MENA
SELECT

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Energy for the Future

Evaluating different electricity-generation technologies against selected performance characteristics and stakeholder preferences: Insights from the case study in Jordan

Authors:

Komendantova, Nadejda (IIASA), Ekenberg, Love (IIASA/ Stockholm University), Marashdeh, Leena (University of Jordan), Al-Salaymeh, Ahmed (University of Jordan), Mats Danielson (Stockholm University), Linnerooth-Bayer, Joanne (IIASA)

Contributing authors:

Tanbour, Jomana, (University of Jordan), Irshaid, Jenan (IIASA), Spiegelhofer, Johanna (IIASA), Larsson, Aron (Preference Inc), Karlgren, Jussi (KTH – The Royal Institute of Tecknology, Stockholm)

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SUMMARY

Currently, energy policy in Jordan is facing the challenge of having to cover the country's electricity demand which is growing because of different factors, among them population growth, cooling of houses, desalination, large consumption centres and industry. The goal to provide reliable and affordable electricity includes diversification of electricity-generation sources from extensive reliance on fossil fuel imports to the generation of electricity from locally available resources, such as renewable energy sources but also nuclear energy and shale oil.

Energy transition towards a more significant share of domestically generated resources will inevitably lead to a societal transformation in Jordan, which will affect interests of existing and emerging electricity-generation industries and other stakeholders. To be sustainable, such a transition should also address issues of environmental protection and its contribution to socio-economic development. Therefore, it is necessary to develop compromise solutions to mitigate the risk that differences in views about electricity-generation technologies needed for energy transition will turn into conflicting opinions. Also, energy transition should address not only national energy security targets, but it should also integrate interests of local communities in the vicinity of future electricity-generation and transmission infrastructure.

This report is based on the assumption that human factors play an important role in energy transition. These human factors include perceptions of different risks connected with the use of certain technologies as well as views about benefits and impacts generated by different technologies. An innovative methodology was developed to address these views. This methodology allows us to assess the relevance of Jordan's electricity-generation technologies, such as utility-scale photovoltaic (PV), concentrated solar power (CSP), onshore wind, utility-scale hydro-electric, bituminous coal, heavy fuel oil, shale oil and natural gas against a set of criteria, which reflect environmental, social and economic components of sustainable development.

The results show that stakeholders prefer utility PV technology over all other technologies. The results also show that at the time of writing, the discourse in Jordanian society is dominated by economic rationality, such as electricity costs, supported by concerns about safety during operation and maintenance of electricity-generation power plans. The results also show a strong desire of all stakeholder groups for an opportunity to engage in decision-making processes on energy transition as the alternative of being simply compensated for the installation of electricity-generation and -transmission technologies does not appeal to local communities.

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INTRODUCTION

The Hashemite Kingdom of Jordan is considering different options to satisfy its energy demand. Among these options are fossil fuels, such as coal, gas and oil, new fuels, such as shale oil, nuclear energy and renewable energy sources, such as wind and solar energy sources. These technologies are needed to satisfy growing energy demand in Jordan. Projections show that energy demand in Jordan will be increasing during the next decades largely due to population growth, migration dynamics in the region, an increase in the quality of life as well as the increasing need for desalination of water and cooling due to climate change—both requiring large amounts of energy. For example, energy demand forecasts for Jordan show an annual increase in five per cent of Jordan's primary energy demand and six per cent of Jordan's electricity demand annually by the year 2020 (Komendantova et al., 2017).

The deployment of new and the increasing use of existing technologies needed to cover energy demand and to diversify energy supply will lead to an energy transition in Jordan and a transformation of the Jordanian energy system. This transition in Jordan will be and already is a complex process, which has political, social, economic and technical dimensions. Therefore, a holistic, inclusive and comprehensive governance approach to energy transition is essential. The process of substituting one energy source by another and of one technology by another can result in significant socio-technical changes, which might lead to many frictions and conflicts. These changes will go along with shifts in generation and distribution technologies, business models, governance structures, consumption patterns, values and worldviews. For a sustainable implementation of this process, new forms of governance are needed.

Several scientific works on energy transition in Jordan have dealt with economic and technological factors. Following national and international practice and taking into account Jordanian political will, Jordan has been developing a legal and regulatory framework to attract investment in renewable energy expansion. There has been little debate, however, about the Jordanian society's energy transition and transformation, which might result in the large-scale use of new technologies and about the human factors and socio-economic consequences of this transformation of energy systems.

Energy transition in Jordan must be regarded as an arena where different individual or organized stakeholders are competing for legitimization of their actions and organizational settings for the future. Today, the energy field in Jordan is dominated by large providers, often owned by the public hand, which generate, transmit and distribute electricity to consumers. This field evolved on the basis of a strict centralized solution. Often, electricity providers, coal, oil and gas companies are regarded as incumbents, namely actors who have disproportionate influence within the field. Their views and interests are also often reflected in the dominant organization of the strategic action field, which might be entirely shaped by the worldviews, interests and positions of these incumbents. New technologies, such as renewable energies, nuclear or oil shale, or governance modes, such as a more decentralized energy generation or participatory governance, can challenge the power distribution within this field. In this context, lessons learned from other regions and modes of technology transfer, which go beyond single projects, but include regional models of energy transitions and transformation of society, should also cautiously be considered. There are several examples and good practices from Europe, such as the "*Energiewende*" (energy transition) in Germany or energy transition through climate and energy models in Austria. As a matter of course, plans for energy transition in the MENA region should bear in mind entirely different energy market structures, stakeholder networks and societal aspirations towards energy, climate and environmental policies in the region (FES, 2015). Therefore, careful consideration of stakeholders' views, concerns and conflicting priorities is required when considering a sustainable energy transition and transformation of the energy system as well as compromise-oriented energy governance solutions.

BACKGROUND

Energy transition in Jordan

Jordan is an energy-importing country (around 97 per cent of its energy needs are covered by imported crude oil, natural gas and petroleum products). Renewable energy contributes only a minor share of Jordan's electricity mix. Jordan also has plans for the use of other energy sources such as shale oil or nuclear power. The debate about large-scale deployment of renewable energy systems (RES) in Jordan, as well as in the entire MENA region, started with large-scale international projects such as DESERTEC and the Mediterranean Solar Plan, even though single initiatives to deploy RES had already existed before. The DESERTEC concept was based on the idea of developing solar and wind projects in the MENA region and of generating electricity for exports to Europe via high voltage direct current cables (Czisch, 2005). In response to this idea, various assessments were carried out to evaluate the technical and economic feasibility of such solutions (German AerospaceCenter, 2005, 2006; Ummel & Wheeler, 2008). The DESERTEC idea constituted the basis for the DESERTEC Industrial Initiative, which planned to stimulate €440 billion in investment into RES capacities in MENA. In 2008, the French government proposed the creation of the Union for the Mediterranean and the Mediterranean Solar Plan (MSP) as a starting initiative for this process. MSP had as a target to deploy 20 GW of solar capacity in the MENA region by 2020.

These incentives paved the way for technology transfer to the MENA region. However, they failed due to a variety of factors, amongst them social and public acceptance (Komendantova et al., 2017). Other reasons included the governance of this transition, which was based on a top-down framework of national renewable energy master plans elaborated by the MENA governments. The implementation of these plans lagged far behind the targets, mainly, because energy transition roadmaps underestimated the intricacy of managing transformative change towards sustainable energy systems (Brand, 2015).

Being dependent on imported energy sources is a heavy burden for the socio-economic and energy security of Jordan. During the last decades, energy supply to Jordan was very volatile, not only because of volatility in prices for energy carriers but also because of a number of external political shocks and setbacks. For example, increasing prices of crude oil during the Arab Spring in Egypt significantly affected Jordan, which depends on energy imports from Egypt. The interruption of the Egyptian gas supply forced Jordan to switch to much more expensive heavy oil. This created a heavy burden for the Jordanian budget and increased significantly the already existing budget deficit. The Jordanian government had to heavily subsidize energy imports to cover for the difference between imported energy costs and its affordability on the local market, which further increased its national deficit.

Current situation in the energy sector in Jordan

Because of the lack of energy resources, the question of how to cover energy demand is a constant challenge in Jordan. This country is heavily dependent on imports of energy, largely from fossil fuels. It, therefore, also suffers from the fluctuation of energy prices, which increases the Jordanian national debt and affects its national economy. According to the Ministry of Energy and Mineral resources (MEMR), Jordan's energy imports cover over 95 per cent of its energy needs. This situation will become even acuter when the annual growth of primary energy demand of seven per cent is taken into account.

One of the significant achievements in the Jordanian energy sector in 2017 was the completion of the Aqaba terminal. The goal of this project was to secure the supply of crude oil and oil products to Jordan. The terminal has storage capacities for crude oil, oil products and liquefied petroleum gas. The Logistic Company for Jordan's Oil Facilities was established in the year 2016 as the operator and manager of this project. The costs of crude oil and oil products imports reached JOD 1.333 million in 2016. In general, the year 2016 witnessed a decrease in around 21 per cent in the consumption of oil products because of lessening demands for oil products used in electricity-generation and large imported quantities of natural gas.

The oil shale sector also experienced significant development in that year. Jordanian decision-makers consider this energy source to be strategically important, considering the fact that Jordan has the fourth-largest oil shale reserve in the world, exceeding 70 billion tons. In 2017, the Jordanian government signed several memoranda of understanding and granted local and international companies concessions to invest in oil shale production, including in-situ retorting and direct burning to generate electricity.

In 2017, not only the oil shale sector but also the natural gas sector expanded. The National Petroleum Company signed the production-sharing agreement with the IPG Company to develop the Risha field. Two liquefied natural gas (LNG) agreements were also signed between NEPCO and Shell International Company to bolster the use of natural gas in power plants and industries.

In 2017, direct agreements were signed with the projects developers and the financing community for a rehabilitation project of the Al Hussein thermal station. It is expected that the commercial operation of the station will start in the second half of 2018.

In 2017, Jordan, represented by NEPCO, and the Gulf Cooperation Council Interconnection Authority GCC, also signed a memorandum of understanding to initiate the preparation of technical and economic feasibility studies for electricity interconnections in the region.

Jordan has excellent potential sources of renewable energy, particularly solar and wind energy. In 2016, the installed capacity of conventional resources was 4.100 MW, while the installed capacity of renewables reached 544 MW. The renewables' contribution to installed capacity is 13 per cent, and 5.6 per cent to generated electricity (MEMR, 2017). The Ministry of Energy and Mineral Resources has adopted an ambitious programme to increase the contribution of renewables to the total energy mix to a 10 per cent share by 2020.

About 2.400 MW of wind and solar PV projects are expected to be developed in Jordan by 2020. In 2017, more than 625 MW were already operational. The share of solar and wind in 2017 reached 6.5 per cent of generated electricity. There are also 625 MW of wind and solar PV under construction. For these projects, MEMR follows a four-tracks-approach in developing renewables: The direct proposal scheme, the competitive bidding, the EPC turn-key projects and the small-scale renewable energy schemes (net metering) (MEMR, 2017).

In 2017, the green corridor project saw ongoing grid expansion and reinforcement plans and will continue, as NEPCO is planning for it to contribute to the upgrading of the national grid capacity to assimilate 1.200 MW of renewable energy projects in the southern area of Jordan. It is expected that the project will be completed by the end of 2018 (NEPCO, 2015).

Participatory governance

Energy transition in Jordan is a complex process, which involves different views on risks and benefits of available and emerging electricity-generation technologies. This process is also changing the existing Jordanian energy mix, with some technologies losing their importance and other ones winning the market share. The use of new electricity-generation and -transmission infrastructure also affects local communities with regard to water and land use as well as human health, air and the environment, in general. Such a complicated process requires a participatory approach in which existing differences in views can be addressed and compromise solutions developed.

Scientific evidence shows that the transformation of energy systems often faces risks and boundaries regarding the implementation of climate change mitigation policies, which are connected with decision-making processes (Patt, 2015). These boundaries include not only technological and economic factors but also human factors, such as conflicting views of risks and benefits of different technologies as well as social and public acceptance, willingness to use technology and to pay for it (Komendantova et al., 2018).

Today, public interest in energy infrastructure is different than it was half a century ago when the existing infrastructure was built. The existing energy infrastructure was perceived as a driver for socio-economic development. Nowadays, people want to participate in the decision-making process on technologies that affect their communities. Participation in decision-making processes is often perceived as a democratic principle of the inclusiveness of people (Beierle & Cayford, 2012). The lack of opportunity to exercise this right leads to protests, delays in the implementation of the projects and even the cancellation of projects because of public protests or actions of stakeholders who were not included in the decision-making process (Kunreuther et al., 1994).

International legislation also lays down the right to participate. The Aarhus Convention requires the involvement of stakeholders in decision-making processes on infrastructure projects and on providing clear and transparent information about how to get involved. However, often there are limits to participation; the fact that energy transition is a topic heavily dominated by technological and economic content hinders effective public participation (Devine-Wright, 2012). Jordan is not a party to the Aarhus Convention, but we assume that people still expect to participate in this country.

Different views on participatory governance exist. Some argue that complex decision-making processes on critical infrastructures, such as energy, should be left in the hands of experts and scientists. Public participation is reserved as a method for evaluating this decision-making process and its outcomes (Rowe & Frewer, 2000). Others argue that participation is very beneficial because it brings additional knowledge of stakeholders at the national level (Hänlein, 2015), which might otherwise be limited, such as the knowledge of local areas (Jasanoff, 1997). There is also evidence that to integrate views of all stakeholders—and not only those of specialized experts—can enhance the legitimacy of decision-making processes and build trust (Renn, 2008).

Evidence from energy-generation and -transmission projects in Europe shows that decision-making processes along the so-called decide-announce-defend (DAD) model, where the decision is taken by the national government, aided by experts and then implemented through a top-down approach, is no longer feasible (Wolfsink, 2000; Komendantova & Battaglini, 2016). The DAD model often leads to conflicting opinions as well as protests which delay implementation and may even lead to cancellation of the projects (Wolfsink, 2012). Discussions in the framework of the so-called not-in-my-backyard-(NIMBY) concept often end up simply identifying factors of acceptance, which is a more passive attitude towards a top-down decision-making process where someone cannot change anything. Nowadays, many scientists argue that NIMBY is a misleading concept to understand local objections and concerns. One flaw of the concept is that it does not involve local knowledge to improve the results of decision-making processes (Batel & Dewine-Wright, 2015).

There is also the need to understand how engagement and participation can go beyond a discussion of the projects' details and shape the discussion about centralized and decentralized energy transition as this is a complex topic where human factors play a significant role. Understanding is needed about how participatory governance works in different countries and how centralization or decentralization of decision-making shapes the process of stakeholders' involvement in the discussion about energy transition issues (Komendantova et al., 2015).

Even though a significant part of existing literature on participatory governance research focuses on Europe, there is also evidence about advantages of a participatory approach for other countries. For instance, Xavier et al. (2017) studied implications of human factors on the transformation of the energy sector in South Africa. Having analyzed several infrastructure projects, the authors express the need to incorporate public participation within the project cycle and to institutionalize it as a part of the whole decision-making process. They also find that existing conflicts in stakeholders' views and opinions can be mitigated through engagement and different methods of multi-criteria discussion.

Yazdanpanah et al. (2015) also looked at human factors of energy transition in Iran that influence the willingness to use renewable energy sources. By applying the theory of planned behaviour, the authors identified the main factors as moral norms, attitudes and perceived behavioural control which is also connected with the possibility to influence decision-making processes.

METHODOLOGY AND CRITERIA

MENA-SELECT methodology

In the MENA-SELECT project, a set of criteria[1] was developed. The research team compared technologies against a set of evaluation criteria and performance indicators. These criteria are essential to understanding how we obtained our results.

Each Jordanian technology that is considered in the national energy planning was evaluated against a set of criteria. Altogether, there were 11 criteria, which included 20 indicators, nine of which were quantitative, and 11 were qualitative. Data for quantitative indicators was collected from national and international statistical databases, reports and projects. Data for qualitative indicators was collected from surveys with stakeholders in Jordan.

We developed these criteria based on the review of scientific literature on energy-generation and -transmission technologies as well as on the analysis of national policy documents for three relevant countries for MENA-SELECT (Morocco, Jordan and Tunisia).

All criteria were divided into two sets:

\ **Contribution to national energy policy targets** such as to secure reliable and affordable power supply. It included such criteria as decreasing dependence on foreign resources, climate change mitigation, domestic industry development, technology and knowledge transfer, as well as affordable electricity systems costs.

\ **Sensitivity to local conditions and impacts on local communities**. They included aspects of land and water resources, on-site job creation, air pollution and health, hazardous waste and safety issues.

The project team selected 11 out of initially 32 relevant criteria. These were then discussed during the stakeholder workshops to see whether the stakeholders agree with the criteria definition, whether the criteria are relevant for the case countries and whether stakeholders would recommend any further criteria. The stakeholders' reactions confirmed the robustness of the selected criteria and their definitions that were also communicated to stakeholders during the workshops.

[1] The criteria themselves including the methodology of their development and calculation are described in more detail in Schinke et al. (2017).

MENA-SELECT criteria

Criterion 1: Use of domestic energy sources. The dependence on foreign energy imports can be decreased by tapping into domestic resources that are either available today or could be exploited in the mid- to long-term. Two indicators are relevant here: a) current domestic potential of each technology's energy carrier to decrease energy import dependence today, and b) future domestic potential of each technology's energy carrier to decrease energy import dependence by 2040/50.

Criterion 2: Global warming potential. The technology should contribute to the mitigation of climate change. The criterion is based on the indicator "Total life-cycle GHG emissions (CO2-eq) per generated kWh".

Criterion 3: Domestic value chain. The technology should have a high potential of using components and services provided by domestic industries throughout the entire value chain. The criterion is based on the indicator "Existing potential for the integration of domestic industries to manufacture a significant share of components and provide essential services during the Manufacturing, Construction and Installation (MCI) and Operation and Maintenance (OM) phases of the technology".

Criterion 4: Technology and knowledge transfer. Based on existing policies, the technology should have a high potential of benefiting from technology and knowledge transfer to stimulate future domestic value added in electricity-generation. The criterion is based on the indicators a) effectiveness of educational policies in fostering skill development and R&D, and b) effectiveness of industrial policies in enhancing industry linkages between domestic and foreign firms geared towards horizontal technology transfer.

Criterion 5: Electricity systems cost. The electricity systems cost of the technology should be as low as possible as not to constitute a burden for Jordan's overall budget. The criterion is based on the indicators a) electricity-generation cost measured as Levelized Cost of Electricity (LCOE) in €/MWh, and b) estimated additional integration cost at increasing penetration levels based on uncertainty/variability and distance/location.

Criterion 6: On-site job creation. The technology should have a high potential of creating direct on-site jobs over the entire lifetime of the power plant. The criterion is based on the indicators a) MCI: Average amount of labour in FTE person-years per MW, and b) OM: Average amount of labour in FTE permanent jobs per MW.

Criterion 7: Pressure on local land resources. The technology should cause minimal additional pressure on valuable land resources regarding amount and value of required land to avoid the deprivation of any locally relevant livelihood resources. The criterion is based on the indicators a) land requirement: The area of land directly required by the technology at the site of its deployment in ha/MW, and b) land value: The importance of the land surrounding typical project sites for providing livelihood resources and services to adjacent communities.

Criterion 8: Pressure on local water security. The technology's water consumption should be appropriate to the local water risk context and cause minimal pressure on local water security. The criterion is based on the indicators a) average operational water consumption of each technology measured in L/MWh, and b) average water risk at typical project sites of each technology based on the Water Risk index of WRI (2014).

Criterion 9: Occurrence and manageability of non-emission hazardous waste. The disposal of non-emission hazardous waste produced during the operation of the technology as well as the risk stemming from national waste management capabilities should be low to minimize adverse consequences on human health and the environment. The criterion is based on indicators a) disposal of non-emission hazardous waste, and b) potential national capabilities to manage the disposal of the respective types of non-emission hazardous waste".

Criterion 10: Local air pollution and health. The number of air pollutants (NOx, SO2 and PM) emitted by the technology should be low to minimize pressure on local air quality and health risks for people in adjacent communities. The criterion is based on the indicators a) air pollutants (SO_2, NOx, and $PM_{2.5}$) emitted by O&M activities of power plants in kt/MWh, and b) premature deaths by PM2.5/MWh of electricity produced.

Criterion 11: Safety. Severe accidents from the construction, operation and maintenance of electricity-generating technologies, as well as during the transport and storage of resources and equipment, should be minimized to reduce accidents resulting in fatalities within and outside power plants. The criterion is based on the indicators a) historical immediate fatalities from severe accidents during transport and storage of resources and equipment, and operation and maintenance activities of power plants, per unit of electricity (MWh) produced (hereafter referred to as "normalized fatalities"), and b) potential of regulatory and operational emergency preparedness and response capabilities of the private and public sector to mitigate and manage the risk of catastrophic accidents with maximum and severe consequences during the construction and operation phase of each technology (hereafter referred to as "normalized fatalities".

Workshops to discuss criteria and visions

The workshops with stakeholders lasted the entire day and included several sessions. The first session started with the introduction, during which the organizers presented the workshop and its objectives as well as the goals of the workshop and the agenda. The participants introduced themselves and their organizations.

