., 2017). These have been criticized for lack of transparency, imbalanced representation of the pillars of sustainable development, lack of stakeholder involvement, and burdensome data requirements (Iddrisu and Bhattacharyya, 2015; Narula and Reddy, 2015; Shortall and Davidsdottir, 2017; Sovacool, 2012; Taylor et al., 2017). Indicators for SED need to reflect the context by taking account of the energy-related challenges of a particular energy system to be useful to policy-makers and stakeholders (Shortall and Davidsdottir, 2017; Taylor et al., 2017).

Stakeholder engagement in decision-making, policy development, and indicator selection is progressively more recognized (Irvin and

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Stansbury, 2004; Pintér et al., 2012; United Nations, 1998). Nevertheless, it is not common practice to involve stakeholders during indicator development (Gunnarsdottir et al., 2020). Stakeholder engagement during indicator selection makes it possible to take into account diverse viewpoints, thus increasing validity and comprehensiveness, while also reducing potential bias in indicator selection. A process based on stakeholder input can result in a representative set of indicators that is acceptable to stakeholders (Pintér et al., 2012; Sovacool, 2012). Furthermore, stakeholder engagement is useful when analyzing "essentially contested concepts," such as sustainability and SED (Freeden, 1996; Gallie, 1956).

Gunnarsdottir et al. developed an iterative stakeholder engagement approach to indicator selection for SED (2021b). Throughout their process, stakeholders are involved repeatedly to recognize the challenges and opportunities for SED in the context and develop representative indicators. The objectives of this study are to:

- implement this indicator selection process and present indicators for SED in Iceland
- reveal the potential policy implications of the indicator selection process

The Icelandic energy system is chosen as a case study, and an indicator set is developed, reflecting the challenges facing that system. The following research questions are addressed: What challenges and opportunities are facing the Icelandic energy system on the path towards SED? What should be emphasized to reach SED in Iceland? What should be measured to track progress towards SED in Iceland? Stakeholders of the system are engaged to answer these questions.

The paper is structured as follows: Section 2 contains a review of the concept of sustainable energy development, the relevant indicators, and the Icelandic energy system. The indicator selection process is outlined in the third section. In the fourth section, the results of the study are presented. These results are discussed in the fifth section. In the sixth section, the policy implications are revealed, and the paper is concluded.

2. Background

2.1. Sustainable energy development and relevant indicators

The concept of sustainable energy development (SED) was first put forward in 2000 as a new development paradigm where the impacts of energy development on the environment, economy, and society were considered (UNDP et al., 2000). The importance of not endangering "the quality of life of current and future generations" and staying within ecosystem boundaries was highlighted in this new paradigm. The role of energy in furthering sustainable development was recognized from the start; that is when a definition of sustainable development was presented in the Brundtland report (World Commission on Environment and Development, 1987). However, what that role consisted of was unclear and, initially, was narrowly restricted to reducing emissions and ensuring energy security (World Commission on Environment and Development, 1987). Recognition of the importance of energy in enabling sustainable development has grown, especially since access to modern energy services is now seen as a vital driver for economic growth and social development (UNDP et al., 2000). One of the main challenges for SED is providing energy access to all while limiting the associated negative environmental and health costs (UNDP et al., 2000). For this to be possible, a transformation of the current energy system is necessary (IEA, 2008).

Similar to sustainable development, SED can be viewed as an "essentially contested concept," where interpretations of the concept can vary, and its meaning is still contested to some extent (Gallie, 1956). The contested nature of the concept of SED has resulted in ambiguities in its definition, which highlights the importance of a context-specific analysis (Taylor et al., 2017). Nonetheless, the ultimate goal of SED is to support sustainable development. Shortall and Davidsdottir (2017) identified eight SED themes from a review of the policy literature: access & electrification, affordability & equity, security, efficiency, renewables, economic or cost-efficiency, environmentally benign and clean, and contributes to well-being. Gunnarsdottir et al. (2021a). similarly identified four common interrelated SED themes, described below:

- *Access to affordable modern energy services* is vital for economic growth and promoting social well-being. A lack of modern energy services is connected with some of the main challenges of sustainable development, such as poverty, lack of basic health care, and environmental degradation (UNDP et al., 2000). Energy services need to be affordable to all if they are to be accessible and promote sustainable development.
- *Sustainable energy supply:* A transformation of current energy systems involves a transition to environmentally-sound energy options and sustainable utilization of renewable energy sources. This transition is only possible if those options are economically viable and cost-competitive (Gunnarsdottir et al., 2021a).
- *Energy security:* A secure supply of energy is necessary for sustainable development, which includes a reliable transmission and distribution system and sustainable utilization of energy resources (UNDP et al., 2000).
- *Sustainable energy consumption* involves increased energy efficiency and awareness of the negative impacts of the current energy system that will lead to a change in current consumption patterns (United Nations, 2002).

Multiple different indicators have been developed to measure progress towards SED or some aspect of it. Most of these have been found lacking in some regard, such as non-transparent methods and disproportionally emphasizing economic aspects (Narula and Reddy, 2015; Shortall and Davidsdottir, 2017; Sovacool, 2012). A challenge to indicator development for SED has been ambiguities of the concept and its varying meaning within different contexts (Narula and Reddy, 2015; Shortall and Davidsdottir, 2017). Shortall and Davidsdottir (2017) demonstrated the need for context-specific indicators for SED to inform decision-making at the national or regional level. Nonetheless, the majority of current SED indicator sets are general and do not take account of the context (Gunnarsdottir et al., 2020; Shortall and Davidsdottir, 2017). For instance, the *Energy Trilemma Index* and the *Energy Architecture Performance Index,* well-established SED indicator sets, are designed as national indicators for country comparisons with no flexibility to consider national conditions (Graymore et al., 2008; Shortall and Davidsdottir, 2017). The *Energy Indicators for Sustainable Development (EISD)* are similarly developed as national indicators (IAEA et al., 2005). However, flexibility in the set and guidance on how to update it to reflect the context makes the indicators more suitable. Streimikiene et al. (2007) applied the *EISD* to analyze energy development in Baltic States, which included updating the indicators to reflect priority areas in the region. However, this update resulted in the omission of all social indicators, thus making the indicator set imbalanced and less suitable (Streimikiene et al., 2007). Tsai (2010) developed sustainable development indicators for Taiwan, which included energy indicators. However, these indicators, similar to Streimikiene's study, did not consider the social dimension of SED (Tsai, 2010).

The engagement of stakeholders during indicator development has been recommended to develop representative SED indicators and account for a broad range of perspectives (Shortall and Davidsdottir, 2017; Sovacool, 2012). Stakeholder engagement during indicator selection is found to increase validity and comprehensiveness and reduce bias in selection (Irvin and Stansbury, 2004; Reed, 2008). Furthermore, stakeholder acceptance of the resulting indicators can be increased (Brown, 2009; Schirnding, 2002). Sovacool (2012) found semi-structured interviews appropriate for a discussion on complex concepts, such as energy security and SED. When developing an energy security index, Sovacool was able to determine what energy security means in the context through targeted discussions with stakeholders. Similarly, stakeholder and expert interviews were conducted to identify areas of improvement and inform the selection of weights for the *Energy Architecture Performance Index* (World Economic Forum, 2017). Nonetheless, stakeholders were not involved in the development of most existing SED indicators (Gunnarsdottir et al., 2020).

More recent and widely used indicators that measure progress towards SED are those connected to the UN's SDG 7 on affordable and clean energy. These indicators assess progress towards the global objectives prescribed in the goal, such as universal access to energy services and increasing the share of renewables (SDSN, 2014). However, these indicators only consider limited aspects of SED and do not capture the multi-dimensionality of the concept (Nerini et al., 2018). The entire SDG indicator set is more comprehensive and, arguably, captures some of the missing SED issues. Taylor et al. (2017) argue that the SDG7 indicators should be complemented by national-level indicators and, thus, measure progress where the decisions and policy actions are taken.

2.2. Case study: Icelandic energy system

In this research, the Icelandic energy system is analyzed as a case study. A case study approach allows for an in-depth analysis of a "contemporary phenomenon" within a "real-life context" (Yin, 2009). In this study, the phenomenon studied is SED within the Icelandic energy system. Iceland makes an interesting case study, as its energy system is unique in many ways. The country is rich in renewable energy resources that are used to a limited extent, such as hydro, geothermal, and virtually unutilized wind power. These contribute to a high share of renewables in Iceland's primary energy use (90% in 2020) and electricity production (99,99% in 2019) (Orkustofnun, 2021a, 2021b). Therefore, the challenges facing the Icelandic energy system on the path towards SED are perhaps different from many countries. However, Iceland's energy system is where many countries want to be, and therefore, other countries might catch up and face a similar set of challenges eventually. While the case study chosen may be less representative from the perspective of technological energy systems, it is considered a good choice to implement the approach for indicator development as the organization of Iceland's energy system can be viewed as more or less representative.

Iceland has one of the highest shares of renewables in primary energy use in any national energy budget (International Energy Agency, 2019). The development of primary energy use by energy source can be seen in Fig. 1. The dashed line in the graph shows the gradually increasing share of renewables. In 2020, geothermal energy supplied 70% of primary energy and hydropower 19% (Orkustofnun, 2021a). Hydropower accounts for 69% of electricity production, while geothermal accounts for 31% (Orkustofnun, 2021b). The main use of geothermal power is for space heating, which heats 90% of all houses in Iceland (Orkustofnun, 2021c). Other renewable energy sources, such as wind, have been utilized marginally but could become a significant energy source in the future (Ministry of Tourism Industries and Innovation, 2018). Increasing the diversity of energy sources is often thought to strengthen a country's energy security (IAEA et al., 2005).

In 2020, the last 10% of non-renewables in primary energy use were fossil fuels used for transportation (68%) and the fishing industry (27%) (Orkustofnun, 2021a, 2021d). It is important to note that as a consequence of the Covid pandemic there was a significant drop in fossil fuel usage in 2020, particularly for international transportation (Orkustofnun, 2021a). A challenge facing the Icelandic energy system is the transition of these last 10% towards a 100% renewable system. Multiple benefits of this transition can be recognized, such as reduced emissions, better air quality, and 100% domestic energy generation leading to increased energy security (Shafiei et al., 2019).