Picture 1: Moderator explains the methodology
Source: Nadejda Komendantova, IIASA

During the second session, the visions for Jordan for the period of 2040 to 2050 were discussed. Participants had an opportunity to describe how they see environmental, social and economic aspects of the future of Jordan. Then they wrote their choices on the different coloured cards and put them on a flipchart. Following this, they explained their choices.

Picture 2: Participants discussing the economic, social and environmental future of Jordan
Source: Ahmed Al Salaymeh, University of Jordan

During the third session, the participants discussed the technologies. This discussion started with a presentation of electricity-generation technologies relevant for Jordan and was followed by a discussion of positive and negative sides of each technology. Participants also had a chance to suggest further technologies, which were not originally included in the list of discussed technologies.

Picture 3: Participant discussing negative and positive sides of electricity-generation technologies
Source: Nadejda Komendantova, IIASA

The fourth session focused on the discussion of criteria. First, the criteria and their definitions were presented to the participants. Each criterion was discussed to make sure that participants understand its definition. Participants also had a chance to provide suggestions on how the definition of criteria could be changed and to add further criteria.

Picture 4: Participants discussing the criteria
Source: Nadejda Komendantova, IIASA

The fifth session was on criteria-ranking during silent negotiation, which is a tool for collective ranking but in silence by avoiding any discussion. The following rules applied to the session: At the beginning, the set of cards was displaced on the table in a random order. Then the moderator explained the ranking and the rules and asked participants to order cards in three rounds of silent negotiations. The three rounds were followed by a discussion to identify lines of conflicting opinions. During the first three rounds, participants made eight moves in the first round, five in the second round, three in the third round and finally, after the open discussion, two moves in the fourth and final round. The order how participants were putting the cards was identified by the lottery.

Picture 5: Participants discussing ranking of criteria
Source: Nadejda Komendantova, IIASA

The sixth session was on silent negotiation and white cards. The moderator introduced the blank cards and explained that they show the relative difference in importance for different criteria. The greater the difference in importance between two criteria, the more blank cards should be positioned in-between these criteria. (See Chapter 3.4 for a detailed description of the methodology.) Altogether, there were three rounds of silent negotiations. The first round had three moves, the second had two moves and was followed by the open discussion. The final round had one move.

Picture 6: Participants discussing blank cards and final ranking
Source: Leena Marashdeh, University of Jordan

In the seventh session, the participants discussed procedural and output justice. This discussion focused on the following questions:

\ Access to information: How high is the need for information about the different energy technologies?
\ Meaningful participation in decision-making: How high is the need for participation concerning the different energy technologies?
\ Benefit-sharing: How high is the need to share a reasonable amount of benefits with local communities?
\ Compensation of adverse impacts: How high is the need to claim the right to compensation?

To discuss these questions, the participants formed two groups and tried to reach a compromise on grouping four criteria in a ranking according to what they believed was important. Later, they discussed the results of the ranking and provided their arguments why they found some criteria to be more critical than others.

Picture 7: Participants of the final workshop with mixed groups of stakeholders
Source: Omar AL-Lahham, University of Jordan

Three months later, the research team organized a final workshop to rank the criteria again and to discuss the results. We selected the two most active participants from each stakeholders group. The procedure during the workshop was similar to that during workshops with homogenous groups of stakeholders, except that we did not have discussions about visions and technologies for Jordan. Instead, we had two rounds of rankings where participants had a chance to see and discuss our results between the rankings and then rank the criteria again. Participants from each stakeholder group also had to explain to other participants the reasons why their groups decided in favour of this particular final ranking.

The stakeholder groups

Six groups of different stakeholders were involved in the MENA-SELECT workshops. These groups represent the most relevant stakeholders for energy policy in Jordan: “Policymakers”, “finance and industry”, “academia”, “young leaders”, “national and local NGOs” as well as “civil society” and “local communities”. These groups include the following stakeholders who participated in different events of stakeholders dialogue organized in the framework of the MENA-SELECT project such as workshops and surveys.

Policymakers

This group represents decision-makers in the Jordanian government and representatives of relevant organizations that are responsible for developing and implementing energy policy in Jordan. The participants were from the Ministry of Energy and Mineral Resources (MEMR), the Ministry of Water and Irrigation (MWI), the Amman Chamber of Industry, the Ministry of Public Works, the National Electric Power Company (NEPCO) and the Jordan Press Foundation/ Business section.

Picture 8: Participants of the political decision-makers stakeholder group
Source: Leena Marashdeh, University of Jordan

The **Ministry of Energy and Mineral Resources** (MEMR) is the overarching legislative authority on energy-related issues in Jordan and, as such, lays down the goals and political framework conditions for the development of the energy market.

The **Ministry of Water and Irrigation** (MWI) is responsible for the implementation of the Energy Efficiency and Renewable Energy Policy for the Jordanian water sector. It carries out this responsibility by rehabilitating different systems, installing new systems and renewable energy projects, such as solar energy systems for administrative buildings of the water sector, the use of hydropower potential to power the water sector, the use of biofuel potential in wastewater facilities and large-scale renewable energy-based power-generation for the water sector on available lands (MWI, 2015).

The **National Electric Power Company** (NEPCO) is responsible for the construction, planning, development, operation, maintenance and management of the control systems, the electric transmission and interconnection networks as well as for managing the processes of purchasing, transmitting, control and selling the electric power in Jordan and to the neighbouring countries. It also conducts the planning studies in this regard. The company provides services, consultancy and studies related to electric power to various parties inside and outside Jordan.

The **Amman Chamber of Industry** (ACI) is a non-profit organization which represents the industrial sector in Jordan. The ACI forms and develops a framework to crystallize the industrial point of view of its members in economic issues in general and industrial issues, in particular. To this effect, the chamber cooperates with the ministries' and relevant government economic planning, especially with regard to industry, in coordination with the Jordan Chamber of Industry. Within the framework of ACI's strategy and plans, it aims to promote the use of renewable energy and reduce energy costs for the factories.

The **Ministry of Public Works and Housing** (MPWH) is aiming to provide new governmental buildings that are environmentally friendly and energy-saving.

The **Jordan Press Foundation** is the owner of the Al Rai newspaper and is a shareholding company responsible for media coverage.

Finance and industry

The participants of this group represent energy and environment companies, engineering companies, banks and factories represented by the following companies: Greenviro for renewable energy, control and communication, Al-Masar Engineering Company, Arab Bank, Greenplans Environmental Consult, Petra Elevators Company and Qatrana Cement company.

P

Picture 9: Participants of the finance and private sector stakeholder group
Source: Omar Al-Lahham, University of Jordan

The **Banks** in Jordan are involved in energy projects through signed agreements with the Jordan Renewable Energy and Energy Efficiency Fund (JREEEF) to finance renewable energy projects.

Jordan's **industrial sector** is composed mainly of the "mining and quarrying" and "manufacturing" sub-sectors. Large-scale industries operate primarily in the field of phosphate and potash mining, the industrial production of cement, fertilizers and refined petroleum. The industrial sector's energy consumption represented about 16 per cent of the total energy consumed in Jordan in 2016 (MEMR, 2016).

Al-Masar Engineering is a company specialized in the design and implementation of solar energy systems to generate electricity, store system electricity in batteries or connect them to the network. Al Masar Engineering is one of the first companies to use energy-saving heating pumps to heat water for home use.

GREENVIRO is a Jordan-based company that was established in 2013. The company offers customized energy consumption consultations, energy-saving system designs, energy-saving products as well as the design and installation of solar energy systems.

Control and Communications Company (CCC) was established in 1990. It provides the markets with industrial control systems, file tracking, access control, time attendance, fire alarms and other systems that could be used in the field of renewable energy systems.

Greenplans Environmental Consultations Ltd. Co. is an engineering consulting firm specializing in the environmental engineering and consulting services that cover the areas of water, environment, waste and energy (renewable energies and energy efficiency) related to engineering and environmental projects, industries, facilities and development zones.

Petra Elevators is a company that provides and designs an innovative range of elevators, lifts and other technical devices for smooth riding comfort, preciseness and reliable speed control.

The **Qatrana Cement Company** was established in 2007 with a total investment of 500 million US dollars. Qatrana cement plant is located 80 km south of Amman. A 30-megawatt power plant, which runs on coal, will be constructed to supply energy to the Al Manaseer's cement factory in Qatraneh. It is planned that the project will be operational by 2025.

Academia

This group represents researchers and academics in the field of energy. The participants were faculty members and researchers from the University of Jordan, the King Abdullah II Design and Development Bureau (KADDB), Al-Zaytoona University, Applied Science University and the German Jordanian University. For example, KADDB is an independent government entity within the Jordanian Armed Forces (JAF) aiming at becoming a global defence and security research and development hub in the region. The Bureau's scope of work includes defence design and development, test and evaluation, technology incubation in the Kingdom and defence technology training.

Picture 10: Participants from the academia stakeholder group
Source: Jenan Irshaid, IIASA

The **University of Jordan** is a public university located in Amman. It is Jordan's largest and leading institution of higher education.

The **Al-Zaytoona University** is a private university and includes six faculties, encompassing 19 undergraduate specializations and one graduate programme.

The **Applied Science University** is a private university located in Amman, Jordan. It was established in 1991 as the largest private university in Jordan regarding its campus area and the number of students enrolled.

The **German Jordanian University** is a public university in Madaba, Jordan. It offers more than 20 programmes to about 5,000 students, primarily from Jordan. The University was modelled on the German applied-sciences model, characterized by their focus on putting knowledge into practice and on promoting knowledge transfer. It aims to play a significant role in promoting links between Jordan and Europe, particularly Germany. By taking advantage of the best educational practices in both Jordan and Germany, the University has positioned itself as a leader in its field.

Young leaders

This group represents the graduate students in the field of energy as well as young employees at energy and engineering companies such as Green Essence, KEPCO KPS IPP3 power plant and Gereenviro.

Picture 11: Participants of the stakeholder group of young leaders/ future decision-makers
Source: Leena Marashdeh, University of Jordan

Green Essence specializes in renewable energy systems and is an authorized dealer for Suntech, the global leading PV panels manufacturer ranked as the largest manufacturer in the world. It can be compared to the leading German inverters manufacturer such as SMA.

KEPCO KPS IPP3 power plant is located on a greenfield site at Al Manakher, 30km from the Jordanian capital Amman. It is the world's biggest tri-fuel power plant with an installed capacity of 573MW. The plant is designed to use natural gas and heavy fuel oil (HFO) as its main fuels and light fuel oil (HFO) as backup.

Civil society and NGOs

This group of stakeholders represents the national non- governmental organizations in the field of energy, environment and engineering. The participants were from the Energy Services Center, the Renewable Energy Establishments Society, the Jordan Engineers Association (JEA), the Jordan Environment Society (JES), the Jordan energy chapter and the Sanibel Society for the environment.

Picture 12: Participants of the stakeholder group of local communities and NGOs
Source: Jomana Tanbour, University of Jordan

The **Energy Services Center** is an integrated centre for energy, renewable energy and energy efficiency sector. It provides a range of training and advisory services by a qualified team to build the capacities in this sector.

The **Jordan Engineers Association** is a trade union of engineers in Jordan, and it is the largest trade union in the country.

The **Jordan Environment Society** (JES) was established in 1988 as a non-profit non-government organization (NGO). It is the largest NGO in Jordan in its field. The objective of JES includes, but is not limited to, the protection of the environment and its basic elements such as water, air, soil and wildlife.

The **Jordan Energy Chapter** is partnered with the US American Association of Energy Engineers (AEE), a non-profit professional society of over 18,000 members in more than 100 countries. The mission of AEE is "to promote the scientific and educational interests of those engaged in the energy industry and to foster action for sustainable development" (AEE website).

The **Sanibel Society for the Environment** is a non-profit organization concerned with environmental protection.

Local communities

This group represents the local community from different cities in the north and south of Jordan. The participants were employees from the Ministry of Municipal Affairs in Alsalt city, Madaba city and Zarqa city and interested citizen from Amman and Madaba.

Picture 13: Participants of the local communities stakeholder group
Source: Leena Marashdeh, University of Jordan

Large-scale power-generating projects such as the Hussein Thermal Power Station and the first nuclear power plant are under development and construction in Zarqa City community. The cities of Amman, Alsalt and Madaba host a number of small and large-scale renewable energy projects.

Workshops

\ Group 1: Civil society and NGOs on 7 November 2016;
\ Group 2: Finance and investment on 9 November 2016;
\ Group 3: Academia on 10 November 2016;

\ Group 4: future decision makers on 12 November 2016;
\ Group 5: Local communities on 13 November 2016;
\ Political decision-makers on 15 November 2016;
\ Final workshop with mixed groups of stakeholders on 28 February 2017.

The following organizations participated in the workshops:

Academia: Al Balqa Applied University, Mutah University, University of Jordan, Applied Science University, German Jordanian University, American University.

Local communities: Greater Amman Municipality, Salt community, Ministry of Municipal Affairs, Municipality of Al Zarqa, Municipality of Madaba.

Civil society and NGOs: Energy Services Center, Renewable Energy Establishments Society, Jordan Engineers Association, Jordan Environment Society (JES), EDAMA, Sanibel Society for Environment, Jordan press foundation.

Private sector: Arab bank, Gereenviro for renewable energy, Control and communication company, Al-Masar engineering company, Green plans consult, Qatrana Cement, NEPCO.

Government: Ministry of Public Works, Ministry of Water and Irrigation, Ministry of Municipal Affairs, Amman Chamber of Industry, Ministry of Energy and Mineral resources, Parliament.

Criteria-ranking

One of the problems with most models for ranking criteria is that numerically precise information is seldom available, and most decision-makers experience difficulties with entering realistic information when they analyze the challenges of decision-making. For instance, Barron & Barrett (1996b) argue that the elicitation of exact weights demands an unreasonable exactness which does not exist. There are other problems, such as that ratio weight procedures are difficult to accurately employ due to response errors (Jia et al., 1998). The general lack of reasonably complete information increases this problem significantly. Several attempts have been made to resolve this issue. Methods allowing for less demanding ways of ordering the criteria, such as ordinal rankings or interval approaches for determining criteria weights and values of alternatives, have been suggested, but the evaluation of these models is sometimes quite complicated and difficult for decision-makers to accept.

The use of ordinal or imprecise importance information to determine criteria weights is a way of handling this, and some authors have suggested surrogate weights as representative numbers assumed to represent the most likely interpretation of the preferences expressed by a decision-maker or a group of decision-makers. The idea is to enable decision-makers to use the information they can supply and then generate representative weights from some underlying distribution and investigate how well they perform. One such type is derived from ordinal importance information (Barron & Barrett, 1996ab; Katsikopoulos & Fasolo, 2006), where decision-makers supply ordinal information on importance, and the information is then subsequently converted into surrogate weights corresponding to and consistent with the extracted ordinal information. Often, rank sum (RS) weights, rank reciprocal (RR) weights (Stillwell et al., 1981) and centroid (ROC) weights (Barron, 1992) are used.

Still, the problem here is to elicit stakeholder information. Different elicitation formalisms have been proposed by which a decision-maker can express preferences. Such formalisms are sometimes based on scoring points, as in point allocation (PA) or direct rating (DR) methods. In PA, the decision-maker is given a point sum, e.g. 100, which they distribute among the criteria. Sometimes, it is pictured as putty with the total mass of 100 being divided and put on the criteria. The more mass, the larger weight on a criterion, the more important it is. When the first N−1 criteria have received their weights, the last criterion's weight is automatically determined as the remaining mass. Thus, in PA, there is N−1 degrees of freedom (DoF) for N criteria. DR, on the other hand, puts no limit on the total number of points to be allocated. The decision-maker allocates as many points as desired to each criterion. The points are subsequently normalized by dividing the overall sum by the sum of points allocated. When the first N−1 criteria have received their weights, the decision-maker will still have to assign the last criterion's weight. Thus, in DR, there are N degrees of freedom for N criteria. Regardless of elicitation method, the assumption is that all elicitation is made relative to a weight distribution held by the decision-maker.

Simos proposed a simple procedure, using a set of cards, trying to indirectly determine numerical values for criteria weights (Simos, 1990ab). The Simos method is, however, somewhat different from the methods discussed above. It is a relatively simple method for expressing criteria hierarchies while introducing some cardinality if needed. It has been widely applied and has been well-received by decision-makers. When this method is used, a group of decision-makers are provided with a set of coloured cards with the criteria names written on them. They are also given a set of blank cards. Then, they are asked to rank the coloured cards from the least important to the most important, grouping criteria of equal importance together. Furthermore, the decision-makers are asked to place the blank cards in- between the coloured cards to express preference strengths. Then, the surrogate numbers can be computed. A constant value difference, 'u', between two consecutive cards is assumed here. A blank card between two consecutive coloured cards signifies a difference of 2u, and two blank cards represent a difference of 3u, etc.

However, one problem with the Simos method is that it is not robust when the preferences are changed (Scharlig, 1996) and that it has some other counter-intuitive features, such as that it only picks one of the weight vectors satisfying the model, while there can, of course, be an infinite number of them. What is more, because the weights are determined differently depending on the number of cards in the subsets of equally ranked cards, the differences between the weights also change in an uncontrolled way when the cards are reordered. This is why Figueira and Roy (2002) suggested a revised version, where there is a more robust proportionality when these blank cards are used. It is accomplished by requesting the decision-makers to state how many times more important the most important criterion or criteria group is—compared to the least important. This addition seemingly solves some problems but introduces the complication that the decision-maker has to reliably and correctly estimate a proportional factor 'z' between the largest and the smallest criteria weights.

We, therefore, used a variant of the Simos method for elicitation purposes and kept the card ranking part but changed the evaluation method significantly. At that point, the participants already knew the criteria well from the previous sections of the workshops. The key challenge in our workshops was to elicit a collective ranking. While most methods for ranking and weighting deal with individuals, we had to do it as a group effort. We mainly opted for the card-ranking as it offered silent negotiation, while the calculation behind it was of less importance to us.

Each criterion was written on a coloured card and arranged horizontally on a table. Then, each of the participants successively ranked the cards from the least important to the most important by moving the cards to a vertical arrangement, where the highest-ranked criterion was moved to the uppermost position and so forth. If two criteria were considered to be of equal importance, they were put on the same level. This process went on for four rounds, where the number of moves for each round was 8, 5, 3 and 2. Furthermore, the first and third round was concluded by an open discussion before the following round began. The ranking procedure lasted 120 minutes or until a final ranking was achieved that the participants found acceptable.

It is true that the decreasing number can be disputed and is a weak point of the method since it induces / forces the participants to act strategically in relation to the information they got during the process. So when this method is used, the potential conflicts must come to the open and be dealt with. In some cases, by working with a set of final ranking in the evaluations, where it turns out whether the differences are of importance or not. After the first ordinal ranking was finalized, the participants were asked to introduce preference strengths in the ranking by introducing the blank cards during three additional rounds (with three, two and one move). The number of white cards (i.e. the strength of the rankings between criteria) was also interpreted verbally:

Table 1*:*
Blank cards

Equal level of cards	Equally important
No blank card	Slightly more important
One blank card	More important (clearly more important)
Two blank cards	Much more important
Three blank cards	Extremely more important

The final rankings of the six workshops were handed to the representatives of each stakeholder group during the final workshop that took place two months later, during which this group repeated the exercise. They were then able to present each ranking and its rationale to the other participants during an introductory presentation round.

Methods of analysis

A common approach to solving decision challenges as to multiple criteria is to specify a set of criteria that represent the relevant aspects of a problem, and then define a weight function over the criteria set. Value functions are then defined over the alternatives for each attribute. Common here is to use a weight function over the attribute set using fixed numbers on a normalised scale. The criteria weights thus describe each criterion's significance in the specific decision context. Value functions over the alternatives are defined in a similar way. Thereafter, the overall score of each alternative is calculated by aggregating the various components.

One of the central issues of these methods is how to assign weights while avoiding too much loss of information as well as preserving correctness in the weight assessments. In using criteria ordinal rankings one usually avoids some elicitation difficulties that appear when limited to precise numbers only are used. Techniques for ordinal rankings are, however, quite different as concerns their accuracy, and decision-makers usually also have more useable knowledge of decision situations than knowledge expressed in criteria orderings (cf. e.g. Danielson & Ekenberg, 2017b); knowledge that should also be used. The so called surrogate weights based on an ordering only may thus be too weak a representation. In the analyses, we have therefore included information regarding relational strengths.

Before going into the evaluations, we will explain the issues with eliciting and representing preference orderings in some more detail. A commonly used class of methods here is the SMART[2] family. These methods were already developed in the 1970s for weight assessment from criteria rankings, (cf., e.g., Edwards 1971, 1977). The basic idea is quite simple. Given a ranking, ten points are assigned to the weight of the least important criterion (w_N), whereafter the weights w_{N-1} through w_1 are given points according to the decision-makers' preferences. The overall value, $E(a_j)$, is then a weighted average of the values v_{ij} associated with alternative a_j (Eq. 1) under the criterion c_i:

$$E(a_j) = \frac{\sum_{i=1}^{N} w_i v_{ij}}{\sum_{i=1}^{N} w_i} \qquad (1)$$

Some years later, Edwards and Barron (1994) suggested the SMARTER method, and included an elicitation component for ordinal information before converting this to numbers. First, the weights are ordered as $w_1 > w_2 > ... > w_N$ and are then transformed to numerical weights using ROC weights (see below), and then SMARTER continues as the ordinary SMART method.

The Analytic Hierarchy Process (AHP) is a well-known ratio scoring method (Saaty, 1977, 1980), where a set of alternatives are evaluated under a criteria tree by pairwise comparisons. For each criterion, the decision-makers assess the ordering of the alternatives. Thereafter, they assess the strength of the ordering by quite roughly considering ratios between the alternatives.

These methods, however, have several shortcomings, and we have suggested a set of alternatives in a series of articles. The Cardinal Ranking (CAR) method is one of these, and we have shown that it is a more robust and efficient than those of the SMART family, AHP and many others. [3]

We will use CAR in the analytical part of this report when translating the rankings to surrogate weights and subsequently use these values in the Multi-Attribute Decision Making (MADM) software DecideIT, which is designed to solve these types of problems under uncertainty.

[2] Simple Multi-Attribute Rating Technique

[3] See, e.g., Danielsson and Ekenberg, 2016

Calculations of surrogate weights from the ranking

The CAR method of Danielson and Ekenberg (2016) converts the cardinal criteria ranking including the blank cards into numerical weights, while thereby limiting information loss. The idea is the following:[4]

1. Assign an ordinal number to each importance scale position, starting with the most important position as number 1.
2. Let the total number of importance scale positions be Q. Each criterion i has the position $p(i) \in \{1,\ldots,Q\}$ on this importance scale, such that for every two adjacent criteria c_i and c_{i+1}, whenever $c_i >_{s_i} c_{i+1}$, $s_i = |\, p(i+1) - p(i)\,|$. The position $p(i)$ then denotes the importance as stated by the decision-maker. Thus, Q is equal to $\Sigma s_i + 1$, where $i = 1,\ldots,N-1$ for N criteria.
3. Use a reliable transformation algorithm for the generation of surrogate weights.

To find such an algorithm, we have some alternatives. For instance, consider the counterpart to RS weights (Barron, 1992). The concept of cardinal rank sum (CRS) weights is based on the idea that the rank order strength should be reflected directly in the weights. Then the CRS weights are obtained by Eq. 2

$$w_i^{\mathrm{CRS}} = \frac{Q+1-p(i)}{\sum_{j=1}^{N}(Q+1-p(j))}, \quad (2)$$

based on the importance positions $p(i)$ as stated by the decision-maker. The counterpart to ordinal rank reciprocal weights[5] is defined analogously. According to step 2, let the total number of importance scale positions be Q. Each criterion i has the position $p(i)$ on the importance scale such that $p(i) \leq p(j)$ if $i < j$. Then the corresponding rank reciprocal (CRR) weights are obtained by Eq. 3

$$w_i^{\mathrm{CRR}} = \frac{\frac{1}{p(i)}}{\sum_{j=1}^{N}\frac{1}{p(j)}} \qquad (3)$$

with the usual property that a higher weight is assigned to lower ranking numbers. ROC weights (Danielson et al., 2014) are generalized in the same way. The ordinal ROC weights, given by Eq. 4

$$w_i^{\mathrm{ROC}} = {}^{1}\!/_{N} \sum_{j=i}^{N} \frac{1}{j} \qquad (4)$$

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[4] This is described in more detail in Danielson and Ekenberg, 2015, 2016.

[5] Stillwell et al, 1981

could be interpreted as candidate weights for positions on the importance scale. Then, the corresponding preference strength rank order centroid weights (CRC, Eq. 5) are

$$w_i^{\text{CRC}} = \frac{\sum_{j=p(i)}^{Q} \frac{1}{j}}{\sum_{k=1}^{N}\left(\sum_{j=p(k)}^{Q} \frac{1}{j}\right)} \qquad (5)$$

Finally, the SR weights (Danielson & Ekenberg, 2014) are generalized in the same way. The ordinal SR weights are given by the Eq. 6

$$w_i^{\text{SR}} = \frac{1/_i + \frac{N+1-i}{N}}{\sum_{j=1}^{N} w_j^{\text{SR}}} \qquad (6)$$

and the corresponding preference strength SR weights (CSR, Eq. 7)

$$w_i^{\text{CSR}} = \frac{1/_{p(i)} + \frac{Q+1-p(i)}{Q}}{\sum_{j=1}^{N}\left(1/_{p(j)} + \frac{Q+1-p(j)}{Q}\right)} \qquad (7)$$

is a similar generalization as the other weights.

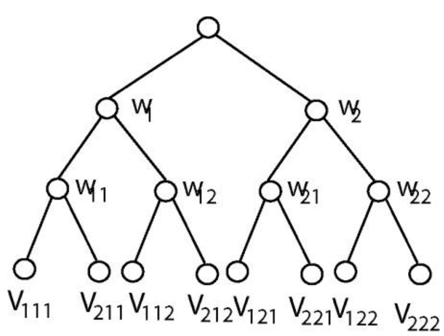
Ordinal weight methods are thereby easily generalized to their respective counterparts, and we demonstrate in Danielson and Ekenberg (2017a) that CSR should be preferred to the other candidates. This is also the evaluation method for the criteria ranking component used in CAR.

Now, we turn our attention to the general evaluation of the entire decision problem.

Multi-Criteria Decision Analysis (MCDA)

Typically, a multi-criteria decision situation is modelled like a tree, as in the figure below, where the *w:s* are criteria weights and the *v:s* are values of alternatives under the different criteria.

Figure 1: A multi-criteria tree



The normalization constraint means that the weights are restricted by the equation $\sum w_j = 1$, where w_j denotes the weight of a criterion G_j and the weight of sub-criterion G_{jk} is denoted by w_{jk}. Denote the value of alternative a_i under sub-criterion G_{jk} by v_{ijk}.

A common value function for evaluating alternatives in the analyses is a weighted average of the components involved. For instance, consider an alternative A_i under two criteria, with the respective weights w_1 and w_2. The overall value of this alternative can be calculated by a weighted average:

$$E(A_i) = \sum_{j=1}^{2} w_j \sum_{k=1}^{2} w_{jk} \, v_{ijk} \qquad (8)$$

This can easily be generalized into multi-criteria decision trees of arbitrary depth and solved as corresponding multi-linear equations.

As mentioned above, one of the problems with most models for criteria ranking is that numerically precise information is seldom available. We have solved this in part by introducing surrogate weights. This, however, is only a part of the solution since the elicitation can still be uncertain, and the surrogate weights might not be a fully adequate representation of the preferences involved, which of course, is a risk with all kinds of aggregations. To allow for analyses of how robust the problem is to changes of the input data, we also introduced intervals around the surrogate weights as well as around the values of the technology options. Thus, in this elicitation problem, the possibly incomplete information is handled by allowing the use of intervals (cf., e.g., Danielson & Ekenberg, 1998, 2007), where ranges of possible values are represented by intervals (in combination with pure orderings without the use of surrogate weights at all, if the latter turns out to be inadequate).

There are thus several approaches to elicitation in MCDM problems, and one way of partitioning the methods into categories is to examine how they handle imprecision in weights and values, such as fixed numbers, comparative statements, representing orderings or intervals.

Computationally, methods using fixed numbers are very easy to solve, while systems of relational or interval constraints normally require more elaborated optimization techniques. Yet, if the model only accepts fixed numbers, we impose constraints that might severely affect the decision quality. If we allow for imprecision in terms of intervals and relations, we usually get a more realistic representation of the problem. These intervals can, for instance, be represented by interval statements, such as $w_i \in [y_i - a_i, y_i + b_i]$, where $0 < a_i \le 1$ and $0 < b_i, \le 1$, or comparative statements, such as $w_i \ge w_j$.

Systems of such equations can be solved, and aggregations of decision components in these formats can be optimized, by using the methods from Ekenberg et al. (2011). The disadvantage here is that many decision-makers at times find these methods difficult to understand and accept, because of complex computations and loss of user transparency.[6]

In the case of our research, the performance of the different electricity-generation technologies was estimated from a larger expert survey. Together with the surrogate weights, they thus provided the decision base for the multi-criteria analysis. Using the weighted aggregation principle in (Eq. 8), we combined the multiple criteria and stakeholder preferences with the valuation of the different technology options under the criterion of surrogate weights.

The results of the process were (1) a detailed analysis of each technology's performance compared with the other technologies, and (2) a sensitivity analysis to test the robustness of the result.

During the process, we considered the entire range of values as alternatives presented across all criteria as well how plausible it was that an alternative outranked the remaining ones and thus provided a measure of robustness. Because of the complexity in these calculations, we used the state-of-the-art MCA software DecideIT for the analysis, which allows for imprecision of the kinds that exist here (Ekenberg et al., 2011). Earlier versions of DecideIT were used successfully in a variety of decision-making situations, such as the storage of nuclear waste, insurance portfolios, demining and financial risks (Danielson et al., 2003; Danielson, 2005; Danielson & Ekenberg, 2007; Danielson et al., 2007).

[6] This should be kept in mind here as always when working with aggregation methods of whatever kind and this should affect how the elicitation mechanisms and software tools that are used.

RESULTS

The empirical data collected during the workshops allowed us to develop the following sets of results:

- Stakeholders' visions about the economic, societal and environmental future of Jordan.
- Perceptions of risks and benefits of different electricity-generation technologies.
- Rankings of different criteria.
- Trade-offs of technologies, including results based on a modelling of criteria ranking.
- Individual evaluations during the following up survey.
- Discussion about energy transition in Arabic in the mass media and social media.

Visions of the economic, social and environmental future of Jordan

The majority of stakeholder groups perceived a positive dynamic for the future of Jordan. A host of expectations is connected with economic growth, such as Jordan being an economic leader in the region, the further development of its manufacturing sector, the development of different kinds of businesses due to an improved environment for doing business or better cooperation among partners. Major expectations on drivers of economic development were connected with the reduction of debts and energy imports.

The perceptions about the social future were more polarized. Indeed, there were expectations about the development of further potential for job creation processes. At the same time, concerns were expressed that the industrialized society will destroy traditional values or the traditional family structure.

As to the environmental future, stakeholders expressed their hopes that one the one hand, new technologies will allow the reduction of the human footprint and thus impact on the environment. At the same time, they voiced concerns about exacerbating the state of resources in Jordan, such as contributing to further water scarcity.

The visions of positive and negative factors influencing the economic, social and environmental future of Jordan are described in Tables 2 and 3. The detailed description of factors in each stakeholders group is provided in the Annex.

Table 2

Visions of a positive economic, social and environmental future of Jordan

	Economic	Social	Environmental
Civil society and NGOs	Economic leader in the region, attractive for investment, stable and resilient. Energy is essential for economic growth	Additional employment created in services sector	Changing human behaviour towards reducing pressure on the environment, improved water management practices, more environmentally friendly transport
Finance and investment	Reduced dependency on energy imports, more local manufacturing of components for renewable energy industries, reduction of government debt	Greater awareness of renewable energy sources, establishment of smart self-sufficient cities, know-how and technology transfer	Implementation of green building standards, green growth, green and clean cities, reduction of environmental pollution
Academia	Better cooperation between private and public sectors, create new opportunities for electricity export	Green growth contributes to socio-economic development, increased quality of life, young people will become leaders of social change	Reduced pressure on the environment as a result of international cooperation
Future decision-makers	Reduced debts and level of poverty due to impulses created by green growth for socio-economic development, increased energy-generation from locally available resources	Green growth leads to new direct, indirect and induced jobs as well as new opportunities in education	Reduced impacts on the environment, especially in such sectors as energy and construction, increased level of environmental awareness among the Jordanian population
Local communities	Increased cooperation between private and public partners on the implementation of infrastructure projects, increased efficiency, use of RES will help to improve investment climate and will attract further investment	Increased level of awareness will lead to more acceptance of RES and a more open-minded society	Energy-generation will be connected to reduced impacts on the environment
Political decision-makers	Technology transfer and energy generation from domestically available resources as drivers for socio-economic development, will create impulses for the development of manufacturing and agricultural sectors, improve investment climate and attract further investment	Existing sense of solidarity and social responsibility	Technologies such as waste-to-energy will help to reduce pressure on the environment

Table 3

Visions of a negative economic, social and environmental future of Jordan

	Economic	Social	Environmental
Civil society and NGOs	Tax increase, worsening banking system, unemployment	Potential societal conflicts, criminalization and destruction of family structure. Unsustainable patterns of urbanization have to be addressed.	Water scarcity, soil degradation
Finance and investment	Demographic trends and energy transition will lead to less reliable energy supply, levelized costs of electricity will also increase due to energy transition, local currency will devaluate	Changed family structure	Pressure on water resources
Academia	Growth should be followed by governance reforms	Changed family values, morals and ethics. Increase of social divide	Risks of increased water, land, air pollution as well as water scarcity
Future decision-makers	None	None	None
Local communities	Potential increase of electricity prices	Traditional values will get lost	Energy generation will be connected with reduced impacts on environment
Political decision-makers	Growing energy prices will lead to social instability and difficulties for some social groups to cover their basic needs	Energy transition will result in destruction of traditional values	Jordan still has to learn how to adapt to climate change

Perceptions of risks and benefits of different technologies

The most frequently perceived benefits of PV were the potential for low-cost electricity-generation and for climate change mitigation. The most frequently named concerns were connected with high initial investment costs as well as technical risks such as intermittency, volatility and the need for storage (Table 4).

Table 4

Perceptions of risks and benefits of utility PV

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Creates jobs	X					
Climate change mitigation	X		X			X
Low costs electricity		X	X		X	
No environmental impacts		X				X
Easy to use			X	X		
Abundant resources				X		
Possible use in remote areas					X	
Negative						
Intermittency risks, volatility, storage needed	X	X	X	X	X	
Need for recycling	X					
High investment costs		X		X		X
Absence of domestic market			X			
Components are manufactured abroad, absence of the market			X			
Need for cleaning and maintenance					X	X

The most frequent benefits of CSP are low impacts on the environment, the potential for climate change mitigation and a high level of efficiency. At the same time, the perceived negative characteristics are high investment costs and land requirement (Table 5).

Table 5

Perceptions of risks and benefits of solar power

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Low impacts on the environment	X	X	X			X
Possibilities for storage, stabilization of the grids and base load	X	X				
Climate change mitigation			X	X		X
Generation of electricity for large consumers is possible				X	X	
High level of efficiency of power stations				X	X	X
Safe						X
Negative						
Intermittency due to variations in solar irradiation	X					
Need for battery replacement	X					
High investment costs		X		X	X	X
Land requirement			X	X		X
Water usage			X			
Difficult to install and maintain					X	X

The most frequent perceived characteristic of wind is that it is safe and clean. However, the perceived concerns are high initial investment costs, intermittency of electricity-generation and noise (Table 6).

Table 6

Perceptions of risks and benefits of wind

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Safe and clean	X	X	X	X	X	X
Cheap electricity			X		X	X
Easy in operation and maintenance						X
Low land requirement				X	X	X
Efficiency				X		
Abundant resources		X				
Climate change mitigation		X				
Negative						
High costs	X	X	X	X	X	X
Site specific						X
Noisy	X	X	X	X	X	X
Intermittency		X	X	X	X	
Impacts on birds				X		
Absence of local manufacturing of components and difficulty in maintenance	X		X			
Impacts on landscape visibility		X				

Hydro is perceived as a clean and environmentally friendly technology, which also has high efficiency in electricity-generation. At the same time, the greatest concern is the lack of resources for hydroelectricity-generation in Jordan (Table 7).

Table 7

Perceptions of risks and benefits of utility hydropower

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Clean and environmentally friendly		X	X	X	X	
Low costs		X				
High efficiency		X		X		X
Ease in maintenance		X				X
Reliable, stable and dispatchable			X		X	
Jobs						X
Negative						
Absence of resource in Jordan	X	X		X	X	X
Environmental impacts on land areas		X				
High initial costs			X	X		
Needs certain topography					X	

The major felt benefits of coal are perceived cheap electricity-generation and a potential for providing baseload. At the same time, it is perceived as a polluting technology with negative impacts on human health and the environment (Table 8).

Table 8

Perceptions of risks and benefits of coal

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Cheap electricity-generation		X	X	X		X
Dispatchability and baseload	X		X	X		
Can be combined with carbon capture and storage				X		
Negative						
Not safe due to the lack of advanced technology						X
High initial costs						X
Negative impacts on human health and environment	X	X	X	X	X	X
Resources are not available in Jordan			X	X		

The major perceived benefit of gas is that it can provide stable baseload and can also be used as a back-up capacity. It also has low greenhouse gas emissions. At the same time, the major concern is the fact that there are no local deposits of the resource and the consequent need to import it from abroad (Table 9).

Table 9

Perceptions of risks and benefits of gas

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Clean in terms of GHG emissions	X		X		X	
Baseload and back up potentials	X	X		X	X	X
Efficiency		X			X	
Does not require modification of grids			X			
Low costs				X		
Negative						
Dependency on imported resources	X	X	X	X	X	X
Impacts on the environment				X		

Oil has few perceived benefits. The most frequently named one was reliability of electricity-generation in terms of baseload. At the same time the most frequently expressed concern was its impact on the environment and human health (Table 10).

Table 10

Perceptions of risks and benefits of oil

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Available in countries with similar to Jordan socio-economic conditions			X			
Reliable technology in terms of baseload	X	X				
Negative						
Air and environmental pollution	X	X	X	X	X	X
Usage of water						X
Dependence on imported resources	X		X	X		X
Impacts on human health					X	X

Nuclear energy is perceived as a technology with low levelised costs of electricity, which generates sufficient quantities to cover the entire Jordanian growing energy demand. At the same time, there are significant concerns about high risks for human health and the environment in case of accidents. The nuclear waste and usage of water were two other discussed issues.

Table 11

Perceptions of risks and benefits of nuclear power

	NGOs	Finance	Academia	Future decision makers	Local communities	Decision makers
Positive						
Low levelised costs of electricity		X	X			X
High efficiency and output		X		X		
Can cover growing energy demand			X		X	X
Can deliver large consumers			X			
Jobs				X		
Positive impacts on know-how and skills					X	
Negative						
Nuclear waste	X		X	X		X
High risks for human health and environment	X	X	X	X	X	X
Usage of water	X	X	X	X	X	X
High costs of electricity	X					
High initial capital costs		X			X	
High political risks			X			

The detailed description of the discussions during the workshops is in the Annex.

Ranking of different criteria

The ranking of different criteria during the six workshops with homogenous groups of stakeholders showed that all groups of stakeholders perceive electricity systems costs as an important criterion. They also believed that safety and global warming potential are important criteria. Decision-makers considered safety to be of the utmost importance while local communities, future decision-makers and finance and investment considered it important. Global warming potential is important for local communities and for finance and investment. Global warming potential was a contested criterion, as academia considered it to be least important. At the same time, almost all stakeholder groups excluding academia and decision-makers found the domestic value chain integration to be the least important criterion. Non-emissions hazardous waste was the least important criteria for civil society, academia, future decision-makers and current decision-makers. Pressure on local land resources was ranked as the least important criterion for academia, and pressure on local water resources was ranked as the least important criterion for decision-makers (Table 12).

Table 12

Ranking of criteria during individual stakeholder groups

Group	*Most important criteria*	*Least important criteria*
Civil society and NGOs	Electricity systems costs	Non-emission hazardous waste and domestic value chain integration
Finance and investment	Global warming potential, safety and electricity systems costs	Domestic value chain integration
Academia	Electricity systems costs	Global warming potential, non-emission hazardous waste and pressure on local land resources
Future decision makers	Safety and electricity systems costs	Domestic value chain integration and non-emission hazardous waste
Local communities	Global warming potential, safety and electricity systems cost	Domestic value chain integration

Table 13 shows different criteria and their importance for six stakeholders groups. The detailed description of the rankings in stakeholders groups is in the Annex.

Table 13

Ranking of criteria by different stakeholder groups

Stakeholders	Use of domestic energy sources	Global warming potential	Domestic value chain integration	Technology and knowledge transfer	Electricity system costs	On-site job creation	Pressure on land resources	Pressure on local water security	Non-emission hazardous waste	Local air pollution and health	Safety
Young leaders	Moderate-low importance	Moderate-low importance	Least importance	Moderate importance	High importance	Moderate importance	Least importance	Moderate importance	Least importance	Moderate-low importance	High importance
National NGOs	Moderate-low importance	Moderate-low importance	Least importance	Moderate-low importance	High importance	Moderate-low importance	Least importance	Moderate-low importance	Least importance	Least importance	Moderate-low importance
Local communities	Least importance	High importance	Least importance	Least importance	High importance	Least importance	Least importance	Moderate-low importance	Least importance	Moderate-low importance	High importance
Academia	Moderate importance	Least importance	Moderate-low importance	Moderate importance	High importance	Moderate importance	Least importance	Moderate importance	Least importance	Moderate importance	Moderate-low importance
Finance/Industry	Least importance	High importance	Least importance	Least importance	High importance	Least importance	Least importance	Moderate-low importance	Least importance	Moderate-low importance	High importance
Policy-makers	Moderate importance	Least importance	Moderate-low importance	Least importance	Moderate importance	Least importance	Moderate-low importance	Least importance	Least importance	Least importance	High importance
Compromise	Moderate-low importance	Least importance	Least importance	Moderate-high importance	Moderate-high importance	High importance	Least importance	Moderate-high importance	Moderate-low importance	High importance	Moderate-low importance

The ranking of the criteria by **civil society and NGOs** showed that electricity systems cost is by far the most important criterion and weights more than one-third in the decision-making process with all ten remaining criteria amounting to less than 70 per cent. In the round of open discussion after the ranking exercise, the following arguments were discussed and the criteria of electricity systems costs, socio-economic impacts and safety were debated as the most important.