Iceland has one of the highest rates of electricity production per capita in the world (IEA, 2019). In 2019, 19.5 TWh of electricity were produced in the country (Orkustofnun, 2021e). This high production rate is due to energy-intensive industries in the country, principally

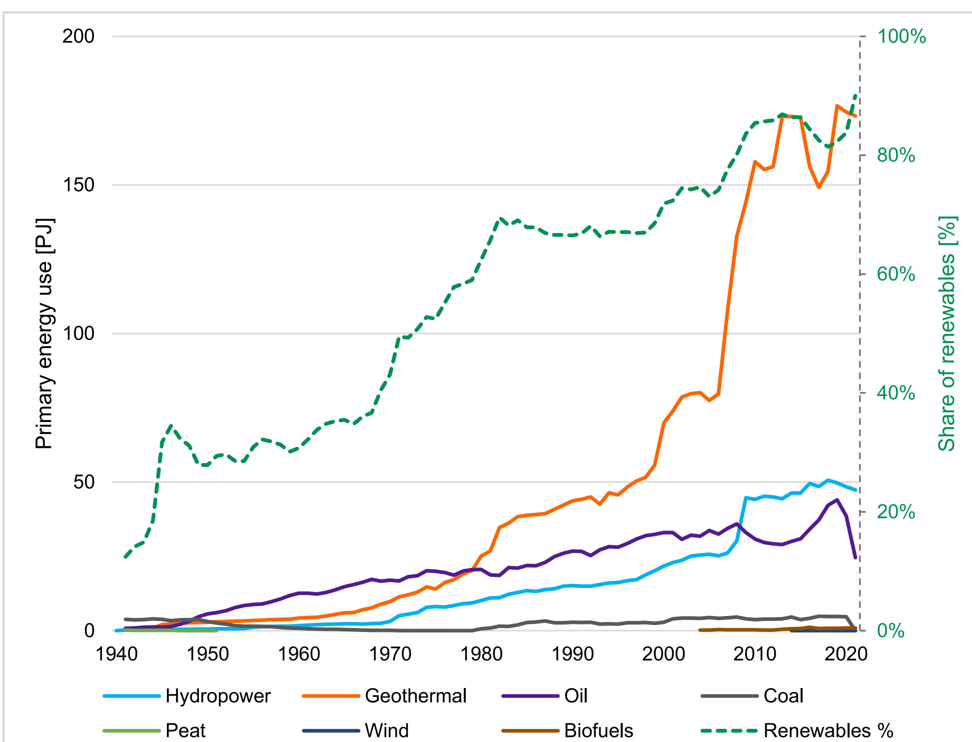

Fig. 1. Primary energy use in Iceland by energy source from 1940 to 2020. The solid lines show the amount of primary energy use by energy source. The dashed line shows the gradually increasing share of renewables in primary energy use in the country (Orkustofnun, 2021a).

aluminium smelters. In 2019, heavy industries consumed 78% of electricity produced in the country, see Fig. 2 (Orkustofnun, 2021e). This reliance on one type of consumer creates vulnerability in the system. It is important to note that, in a sense, (embodied) energy is one of the main exports of Iceland and a pillar of the Icelandic economy (Statistics Iceland, 2018).

When looking at the indicators for SDG7, the Icelandic energy system seems sustainable due to its high share of renewables and access to modern energy services for all (SDSN, 2014; Statistics Iceland, 2020). Nonetheless, various challenges face the system on the path towards SED. Energy resources need to be sustainably utilized to ensure energy security. For instance, excessive production in a geothermal field can lead to a temporary depletion of a geothermal reservoir (Spittler et al., 2019). The transmission and distribution system needs to be improved to increase energy security across the country further as well as to ensure energy equity. Currently, the system is more secure around the capital and highly populated areas and less so in sparsely populated regions of the country (Ministry of Industries and Innovation, 2018). Furthermore, the efficiency of the system can be improved, both on the supply and demand side (Ministry of Industries, 2011). By improving the efficiency, the need for increased energy production with the associated environmental costs could be reduced.

SED in Iceland may lead to a carbon-neutral energy system due to an energy transition towards renewables as well as increased carbon sequestration efforts. The CarbFix project, where carbon is permanently stored in the subsurface through mineral carbonation, was pioneered in Iceland (Snæbjörnsdóttir et al., 2020). Technological breakthroughs such as that one and their implementation can push the system towards increased SED.

In 2020, new long-term energy policy, "*Energy policy to 2050: Sustainable energy future*", was proposed in Iceland (Cabinet of Iceland and Ministry of Industries and Innovation, 2020). The main aim of the policy was to provide a clear vision of a sustainable energy future in Iceland which included twelve goals thought to enable such a future. The new energy policy was developed by a cross-political working group with representatives of all parties in parliament and the four relevant ministries. Public consultation was carried out via the government's online consultation portal where stakeholders were asked to share what they thought a long-term energy policy in Iceland should entail (Ministry of Industries and Innovation, 2020). A comparison of the new energy

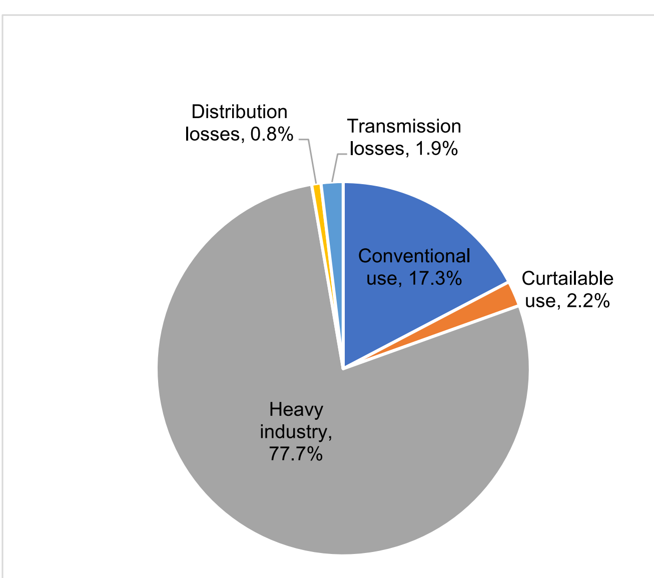

Fig. 2. Breakdown of electricity consumption in Iceland in 2018. Graph shows clearly the dominance of heavy industries in the country's electricity consumption (Orkustofnun, 2021e).

policy with the results of this analysis is presented in the final section of this paper.

3. Methodology

An iterative stakeholder engagement approach was applied for the development of SED indicators for Iceland. This approach was presented originally in the paper *It is best to ask: A stakeholder-centric approach to selecting sustainable energy development indicators* (Gunnarsdottir et al., 2021b). Therefore, the methodology is only briefly explained here. This approach is not limited to SED as it could be used for the development of indicators for other aspects of sustainable development.

The indicator development process consists of seven steps seen in Fig. 3. Stakeholder engagement is at the heart of the process, and their input provides a foundation for indicator selection. The first four steps of the process involve identifying what SED entails in the context. Initially, a diverse group of stakeholders is engaged once through semi-structured individual interviews or focus groups to determine stakeholder goals regarding energy development. A grounded theory approach is applied for the analysis of these interviews to identify prominent themes of SED in the context (Glaser and Strauss, 1967).

Thereafter, two rounds of a Delphi survey are sent to interviewees. The purpose of the survey is to get stakeholder feedback on identified SED themes. Thereby, stakeholders can verify prior results and add topics that might have been overlooked in the interviews. In this approach, the standard deviation of answers can be a measure of stakeholders' agreement on the different sustainability goals (Shortall

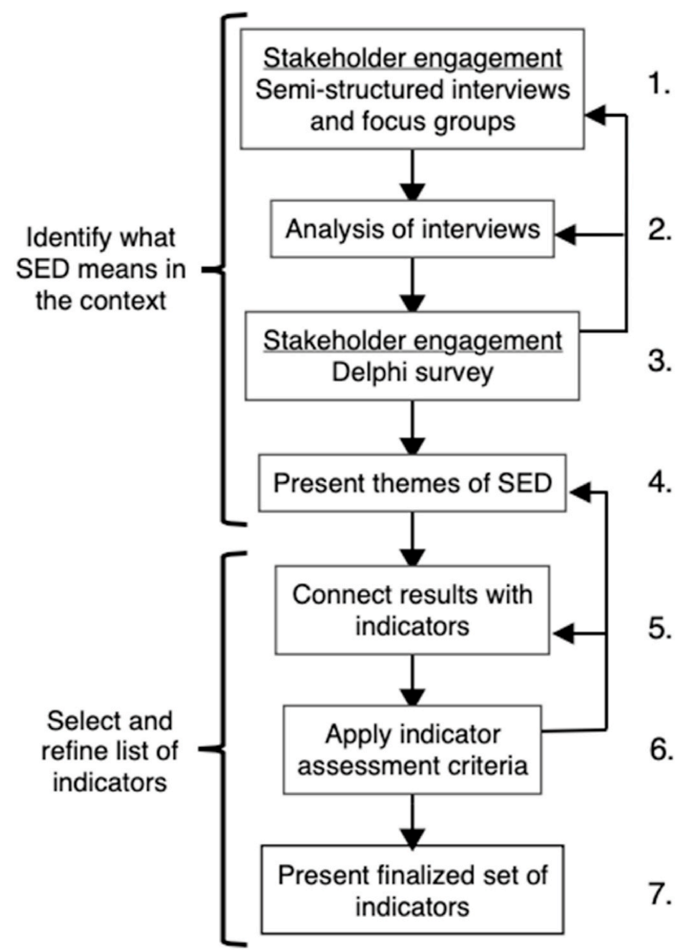

Fig. 3. Iterative stakeholder engagement approach for indicator development. The seven steps of the process and their purpose is shown. The iterative nature of the process is indicated by arrows in the diagram. Approach and diagram originally presented by Gunnarsdottir et al. (2021b).

Table 1
Likert scale of importance for the Delphi survey.

Score	Definition
5 – Very important	Has a direct impact and must be resolved. Priority task.
4 - Important	Has an impact and is relevant. Not a priority task.
3 – Moderately important	May have an impact and is somewhat relevant. Can be a determining factor.
2 - Insignificant	Has little impact and insignificantly relevant. Not a determining factor.
1 – Not important	Has no impact or relevance. Should not be considered further.

et al., 2015). Stakeholders were asked to assess the importance of the identified themes and goals for SED, see Table 1 below. Three was chosen as a minimum mean score of importance for a topic to pass between rounds of the survey. Topics that did not meet this criterion were deemed unimportant and eliminated from further analysis. More details on the Delphi survey can be seen in Appendix B.

The results of the stakeholder engagement are presented as themes of SED and organized within a thematic conceptual framework. The following steps involve connecting indicators with these identified themes and sustainability goals to produce a preliminary list of indicators and, subsequently, refining that list of indicators. Initially, established SED indicators are considered, namely, those analyzed by Gunnarsdottir et al. (2020) in a review paper of indicators for SED, as well as indicators developed for Iceland. The aim is to find indicators that can measure progress towards the identified SED themes and goals. Novel indicators are created when no indicators are found that fit a specific goal. Subsequently, indicator assessment criteria are applied to ensure the suitability and quality of indicators, see Table 2. These criteria are based on commonly used checklists for assessing the suitability of indicators, such as the Bellagio STAMP principles, and the OECD's criteria for indicator selection (OECD, 1993; Pintér et al., 2012). The final result of the process is a set of context-specific indicators for SED.

The iterative nature of the process allows for the repetition of previous steps if necessary, as shown by the arrows in Fig. 3. For instance, if the results of the Delphi survey indicate a lack of saturation in stakeholder views where multiple new topics are added. Then, stakeholder interviews and qualitative analysis might need to be revisited for a more thorough examination. The iterative nature of the process increases the robustness of results.

3.1. Stakeholders of the Icelandic energy system

For this study, the relevant stakeholders were "those that affect or are affected by the [Icelandic] energy system" (Gunnarsdottir et al., 2021b). Multiple different approaches to stakeholder identification exist, e.g., brainstorming, mind-mapping, stakeholder consultation, and life-cycle analysis (Durham et al., 2014). As suggested by Gunnarsdottir et al. (2021b), stakeholders were identified through a top-down analysis of the system with a combined value chain and mind-mapping approach. Stakeholders of the energy system were split into two groups: the value chain of the system and those that influence or enable that value chain. This combined approach was found to be inclusive and more comprehensively capture the system in question than the different approaches did on their own (Gunnarsdottir et al., 2021b).

A stakeholder map of the Icelandic energy system can be seen in Fig. 4. This map expands into more detail, as indicated by the numbers on the right, which signify sub-groups. Purposeful sampling was carried out to select stakeholders of maximum variation (Merriam and Tisdell, 2016). Thereby, diverse opinions and a comprehensive picture of the system could be captured. For this study, this involved selecting stakeholders that represented each group within the "value chain" and "value chain influencers & enablers" groups. Some stakeholders belonged to more than one group, for instance, the focus groups captured the opinion of both "consumers" and "public." Additional considerations were selecting stakeholders associated with the different primary energy sources (i.e., hydro, geothermal, and fossil fuels), attempting an equal gender ratio of interviewees, and reaching stakeholders of different ages. Stakeholder groups that might have been underrepresented are, e.g., public service providers, international organizations, and financial service providers.

In this study, sixteen individual interviews were carried out and two focus groups, one in the local community of recent energy development and one in the capital region where energy development is more out of sight. For the focus groups, a community-based participatory approach was used, where a member of the community was involved in finding participants (Makosky Daley et al., 2010). No additional interviews were carried out since qualitative analysis showed a saturation in interviewees' responses, where no new ideas were being introduced (Gunnarsdottir et al., 2021b). Following an analysis of the interviews, interviewees were sent two rounds of a Delphi survey to verify prior results. The Delphi survey confirmed the saturation of data.

Table 2
Indicator assessment criteria based on commonly used criteria for indicator selection. The original version of the table presented by Gunnarsdottir et al. (2021b).

Criteria element	Brief description
Interpretability	Simple, easily interpreted and applied.
Trends	Sensitive to changes and shows trends over time.
Grounded in research	Theoretically sound and measured based on standardized measurement methods that enable international comparison of indicators.
Data availability and quality	Based on data of good quality that are available or readily collected. Data are collected regularly and reported with a minimal time lag to report current information.
Linkages	The interrelation of indicators should be considered to eliminate correlated ones. Indicators should be meaningful on their own as well as together with other indicators of the set

4. Results

4.1. Sustainable energy development in Iceland

A picture of what a sustainable energy future in Iceland might entail was captured by engaging stakeholders of the energy system. Stakeholders were asked to discuss the current state of the system, what a sustainable energy future might entail, and what steps would further SED. Stakeholder engagement and qualitative analysis led to the identification of SED themes. These themes overlap, interrelate, and reflect the sustainability goals of stakeholders. These results are only briefly described as the objective of this study is to present SED indicators for Iceland.

The Delphi survey served the purpose of verifying results of stakeholder interviews and allowing stakeholders to add topics potentially missed in the interviews. In the first round of the survey, no themes or sustainability goals received a mean score below three, and, therefore, none were eliminated. However, ten goals were reworded or split up based on stakeholders' comments and high standard deviation of answers. The standard deviation of answers reduced significantly between rounds of the survey, indicating a higher level of agreement among stakeholders. In the second round, two goals received a mean score below three, indicating that stakeholders did not find them important. However, stakeholders did not seem to agree on the importance of these goals, as shown by the high standard deviation of answers. Both of these goals were related to a submarine interconnector to Europe, either as a way of increasing energy security or economic efficiency by making energy an export. The results of the Delphi survey are integrated into the

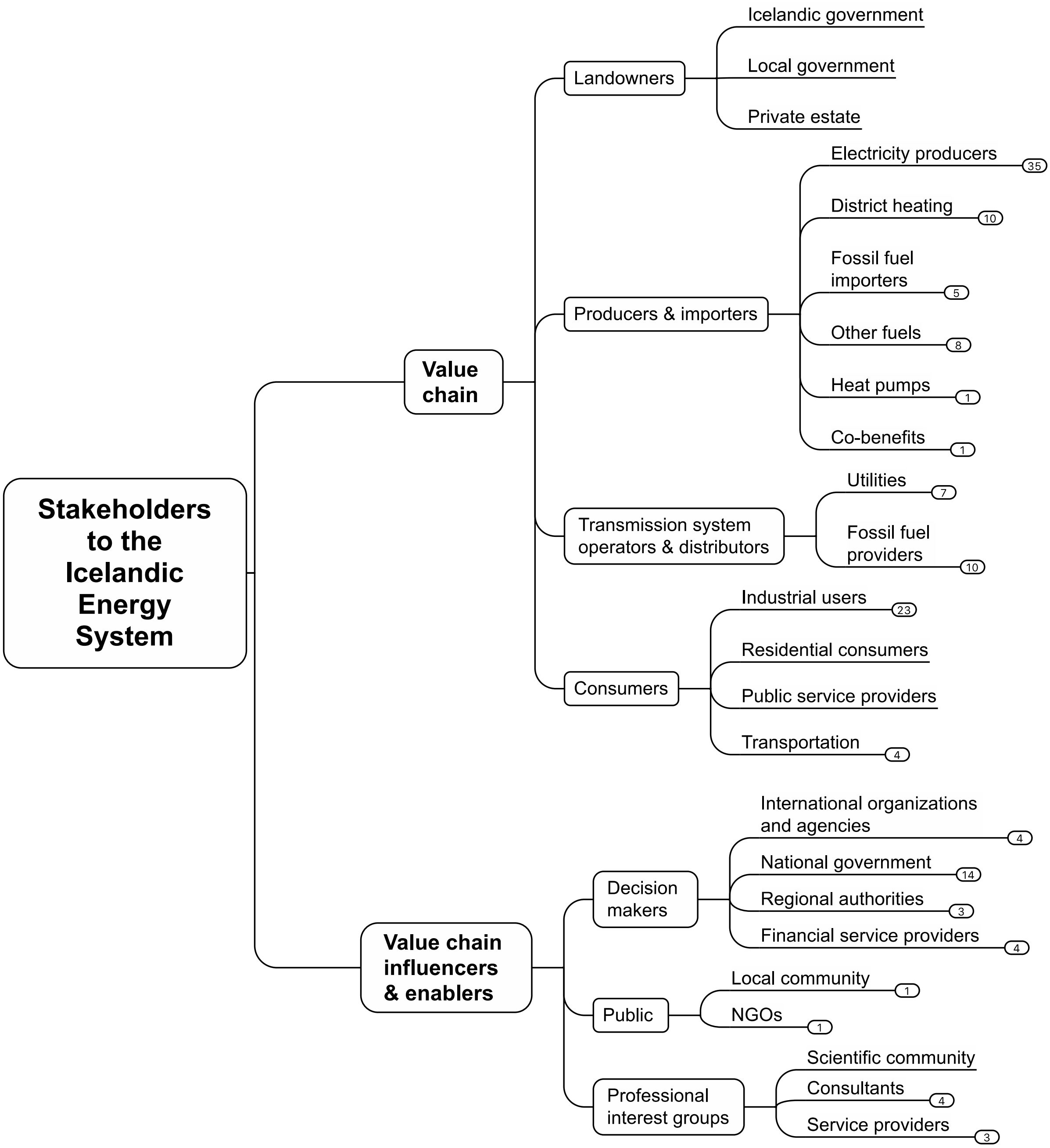

Fig. 4. Stakeholder map of the Icelandic energy system. Map expands into more detail as indicated by numbers on the right, which signify the number of subgroups. Diagram based on an approach presented by Gunnarsdottir et al. (2021b).

discussion below. The anonymity of the Delphi survey hinders the researchers from knowing the answers of different stakeholder groups and who changed their opinion during the process. Details on the Delphi survey can be seen in Appendix B.

Based on stakeholder engagement, the overarching goal was determined to be the sustainable development of the Icelandic energy system. Six main themes of SED for Iceland were identified, see Fig. 5. All of these themes need to be addressed for SED to be realized in Iceland.

The first theme of nature conservation was highlighted to some extent by all stakeholders. This theme reflects the goal of protecting Iceland's untouched nature and wilderness from future energy development, both from energy production and distribution. The environmental impact of energy development should be minimized, and the visual pollution of the energy system reduced. Several stakeholders discussed how visual pollution from energy development could have negative impacts on tourism, and effective design could reduce the energy system's impact area. A potential solution mentioned was increasing the share of subterranean transmission lines. Stakeholders agreed on the importance of minimizing environmental impact as the goal received the highest mean score in the second round of the Delphi while having the lowest standard deviation.

The second theme reflects the goal of ensuring that society benefits from energy development, whether it be in the local community or at a higher level. Some highlighted that benefits from energy development should be felt in the local community in the long run, such as job creation, socially beneficial initiatives, and infrastructure upgrades. Public acceptance of actions was deemed necessary. Increased public participation and informed debate on energy-related decision-making and policy development were thought to increase public acceptance. Stakeholders agreed on the importance of increased public participation

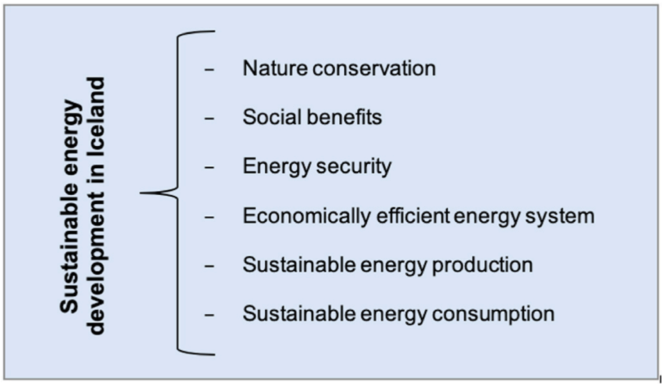

Fig. 5. SED themes for Iceland. An overarching goal of sustainable energy development and themes there under identified from stakeholder engagement and qualitative analysis.

and more informed debate with the highest mean score and lowest standard deviation in the second round of the Delphi. This theme also included topics such as knowledge creation, innovation, and technological advancements that were recognized as necessary enablers of SED.