Participants voiced the following arguments in favour of the high importance of electricity systems costs:

> *Currently the costs of renewable energies are high and there is an uncertainty in the costs prediction. At the same time the costs of fossil fuels are fluctuating less, they are fixed and the technology proved to be reliable. As the costs of renewable energy sources will go down, this will become more and more attractive option to satisfy energy demand. At the same time as energy demand growth will be significant fossil fuel power plants will still have to be maintained to guarantee baseload capacity and to cover the picks in case of additional demand.*

They also mentioned the importance of socio-economic impacts:

> *It is important to use local resources and to facilitate technology transfer to create employment opportunities. Further regulatory and institutional frameworks are needed to facilitate technology transfer from Europe and the United States as well as from other countries to Jordan.*

Safety was discussed in light of further efforts which are needed to develop safety regulations for existing and emerging technologies. The question was also how to include safety regulations into the national legislative framework.

For **finance and investment** stakeholders, the main focus of discussion was on the safety of electricity-generation. While safety seems to be one of the most important criteria, they were aware that the implementation of safety measures will lead to higher energy costs. Participants also were concerned that authorities monitoring safety in Jordan are lacking the power to reinforce safety regulations. They recommended that the level of responsibility of stakeholders be increased to guarantee the safety of power plants' operations. Participants believed that as technologies such as nuclear power will be transferred from more experienced countries, the know-how and guarantees for safety will also be transferred.

During the open discussion among **academia,** a heated debate took place among those participants who thought that electricity systems cost is the most important criterion and those who believed that safety and security is the most important, indeed vital. One participant summarized this sentiment as follows: *"I need to be able to pay my electricity bills and have a wish to stay in good health without impacts of environmental pollution and safety risks of energy-generation".*

Among **future decision-makers,** the electricity systems costs criterion was considered as the most important one, especially bearing in mind a limited budget and budget deficit in Jordan. However, there was no consensus on this criterion among participants. Other participants objected strongly that values are more important than costs. Safety and transfer of knowledge were considered crucial as regards the implementation of safety regulations. The risk of climate change impacts was also closely connected with safety issues.

Representatives of **local communities** intensively debated about whether the criterion of safety or that of impacts on human health and locally available resources such as water and land was more important. Local communities also considered electricity costs to play a significant role. Yet, there was no common opinion on these criteria among different communities, and the participants were not able to agree on a compromise regarding the most important criterion.

The discussion after ranking among **decision-makers** was short, and participants agreed on the ranking and on the importance of the safety criterion. The aspect of safety was picked up again during the ranking of the procedural criteria where it was agreed that safety should remain top priority.

Procedural and output justice

Representatives of **civil society and NGOs** argued that every infrastructure project should be combined with participation procedures in the framework of environmental impact assessments. These procedures should guarantee that local communities would benefit from the project. Measures must be undertaken so that the population becomes more aware of and knowledgeable about the projects as well as about possibilities to participate. In the course of that debate there was a controversy whether access to information could be considered as participation or not. The question also arose how to deal with compensation, namely, who should be responsible, how it should be organized and who should be compensated.

The main focus of discussion among **finance and investment** was about the access to information and meaningful participation. While some participants argued that access to information should be more a prerequisite for a meaningful participation, others argued that participation produces access to information. However, a consensus was reached that benefit-sharing should come after the access to information and meaningful participation and that compensation should be the least important criterion. This is mainly because participants agreed that compensation is only due after the occurrence of a disaster.

Academia intensively debated whether providing information is a part of stakeholders' involvement and inhabitants' engagement or not. It was agreed that conditions for engagement and participation should be provided during all phases of decision-making processes rather than compensating for adverse impacts of non-inclusive and intransparent decision-making processes.

Some participants among **future decision-makers** argued that participation in decision-making processes should be prioritized. Participants initially had different ideas on what "access to information" meant. It was argued that access to information reduces fear and enables participation; therefore, access to information should the most important criterion. It was agreed that the access to information criterion should precede the participation criterion in the decision-making process. Further it was decided that benefits should be ranked third, especially if the technology creates benefits for entire society, the state and the economy nationwide.

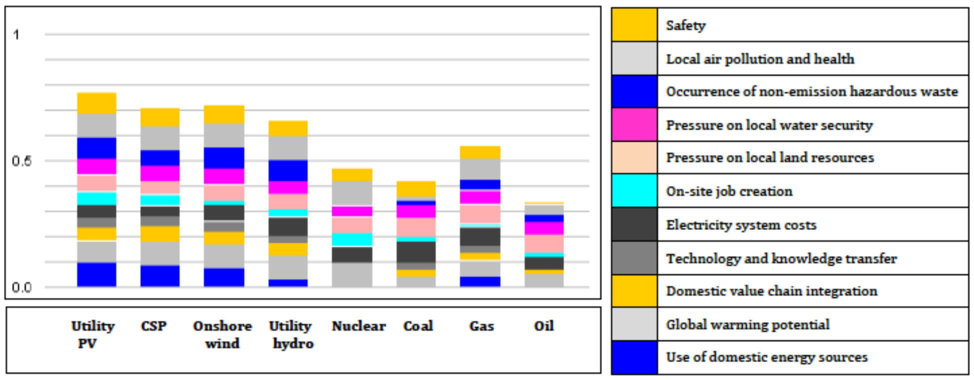
The aspects of involvement and participation were intensively discussed by **local communities**. It was agreed that community involvement in decision-making processes is the most important criterion, which should go much beyond simply informing and providing information, even though availability of clear and transparent information is a necessary requirement. It was also agreed that compensation is the last criterion and that the purpose of projects in general should be to improve living conditions of communities during and after a project rather than simply compensating them for detrimental impacts the projects have had.

Decision-makers agreed that awareness-raising measures are a first step. Therefore, clear and transparent information should be available to stakeholders and inhabitants to guarantee public and social support for infrastructure deployment.

Trade-offs of technologies

The analysis by and application of the Decide IT software allowed identifying the preferences of stakeholders in terms of criteria. It also helped to find out what this meant for the most preferable technology (Figure 2). Figure 2 shows an example of such a technology assessment. The detailed representation of results for each stakeholder group based on DecideIT can be found in the Annex.

Figure 2
Example of technology ranking



Source: Döring et al., 2018

The results for the **civil society and NGOs** group show that utility PV is the most favoured technology, slightly better than coal and nuclear, followed by gas, large-scale hydro, oil shale, CSP, onshore wind and oil. The group was very confident in its belief that oil is much worse than most of the technologies, and that coal, nuclear and gas are better than onshore wind, CSP, oil shale and large scale hydro. The electricity systems costs criterion, which was considered to be one of the most important criteria and pushed coal, gas, nuclear and PV to the top of the ranking, played a significant role in these results.

The **finance and investment** stakeholder group considered utility PV as the most favourable technology. Utility PV was slightly better than nuclear and large-scale hydro, followed by onshore wind, CSP, gas, coal, oil shale and oil. The group was very confident in its belief that oil is worse than all other technologies except oil shale, and that utility PV, nuclear and large-scale hydro is better than all other technologies. The criterion global warming potential improves the positions of most technologies except coal, oil and gas. The criterion of electricity systems costs pushes up coal, nuclear, gas and large-scale hydro.

A**cademia** considered utility PV to be the most favourable technology, followed by nuclear, oil shale, coal, gas, CSP, onshore wind, large-scale hydro and oil. The group was very confident in its belief that oil is worse than other technologies except large-scale hydro, onshore wind and CSP. They considered utility PV to be a much better technology than all technologies except oil shale. Nuclear power was much better than onshore wind, large-scale hydro and oil. Local air pollution plays a role in these results and pulls back coal. Electricity systems costs push up nuclear, coal and gas. On-site job creation is considered as important for oil shale. At the same time, pressure on water resources pulls this technology down.

The results in the group of **future decision-makers** show that they consider utility PV to be the most favourable technology, slightly better than coal and nuclear, followed by gas, large hydro, CSP, onshore wind, oil shale and oil. The group was very confident in its belief that oil is worse than almost all other technologies except oil shale as well as that utility PV, coal and nuclear are better than all other technologies. Safety is an important criterion for stakeholders of this group. Also electricity systems costs push up nuclear, coal and gas as well as PV.

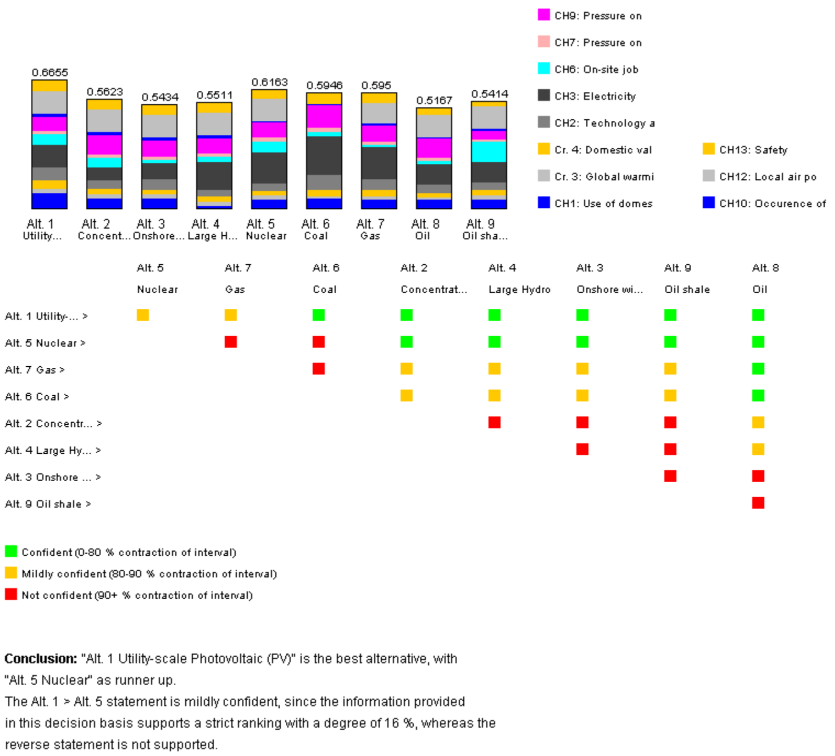
In the group of **local community representatives,** utility PV is considered the most favourable technology, slightly better than coal and gas, followed by nuclear, onshore wind, large-scale hydro, CSP, oil and oil shale. The belief is strong that oil shale is worse than all technologies and that utility PV and coal are better than onshore wind, large scale hydro, CSP, oil and oil shale. A safety criterion plays a significant role for all technologies and pulls down oil and oil shale. Electricity systems costs push up nuclear, coal and gas. Pressure on local water resources reduces the positions of oil shale and nuclear power. The availability of domestic resources reduces the positions of large-scale hydro.

The stakeholder group of **decision-makers** considered utility PV to be the most favourable technology, followed by oil shale, nuclear, coal, gas, large-scale hydro, onshore wind and CSP and oil. They strongly believe that oil is worse than most other technologies, except CSP, onshore wind and large-scale hydro and that utility PV is better than gas, large-scale hydro, onshore wind, CSP and oil. They also consider electricity systems costs to be an important criterion, which pushes up nuclear, gas and coal. Local air pollution reduces the positions of gas, and the availability of domestic resources criterion reduces the positions of large-scale hydro. Pressure on water resources reduces the positions of oil shale and nuclear.

Final workshop

During the first round of the final workshop, with representatives from different groups of stakeholders, utility PV was considered as the most favourable option followed by nuclear, gas and coal as well as CSP, large-hydro, onshore wind, oil shale and oil. They strongly believed that oil is worse than utility PV, nuclear, gas and coal, and that nuclear is better than CSP, large-hydro, onshore wind, oil shale and oil. Electricity systems costs play an important role and push up nuclear, coal and gas. Local air pollution reduces the positions of coal. On-site job creation is important for oil shale. Pressure on water resources reduces the positions of oil shale and nuclear (Figure 3).

Figure 3
Results of the first round of the final workshop



The final ranking during this workshop showed that utility PV is definitely the most preferable option followed by CSP, nuclear, oil shale, onshore wind, large-scale hydro, gas, oil and coal. There is strong evidence that

\ coal is the least preferable option except oil

\ that utility PV is better than all other options and

\ that CSP, nuclear and oil shale are better than oil and coal.

Local air pollution plays an important role for all technologies and pushes down coal. On-site job creation is important for oil shale. Pressure on water resources reduces the positions of oil shale and nuclear. Electricity systems costs are less important than in the previous round but still play a role together with local air pollution, on-site job creation and pressure on water resources (Figure 4).

Figure 4

Results of the second round of the final workshop

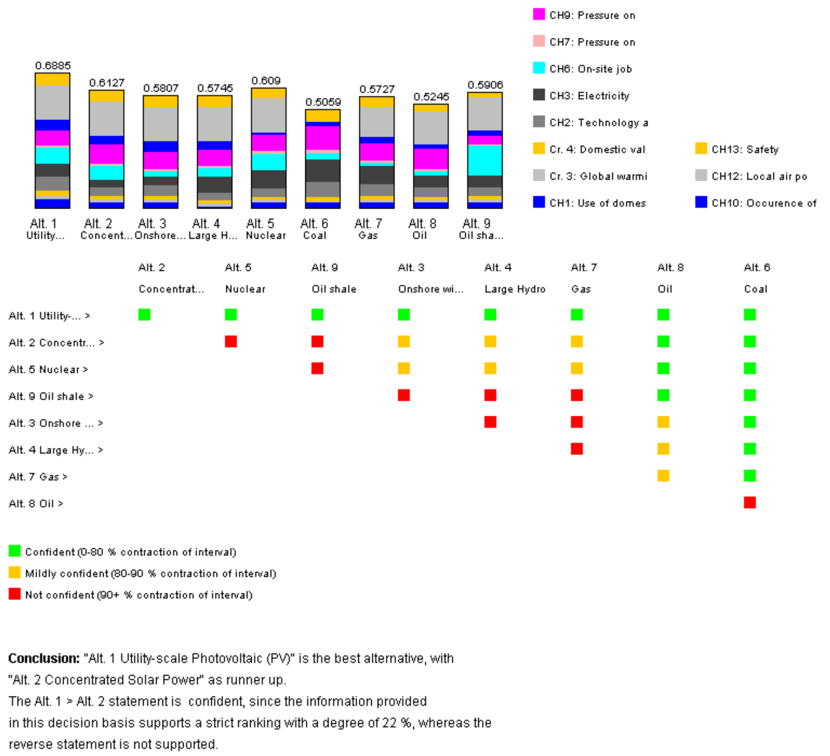
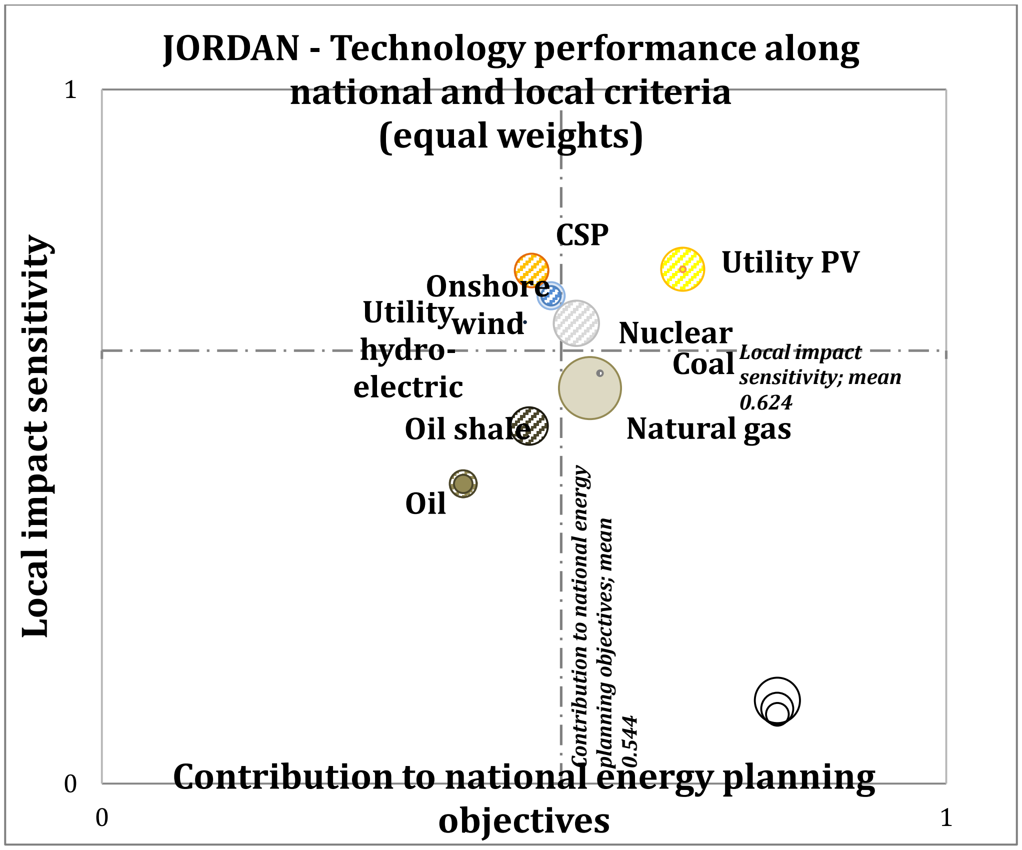


Figure 5 shows the distribution of different technologies across the nationally and locally relevant criteria. It also shows the results considering the equal weighting of criteria. Figure 7 shows the results with the compromise weighting of criteria.

Figure 5
Technology performance in the context of Jordan's national energy planning objectives and local impact sensitivity with equal weights

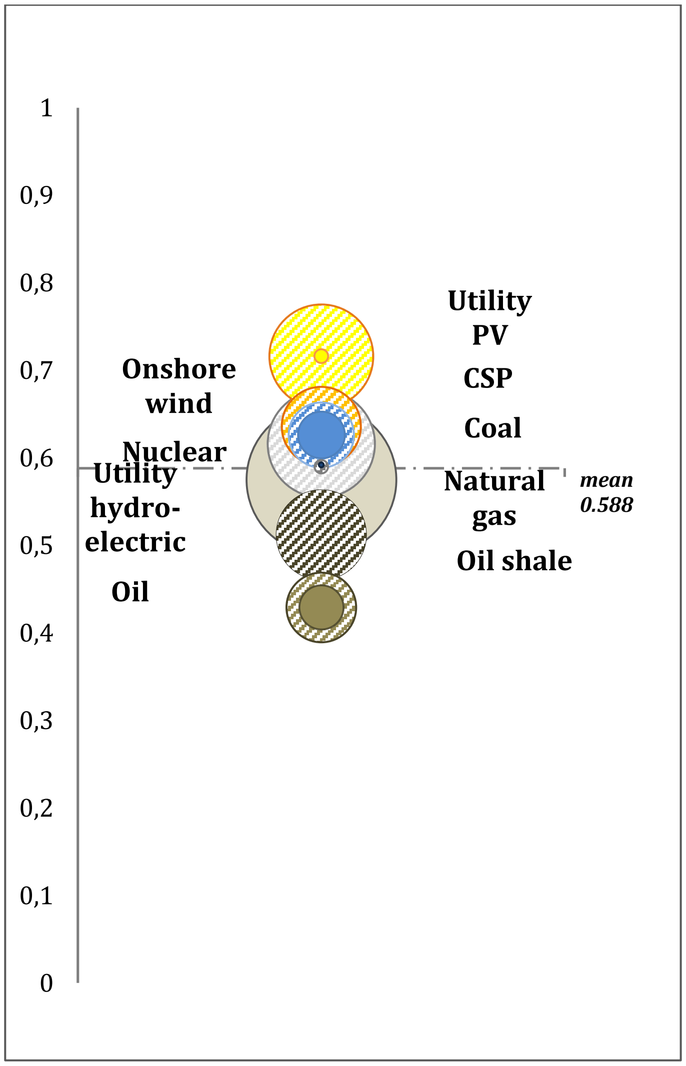


On the horizontal axis is the index of the five criteria that are predominantly related to the objectives of the National Energy Strategy, whereas on the vertical axis, the index of the six predominantly local criteria is plotted. Boundaries of the four quadrants are defined by the mathematical mean calculated for all eight technologies along the two criteria indices (Schinke & Klawitter, 2016).

The results show that technologies, which are at the top right quadrant, have the highest benefits and the lowest impacts across the national and local dimensions. For example, utility PV is at the top of the right quadrant, at the same time as oil is at the very bottom.