Stakeholders acknowledged the necessity of increased energy security. Several actions were mentioned to reach this goal, such as increasing the diversity of energy resources utilized, ensuring the sustainable utilization of resources, and strengthening the transmission and distribution system, particularly in rural areas. Furthermore, most mentioned an energy transition, mainly in transportation, from imported fossil fuels towards domestic renewables to increase energy independence and energy security. This energy transition towards a fully renewables-based system was also thought to be one of the main challenges facing the system. An energy transition was the highest-scoring goal in the first round of the Delphi and one of the highest in the second round. One of the lowest scoring goals in both rounds of the Delphi was distributed energy generation related to energy security.

An economically efficient energy system was recognized as part of SED. According to stakeholders, the supply side of the energy system needs to be economical and profitable to be sustainable. Some stakeholders thought the profitability of energy supply could be increased through appropriate investments and technological advancements. A few thought a combination of public and private investments in the system was necessary. The possibility of the government implementing a carbon tax, removing fossil fuel subsidies, or applying other economic tools to further SED, in particular, an energy transition, was mentioned. The lack of diversity in energy consumers, mainly energy-intensive industries, was highlighted as a risk. These energy-intensive consumers with long-term power purchase agreements are all in the same sector and, thus, subject to the same economic influences. In this context, the possibility of a submarine interconnector to Europe and, thereby, making energy an Icelandic export was mentioned. The Delphi showed that stakeholders were not in agreement on the importance of such a connector, where a low mean score in the second round indicated that most were against it. Furthermore, the importance of affordable energy prices to households across the entire country was discussed.

The fifth theme reflects the goal of sustainable energy production. This theme was one of the most prominent ones. Sustainable energy production was thought to involve minimizing the environmental impact of production. Therefore, emissions from energy production, both carbon dioxide and other air pollutants, need to be reduced, and the impact area of power plants minimized. One stakeholder mentioned the ultimate goal of a carbon-negative energy system made possible with increased carbon sequestration efforts. The goal of reducing emissions from the energy system was one of the highest-scoring ones in the second round of the Delphi survey as well as having a low standard deviation. Some discussed past mistakes concerning the use of geothermal resources and emphasized the sustainable utilization of energy resources.

The sixth theme pertains directly to all stakeholders of the system and reflects the goal of making the consumption of energy more sustainable. To reach this goal, stakeholders mentioned that overall energy consumption needs to decrease, and energy efficiency needs to increase. These two sub-goals received the highest scores of the second round of the Delphi survey. Many discussed the need for increased awareness of the harmful impacts of current energy systems and a change of attitude towards a more environmentally conscious one. A change of attitude was discussed as an essential catalyst for an energy transition. Stakeholders talked about how the government should lead by example as well as apply economic tools to, for instance, promote energy efficiency and an energy transition. A couple of stakeholders argued that cleaner fossil fuels should be mandated with more stringent quality requirements.

A definition of SED for Iceland can be derived from these themes. All three pillars of sustainable development, economic, environmental, and social, need to be considered for SED to be realized in Iceland. The future economic prosperity of the energy system is ensured through sustainable utilization, more diverse consumers, and necessary investments. The Icelandic energy system becomes more environmentally friendly with an energy transition, sustainable energy production, nature conservation, and change of attitude of its stakeholders. The ultimate aim is a carbon-neutral or negative energy system. The social aspect of SED entails increased public participation, ensuring social benefits of development, affordable and equitable energy, and more environmentally conscious consumers. SED cannot be reached without a secure energy system. The necessary technological advancements and knowledge creation will push the system further towards SED.

According to stakeholders, a critical challenge for SED in Iceland was the lack of comprehensive long-term energy policy. Due to the lack of energy policy, there has been no clear direction for energy development, and decisions have been taken on a case-by-case basis. All-encompassing long-term energy policy should include a roadmap towards SED, which addresses all of the above themes. Since these interviews were conducted, new long-term energy policy has been proposed in Iceland. The results of this study and the new energy policy are compared in section 6 of this paper.

4.2. Indicators for sustainable energy development in Iceland

Indicators were selected to measure progress towards the sustainability goals discussed by stakeholders and, as such, assess SED in Iceland. A comprehensive and flexible set of indicators was chosen, which can be used in different ways depending on the purpose of the analysis. For instance, some sub-themes are linked to a few indicators that were thought equally good but might not all need to be analyzed. In Tables 3–8, indicators for each of the six SED themes can be seen. A more detailed description of the indicators and their methodology can be seen in Appendix A.

4.2.1. Nature conservation

Table 3
Indicators for the theme of nature conservation.

Theme	Sub-theme	Indicator	Reference
Nature conservation	Protect the wilderness	Total impact area of power plants	1
	Minimize visual pollution	Subterranean share of transmission and distribution system	Original
		Total impact area of power plants	1

1.Steering committee, 2016.

4.2.2. Social benefits

Table 4
Indicators for the theme of social benefits.

Theme	Sub-theme	Indicator	Reference
Social benefits	Public acceptance	Public participation in energy-related policymaking	2, 4
		Transparency of government policymaking	3
	Benefit from energy development	Socially beneficial initiatives	2
		Job creation	4–6
	Knowledge creation and technological advancements	Total R&D expenditure within the energy sector	5, 11
		Number of patents in the energy sector	3,5
		FDI & technology transfer	3
		Capacity for innovation	3
		University-industry collaboration in R&D index	3

2. Austurbrú, n.d., 3. World Energy Council and Oliver Wyman, 2017, 4. Neves and Leal, 2010, 5. Sovacool and Mukherjee, 2011, 6. Shortall et al., 2015, 11. SDSN, 2014.

4.2.3. Energy security

Table 5
Indicators for the theme of energy security.

Theme	Sub-theme	Indicator	Reference
Energy security	Sufficient energy reserves	Total primary energy supply	5,6,9,11,19
		Dynamic reserve/production ratio	5,12–15,19–21
		Critical surplus	9
	Diverse energy sources	Diversity-index for energy supply by type	3,5,7,14–16,21
	Strengthen the transmission and distribution system	Government investments in energy infrastructure development	5
		Efficiency of energy conversion and distribution	3,12–15,20
		Subterranean share of transmission and distribution system	Original
	Quality of supply: urban vs. rural	Frequency of electric power grid	5
		Frequency and duration of blackouts	5
	Energy independence: domestic energy	Total domestic generation and share by type	21
		Proportion of domestic energy sources in TPES	3,21,22
	Energy independence: import dependence	Proportion of imported energy in TPES	3,9,15,20,21
	Energy independence: risk of imports	Share of imports coming from politically unstable countries	5,7, 14
		Degree of transportation risk management	17
	Energy transitions	Number of fast-charging spots and other eco-friendly multi-fuel stations	10
		Share of passenger cars by fuel type	8
		Energy consumption for transportation by fuel	5,8
		Proportion of renewable fuels in total fuel for ships	10
		Number of planes that use land connected electrical charging	10

3. World Energy Council and Oliver Wyman, 2017, 5. Sovacool and Mukherjee, 2011, 6. Shortall et al., 2015, 7. Asia Pacific Energy Research Centre, 2007, 8. Eurostat, 2017, 9. García-Álvarez et al., 2016, 10. Ministry of Environment and Natural Resources, 2018, 11. SDSN, 2014, 12. Sovacool et al., 2011, 13. Sovacool, 2013, 14. Martchamadol and Kumar, 2013, 15. IAEA et al., 2005, 16. World Economic Forum, 2017, 19. Helio International, 2000, 20. Yu et al., 2010, 21. Global Network on Energy for Sustainable Development et al., 2010

4.2.4. Economically efficient energy system

Table 6
Indicators for the theme economically efficient energy system.

Theme	Sub-theme	Indicator	Reference
Economically efficient energy system	Diversity in income and industries	Diversity-index for energy consumption by sector	7
	Government expenditure/revenue	Government revenue from energy sales	5
		Tax revenue of carbon tax and fossil fuels	5,8-10
		Government expenditure on fossil fuel subsidies	5,11-13
		Government investments in infrastructure development	5
	Economical and profitable energy system	Investment in the energy sector	3
		Energy intensity by sector	3,5,11–19
		Average levelized cost of electricity	Original
		Proportion of energy use covered by long-term contracts	Original
	Affordable energy prices	Share of household income spent on energy	4,5,9,15,19
		Energy price volatility by type	5,12,13

3. World Energy Council and Oliver Wyman, 2017, 4. Neves and Leal, 2010, 5. Sovacool and Mukherjee, 2011, 7. Asia Pacific Energy Research Centre, 2007, 8. Eurostat, 2017, 9. García-Álvarez et al., 2016, 10. Ministry of Environment and Natural Resources, 2018, 11. SDSN, 2014, 12. Sovacool et al., 2011, 13. Sovacool, 2013, 14. Martchamadol and Kumar, 2013, 15. IAEA et al., 2005, 16. World Economic Forum, 2017, 17. Murakami et al., 2011, 18. Global Energy Institute and US Chamber of Commerce, 2018, 19. Helio International, 2000.

4.2.5. Sustainable energy production

Table 7
Indicators for the theme of sustainable energy production.

Theme	Sub-theme	Indicator	Reference
Sustainable energy production	Carbon neutral energy system	Total generation and share by type	3,8,16,23,24
		Share of renewables in TPES	4-9,12–14,19,20,22,25–27
		Amount of carbon sequestration by energy industry	1,2
	Sustainable utilization of resources	Dynamic reserve/production ratio	5,12–14,19–21
	Minimize impacts on land	Total impact area of power plants	1
	Minimize emissions	Net emissions from energy production and utilization For: GHG, NOx, CH4, SO2, H2S, and PM2,5 Per capita, over GDP, by sector, or by TPES	2-6,8,9,12–15,18,20,22–24,26
		Ambient concentrations of air pollutants in urban areas	15

1. Steering committee, 2016, 2. Austurbrú, n.d., 3. World Energy Council and Oliver Wyman, 2017, 4. Neves and Leal, 2010, 5. Sovacool and Mukherjee, 2011, 6. Shortall et al., 2015, 8. Eurostat, 2017, 9. García-Álvarez et al., 2016, 12. Sovacool et al., 2011, 13. Sovacool, 2013, 14. Martchamadol and Kumar, 2013, 15. IAEA et al., 2005, 16. World Economic Forum, 2017, 18. Global Energy Institute and U.S. Chamber of Commerce, 2018, 19. Helio International, 2000, 20. Yu et al., 2010, 21. Global Network on Energy for Sustainable Development et al., 2010, 22. Iddrisu and Bhattacharyya, 2015, 23. European Environment Agency, 2014, 24. Scheepers et al., 2007, 25. Doukas et al., 2012, 26. Schlör et al., 2013, 27. Lee and Zhong, 2015
Note: Indicators calculated on an annual basis.

4.2.6. Sustainable energy consumption

Table 8
Indicators for the theme of sustainable energy production.

Theme	Sub-theme	Indicator	Reference
Sustainable energy consumption	Reduce energy consumption	Total energy consumption (primary or final) By type, per capita, over GDP, or by sector	3,4,9,12–15,19,20,22,23
	Energy efficiency	Energy intensity by sector	3,5,11–19
		Ratio of final over primary consumption	19
		Load factor for gross electric capacities	24
		Average age of cars and ships	23
	Cleaner fossil fuels	Emission factor of fossil fuels	5,19
	Change of attitude	Share of different forms of transportation chosen	1,4
		Share of passenger cars by fuel type	8
		Energy consumption for transportation by fuel	5,8

1.Steering committee, 2016, 3. World Energy Council and Oliver Wyman, 2017, 4. Neves and Leal, 2010, 5. Sovacool and Mukherjee, 2011, 8. Eurostat, 2017, 9. García-Álvarez et al., 2016, 11. SDSN, 2014, 12. Sovacool et al., 2011, 13. Sovacool, 2013, 14. Martchamadol and Kumar, 2013, 15. IAEA et al. 2005, 16. World Economic Forum, 2017, 17. Murakami et al., 2011, 18. Global Energy Institute and U.S. Chamber of Commerce, 2018, 19. Helio International, 2000, 20. Yu et al., 2010, 22. Iddrisu and Bhattacharyya, 2015, 23. European Environment Agency, 2014, 24. Scheepers et al., 2007.

5. Discussions

5.1. Sustainable energy development in Iceland

Overall, stakeholders agreed on the necessity of furthering SED, especially considering the increasing threat of climate change. A high level of agreement was detected among the different stakeholder groups on what needs to be done to reach SED. One of the only controversial topics was the possibility of a submarine electricity interconnector from Iceland to continental Europe, where strong arguments were made for and against the connector. An energy transition towards domestic renewables was thought to be one of the most pressing issues. A representative of fossil fuel importers even discussed an “inevitable energy transition” and how their business model needed to change accordingly.

A comparison of the SED themes for Iceland to global SED issues shows that they broadly align (IAEA et al., 2005; Shortall and Davidsdottir, 2017; UNDP et al., 2000). One of the most pressing energy development issues worldwide is access to modern energy services (United Nations General Assembly, 2015). Access to energy does not seem to be a topic in Iceland, which is logical as all Icelanders have access to electricity (The World Bank, n.d.). However, the affordability of energy was discussed to some extent, notably concerning differences in energy prices for urban and rural areas and energy prices to industries.

Globally, there is a push for reducing the harmful environmental impacts of energy production and increasing the share of renewable energy resources (Lund, 2007). Iceland already has a high share of renewables in its primary energy use and has ample availability of more renewables. Therefore, the issues facing Iceland regarding sustainable energy production differ from most countries worldwide. Issues mentioned included completing an energy transition towards a fully renewable system and ensuring the sustainable utilization of renewable resources. Due to an abundance of renewable energy resources, wind power has yet to be utilized to any real extent in Iceland (Orkustofnun, 2021a). This luxury of only utilizing available renewable resources to a limited extent is unique. Generally, stakeholders thought wind power would be a viable option for future energy generation in the country.

Energy consumption behaviour in Iceland seems to differ from other countries around the world, perhaps due to an abundance of available renewable energy resources (Sovacool, 2017). A few stakeholders discussed how energy efficiency has not been a topic in the country, and, as a result, Icelanders tend to be wasteful in their energy consumption. Stakeholders discussed how attitude needs to change towards more sustainable energy consumption.

Emissions from energy production can threaten human health and well-being (UNDP et al., 2000). Harmful emissions seem to be less of a threat in Iceland since renewable energy resources are utilized. The only health-related impacts mentioned were those associated with geothermal power plants and emissions of hydrogen sulphide. Some discussed the necessity of minimizing emissions from geothermal power plants and cleaning hydrogen sulphide from emissions.

One of the main attractions of Iceland is its pristine and untouched nature (Íslandsstofa - Promote Iceland, 2019). Nature protection is particularly important, considering that tourism has become a pillar of the Icelandic economy (Sutherland and Stacey, 2017). Therefore, stakeholders highlighted the value of Iceland’s nature and the necessity of minimizing both the environmental and visual impact of future energy development.

5.2. Indicators for sustainable energy development in Iceland

Multiple issues discussed, such as the lack of comprehensive energy policy, were binary, something that has been done or not. An indicator measuring progress towards binary objectives does not show incremental progress over time, apart from just ticking a box when it is done. Most guidelines for indicator selection prescribe that indicators should be sensitive to changes and show trends over time (Jain and Tiwari, 2017; OECD, 1993). Therefore, the indicators did not reflect these binary issues and instead tracked progress towards other non-binary objectives mentioned. The addition of a to-do list with the binary objectives mentioned by stakeholders would complement the indicator set.

Both the themes and the selected indicators overlap and interrelate. Therefore, some indicators are situated within more than one theme. For instance, the indicator “total impact area of power plants” is within two themes; nature conservation and sustainable energy production, and connected to three different sustainability goals; protect the wilderness, minimize visual pollution, and minimize impacts on land. It is beneficial to identify potential linkages between indicators to assess a complete picture of SED and eliminate overly correlated indicators. Linkages between indicators can be seen in Appendix A.

The indicators are meaningful on their own but should also be analyzed as a part of a set. An analysis of the entire set gives a complete picture of the status of the system. Furthermore, a change in one indicator could affect another. For instance, the utilization of energy-intensive technologies for carbon sequestration would register as a positive development in the “amount of carbon sequestration by industry.” However, this could result in a negative change in indicators for energy consumption and efficiency. Interactions such as this one are the reason why the indicator set was not aggregated. Because of the “information iceberg” effect, much information can be lost with the aggregation of an indicator set (Molle and Mollinga, 2003).

A broad set of indicators was selected to allow for some flexibility. Thereby, indicators that fit the purpose of the study can be assessed. For instance, five different indicators measuring knowledge creation and technological advancements are presented that might not all need to be analyzed. Indicators that were thought equally good were not eliminated based on the preference of the authors. Some of the indicators might only be considered when looking at specific development scenarios. For example, indicators assessing the risk of energy imports could be considered when the impacts of war and blocked transportation routes on Iceland’s energy security would be evaluated.

A common criticism of existing indicators for SED is the lack of a detailed methodology to allow for the application or calculation of the indicators (Gunnarsdottir et al., 2020). In this study, an emphasis was placed on providing sufficient information on indicator methodology to allow for their application, as seen in Appendix A.

The indicators presented in this paper are context-specific and reflect SED in Iceland. Therefore, they differ to some extent from established SED indicator sets, such as EISDs and indicators for SDG7. Broadly, the same issues are covered by all three sets. This indicator set has over fifty indicators, while there are thirty EISDs, and six connected to SDG7. This difference indicates that the presented indicator set captures a much more detailed picture of what SED entails in Iceland. Furthermore, some of the indicators in both the EISDs and SDG7 were deemed irrelevant for Iceland. These indicators were not topics of discussions for stakeholders and, thus, not issues for SED in the country. An example of this would be indicators measuring accessibility to modern energy services or clean cooking fuels. These differences highlight the value of context-specific indicators.

5.3. Iterative stakeholder engagement approach for indicator development

The seven-step indicator selection process implemented in this study was found to produce a comprehensive and representative set of indicators. As the name of the process indicates, *iterative stakeholder engagement approach*, it relies heavily on the input of stakeholders. Through stakeholder mapping, a diverse and balanced group of interviewees was selected. As a result, multiple viewpoints were considered, which provided a complete picture of the energy system and its SED. The same stakeholders were engaged three different times, once through an interview and twice through a Delphi survey. The semi-structured nature of the interviews was found to lead to fruitful discussions with stakeholders. In general, stakeholders stayed on the topic during the interviews. In the rare cases that conversation went off-topic, pre-determined questions were used to steer the conversation back in the right direction. As with any qualitative research, the interviewers had to be aware of their own bias and attempt to say as little as possible during the interviews.

The results of the Delphi survey indicate that stakeholders agreed with the results of the analysis. No goals or themes were eliminated between rounds of the survey. The only topic that did not meet the minimum score criteria in the second round of the survey was the possibility of a submarine interconnector to the European power grid. However, the high standard deviation of answers implied that stakeholders were split on the issue. The Delphi survey was found to be an appropriate way of verifying results and strengthening the process overall. A benefit of the Delphi survey was that it allowed stakeholders to reflect on the analysis and, in a way, communicate with each other as results are shared between rounds (Lim and Yang, 2009). The main criticism of the Delphi survey in this study was the decreasing response rates, with only 11 people responding to the second round of the survey, see Appendix B.

While stakeholder interviews are flexible and allow for a broad discussion, topics can be entirely overlooked based on the direction the interview takes. This combination of interviews and a Delphi survey was found to ensure that a complete picture was captured while minimizing the researchers' own bias. The choice of a thematic conceptual framework fits well with the stakeholder engagement and grounded theory approach. Conceptual frameworks can serve an important role in constructing complex problems, such as SED, and increasing the transparency of indicator selection (Jain and Tiwari, 2017; UN DESA, 2007). Thematic frameworks are flexible and can capture the relevant policy issues, which has made them popular (Gunnarsdottir et al., 2020; UN DESA, 2007). The main flaw of thematic frameworks is that problems can be oversimplified, where connections between issues can be overlooked (Iddrisu and Bhattacharyya, 2015; Stanners et al., 2007). When using a thematic framework, the UN has emphasized the consideration of linkages between themes and indicators (UN DESA, 2007). Linkages are considered in Appendix A.