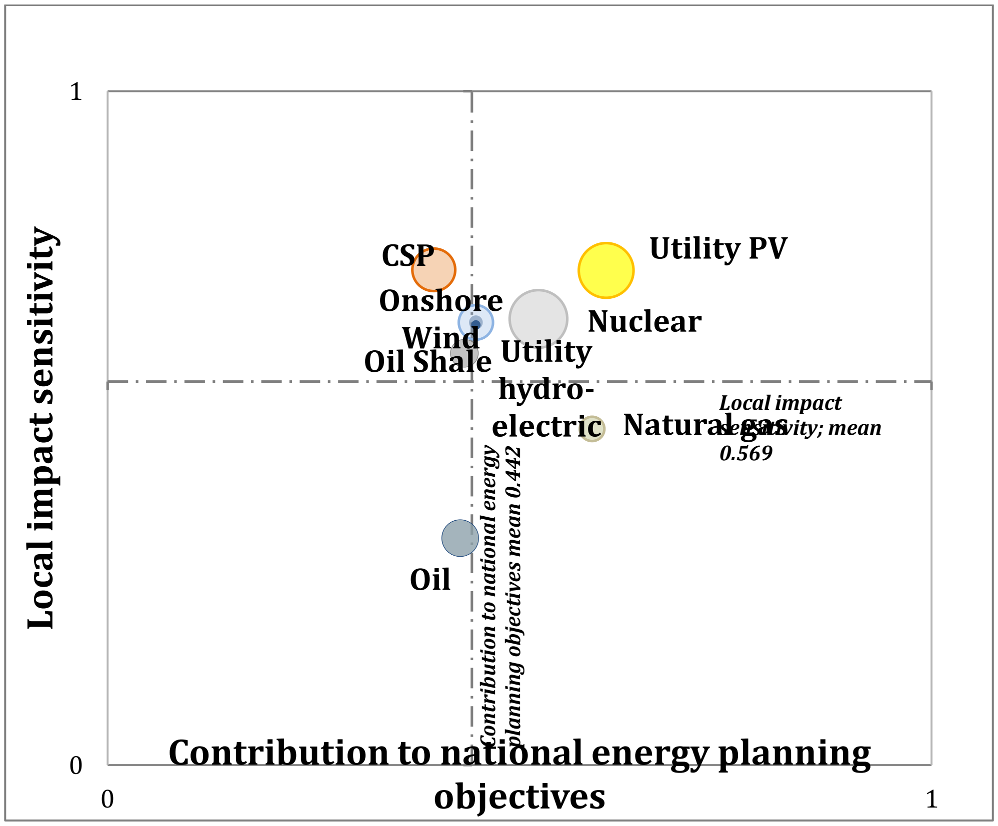
Figure 6 shows that solar PV also has the highest potential for societal support while oil is the technology with the lowest potential for support.

Figure 6
Potential of societal support (equal weights)



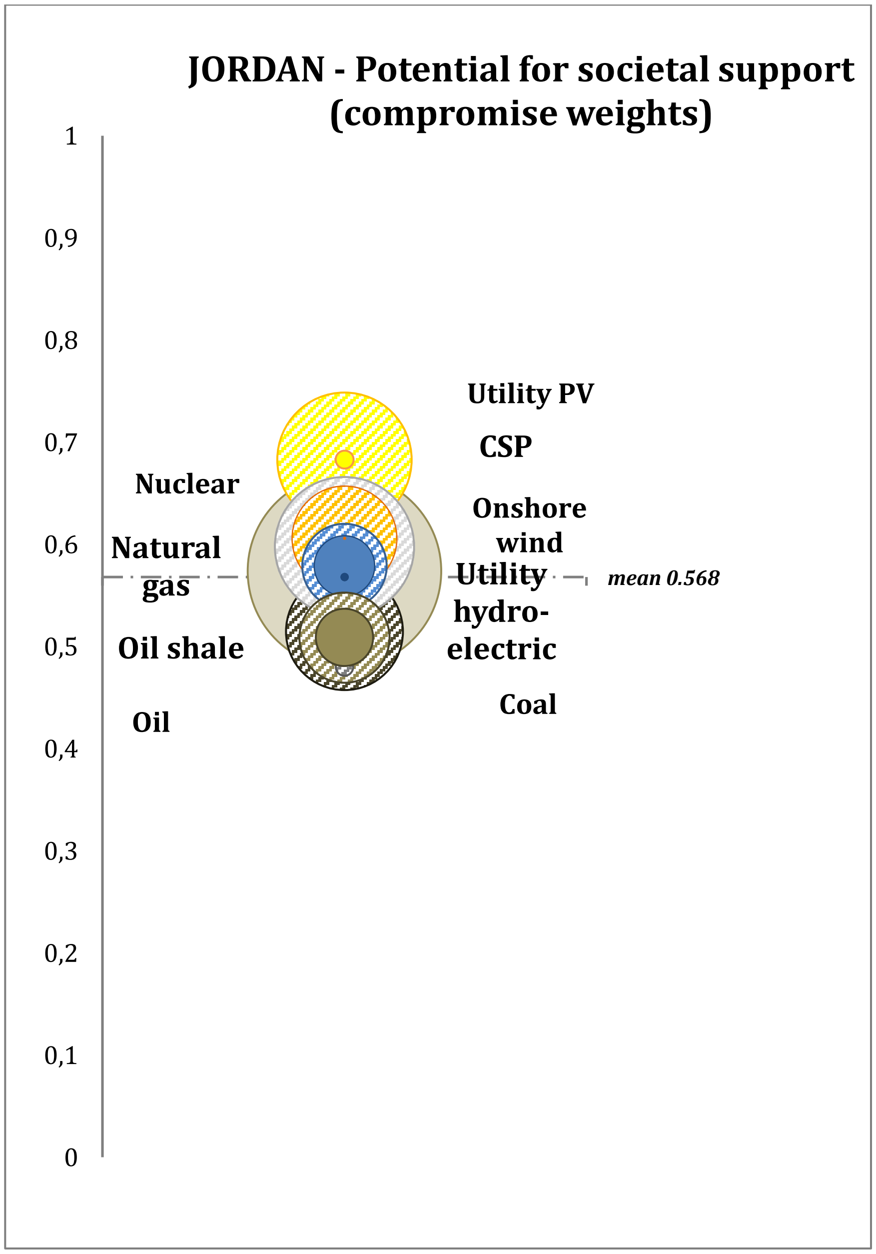
Utility PV still remains the most favourable technology with the highest benefits and the lowest impacts.

Figure 7
Technology performance along national and local criteria (compromise weights)



Utility PV remains the technology with the highest potential for societal support (Figure 8).

Figure 8
Potential for societal support (compromise weights)

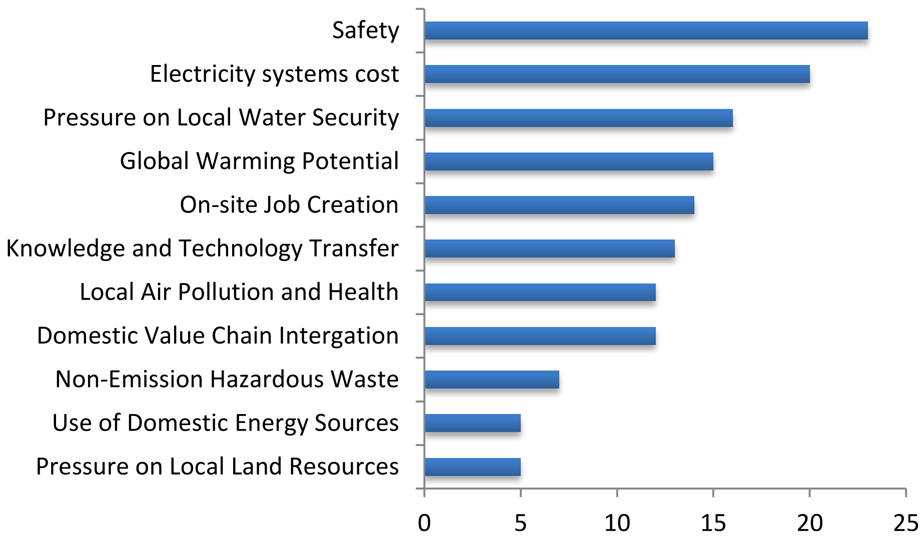


Our results show that during the final workshop with mixed groups of stakeholders, some criteria were more strongly disputed than others.

Figure 9 shows the number of moves for each criterion during the first, second, third and fourth round of the negotiation process.

Figure 9 also illustrates the total moves which were made by participants for each criterion. It also shows which criteria were mostly discussed such as safety (24 moves), electricity systems cost (22 moves), pressure on local water security (17 moves and global warming potential (15 moves). At the same time, pressure on local land resources (five moves) and the use of domestic energy sources (five moves) were almost not moved.

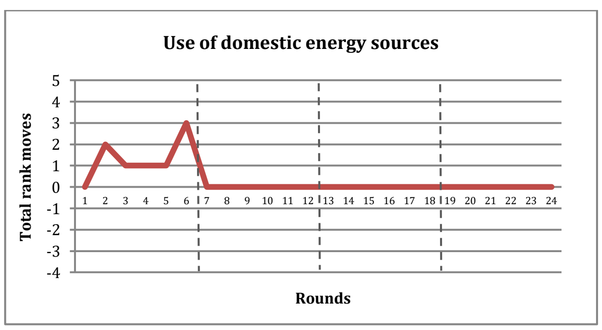
Figure 9
Number of moves



As an example: Even though the criteria of safety and electricity systems costs were considered to be the most important criteria during the previous six workshops with homogenous groups of stakeholders, stakeholders actively moved up and down these criteria during the final workshops.

The charts below show that some criteria were much more intensively debated than others. For instance, solutions were found quite quickly on such criteria as use of domestic energy sources (Figure 10).

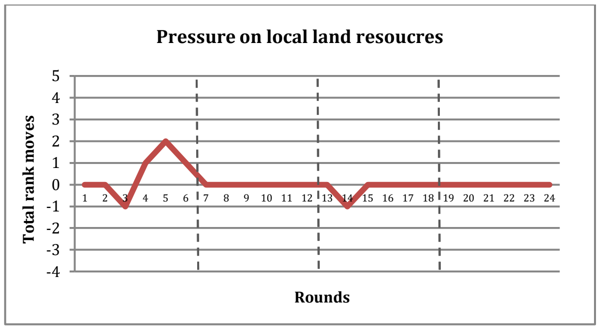
Figure 10
Moves throughout the negotiation process on the use of domestic energy sources



The criterion "pressure on local land use" was also not intensively discussed (Figure 11).

Figure 11

Moves throughout the negotiation process on the pressure on local land resources



The major discussion happened between three criteria: Electricity systems costs (Figure 12), pressure on local water security (Figure 13) and global warming potential (Figure 14).

Figure 12

Moves throughout the negotiation process on electricity systems costs

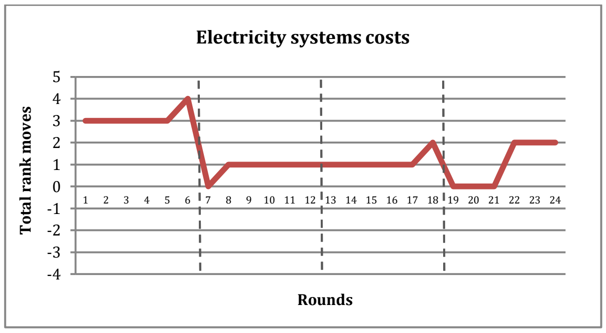


Figure 13

Moves throughout the negotiation process on pressure on local water security

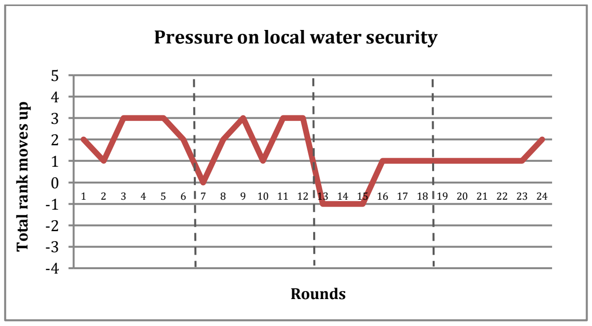
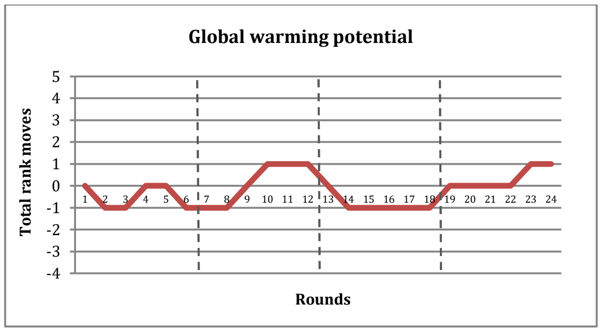


Figure 14

Moves throughout the negotiation process on global warming potential



The analysis of moves for separate criteria has shown that there was a divergence in opinion among different stakeholders. For instance, decision-makers and industry and finance had a common position on the criterion of electricity systems as they kept moving this criterion up in the ranking, as if they wanted to say that electricity has to be delivered at the lowest possible costs, and that this is a top priority. At the same time, NGOs together with young people / future decision-makers kept moving this criterion down for the sake of environmental criteria such as pressure on water resources.

Figure 15

Group convergence on the criterion of electricity systems costs

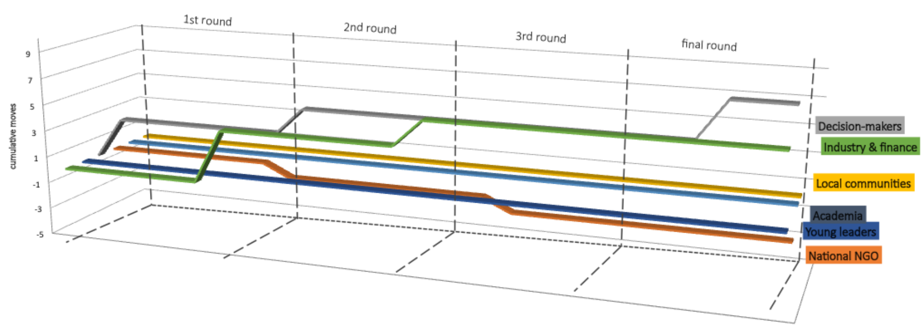
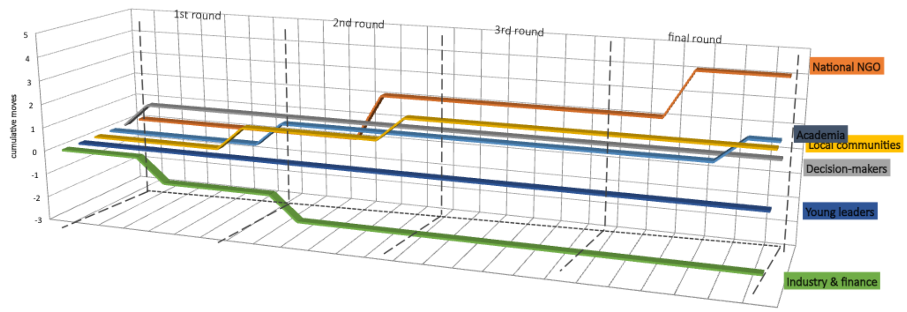


Figure 16 on pressure on water resources shows the opposite to electricity systems costs criterion, namely that national NGOs together with academia and local communities were moving the criterion on pressure on water resources up and the industrial and finance stakeholders were moving it down.

Figure 16

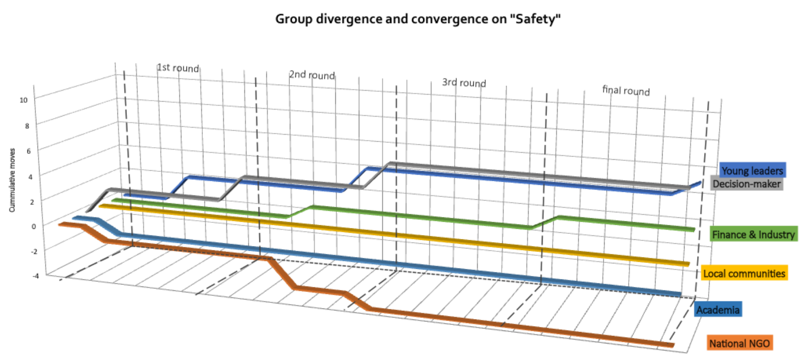
Group convergence on the criterion of pressure on local water resources



It is also interesting to see that criteria that were not contested in homogenous stakeholders groups, such as safety, also show a dynamic of moves among different stakeholders (Figure 17).

Figure 17

Group convergence on the criterion of safety



The group convergence / divergence on the safety criterion shows that representatives of NGOs and academia had similar positions as they moved this criterion down. At the same time, the criterion was extremely important for decision-makers and also for young people / future decision-makers. Representatives from finance and industry as well as local communities had a rather neutral position towards this criterion, shown by the fact that the local community did not move it at all.

Figure 18 and Table 13 show the criteria with the highest ranking, namely, electricity systems costs and safety were selected by several groups of stakeholders as the criteria with the highest priority. Yet, opinion differs about these criteria. For instance, there was a higher divergence of opinions about the criterion of safety then about the criterion of electricity systems costs. The biggest difference in opinions about the safety criterion was among policymakers, for whom safety has a high priority, and academia and national NGOs, who ranked this criterion as less significant.

Global warming potential was another criterion with a high polarization of opinions, with local community representatives who ranked the criterion high, and academia and policymakers, who ranked the criterion low. Pressure on local water security and non-emission hazardous waste were two criteria which received a low ranking but where positions of stakeholders were homogenous. National NGOs and academia ranked technology and knowledge transfer and on-site job creation significantly higher than local community and policymakers did. The use of domestic energy sources was also a criterion with a high polarization of opinions which was ranked high by decision-makers, national NGOs and academia, and received a low ranking from finance and industry as well as local communities.

Individual preferences

The following results are describing individual preferences, which were received during the stakeholders' survey, distributed to participants six months after the last stakeholders' workshop. These results allowed us to validate results received during the focus group discussions. (For a detailed description of results, please refer to the Annex.)

The majority of respondents were satisfied with the ranking of criteria (53%) and very satisfied (27%). However, the share of respondents who were not satisfied was also significant (22%), which shows that our stakeholder groups were not homogenous and that there was a conflict in opinion within the groups themselves. The majority was also satisfied (64%) and very satisfied (17%) with the final ranking of technologies. Some respondents were also unsatisfied with the ranking (18%).

The respondents also had an opportunity to rank criteria and technology individually. The survey results showed that utility PV and CSP were ranked as the most attractive technologies and electricity costs and safety were ranked as the most important criteria.

These results show that the individual ranking followed the same pattern as the ranking during the final workshop. The major difference was found regarding criteria and technology in the middle of the ranking (Table 14).

Table 14

Final ranking of criteria and technologies during the final workshop and during the on-line survey

Criteria		***Technologies***	
Original ranking from final workshop	*Ranking based on survey*	*Original ranking from final workshop*	*Ranking based on survey*
Electricity costs	Electricity costs	Utility PV	Utility PV
Safety	Safety	CSP	CSP
Air / health	Domestic energy	Nuclear	On-shore wind
Water	Job creation	On-shore wind	Gas
Tech. transfer	Value chain	Large hydro	Large-scale hydro
Job creation	Air / health	Gas	Oil shale
Domestic energy	Water	Coal	Nuclear
Waste	Waste	Oil shale	Oil
Value chain	Land	Oil	Coal
Land	Tech. transfer		
Global warming	Global warming		

These results show that the most important and the least important criteria remained the same. For instance, electricity costs and safety are the most important criteria in both rankings. Global warming potential is the least important criterion.

Second, during the survey ranking, several socio-economic criteria were moved up, such as domestic energy use, job creation, domestic value chain generation. The criterion on technology and knowledge transfer was moved down, but this is mainly due to the fact, as the discussions during the workshops had shown, that technology and knowledge transfer was perceived already as a part of domestic value chain generation.

Third, environmental criteria were moved to the bottom of the ranking, with waste having the same place in both rankings, but pressure on air quality and health as well as the pressure on water security were also moved to the bottom. Pressure on land was moved up, but mainly due to the fact that technology and knowledge transfer was moved down as a least important criterion together with global warming potential.

Finally, the most preferable technologies remained the same, such as PV and CSP being at the top of the ranking. However, nuclear and coal were moved to the bottom of the ranking, with coal being the least favourable technology and nuclear being downgraded from third to seventh position. Oil and oil shale improved both their rankings, with shale oil being more popular than oil. On-shore wind and gas also improved their positions. Large-scale hydro remained the same.

Analysis of the energy transition discussion in Arabic in mass and social media

During all of 2017, we used the Gavagai Monitor, which is a media-monitoring tool and is based on the general theory of distributional semantics (Magnus, 2008). The tool is implemented through the self-learning Random Indexing framework (Kanerva et al., 2000). The background semantic model of term-term association is built through observing the occurrences and co-occurrences of terms in natural text, which are used to infer relationships between terms (Sahlgren et al., 2016). The system takes as input the definition of a target of interest through a number of terms entered by the user, and it suggests supplementary terms strongly associated with the given ones using the background semantic model. When the suggested target is specified appropriately, the system tracks mentions of it in online media and displays them in a line graph to demonstrate the volume of mentions over time.

Analysis of sentiment in text is a new and rapidly growing field of study and application. The various human ranges of subjectivity such as emotion, attitude, mood, affect, sentiment, opinion, and appeal all contribute to the basic categories of sentiment analysis of text and have been studied in their own right for a long time in the behavioural sciences rather than in technology. For the purposes of media monitoring, the surface manifestation of human subjectivity in writing can be considered to be encoded mostly in lexical choice by selecting terms that are appropriate to the attitude in question. It is an editorial decision to be made by the responsible analyst to decide which aspects of subjectivity are most useful for a task (Karlgren et al., 2012).

The goal was to analyse discussions on energy sources in the Arabic language media[7]. Karlgren screened all available editorial media, such as news sites and news streams, as well as journals, social media such as blogs, forums, and discussion boards, real-time microblogs, including BBSes and Twitter.