A multitude of established SED indicators exists that were reviewed while connecting indicators with identified themes and goals. Review papers, such as the one by Gunnarsdottir et al. (2020), are useful during this step and can reduce the amount of work involved significantly. Numerous established indicators were eliminated due to a lack of transparency in their purpose and methodology. The following step of applying assessment criteria to assess the suitability of indicators was sometimes challenging. The criteria selected were found quite broad and, at times, difficult to evaluate, especially since no data was connected to the indicators. More detailed criteria with clearly defined parameters would be more useful. Additionally, many indicators were found equally good. In the end, a choice was made to select a broader and more flexible set of indicators rather than eliminating indicators based on the authors' preferences.

The benefits of the chosen approach were demonstrated through its implementation in Iceland. The value of both stakeholder engagement and context-specific indicators is highlighted throughout. As described in the background section, most current indicator sets for SED are neither context-specific nor based on stakeholder engagement. Nevertheless, recent studies have started to recognize the advantages of both. What is novel about this approach is the integration of qualitative and quantitative methods. Initially, qualitative data is collected through stakeholder interviews. Subsequently, these qualitative results are verified and quantified through the Delphi survey. These results are then compared with the SED literature when indicators are connected with sustainability goals. This combination of qualitative and quantitative methodology is found to produce a well-rounded and comprehensive set of indicators that is accepted by stakeholders. Numerous steps of verification ensure the robustness of the resulting indicator set. A completely different set of indicators would have been selected if only the literature had been reviewed and no stakeholder had been involved. Indicators reflecting the unique conditions of Iceland, such as subterranean share of the transmission and distribution system and proportion of energy use covered by long-term contracts, would not have been included. Transparency is ensured with detailed descriptions of the different steps involved and methodology for each indicator (see Appendix A).

This stakeholder engagement approach is found particularly relevant due to the contested nature of the concept of SED. Sustainable development and SED can be viewed as "essentially contested concepts" as they are products of "social, historical, and cultural constructs" (Freeden, 1996; Gallie, 1956). There is no universally accepted definition of these concepts. One of the main hindrances of creating appropriate sustainability indicators has been ambiguities in what these concepts encompass, particularly in the local context (Narula and Reddy, 2015; Shortall and Davidsdottir, 2017). Therefore, stakeholder engagement is appropriate to evaluate what SED means in the context and to identify local shared values.

Even though the main objective of the process is to produce a set of indicators, many different by-products can be identified. At the beginning, the system in question, and its stakeholders are analyzed thoroughly. Subsequently, the sustainability goals of different stakeholder groups are identified. Based on this, a definition of what SED entails in the context can be presented. This definition consists of the different goals and actions laid out by stakeholders that will push for a more sustainable energy system. The opportunities and challenges facing the system on the path towards SED are identified as well. Public acceptance of actions is valuable to ensure their success, as mentioned by stakeholders during interviews. Therefore, an analysis of the relevant stakeholders and their views is valuable for the policy and decision-making process. Furthermore, the process promotes public participation and transparency in the decision-making process. This analysis can be used to explore scenarios of a sustainable energy future. Through a backcasting approach, pathways, and necessary policy actions towards those scenarios can be evaluated (Börjeson et al., 2006).

Some potential drawbacks of the process were identified during implementation. The process can be quite labour-intensive and time-consuming. Effective organization, especially concerning stakeholder engagement, can save considerable time. Access to stakeholders is necessary, which could be a challenge in some places. Identifying useful contacts that can connect researchers with other stakeholders can be helpful. Since stakeholders are engaged several times, there is potential for stakeholder fatigue (Gramberger et al., 2014). While stakeholders were open to an interview, participation in the survey decreased gradually. The timing of stakeholder engagement was found to be influential. The second round of the Delphi survey was sent in late summer, which might have contributed to decreased participation.

A few more lessons were learned during implementation. Firstly, the topic of indicators could be introduced earlier in the process. The stakeholder engagement was focused entirely on identifying what SED means in the context. Indicators were never discussed apart from researchers' mentioning that the ultimate goal was SED indicators for Iceland. An exploratory discussion with stakeholders on potential indicators could be valuable. Nonetheless, the main focus of the stakeholder engagement should remain the same, capture the meaning of SED in the context. Secondly, it would be beneficial to add a final step of

Table 9
Comparison of the new energy policy in Iceland with SED themes in Iceland presented in this study (Cabinet of Iceland and Ministry of Industries and Innovation, 2020).

	Proposed energy policy from 2020		Research conducted by Gunnarsdottir et al.	
	Themes	Priority issues	Themes	Sub-themes
Main SED themes in Iceland	Environment	Nature protection and minimizing environmental impacts	Nature conservation	Protect the wilderness Minimize visual pollution
	Energy security	Reliable and secure infrastructure across the country Secure energy supply	Energy security	Sufficient energy reserves Diverse energy sources Strengthen the transmission and distribution system Quality of supply: urban vs. rural Energy independence: domestic energy Energy independence: import dependence Energy independence: risk of imports
	Energy transition	Energy transition and climate change Renewable energy	Sustainable energy production	Energy transitions Carbon neutral energy system Sustainable utilization of resources Minimize impacts on land Minimize emissions
	Energy efficiency and conservation	Energy efficiency, smart technology and diversity	Sustainable energy consumption	Reduce energy consumption Energy efficiency Cleaner fossil fuels Change of attitude
	Society and economy	Benefits to the society and consumers	Social benefits	Public acceptance Benefit from energy development Knowledge creation and technological advancements
		Competition and value creation	Economically efficient energy system	Diversity in income and industries Government expenditure/ revenue Economical and profitable energy system Affordable energy prices

communication of the indicators and their results to the process. Effective communication can be a deciding factor for why an indicator set is used or not (Gunnarsdottir et al., 2020; Pintér et al., 2012). Indicators and their results should be communicated in a transparent and visually appealing way to ensure their usefulness and application (UN DESA, 2007). Thirdly, a periodic update of the indicator set is important (Pintér et al., 2012). This update could be done every few years through a Delphi survey sent to stakeholders. Then the purpose of the survey would be to reassess the relevance of the selected indicators and sustainability goals as well as identify new topics of concern.

6. Conclusion and policy implications

In this study, an iterative stakeholder engagement approach was applied to produce context-specific indicators for SED in Iceland. These indicators reflect sustainability goals for the Icelandic energy system, according to its stakeholders. If the same approach were applied within a different context, a different set of indicators would be produced, reflecting the challenges facing that energy system. The approach shows the value of stakeholder engagement for indicator selection and context-specific indicators, especially when measuring progress towards a contested and complex concept such as SED. A strength of the approach is the integration of qualitative and quantitative methodology where multiple steps of stakeholder engagement and verification ensure a comprehensive and robust set of indicators. Without stakeholder input, one-of-a-kind indicators reflecting Iceland's unique SED challenges would not have been included in the set.

Generally, indicators reflect the underlying issues of a goal and can highlight what changes are needed. As such, the choice of indicators can act as a catalyst for action. An example of this is the inclusion of an energy goal in the UN's SDGs that, thus, recognized the importance of energy for sustainable development. The indicators presented in this study can serve the dual role of monitoring and communicating important SED issues in Iceland. These indicators reveal the national priorities for SED in Iceland. The numerous by-products of the process, analysis of stakeholders and their views, the definition of SED in the context, SED roadmap, and identification of linkages between indicators, can shape energy policy.

Potential policy implications of applying the indicator selection process in Iceland include the identification of concrete policy goals like ensuring sustainable utilization of resources, increasing the diversity of consumers, and completing an energy transition. Most of the identified stakeholder goals can have direct policy implications and shape SED in Iceland. In 2020, new long-term energy policy called "Energy policy to 2050: Sustainable energy future" in Iceland was proposed (Cabinet of Iceland and Ministry of Industries and Innovation, 2020). A comparison of the results of this study with the new policy can be seen in Table 9. This comparison demonstrates that the same broad themes and priority issues were identified, albeit organized differently. Therefore, the new energy policy confirms that a complete picture of the Icelandic energy system and its sustainable development was captured in this study. During the policy's development, stakeholders were able to share their views of Iceland's energy policy via the government's online consultation portal. A more robust approach to stakeholder engagement was taken in this study, where a comprehensive and balanced group of stakeholders was engaged multiple times resulting in a more in-depth and multi-layered analysis of what SED means in Iceland. Furthermore, bias was minimized by using a structured and clear stakeholder engagement approach. The research presented here surpasses the new energy policy by developing indicators that enable the monitoring of progress towards SED in Iceland.

The highest scoring sustainability goals of the Delphi survey highlight some of the more specific and concrete policy implications of this study. Stakeholders agreed that an energy transition towards domestic renewables, especially for transportation, is a pressing issue. An energy transition would both increase energy security as well as reduce harmful emissions of the system. Reducing GHG emissions and improving air quality is of concern, where the ultimate goal is a carbon-neutral system. Stakeholders emphasized raising awareness to promote more sustainable energy consumption and, thereby, enable an energy transition and improve energy efficiency. Stakeholders believed that minimizing the environmental impact of energy development, e.g., through effective design, should be a guiding light for SED in the country. Social acceptance of actions was thought vital to realize SED in Iceland, which is enabled through public consultation during decision-making and more informed debate.

One of the most surprising results of this study was the high level of agreement among stakeholders on what is important to achieve SED in Iceland, apparent from both the interviews and the Delphi survey. On the surface, energy development seems to be a disputed topic. However, this analysis shows that the different stakeholder groups all aim towards a more sustainable energy future and largely agree on what actions need to be taken to reach that future. It is valuable to know that stakeholders are on board with furthering SED. Ultimately, this study and the resulting indicators can support the newly proposed energy policy in Iceland, for instance, by monitoring progress towards a sustainable energy future in the country.

CRediT authorship contribution statement

I. Gunnarsdottir: Conceptualization, Methodology, Validation, Formal analysis, Investigation, Data curation, Writing – original draft, Writing – review & editing, Visualization, Funding acquisition. **B. Davidsdottir:** Conceptualization, Methodology, Validation, Writing – review & editing, Supervision, Project administration, Funding acquisition. **E. Worrell:** Writing – review & editing. **S. Sigurgeirsdottir:** Writing – review & editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Methodology of indicators

Table 10
The methodology of indicators for the theme of nature conservation

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
Nature conservation	Protect the wilderness	Total impact area of power plants	The impact area of a power plant is both the sq. km for the plant, as well as the surrounding area that is impacted in some way. The methodology for this indicator is quite complex and varies somewhat based on the type of energy sources. Parameters considered are, for instance, impacts on hydrology, geology, ecology, and tourism.	Total impact area of power plants in Iceland in sq. km over total number of power plants in Iceland	sq. km/ plant	NC - Minimize visual pollution SEP - Minimize impacts on land	NEA
	Minimize visual pollution	Subterranean share of transmission and distribution system	A higher share of subterranean power lines leads to less visual pollution. Subterranean power cables are less sensitive to extreme weather conditions.	km of system subterranean over total km of system	%	ES - Strengthen transmission and distribution system	NEA, Landsnet
		Total impact area of power plants	See above	Total impact area of power plants in Iceland in sq. km over total number of power plants in Iceland	sq. km/ plant	NC - Protect the wilderness SEP - Minimize impacts on land	NEA

Note: Indicators calculated yearly.
NEA = National Energy Authority.
1. Steering committee, 2016.