Within the main focus of this research, public opinion on a vast array of questions and issues was tracked. Karlgren targeted the following terms:

1. Oil
2. Coal, shale, gas
3. Hydroelectric power
4. Nuclear power

[7] Professor Jussi Karlgren (KTH – The Royal Institute of Tecknology, Stockholm) collected the data and analyzed them.

5. Solar power
6. Wind power

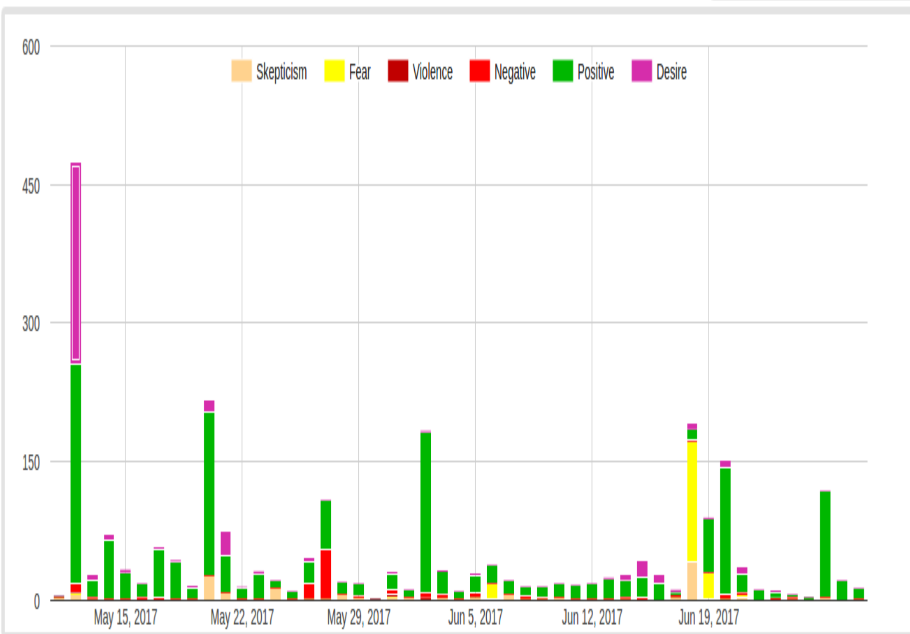
Besides the terms mentioned above, Karlgren also tracked a number of topical aspects to capture foreseeable aspects of public discourse. These attitudes were:

1. Trustworthy
2. Politics, controversy
3. Pollution
4. Waste
5. Safety
6. Expertise, competence and authority
7. National interest

The results (for more details, please refer to the Annex) show that the discussion about oil and nuclear power is much more intensive than on any other power source. This discussion is also influenced by regional drivers, like the current deal between the US and Iran, which has significant political implications for the deployment of nuclear power in the Middle East.

Solar energy is also mentioned frequently and is actually the third most discussed electricity source in the media. The news coverage about solar power tends to be positive. There is also a certain degree of curiosity in the solar development (Figure 18).

Figure 18
Attitudes towards solar energy



These results show that there is also a certain desire for technology. At the same time, discussions also show concerns about solar technology.

5. CONCLUSIONS

The results of group and individual rankings of criteria and technologies as well as discussions not only about the visions about the future of Jordan but also about the importance of different criteria allowed us to develop the following conclusions.

Conclusion 1: Utility PV remains the most favourable technology. It was ranked as the top priority by all stakeholder groups. Utility PV was also ranked at the top of the list during the final ranking with the mixed group of stakeholders. During the individual ranking, stakeholders also ranked PV as the most favourable technology. Other solar technology, such as CSP, is ranked significantly lower. The main reason for this are the high investment costs of this technology.

Conclusion 2: The discourse about the energy transition in Jordan is strongly dominated by energy security concerns. In almost all group rankings, the safety of energy generation as well as the affordability of electricity were ranked as a top priority. The criteria relevant for social and environmental impacts of technologies were moved to the middle or the bottom of the ranking. It seems that concerns about climate change mitigation are not part of the dominant discourse as the criterion climate change mitigation was frequently ranked at the bottom of the list. One stakeholder group, the local communities, ranked global warming potential the highest, probably because people on the ground are feeling the direct impacts of climate change. However, when evaluating the renewable energy technologies, stakeholders named the most frequent positive characteristic as “clean” and “with little impact on the environment”. It seems that there is a certain level of awareness about environmental protection issues while the level of awareness about climate change risks and the need for climate change mitigation is lower.

Conclusion 3: Comparison of visions of the environmental, social and economic future of Jordan showed that the young people have the most optimistic approach. For instance, they did not identify any negative tendency. Among economic factors, stakeholders mentioned most frequently positive expectations connected with investment in new technologies and the reduction of dependency on energy imports. The positive expectations about social development are connected with the creation of employment opportunities and the generation of further knowledge. In general, there was a perception that the environmental future of Jordan is positive. Among negative tendencies, the most frequently mentioned concern was a possible increase in electricity costs. In the social area, one concern was the destruction of traditional values and of the traditional family structure. As to the environment, the most frequent concerns were about water scarcity.

Conclusion 4: By discussing procedural and output justice, the majority of stakeholders were of the opinion that to compensate affected communities for infrastructure projects is the least favourable criterion and that further efforts are necessary to facilitate engagement of stakeholders and laypeople into decision-making processes on energy transition. Providing possibilities for participation in decision-making processes was considered the most important criterion among four criteria of procedural and output justice.

Conclusion 5: Solar and nuclear power, as well as oil, are three mostly discussed energy generation technologies in the Jordanian media. However, opinions regarding these technologies are quite different. Solar energy is perceived mostly positively, with PV being a top priority technology. At the same time, CSP does not enjoy the same high level of support as PV. Nuclear energy was often considered a second or third favourable technology. However, opinions here are highly polarized, and several stakeholders are strongly against nuclear. Even though oil is frequently being discussed in the media, all groups of stakeholders consider it to be the least favourable technology. Views on shale oil are much more positive, mainly due to available local resources and aspirations for technology transfer and impulses for socio-economic development, which are connected with the deployment of this technology.

Conclusion 6: The strong recommendation from stakeholders during almost all workshops was to add oil shale technology as one of the most discussed in Jordan. Some stakeholders groups, such as academia or local communities, also recommended to add waste to energy technology with the major arguments about its positive features such as possibilities to reduce costs of waste disposal, clean technology and potentials to create green jobs.

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7. ANNEXES

Annex 1: Data from experts' survey

Criterion 1: Use of domestic energy sources

Question 1: If Jordan aims to decrease its energy import dependency, how do you evaluate the existing potential of the listed electricity-generation technologies to contribute to this goal?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	26,50	9,00	14,00	3,00	8,50	11,50	10,50	5,00	10,00	20,50	50,00
Min	0,00	0,00	1,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00
Median	49,00	30,00	34,00	9,00	22,00	38,00	26,00	27,00	29,00	50,00	68,00
Average	47,84	30,77	32,21	11,33	30,77	36,74	36,33	30,11	31,77	49,77	60,91
Max	100,00	100,00	80,00	49,00	90,00	89,00	95,00	95,00	90,00	100,00	100,00
Quantile 3 (75%)	70,00	50,00	49,00	14,00	48,00	59,50	64,00	54,00	46,00	77,50	80,00

Table 15: Data on the use of domestic energy sources

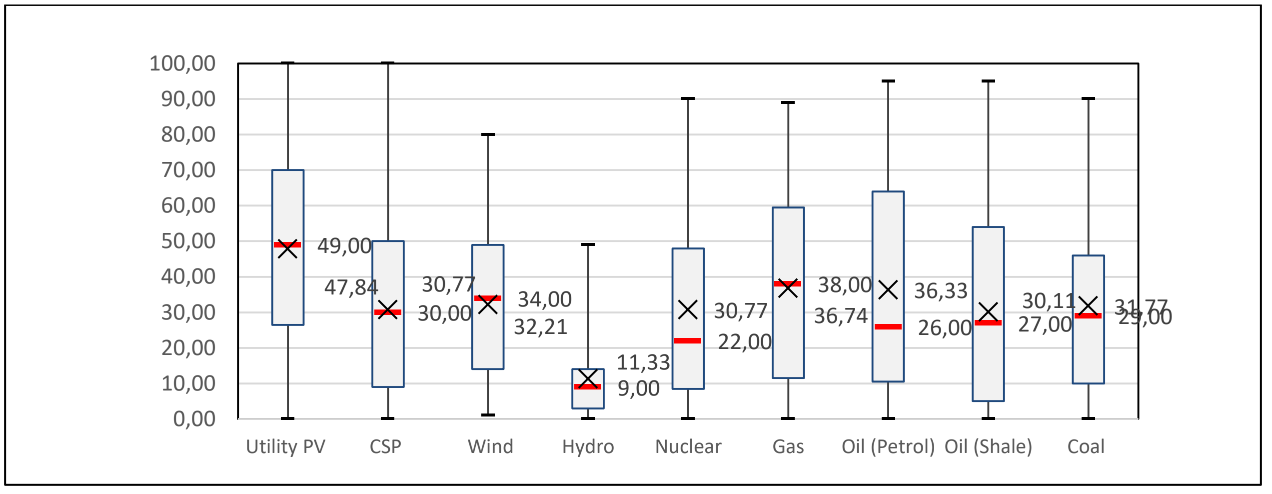


Figure 19: Data on the use of domestic energy sources

Question 2: If Jordan wants to decrease its energy import dependency, how do you evaluate the future potential of each electricity-generation technology to contribute to this goal?

Please take into account your judgment of proven non-renewable and renewable energy sources and the likelihood of the resources to be exploits and used for electricity-generation until 2040.

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	30,00	18,25	14,25	6,50	14,00	13,75	11,00	10,00	10,00	38,50	50,00
Min	0,00	0,00	5,00	0,00	5,00	0,00	4,00	5,00	0,00	8,00	7,00
Median	69,00	30,50	36,50	10,00	26,00	20,50	19,00	20,50	35,00	51,00	66,00
Average	56,79	37,86	38,79	14,63	31,71	25,04	24,36	33,08	38,21	53,35	62,44
Max	100,00	100,00	100,00	47,00	80,00	70,00	91,00	97,00	95,00	91,00	99,00
Quantile 3 (75%)	81,00	59,25	60,00	18,50	43,00	31,75	30,00	54,00	57,75	77,50	80,00

Table 16: Data on the use of domestic energy sources (future potentials)

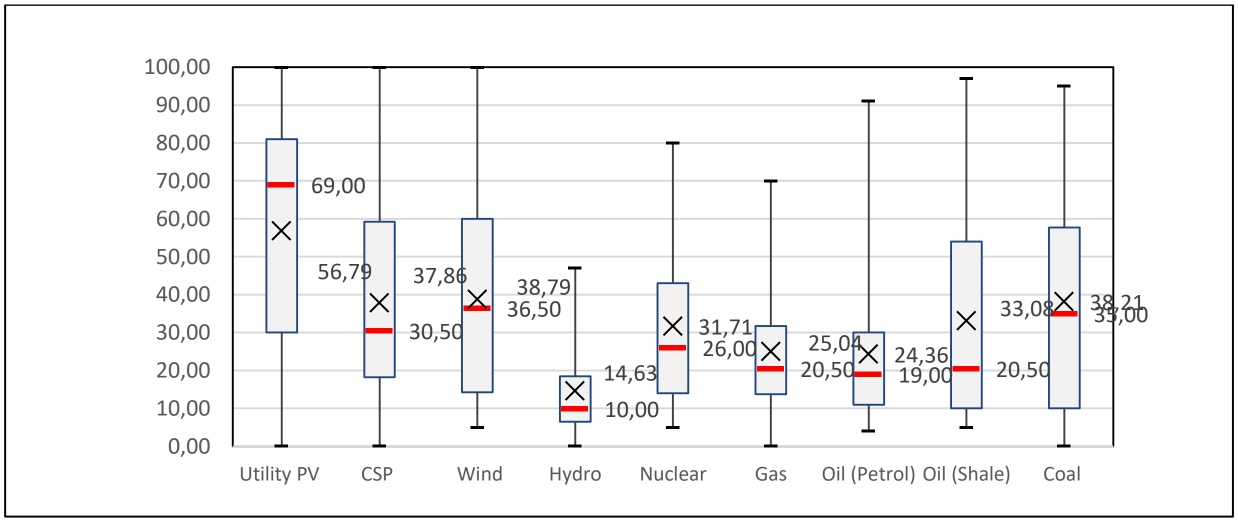


Figure 20: Data on the use of domestic energy sources (future potentials)

Criterion 2: Domestic Value Chain Integration

Question: How do you assess the possibilities of the Jordanian industry to manufacture a significant share of components and provide essential services during the construction and operation phases for each technology?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	20,00	13,50	10,00	5,50	6,50	11,75	9,25	10,50	14,00	32,25	50,00
Min	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	10,00
Median	35,00	22,00	22,00	18,00	18,00	31,00	18,00	15,00	30,00	50,00	71,00
Average	42,35	29,00	25,88	26,89	24,28	34,40	26,00	27,22	34,28	48,88	65,93
Max	93,00	80,00	73,00	76,00	78,00	86,00	74,00	84,00	100,00	90,00	95,00
Quantile 3 (75%)	60,00	42,50	40,00	47,50	37,00	50,25	41,25	46,50	50,00	70,00	81,00

Table 17: Data on the domestic value chain integration

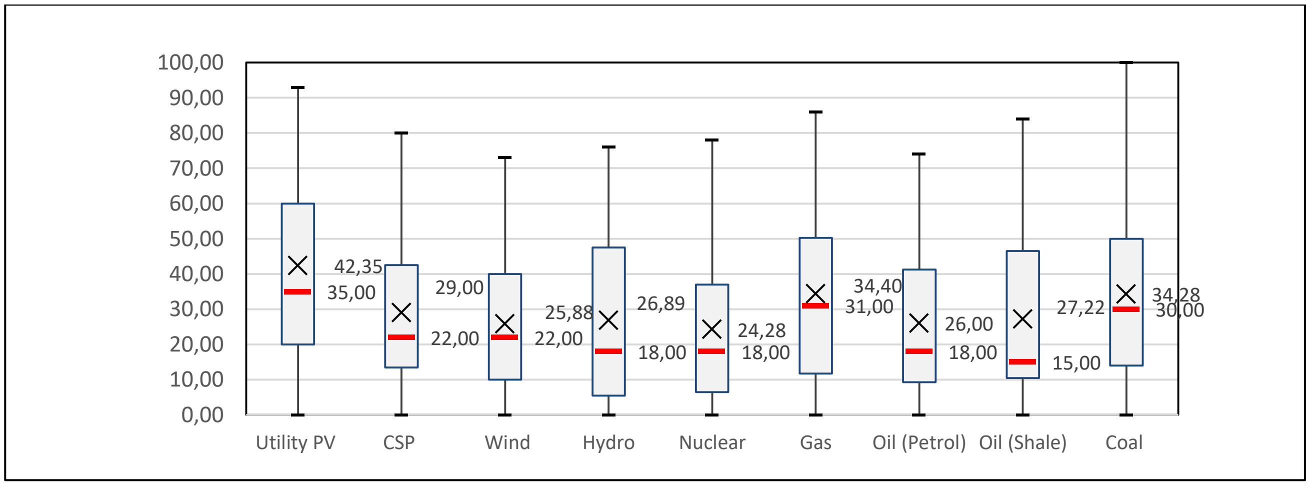


Figure 21: Data on the domestic value chain integration

Criterion 3: Technology and Knowledge Transfer

Question 1: How would you assess the effectiveness of national policies and institutions to develop educational curricula through vocational training and university programs for the deployment and development of each technology?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	27,50	11,50	14,25	8,00	10,00	11,00	20,00	11,50	28,00	20,75	63,50
Min	2,00	1,00	2,00	0,00	1,00	4,00	0,00	4,00	8,00	8,00	20,00
Median	35,00	25,00	30,00	12,00	20,00	34,00	35,00	34,00	48,00	53,00	80,00
Average	39,91	29,47	33,23	24,27	23,94	38,12	35,47	31,05	45,70	47,90	71,63
Max	91,00	80,00	80,00	70,00	60,00	100,00	78,00	75,00	90,00	82,00	100,00
Quantile 3 (75%)	51,50	40,00	50,50	35,50	37,00	55,00	50,00	42,50	68,00	70,75	89,00

Table 18: Data on technology and knowledge transfer

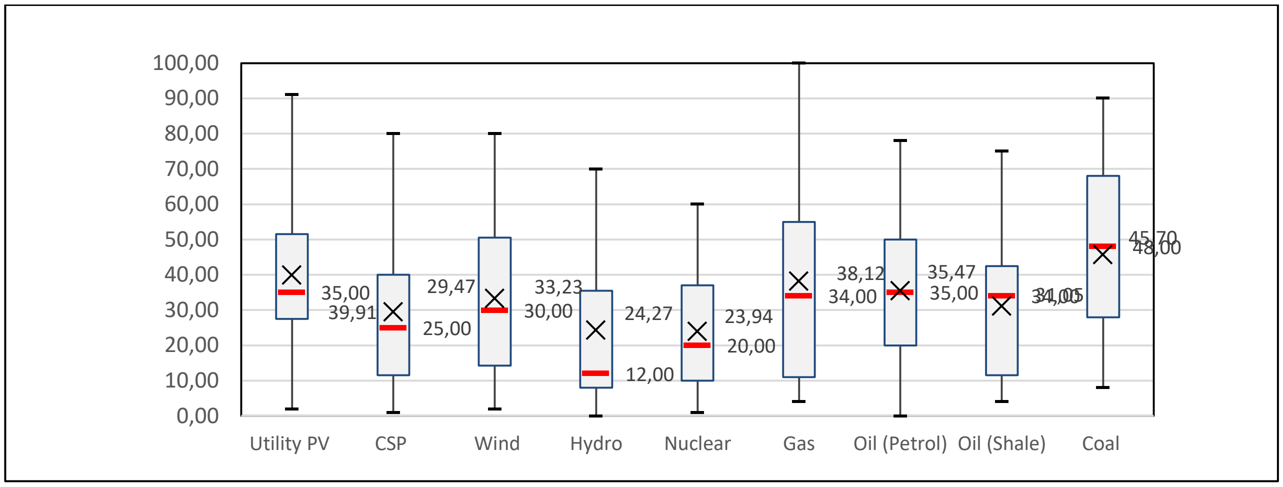


Figure 22: Data on technology and knowledge transfer

Question 2: How would you assess the effectiveness of national policies and institutions to facilitate joint ventures between domestic and foreign firms in order to benefit from knowledge transfer for each technology?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	24,00	16,00	24,00	4,00	8,00	15,50	7,50	8,00	31,75	41,00	60,00
Min	2,00	0,00	5,00	0,00	2,00	0,00	0,00	0,00	13,00	4,00	10,00
Median	50,00	28,50	40,00	16,00	30,00	43,00	12,00	17,00	52,50	58,00	74,00
Average	49,78	34,50	43,09	29,29	34,82	39,39	27,63	27,68	53,69	54,24	68,50
Max	100,00	100,00	100,00	100,00	100,00	100,00	100,00	100,00	95,00	90,00	100,00
Quantile 3 (75%)	78,00	49,50	59,50	54,00	51,00	54,75	49,00	45,00	76,75	70,00	83,75

Table 19: Data on technology and knowledge transfer (effectiveness of policies and institutions)

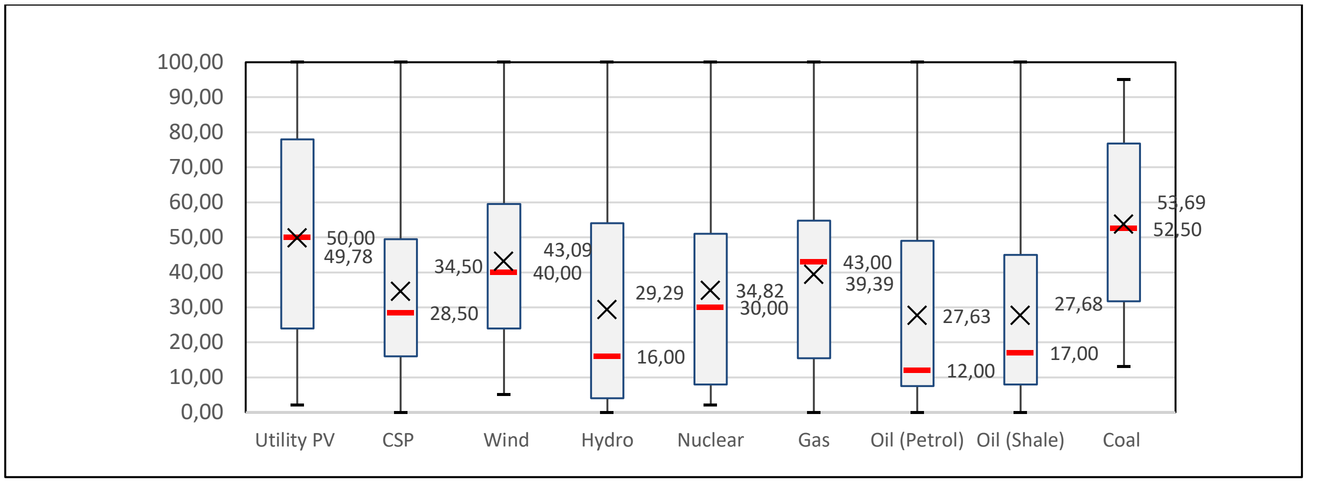


Figure 23: Data on technology and knowledge transfer (effectiveness of policies and institutions)

Criterion 4: Occurrence and Manageability of Hazardous Waste

Question: How would you assess Jordan's capabilities (i.e., environmental waste management regulations and their enforcement, waste management monitoring) to safely and efficiently handle the disposal of hazardous waste stemming from each technology?