Table 11
The methodology of indicators for the theme of social benefits

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
Social benefits	Public acceptance	Public participation in energy-related policymaking	This indicator involves sending an annual opinion poll to stakeholders of the system, both local and national, to assess public acceptance, public participation, and the availability of information on energy-related policymaking.	Survey	% or qualitative		Survey
		Transparency of government policymaking	This indicator assesses how easily businesses can access information on changes to government policies and regulations that might affect their practices.	Survey	# and country rank		WEF
	Benefit from energy development	Socially beneficial initiatives	This indicator involves sending an annual opinion poll to stakeholders of the system, both local and national, to assess socially beneficial initiatives.	Survey	% or qualitative		Survey
		Job creation	Reflects the benefits of energy development in a community and can be measured locally or at a larger scale. Direct, indirect, and induced jobs associated with energy projects are considered.	Ratio of energy-related jobs over population	%	EEES - Government expenditure/ revenue & Economic and profitable energy system	SI
	Knowledge creation and technological advancements	Total R&D expenditure within the energy sector	This indicator accounts for both public and private expenditure on generating new knowledge through basic and applied research as well as the application of new knowledge and experimental development.	Total research expenditure (public & private) over GDP	%		SI, FJS
		Number of patents in the energy sector	Indicates the level of research and development in the energy sector. Measured on a national level.	Total number of patents	#	EEES - Economic and profitable energy system	WIPO, WB
		FDI & technology transfer	This indicator shows to what extent foreign direct investment brings new technology. FDI is a key source of new technology.	Scale of 1–7 (1 = not at all; 7 = to a great extent)	# and country rank		WEF
		Capacity for innovation	Indicates the capacity of businesses to innovate.	Scale of 1–7 (1 = not at all; 7 = to a great extent)	# and country rank		WEF
		University-industry collaboration in R&D index	Measures to what extent universities and businesses collaborated on research and development.	Survey. Scale of 1–7 (1 = not at all; 7 = to a great extent)	# and country rank		SI, WEF

Note: Indicators calculated yearly.
WEF = World Economic Forum, SI = Statistics Iceland, WIPO = World Intellectual Property Organization, WB = World Bank, FJS = The Financial Management Authority.

Table 12
The methodology of indicators for the theme of energy security

Theme	**Sub-theme**	**Indicator**	**Explanation**	**Metric**	**Unit**	**Linkages**	**Data source**
Energy security	Sufficient energy reserves	Total primary energy supply	This indicator measures the amount of available energy in the country as primary energy, both domestic and imported.	Sum of domestic and imported primary energy	TWh	SEP - Carbon neutral energy system	NEA
		Dynamic reserve/ production ratio	Indicator measures the availability of energy reserves and the sustainability of utilization. The indicator is calculated from current production levels, estimated potential, and energy demand forecasts.	Reserves (current and estimated potential) over production (current and future demand)	Ratio	SEP - Sustainable utilization of resources	NEA, MP
		Critical surplus	Another indicator measuring the amount of available energy by	Total supply over total demand	Ratio	SEP - Carbon neutral energy system	NEA

(continued on next page)

Table 12 (*continued*)

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
			comparing total supply with total demand.			SEC - Reduce energy consumption	
	Diverse energy sources	Diversity-index for energy supply by type	Diversity in energy supply promotes energy security and independence. This indicator is calculated in primary energy by fuel type.	Modified Shannon-Wiener or HHI diversity index for primary energy supply by fuel type	%	SEP - Carbon neutral energy system	NEA
	Strengthen the transmission and distribution system	Government investments in infrastructure development	To maintain a strong energy system, investments in energy infrastructure are necessary.	Total investments over GDP	ISK/ GDP	EEES - Government expenditure/ revenue	SI, FJS
		Efficiency of energy conversion and distribution	Indicates the efficiency of the system, which is associated with reduced energy needs and emissions. Improvements in efficiency lead to more effective utilization of resources and reduce environmental impacts.	Average the efficiency of power generation and rate of electricity T&D losses	%	Energy needs & emissions	NEA, LN
		Subterranean share of transmission and distribution system	See above in Table 7	km of system subterranean over total km of system	%	NC - Minimize visual pollution	LN
	Quality of supply: urban vs. rural	Frequency of electric power grid	These indicators compare the quality of electricity distribution in urban and rural areas. Measures the equity of the system.	Frequency of electricity in urban and rural areas	Hz	SB - Benefit from energy development	LN
		Frequency and duration of blackouts		Numer of blackouts and their duration in urban and rural areas	# & min	SB - Benefit from energy development	LN
	Energy independence: domestic energy	Total domestic generation and share by type	These indicators reflect the energy independence of Iceland and, as such, its energy security. Measure the amount of domestic energy generation as primary energy and its share in TPES.	Total domestic generation as primary energy by energy type	TWh	SEP - Carbon neutral energy system	NEA
		Proportion of domestic energy sources in TPES		Domestic energy generation as primary energy over TPES	%		NEA
	Energy independence: import dependence	Proportion of imported energy sources in TPES	Measures import dependence. A high import ratio indicates exposure to supply shocks, price spikes, and other political risks.	Energy imports as primary energy over TPES	%		WB, NEA
	Energy independence: risk of imports	Share of imports coming from politically unstable countries	Measures the share of imported energy coming from politically unstable countries. Impacts the country's energy security.	Energy from politically unstable regions over total imported energy	%		NEA, OECD
		Degree of transportation risk management	Measures the share of imported energy transported through choke points. Impacts the country's energy security.	Energy transported through chokepoints over total imported energy	%		NEA, IEA
	Energy transitions	Number of fast-charging spots and other eco-friendly multi-fuel stations	Measures the rate of infrastructure improvements to enable an energy transition.	Count	#	SEC - Change of attitude	EP
		Share of passenger cars by fuel type	These indicators measure the rate of an energy transition and reflect a change of attitude. Furthermore, they show energy use patterns for different types of energy for transportation.	Number of passenger cars by fuel type over total number of passenger cars	%	SEC - Change of attitude	SI
		Energy consumption for transportation by fuel		Energy consumption fuel type over total energy consumption for transportation	%	SEC - Change of attitude	NEA, SI
		Proportion of renewable fuels in total fuel for ships	Measures the rate of an energy transition for ships.	Renewable fuels over total fuels for ships	%		SI, ITA
		Number of planes that use land connected electrical charging	Measures the rate of a possible energy transition for planes.	Count	#		ITA

Note: Indicators calculated yearly.
NEA = National Energy Authority, MP = The Master Plan for Nature Protection and Energy Utilization, LN = Landsnet, WB = World Bank, OECD = Organisation for Economic Co-operation and Development, IEA = International Energy Agency, SI = Statistics Iceland, EP = Energy providers, ITA = Icelandic Transport Authority.

Table 13
The methodology of indicators for the theme of economically efficient energy system

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
Economically efficient energy system	Diversity in income and industries	Diversity-index for energy consumption by sector	This indicator measures the diversity of energy consumers and, as such, the economic vulnerability of the system.	Modified Shannon-Wiener or HHI diversity index for energy consumption	%	SEC - Reduce energy consumption & energy efficiency	NEA
	Government expenditure/ revenue	Government revenue from energy sales	Energy sales are a pillar of the Icelandic economy. This indicator measures whether the energy system is remaining profitable.	Revenue from energy sales over GDP	ISK/ GDP	SEC - Energy efficiency	SI, FJS
		Tax revenue of carbon tax and fossil fuels	Economic tools applied by the government. Ideally, if no changes are made to these taxes, the revenue would decrease over time, indicating fewer carbon emissions and less utilization of fossil fuels.	Total revenue from carbon tax over GDP	ISK/ GDP	SEP - Minimize emissions ES - Energy transitions SEP - Change of attitude	SI, FJS
		Government expenditure on fossil fuel subsidies	This indicator measures the potential distortion of fossil fuel prices. These subsidies counteract other efforts in reducing fossil fuel consumption and supporting an energy transition.	Total subsidies over GDP	ISK/ GDP	ES - Energy transitions SEP - Change of attitude	SI, FJS
		Government investments in energy infrastructure development	See in Table 9	Total investments over GDP	ISK/ GDP	ES - Strengthen transmission and distribution system	SI, FJS
	Economical and profitable energy system	Investment in the energy sector	Measured by the amount of foreign direct investment net inflows in the energy sector. Indicates how desirable it is to invest in the Icelandic energy system and economy.	FDI in the energy sector over GDP	%	SB - Knowledge creation and technological advancements	WB, IMF
		Energy intensity by sector	Energy consumed per value-added for each sector, e.g., industry, households, and transport. Indicates the profitability of the economic activity, its energy efficiency, and the potential decoupling of energy use from GDP. Can also reflect changes in the fuel mix and technological improvements.	Final energy consumption over value added by sector	kWh/ ISK	SEC - Energy efficiency	NEA, SI
		Average levelized cost of electricity	Indicates the economic efficiency of energy generation. Usually, calculated as a technical parameter per energy plant, but here the indicator is averaged across all electricity power plants in the country.	Costs over electricity produced over lifetime averaged across all plants	ISK/ years		NEA
		Proportion of energy use covered by long-term contracts	Measures whether Icelandic energy is cost-competitive internationally as long-term contracts are made mainly with foreign industry. It can also be an indicator of economic growth.	Energy use in long-term contracts over TPES	%	SEC - Reduce energy consumption & energy efficiency	NEA, FJS
	Affordable energy prices	Share of household income spent on energy	This indicator measures the affordability of energy for households. The affordability of energy to lower-income groups needs to be ensured.	Household expenditure on energy over household income	%	SEC - Reduce energy consumption	SI
		Energy price volatility by type	Volatile energy prices can negatively affect consumers and can indicate a lack of security in the system.	Annual change in energy price per type	% by type	ES - Energy independence	SI

Note: Indicators calculated yearly.
NEA = National Energy Authority, SI = Statistics Iceland, FJS = The Financial Management Authority, WB = World Bank, IMF = International Monetary Fund.

Table 14
The methodology of indicators for the theme of sustainable energy production

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
Sustainable energy production	Carbon neutral energy system	Total generation and share by type	Shows the energy supply mix and availability of energy, which reflects both energy security and the sustainability of energy production.	Total energy generation &	TWh & %	ES - Sufficient energy reserves & Diverse energy sources & Energy independence	NEA
		Share of renewables in TPES	A higher share of renewables in TPES leads to fewer emissions of GHGs and air pollutants with the associated negative environmental and health impacts. Furthermore, it increases energy security for the long-run.	Sum of primary energy from renewables over TPES	%		NEA
		Amount of carbon sequestration by energy industry	This indicator measures the carbon offsetting of the energy industry through various methods of carbon sequestration. Such efforts will be necessary to achieve a carbon-neutral energy system.	Tonnes of CO2 eq. sequestered by the energy industry	t CO2 eq.		EAI
	Sustainable utilization of resources	Dynamic reserve/ production ratio	See above in Table 9	Reserves (current and estimated potential) over production (current and future demand)	Ratio	ES - Sufficient energy reserves	NEA
	Minimize impacts on land	Total impact area of power plants	See in Table 7	Total impact area of power plants in Iceland in sq. km over total number of power plants in Iceland	sq. km/plant	NC - Protect the wilderness & Minimize visual pollution	NEA
	Minimize emissions	Net emissions from energy production and utilization For: GHG, NOx, CH4, SO2, H2S, and PM2,5 Per capita, over GDP, by sector, or by TPES	Measures the amount of emission of GHG and air pollutants from energy production and utilization. These emissions have a direct impact on climate change and have adverse environmental and health effects. The intensity of emissions can be measured in terms of capita, GDP, by sector, and TPES.	Emissions of [GHG, SO2, H2S, PM2,5 or NOx] over [capita, GDP, TPES, by sector]	t of emissions/ [population, ISK, TWh]	SEC - Reduce energy consumption & Energy Efficiency & Cleaner fossil fuels	EAI
		Ambient concentrations of air pollutants in urban areas	Measured for air pollutants such as SO2, H2S, NO2, and PM2,5. These air pollutants can be sourced from energy production and utilization and tend to have higher concentrations in urban areas. These can lead to adverse health impacts.	Concentration of air pollutants per cubic meter	μg per cubic m.	SEC - Cleaner fossil fuels	EAI

Note: Indicators calculated yearly.
NEA = National Energy Authority, EAI = Environment Agency of Iceland.

Table 15
The methodology of indicators for the theme of sustainable energy consumption

Theme	Sub-theme	Indicator	Explanation	Metric	Unit	Linkages	Data source
Sustainable energy consumption	Reduce energy consumption	Total energy consumption (primary or final) By type, per capita, over GDP, or by sector	Measures the level of energy use, shows energy-use patterns, and energy intensity of society or sectors. Can be measured in terms of primary or final energy and by type, over capita, GDP, or by sector depending on the purpose of the analysis. When measured over GDP, it indicates the relationship of energy use to economic development.	kWh as primary or final energy over [GDP, capita] or by [energy type, sector]	kWh/ [capita, ISK, energy type, sector]	EEES - Economic and profitable energy system	NEA, SI
	Energy efficiency	Energy intensity by sector	See in Table 10	Final energy consumption over value added by sector	kWh/ISK	EEES - Affordable energy prices & Economic and profitable energy system SEC - Energy efficiency	NEA, SI
		Ratio of final and primary consumption	Measures the efficiency of energy transformation. Shows the relationship between the energy that enters the system as primary energy and the energy that is available to consumers as final energy.	Final energy consumption over primary energy consumption	%	ES - Strengthen transmission and distribution system	NEA
		Load factor for gross electric capacities	Use-side indicator. Measures the utilization rate or efficiency of electrical energy usage.	Average load over peak load for electricity	%	EEES - Government expenditure/ revenue	NEA
		Average age of cars and ships	A use-side indicator reflecting the efficiency of the vehicle or ship fleet. Younger technologies are generally more efficient than older ones.	Sum up age of [cars or ships] over total number of [cars or ships]	Years	ES - Energy transitions	SI
	Cleaner fossil fuels	Emission factor of fossil fuels	Measures the quality of fossil fuels utilized and is a predictor for associated emissions.	Amount of emissions per unit utilized for each fuel	tCO_2 eq./ Mtoe	SEP - Minimize emissions	EAI
	Change of attitude	Share of different forms of transportation chosen	Annual travel habit surveys measure the share of different transportation modes chosen. Can indicate the rate of an energy transition in transportation.	Survey	%	ES - Energy transitions	SSH
		Share of passenger cars by fuel type	See in Table 9	Number of passenger cars by fuel type over total number of passenger cars	%	ES - Energy transitions	SI
		Energy consumption for transportation by fuel	See in Table 9	Energy consumption fuel type over total energy consumption for transportation	%	ES - Energy transitions	NEA, SI

Note: Indicators calculated yearly NEA = National Energy Authority, SI = Statistics Iceland, EAI = Environment Agency of Iceland, SSH = Samtök sveitarfélaga á höfuðborgarsvæðinu.

Appendix B. Delphi survey

ExQample questions

During the first round of the survey, stakeholders assessed the importance of different sustainability goals and got the opportunity to add topics thought missing from the analysis. An example question from the first round of the survey can be seen below.

Example question from the first round of the Delphi survey:

Theme 1: Nature conservation.

Sub-goal 1: Minimize environmental impact and visual pollution of the energy system.

Examples of actions mentioned: Evaluate the impact on ecology, geology, etc., more subterranean power cables, minimize impact through design.

o Very important
oImportant
oModerately important
oInsignificant
oNot important

Comments

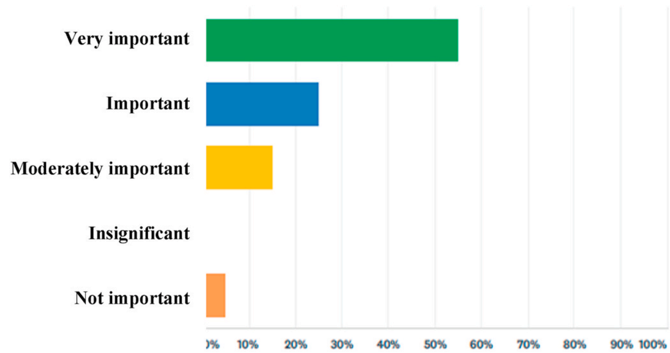
The second round of the survey consisted of updated questions based on the results of the first round, such as the elimination of low scoring topics and the addition of missing ones. In this second round, a simple graph showing the distribution of answers for each question from the first round was included; see the example question below along with a graph in Figure6. An important feature of the Delphi survey is controlled feedback between rounds, which allows participants to re-estimate their responses with the knowledge of the general opinion of the group (German Association of Energy and Water Industries (BDEW) et al., 2016).

Example of an updated question from the second round of the Delphi survey:

Results of the first round of the survey:

Theme 1: Nature conservation.

Sub-goal 1: Minimize environmental impact and visual pollution of the energy system.



Updated questions:

Theme 1: Nature conservation.

Sub-goal 1a: Minimize the environmental impact of the energy system.

Examples of actions mentioned: Evaluate the impact on ecology, geology, etc., minimize environmental impact through design.

oVery important
oImportant
oModerately important
oInsignificant
oNot important

Comments:

Theme 1: Nature conservation.

Sub-goal 1b: Minimize visual pollution of the energy system.

Examples of actions mentioned: More subterranean power cables, minimize visual impact through design.

oVery important
oImportant
oModerately important
oInsignificant
oNot important

Comments:

Response rates

The response rates of Delphi participants can be seen in Table 16. The first round of the Delphi had a high response rate of 74%. However, the response rate dropped significantly in the second round of the survey to 41%. Potential reason for this drop is stakeholder fatigue or perhaps the timing of the second round of the survey (late July to early August).

Table 16
Response rates of Delphi participants.

	Invited	Responded	Response rate
Round 1	27	20	74%
Round 2	27	11	41%

Overarching results

The general results of the two rounds of the Delphi survey can be seen in Table 17. The standard deviation of answers decreased between rounds of the survey indicating a higher level of agreement in the second round of the survey. Tables 18 and 19 show the highest and lowest scoring goals of the two rounds of the Delphi survey.

Table 17
General results of the Delphi survey

		Round 1			Round 2		
		Mean	Max	Min	Mean	Max	Min
Score of importance	Mean	4,09	4,60	3,30	4,09	4,73	2,18
Measure of agreement	Standard deviation	1,00	1,39	0,59	0,83	1,47	0,47

Table 18
Highest scoring goals of the Delphi survey

Theme	Goal	Round 1		Round 2	
		Mean score	St. Dev.	Mean score	St. Dev.
Nature conservation	Minimize the environmental impact of energy development - assess env. impact & minimize impact through design*	–	–	4,73	0,47
Social benefits	Social acceptance, increased public participation & informed debate - public consultation & access to information	4,40	0,75	4,73	0,47
Energy security	Energy transition (especially for transportation on land and sea) - reduce consumption of fossil fuels, infrastructure upgrades, economic incentives & raising awareness	4,60	0,82	4,55	0,93
	Energy independence - less reliance on imported fossil fuels, energy transition, economic incentives & energy transition	4,50	1,05	4,45	1,04
Sustainable energy consumption	Improve air quality and reduce GHG emissions - Less consumption of fossil fuels, support carbon sequestration & quality restrictions on fossil fuels	4,55	0,83	4,73	0,65
	Reduce overall energy consumption and improve energy efficiency - economic incentives for energy efficiency, government leads by example, improved public transportation & bike paths	4,40	0,88	4,73	0,65

* Goal updated between rounds. Therefore, only scores for one of the two rounds.

Table 19
Lowest scoring goals of the Delphi survey

Theme	Goal	Round 1		Round 2	
		Mean score	St. Dev.	Mean score	St. Dev.
Nature conservation	Reclaim nature - wetland restoration, land reclamation & decommission of older power plants	3,6	1,14	3,64	0,92
Energy security	Distributed energy generation – more geographical distribution of power plants & small-scale power plants	3,3	1,17	3,36	1,36
	Ensure that the transmission and distribution system does not stop development - connect with the European power grid*	–	–	2,18	1,33
Economically efficient energy system	Increase diversity in national income – decrease economic risk with more diverse energy consumers, knowledge as export & energy as an export (interconnector)*	3,4	1,23	–	–
	Energy as an export - submarine cable to Europe & domestic industry to produce exports*	–	–	2,82	1,47
Sustainable energy consumption	Social acceptance of energy utilization - More diverse energy consumers, inform the public & reconsider emphasis on heavy industries	3,55	1,39	3,73	1,42

* Goal updated between rounds. Therefore, only scores for one of the two rounds.

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