	Utility PV	CSP	Wind	Hydro	Nuclea r	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	17,25	11,50	8,00	6,50	2,50	14,50	7,00	5,00	14,50	22,00	48,00
Min	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	5,00	8,00	9,00
Median	36,50	31,00	29,00	18,50	15,00	27,00	26,00	24,50	47,00	48,50	61,00
Average	42,65	38,89	38,42	24,64	20,64	30,40	29,40	26,19	42,26	45,94	60,85
Max	100,00	100,00	100,00	80,00	60,00	75,00	75,00	65,00	90,00	90,00	100,00
Quantile 3 (75%)	63,25	59,75	65,00	35,50	35,25	40,00	44,00	41,25	67,50	63,00	80,00

Table 20: Data on occurrence and manageability of hazardous waste

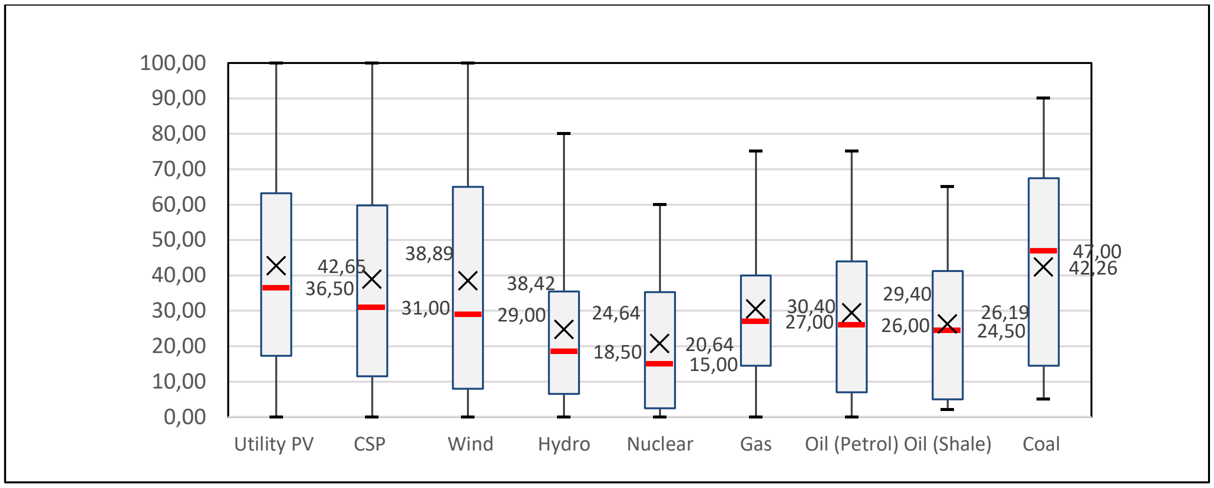


Figure 24: Data on occurrence and manageability of hazardous waste

Criterion 5: Safety

Question: In comparison with international practice, how would you rate Jordan's risk management capabilities of the Jordanian authorities and private sector for preventing, responding to and recovering from accidents due to each technology?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	13,00	11,50	13,75	13,00	2,75	10,00	18,25	7,00	39,50	28,00	53,00
Min	2,00	0,00	2,00	0,00	0,00	3,00	0,00	0,00	2,00	7,00	21,00
Median	50,00	41,00	41,50	40,00	9,50	43,00	36,00	30,00	60,00	51,00	69,00
Average	49,52	37,67	45,05	38,07	16,50	40,06	40,75	35,76	56,07	47,53	63,44
Max	100,00	90,00	100,00	91,00	70,00	80,00	80,00	80,00	95,00	91,00	90,00
Quantile 3 (75%)	83,00	52,25	73,25	60,00	28,50	67,75	69,25	67,00	70,00	60,00	77,50

Table 21: Data on safety

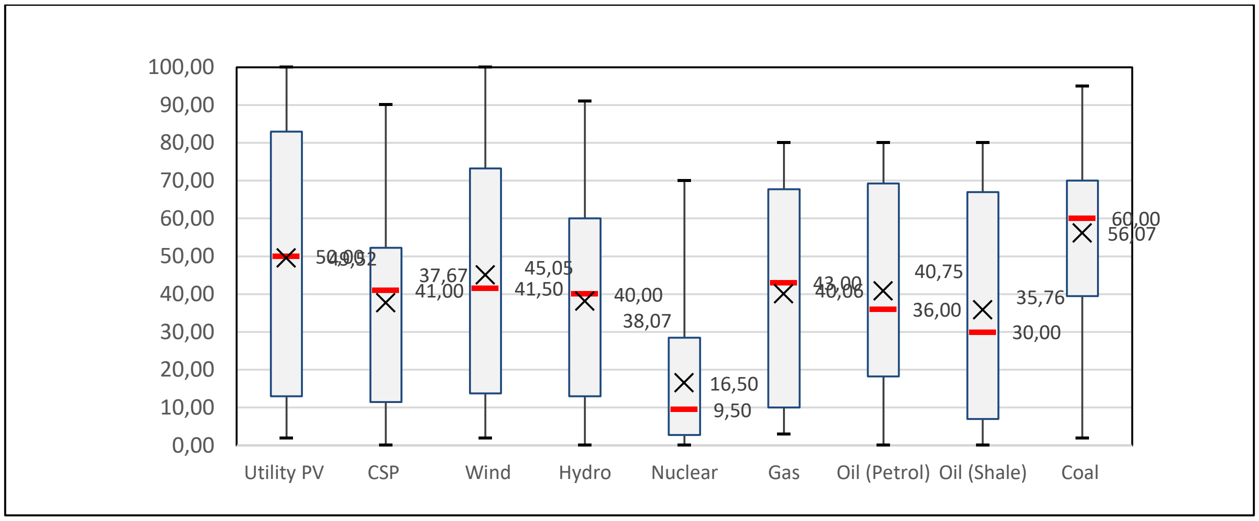


Figure 25: Data on safety

Criterion 6: Local Air Pollution and Health

Question: In comparison with international practice, how would you rate the abatement capabilities of the Jordanian authorities and private sector for decreasing air pollution from power plants and improving air quality?

	Utility PV	CSP	Wind	Hydro	Nuclear	Gas	Oil (Petrol)	Oil (Shale)	Coal	Confidence	Confidence (coal)
Quantile 1 (25%)	20,00	4,50	14,00	18,50	9,00	13,75	8,00	6,75	26,00	27,50	54,50
Min	0,00	0,00	0,00	0,00	0,00	0,00	0,00	2,00	5,00	2,00	16,00
Median	76,00	70,00	66,00	59,00	21,00	36,00	15,00	18,00	49,00	50,50	75,00
Average	57,19	49,84	53,71	52,20	29,27	40,79	33,57	32,71	47,89	46,72	68,89
Max	100,00	100,00	100,00	100,00	80,00	90,00	90,00	80,00	100,00	100,00	100,00
Quantile 3 (75%)	90,00	84,00	85,00	80,50	45,50	68,00	63,75	64,25	72,50	67,50	80,00

Table 22: Data on local air pollution and health

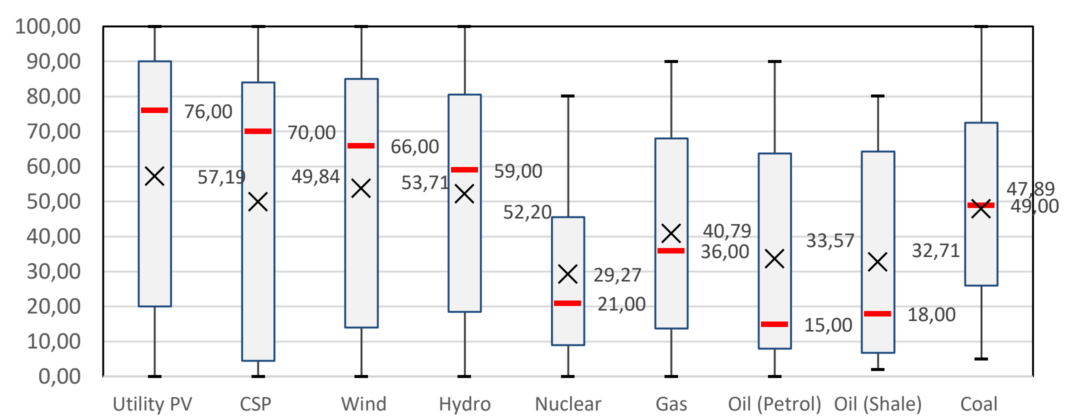


Figure 26: Data on local air pollution and health

Annex 2: Electricity-generation technologies in Jordan

Photovoltaic: A photovoltaic system, also known as the PV system or solar power system, is a power system designed to supply usable solar power by means of photovoltaic technology. Photovoltaic cells directly convert solar radiation into electricity by exploiting the photovoltaic effect using semiconductor materials (Kaltschmitt et al., 2007).

A PV system consists of an arrangement of several components, including solar collectors to absorb and directly convert sunlight into electricity, a solar inverter to change the electric current from DC to AC, as well as mounting, cabling and other electrical accessories (Kaltschmitt et al., 2007).

In 2016, 12 PV projects including direct offers and the commercial operation to generate electricity with a capacity of 200 MW became operational. Currently, the capacity of these projects is at 428 MW (Marar, 2017):

\ With 10 MW, the Philadelphia Solar Power Company IPP PV project direct proposals round I was achieved in October 2015 in Mafraq. This is the "first-of-its-kind" project connected to the distribution network.
\ In 2016, different PV projects with the overall capacity of 200 MW became operational. The projects were realized by international and local companies.
\ In October 2017, the 13 MW Zatari Solar PV project became operational. The project was financially supported by a German grant.
\ In April 2015, the 5 MWAzraq Solar PV project became operational. The project was supported by a Spanish grant and implemented on the basis of the EPC contract.
\ In 2017, more than 200 MW of small-scale net-metering rooftop systems and solar PV projects became operational.

Jordan considers PV to be an important technology, and several PV projects are currently in the planning or implementation phases (Marar, 2017). These projects include the following:

\ PV projects with a total capacity of 200 MW (50 MW each) in the developmental zones of Al-Mafraq region and Safawi/Azraq. The MEMR signed four memoranda of understanding to achieve financial closures for these projects. It is expected that they will become operational in 2018. The agreed tariff for electricity reached an unprecedented low (ranging between 43-55 fils/kWh).
\ PV project with a total capacity of 103 MW in Qweirah/Aqaba. The project is currently developed by the consortium TSK and Enviromena, is under the engineering, procurement and construction EPC contract and is funded by UAE/ Abu Dhabi Fund for Development. It is expected that the project will become operational in January 2018.

\ In October 2016, Masdar, a clean energy developer based in Abu Dhabi, UAE, signed a Power Purchasing Agreement to build a solar power plant with the overall capacity of 200 MW in Muwaqqar. The project is due for completion in 2018.

\ Small scale solar PV system projects with a capacity of 80 MW are currently under construction.

Concentrated solar power (CSP): The CSP technology concentrates solar radiation via mirrors onto a receiver, and then converts it into thermal energy inside the receiver and transfers it to a heat transfer medium. According to published reports and an announcement by the Ministry of Energy and Mineral Resources (MEMR), the CSP projects are still not implemented in Jordan. The MEMR points to higher technology investment costs compared to those of PV.

Onshore wind: Wind energy converters (WEC) harness the kinetic energy contained in flowing air masses. Jordan has favourable conditions for wind power-generation regarding wind speed and long periods of windy weather. Currently, there are wind projects with a capacity of 197 MW in operation, and projects with a capacity of 171 MW are under construction (Marar, 2017).

In 2017, the following wind projects were in operation:

\ Tafila Wind Farm, which is the first large-scale renewable energy IPP in Jordan with the overall capacity of 117 MW.

\ The Ma'an wind project, with the first phase of 66 MW capacity, which became operational in September 2016 and the second phase of 14 MW capacity, which became operational in September 2017.

In 2017, the following wind projects were under construction:

\ Direct proposals round I with a total capacity of 330 MW in southern Jordan. Purchasing power agreements were signed with five different companies. All projects are expected to become operational in 2018

\ The Korean KEPCO direct offer in al-Fjej/Shoubak with a capacity of 90 MW is expected to be operational by the end of 2018.

Utility hydropower: Hydropower plants harness the potential energy within falling water and use classical mechanics to convert that energy into electricity. A hydroelectric power station, depending on scale, normally consists of a dam or weir, and the system components intake works, penstock, in some cases a headrace, plus the powerhouse and tailrace (Kaltschmitt et al., 2007).

Conventional hydropower resources in Jordan are limited because surface water resources are almost negligible. The available generation capacity of hydropower projects is 12MW (NEPCO, 2016). In 2017, there were two small hydroelectric plants, the King Talal Dam with a rated capacity of five MW and a scheme at Aqaba thermal power station which utilizes the available heat of returning cooling seawater with a capacity of six MW (CEGCO, 2017). Currently, no plans for an expansion of conventional hydropower capacity exist.

Nuclear power: Nuclear power plants split uranium atoms inside a reactor in a process called fission. At a nuclear energy facility, the heat from fission is used to produce steam, which spins a turbine to generate electricity. The central region of Jordan has reserves of 40,000 metric tonnes of uranium, which can supply Jordan for 150 years (Jordan Times, 2017).

In 2017, several decisions were taken to continue with the plans for the use of nuclear power. The Nuclear Power Plant Commission in Jordan will implement the first Jordanian nuclear power plant site in Amra. The Jordan Atomic Energy Commission (JAEC) announced that Rosatom's reactor export subsidiary Atomstoryexport (ASE) will be the supplier of two nuclear units on a build, own and operate (BOO) basis including third-generation and technology of Russian reactors with a capacity of 1.000 MW each. Jordan's first nuclear reactor is expected to start operating in 2024 succeeded by the second reactor two years later (MEMR, 2016).

Coal: Coal-fired power plants convert the chemical energy that is embedded in coal into heat, i.e., the fuel is burned and the heat released during the combustion is captured. The heat is then used to generate steam, which drives a steam turbine generator to produce electricity.

The first power plant in Jordan that runs on coal will be operational by 2025 with a capacity of 30 MW. It will be located in Qatraneh, in the south of Jordan. The agreement was signed in 2016 between MEMR and the Al Manaseer Group. The project is part of Jordan's energy strategy, under which five per cent of total power will be generated by coal by 2025 (Jordan Times, 2016).

Natural gas: The natural gas power stations utilize the kinetic energy of the motion of flowing gas or the potential energy of a gas under pressure to generate electricity via a gas turbine. Most gas-fired power plants use natural gas as a fuel, while other gases and fuels could also be used including distillate fuel oil, hydrogen and gases produced by gasification, such as the gases in IGCC power plants.

In 2016, the electricity generated by natural gas in Jordan was 75.6 per cent of all electricity generated (NEPCO, 2016). MEMR seeks to achieve the strategic objective of increasing the contribution of natural gas in the total energy mix (MEMR, 2016).

There are currently many large-scale power plants in Jordan that work with natural gas. Some of them are:

\ Aqaba Thermal Power Plant (capacity of 656 MW)
\ Risha power plant (capacity of 120 MW)
\ Rehab power plant (capacity of 357 MW)

\ Samra power plant (capacity of 1.168 MW
\ Amman East power plant (Al Manakher)(capacity of 375 MW)
\ Qatrana power plant (capacity of 375 MW)
\ Independent Power Plant 1 Amman East Power Plant (capacity of 380 MW
\ Independent power Plant 2 Al Qatrana Power Plant (capacity of 373 MW)
\ Independent Power plant 3 (capacity of 570 MW)
\ Independent Power Plant 4 (capacity 240 MW)
\ Hussein Repowering power plant (capacity of 485 MW).

Oil: The oil-fired power plant uses the chemical energy of oil to generate electricity with the help of different kinds of steam systems. In general, the year 2016 witnessed the decrease in the consumption of oil products by around 21 per cent. This was due to the falling demand for oil products used in electricity-generation and the replacement of this fuel by large quantities of imported natural gas. The decrease in consumption amounted to 64 per cent for fuel oil and 23 per cent for diesel.

Annex 3: Visions about the economic, social and environmental future

Group 1 (civil society and NGOs)

Economic: The main vision of stakeholders in Group 1 is that Jordan—compared to other countries of the region—is an economic leader in the region. Participants expect large engineering efforts in the coming years and that these will help Jordan to attract investment. This investment, including public and private financing, will become an economic driver in the country. They also envision Jordan to be a country of stability and peaceful development. They believe that the international community will support multiple efforts to keep that stability because of its vivid interest in Jordan. They also believe that there is an interest in keeping Jordan as a stable stronghold in the region. Due to its stable internal and political situation, they consider Jordan to be the best place in the Middle East for exploring renewable energy sources. Stability and resilience to conflicts in Jordan is also closely interlinked with its economy. International and regional policies are playing an important role in keeping the country stable despite the fact that national politics are rather unpredictable. Energy is needed to sustain economic growth. Several options will be implemented such as waste-to-energy generation and biogas power stations. Also, a more sustainable use of energy will be introduced by transforming the transportation system's use of fuel to one that is more sustainable and eco-friendly. However, the existing technologies and resources will not suffice to cover the growing energy demand, and some participants expressed the view that nuclear power will be needed to balance energy supply and demand and to provide base load. Such a stable situation and economic growth should be closely connected with efforts to preserve the environment and to reduce the impact from economic growth and energy-generation on eco and bio systems. The economic situation, however, is likely to be challenged by several new features of Jordanian's domestic economic policy. These include an increase in taxes, increased pressure from refugees on the economic system and a worsening banking situation. Also, youth unemployment will result in a further deceleration of the Jordanian economy and a possible decrease of the living standards.

Social: Potential conflict with refugees, increased criminal activities, a growing population and stress on the labour market pose significant risks to the social situation. But there is the chance that by 2040, refugees will have returned home. There is also the expectation that several employment opportunities will be created in the service sector. A significant increase in the population because of migration and growing urbanization constitutes a risk to food security. Measures that will be taken to address food security issues will result in increased land degradation and water shortage. Therefore, policies are needed today to address these risks for the future. Such policies ought to include improved urban planning policies and strategies to prevent the formation of informal settlements. Strategies are also necessary to uphold the traditional family structure.

Environment: The group has positive expectations about the environmental development as during recent years there have been significant attempts to reduce pressure on the environment. These changes are connected with the changing behaviour of people and of their habits. There are also expectations that the use of renewable energy sources will contribute to a further decrease in the pressure on the environment. Current and future water scarcity is one of the most acute environmental challenges. Water reserves will be affected by a growing population, unsustainable waste management issues, the destruction of forest resources, unsustainable land use issues connected with energy-generation. Water scarcity and unsustainable agricultural patterns will be interconnected with decreasing agricultural production within Jordan and increasing reliance on the import of agricultural products. Soil degradation is another important challenge that arises from the effects of climate change, increased droughts, deforestation and soil degradation. More efforts are needed to protect the soil from impacts of climate change. There is also a need for increased efforts in reforestation and the control of desertification. In general, stakeholders of this group see a good potential for a "green life" trend within society. This trend will lead to a cleaner environment and an improved usage of water. They are also optimistic as concerns expectations regarding changes in the transportation system towards a more eco-friendly fuel as well as technologies that will be implemented to merge waste management with energy production and the establishment of biogas plants.

Group 2 (finance and investment)

Economy: This group of stakeholders expects that renewable energy will reduce Jordan's dependency on energy imports and thus contribute to reducing government debts, which are connected with expensive energy imports. Renewable energy will also contribute to political stability in the region and will create independence from energy imports. Solar power in particular will make a positive contribution as it could be implemented at different scales, and components can potentially be manufactured locally. However, further efforts are needed to reduce the costs of and necessary volumes of investment in renewable energies. In general, the group believes in a positive economic development in the coming years, which will give the people of Jordan more choices and options. However, there are also negative tendencies. These tendencies are a growing budget deficit as well as increasing tax burdens. Energy transition might also result in benefits for some and disadvantages for others. A growing population and increased energy consumption is likely to result in a less reliable energy supply. There is doubt whether the energy supply needed can be produced by renewable energy sources only. Using renewable energy sources will lead to increased levelized costs of electricity due to the need to finance high investment costs of this technology. Unstable energy demand will lead to an increase in energy prices as well as a devaluation of the local currency. While oil shale is expected to contribute significantly to reducing Jordan's dependency on energy imports, it is expected that its production volume will grow slowly as current capacities and investment flows in this area are low.

Social: The level of awareness of renewable energy sources, both centralized and decentralized, will increase. This awareness will include the knowledge about electric mobility technologies and energy efficiency. It is expected that renewable energies will contribute to decentralized solutions and the establishment of self-sufficient smart cities. The use of renewable energy sources will improve public education and create opportunities for people in this field. The group was convinced that family structures will change in the future, from a traditional family to more single-person households. This will be due to the availability of new technologies that facilitate living on one's own.

Environment: In general, cities in Jordan will become cleaner and greener and also less reliant on fossil fuel resources. Green building standards will be implemented. The level of environmental pollution will be reduced. PV and geothermal technology will play an important role in reducing environmental pressure from energy generation. The major shift towards a more environmentally friendly environment will happen as the level of awareness increases about the need to mitigate pressure on the environment. Many opportunities in the area of green growth will also arise.

Group 3 (academia)

Economy: This group envisages a better and closer cooperation between the private and the public sector, which will benefit the entire Jordanian economy. Government debt is expected to decrease, but it is the group's belief that all necessary measures to decrease it should be introduced now. In the mid-term, Jordan will become an electricity exporter after having installed nuclear power plants, increased the share of renewable energy sources and use of oil shale. This will create further job opportunities and lessen the stress on the government's budget. However, to foster such positive development, it is necessary to improve transparency and accountability in the energy sector. An extensive population growth in combination with no governance reforms would magnify the risk of an economic crisis in Jordan.

Social: The group believes that through a diversified energy production landscape and a wider use of local resources, the poverty level will go down, and the quality of life will improve. The group was mainly concerned about the changing family values, morals and ethics in the Jordanian society. They also fear that the currently existing social divide among different population groups will widen. They are cautiously optimistic about the contribution of green growth to socio-economic development. However, it is necessary to make the population even more aware of the impacts of climate change and, therefore, to step up such awareness-raising measures so that the Jordanian society will indeed change its lifestyle. While green growth will also have a positive impact on society, as it will reduce the poverty rate, the necessary skills needed for green growth have to be fostered now. Young people, who represent a large share of the population, will become leaders of change. They will help to rebuild the middle class and to redistribute wealth more fairly. A more vigorous exchange of knowledge between Jordan and international experts will also drive socio-economic change.

Environment: The group believes that international and regional cooperation will be the driver for reducing the pressure on the environment. However, there is no common opinion about Jordan's environmental future. Some participants expect a cleaner and greener environment while others think that besides water scarcity, air, land and water pollution will increase. There is also no common opinion about the feasibility of 100 per cent green society, however, the common belief is that a transfer of renewable energy technologies is necessary and that it will benefit the Jordanian society.

Group 4 (future decision-makers)

Economy: The participants of this group expressed the hope for decreasing debts and a falling level of poverty as well as for more significant impulses for socio-economic development, such as job creation processes. Major drivers of socio-economic development, according to these participants, will be connected with a higher reliance on locally available resources for energy-generation and -consumption, such as oil shale and renewable energy sources. They considered that oil shale could well contribute to energy security of Jordan.

Social: Group participants connected green growth mainly with new arising economic opportunities and the creation of new direct, indirect and induced jobs. Green growth will also lead to new educational opportunities and improve existing educational capacities. This higher level of education will create additional positive drivers for socio-economic development.

Environment: In general, the group participants' expectations were that the future environment will be cleaner and greener, mainly as a result of reduced environmental impacts, especially by such sectors as energy and construction. They believed that the currently ongoing awareness-raising campaigns will result in a higher level of environmental awareness among the Jordanian population.

Group 5 (local communities)

Economy: This group's participants believed that the economic development will be characterized by increased participation of the private and public sectors in the implementation of several investment projects and by increased levels of efficiency resulting from this cooperation. The use of locally available energy sources will lead to a reduction of the government debts as well as to the creation of opportunities for energy export. The use of renewable energy sources will be connected with and contribute to an improved environment for investment. This, in turn, will help to attract further investment.

Social: They posit that society will be more aware of the impacts of climate change and the need to reduce pressure on the environment. This increased level of awareness will result in greater acceptance of energy transition and renewable energy sources as well as in a more open-minded society. They also cautioned that it is likely that some traditional values will get lost in the course of this transition.

Environment: The group is convinced that the level of CO_2 emissions will be reduced significantly as a result of the use of non-fossil energy sources. Technologies such as waste-to-energy, renewable energies, nuclear power but also the implementation of energy efficiency measures will significantly contribute to this. This way of generating energy will contribute to reduced impacts on the environment, will be cleaner and more sustainable.

Group 6 (political decision-makers)

Economy: The group considers the energy sector to be especially important for the economic development in Jordan. A transfer of new technologies as well as the lower energy prices, which will result from the use of domestically available energy sources, will be a significant driver for socio-economic development and will help to attract further foreign direct investment. To attract private investment in energy-generation and -transmission projects, further privatization efforts are needed in the energy sector. Improvements in the energy sector will also be a driver for improvements in other related sectors such as agriculture and manufacturing. However, opinions about the future economic development of Jordan were polarized. Some participants expected more positive development while others expected a more negative economic situation. There was no common opinion in the group about future energy prices, as some participants expected they would go down and others thought that they would go up and would put additional pressure on households, resulting in social instability as people might find it difficult to cover their basic needs.

Social: The group believes that energy transition will lead to a transformation of family values and the creation of more single households as well as a decrease in the number of traditional families. But it also had a positive perception of the role of Jordan in the region, as a country that has provided shelter for refugees, thus shown a sense of responsibility towards the challenges it has been confronted with. They also appreciated the community belonging and solidarity of the Jordanian society and saw its society as open-minded with a significant degree of social freedom. They considered water availability to be the major challenge and source of potential conflicts. This challenge has to be addressed in light of the growing population and migration to the country caused by the refugee crisis. The lack of communication among different stakeholders involved in water security policy issues is one of the major barriers to policy implementation and measures designed to solve this challenge. While the government always leads such efforts, the involvement of further stakeholders is necessary. The group members see a connection between the use of new technologies and the creation of new employment opportunities. But they are also aware that further awareness raising measures are needed to increase social and public acceptance as well as willingness to use these technologies. A more intense cooperation of the public and private sector in the use of these new technologies will lead to further positive impulses for socio-economic development.

Environment: In adapting to impacts of climate change, Jordan has to learn from its past and will have to reduce pressure on the environment. There is also an urgent need to transform the existing transportation system in Jordan to reduce environmental pressure. In the area of energy-generation, waste-to-energy technology has significant potentials. Once this technology is implemented, there will be a significant reduction in the environmental footprint. Further improvements could be achieved by using renewable energy sources and nuclear power.

ANNEX 4: Discussion about benefits and risks of different technologies

Group 1 (civil society)

This group values **photovoltaics (PV)** as positive as it is green energy, creates clean technology jobs and helps to reduce losses in grids by generating electricity on-site. It also contributes to achieving climate change mitigation targets and energy security targets such as the reduction of energy imports. Yet, PV also has some negative sides such as intermittency risks or the need for recycling after 30 years.

Several participants evaluate **concentrated solar power** (CSP) positively, describing it as a clean technology that has a possibility for storage, small and large-scale projects and less impacts on the environment. It also contributes to stabilizing the grids and to providing the base load. They point out that the flaws of CSP are the need for battery replacement as well as intermittency due to variations in solar irradiation.

The positive features of **wind** energy correspond to those of other renewable energies: Clean technology, unlimited resources, no pollution as well as possibilities for small- and large-scale implementation. The negative sides are noise, difficulties in maintenance and costs.

The group rates **hydropower** as negative mainly because of the absence of water resources in Jordan.

They also consider **nuclear power** as negative because it produces hazardous waste, poses high risks to human health and the environment in case of accidents and needs water for cooling. It also needs additional units to guarantee stand-by, and the overall costs of this technology are high.

Coal has positive sides such as a good contribution to the energy mix and balancing of baseload. At the same time, it contributes substantially to the pollution of the environment or to climate change by its emissions. There are also some environmental safety issues.

Gas has its pros and cons: On the one hand, concerning energy security, Jordan would depend on imports of this resource. It is also an expensive technology. On the other, participants consider it to be relatively clean in terms of greenhouse gas emissions and a technology that can provide back-up capacities.

The advantage of **oil** is that it guarantees stable delivery in terms of quantities. Its disadvantages are connected with environmental problems such as CO_2 emissions as well as prices and availability.

Group 2 (finance and investment)

Participants of this group consider **PV** as a clean and inexpensive technology, which is easy to maintain and which has no negative impact on the environment. They view it as the most environmentally friendly technology as it produces no greenhouse gas emissions and uses an abundant energy source. PV is currently connected with increasing efficiency and decreasing costs. The downsides of this technology are relatively high investment and electricity costs, variablility and intermittency.

Participants judge **CSP** as clean and sustainable, with a possibility for storage, though at the price of an expensive technology.

Wind is a clean energy, produced by an abundant (free) energy source and requires little land space for power generation—thus is very efficient. Jordan's potential of wind generation is considerable, with several locations with high wind speeds. Many of the group consider it to be the "way to the future". This technology is environmentally friendly and does not require significant maintenance efforts. It also does not produce greenhouse gas emissions. At the same time, it is not really reliable as turbines usually fail to produce electricity below 30 per cent capacity. It has high initial costs, is loud and noisy. Its initial costs are high and it affects the beauty of landscapes.

The group members perceive **hydropower** to be a clean, environmentally friendly energy source, connected with low costs and easy maintenance, high efficiency and a low impact on the environment. Its major drawbacks are the lack of water in Jordan and environmental impacts on land areas.

Participants consider **nuclear power** as the technology with one of the least levelized costs of electricity, that is very efficient and that produces excellent output. At the same time, it requires water, is connected with high risks to human health and the environment, including pollution by radiation, high running costs, and the initial capital costs are high.

The pros of **gas** are that it is clean, inexpensive, efficient, common and there are low initial costs, The major downside is that there are only modest natural gas reserves in Jordan, the fact that it is resource intensive and has detrimental effects on the environment.

Even though the group members perceive **oil** as a reliable technology, they also acknowledge that it is not sustainable, connected with high costs, harms the environment and has high resource intensity. In using oil, the country will become dependent on the fluctuation of prices and processes in global economics, which can result in high oil prices.

The group considers **coal** to be less expensive, readily available and the option with the lowest cost–electricity-generation ratio. At the same time, it causes high levels of air and land pollution and thus puts significant pressure on the environment.

Group 3 (academia)

Members of this group regard **PV** as a clean, environmentally friendly and low cost technology with improving efficiency of operations. This technology also leads to savings of greenhouse gas emissions and helps to reach national climate change mitigation targets. It is easy to use and can be made available almost anywhere where there is sunlight. Its price is also acceptable. Its disadvantages are that it requires storage batteries, is not domestically developed yet and that there are no production sites in Jordan. It also cannot satisfy all demand.

CSP, too, is a clean energy, which is available in Jordan. It can be used for future electricity-generation, can be stored and used for large projects. One major drawback is that due to the large size of power stations, this technology may not always be suitable for local conditions. Power stations also require large amounts of water and land. High initial investment costs may also be a hindrance.

Wind has a small environmental footprint and is cost effective. There are also good locations for wind-generation in Jordan. It can be combined well with PV. It is also a clean technology that does not cost much. Disadvantages are that electricity from wind is intermittent, is only moderately efficient and is high in initial costs. Wind turbines have negative impacts on the environment, are noisy, and the technology is not manufactured locally.

Hydropower is a clean, reliable and cheap technology. However, it is connected with high initial costs, and there is a significant shortage of water in Jordan.

Nuclear power is cost efficient and can cover all existing Jordanian demand. It can be produced on a large scale and deliver electricity to large consumers such as big cities or energy-intensive industries. It is also able to provide a stable baseload. Its downsides are that there are high risks such as radiation and the handling of nuclear waste. It also requires significant amounts of water for cooling and operating the power station. In case of political instability, a nuclear facility is at the risk of being misused.

Gas is available in the region but has to be imported to Jordan, and the large-scale deployment of gas capacities does not require a modification of the grids.

Also, pollution from gas is limited. The issue with gas is that there are several supply issues as gas must be imported.

Oil is available in the region. It is also available in countries whose socio-cultural conditions are similar to Jordan. At the same time, it pollutes the air, and it is expensive. It is also affected by fluctuation of the prices on international markets. Also political unrest can influence the supply of oil.

Coal is a cheap technology, which can provide a good baseload. But it has impacts on the environment and is not available in the region but has to be imported.

Group 4 (future decision-makers)

PV is clean, and there is a lot of space in Jordan, which could be suitable as site for PV plants. It can be set up on the rooftops of existing buildings. The source is available everywhere. It can be constructed in any size. It is not connected with greenhouse gas emissions and can be effectively used by private households. It also can provide jobs, and there are good potentials in Jordan for the local manufacturing of components. At the same time, it uses some toxic chemicals like cadmium. It can produce electricity only when the sun is shining and requires storage options. It needs more research to increase its efficiency. It is intermittent, and initial costs are still high. It requires large areas of land and is also prone to dust accumulation.

CSP can produce electricity for large-scale projects. It is also carbon free, and the level of efficiency of power stations is high. At the same time, it is expensive and it requires large volumes of water.

Wind has a low level of pollution and is a resource, which is abundant Jordan. This is also a highly efficient technology and land below wind farms could be used for other purposes. At the same time, it is connected with high costs, it is still not dispatchable, it is noisy and has impacts on birds.

Hydro is an effective and a very clean technology. It is also highly efficient, and long-lasting. The main problem is low water availability in Jordan, and the need to identify locations with different heights. It is connected with high initial costs.

Nuclear was perceived as a highly efficient technology for electricity-generation, which also creates many jobs. At the same time, radiation can be very harmful to human health and lead to cancer. There is also low level of acceptance for nuclear among the people from Jordan. It is a risky technology. It is costly and needs lots of water for cooling and operation. The nuclear waste is a big problem.

Coal as such is very cheap and dispatchable. It is suitable for small-scale industries, is very reliable and provides job opportunities. If combined with carbon capture and storage, this technology can also be clean. The negative sides are that without carbon capture and storage, it pollutes the environment, requires investment and is not available locally.

Gas is the lowest-cost technology with a stable baseload. However, it has high import costs, it is not available in Jordan, and it also produces emissions and has adverse impacts on the environment.

Oil has high level of pollution and it is not available in Jordan. It is connected with high costs, produces emissions and has adverse impacts on the environment.

Group 5 (local communities)

PV is the cheap technology, which can be integrated at any level. It is clean and can be developed in remote areas. It is easy to finance and electricity generated by PV is cheap. It is suitable to install and is easy to maintain. At the same time, it is an intermittent technology. The peaks of its electricity-generation are not synchronized with the peaks of its electricity demand. If it is deployed at scale it requires a lot of surface. It is not stable and needs cleaning.

CSP can provide a stable base load. At the same time, it is expensive, requires high initial investment and is difficult to install.

Wind is the cleanest technology of all renewables. It is available everywhere and does not require lot of land for deployment. Its electricity is relatively cheap, and it can be set up in remote areas. At the same time it requires high initial costs of investment, has no storage and is a noisy technology. Its electricity-generation is also not stable.

Hydro is clean and is widely used in several countries. It can provide stable and dispatchable electricity-generation. At the same time, it needs a certain topography and is not feasible in Jordan because of the shortage of water.

Nuclear was described as feasible technology, which guarantees energy security. With technology transfer of nuclear to Jordan, know-how and skills are coming. At the same time, there are issues with safety, it requires high capital investment. Plants are usually large and require huge volumes of water. Skills in Jordan for nuclear are not developed.

Gas is cheap, clean and dispatchable. It is easy to finance, and the local skills exist. It can guarantee stability of the grids and has high efficiency. At the same time, the negative side is the lack of gas reserves within Jordan.

Coal was perceived mainly as a polluting technology, which is dangerous for human health and the environment.

Oil was also perceived as a polluting technology which is dangerous for human health and the environment.

Group 6 (political decision-makers)

CSP is a safe technology, which has low impacts on environment. It is also clean and can contribute to climate change mitigation. It is highly efficient and has a high concentration ration. At the same time, its initial costs are high, and it requires extensive maintenance. It also needs a lot of space.

PV is clean and feasible for Jordan. It has short payback period. It is clean and is the cheapest technology. But it does not generate too many jobs, it is prone to grid disturbances, its efficiency is low, it requires a lot of space.

Wind is safe to use and provides cheap electricity. It has low costs and is efficient. It is also clean and does not require land resources. It is easy in operation and maintenance. It can use local resources. At the same time, it is noisy, it has higher operation and maintenance costs than other renewable energy sources. It is very site-specific and cannot be used everywhere.

Hydro is efficient and controllable. It employs a high number of workers. Its maintenance and electricity-generation is cheap. However, there is a lack of water in Jordan and therefore it is not feasible.

Coal is cheap but at the same time it is not clean, it is not safe due to the lack of advanced technology, it is connected with high initial costs. It has negative impacts on human health and the environment. This is an old technology, which will become more expensive once coal resources are limited.

Gas can provide a baseload in the electricity mix provided by renewable energy sources. However, it is not ideal for Jordan due to the absence of domestically available resources.

Oil creates dependencies as the resource is not available in Jordan, and therefore it will increase the state debt. It has impacts on human health and creates air pollution. It also produces waste and waste water.

Nuclear can cover growing energy demand with cheap and reliable electricity. At the same time, it is connected with high risks for human health and the environment, and it also produces waste and requires a lot of water.

Final workshop discussion

This section summarizes arguments, which were brought by representatives of different stakeholders groups on importance of different criteria.

Finance and private sector: On-site job creation is very important as the number of jobs in the renewable energy sector is low and could be higher.

Academia: Electricity systems costs are important. The last few years have been challenging for Jordan. Expensive energy imports have led to national debt, which affects other areas of society and the economy. Therefore, costs is the most important criterion. The use of domestic energy sources is linked to electricity systems cost. Renewable energies and oil shale are the solution. A transfer of knowledge is important, but domestic expertise exists. The criterion of water resources is important as Jordan has severe water shortages, and water usage must be considered when choosing electricity generation technologies. Renewable energies can be a solution for air pollution. The criterion of job creation is important as jobs should be created locally to support local communities. Safety is important as nuclear energy is a huge safety issue. Renewable energies are considered to be safe. Global warming potential is not an important criterion as Jordan is not a heavy industry state. It is not significant in comparison to other countries.

Young leaders: Safety is the most important criterion as human life is the most precious thing we have. Electricity systems costs are also the most important criterion as Jordan is a poor country and cannot effort expensive electricity. Local air pollution is also an important criterion as is related to safety.

Local communities: Impacts of technologies on the community is the most important aspect. New technologies need to be specifically focused on issues of safety and maintenance. Electricity systems costs is an important criterion as it affects many sectors in life. Knowledge needs to be transferred to communities to make communities more susceptible to new technologies. New technologies should reduce pressure on water resources. Job creation is important but other criteria should be focused on more. If they are achieved then job-creation will follow naturally. Global warming is not an important criterion as its impacts are too uncertain.

Decision-makers: Government has three pillars for decision-making processes: cost, sustainability and job creation. Safety should be the first priority. Electricity systems cost are important in Jordan, energy costs is a big problem which puts pressure on the government budget. Renewable energy and shale oil could contribute to energy independence. A new grid is needed to integrate renewable energies. Land-use needs to be considered carefully and is a main criterion for the government.

ANNEX 5: Ranking of criteria

Group 1 (civil society and NGOs)

The electricity systems cost criterion is followed by such economic criteria as use of domestic energy sources, technology transfer and on-site job creation. Interestingly, criteria that impact on local communities such as pressure on water, air and land as well as waste remained at the bottom of the ranking.

Table 23

Ranking of criteria by civil society and NGOs

Criterion	*Steps (white cards)*	*Weights (in %(*
Electricity systems costs	4	31
Use of domestic energy sources	0	12
Technology transfer	0	12
On-site job creation	4	12
Global warming potential	0	8
Safety	0	8
Pressure on local water resources	3	8
Local air pollution and health	3	5
Pressure on local land resources	0	2
Waste	0	1
Domestic value chain integration	0	1

Group 2 (finance and investment)

The ranking of the criteria by finance and investment (table 24) showed that global warming potential and safety are two most important criteria, followed by electricity systems costs. As in the previous group, domestic value chain integration was ranked at the bottom of the ranking.

Table 24

Ranking of criteria by finance and investment stakeholders

Criterion	*Steps (white cards)*	*Weights (in %(*
Global warming potential	0	21
Safety	0	21
Electricity systems cost	4	21
Pressure on local water resources	0	8
Local air pollution and health	3	8
Pressure on local land resources	0	5
Waste	2	5

Criterion	*Steps (white cards)*	*Weights (in %(*
Use of domestic energy sources	0	3
Technology and knowledge transfer	0	3
On-site job creation	1	3
Domestic value chain integration	0	2

Group 3 (academia)

The ranking of the criteria by academia (Table 25) shows that electricity systems costs is by far the most important criterion. This criterion is followed by the use of domestic energy sources, technology transfer, pressure on water and air, as well as the criterion of jobs.

Table 25

Ranking of criteria by academia

Criterion	*Steps (white cards)*	*Weights (in %(*
Electricity systems costs	2	22
Use of domestic energy sources	0	12
Technology transfer	0	12
Pressure on local water resources	0	12
Local air pollution and health	0	12
On-site job creation	3	12
Domestic value chain integration	0	6
Safety	3	6
Global warming potential	0	2
Occurrence and manageability of non-emission hazardous waste	0	2
Pressure on local land resources	0	2

Group 4 (future decision-makers)

The ranking of future decision makers (Table 26) showed that safety and electricity systems costs are two most important criteria. This was followed by criteria of social and environmental impact of a technology, such as on-site job creation, technology and knowledge transfer as well as pressure on local resources. Waste was ranked at the bottom, as well as the domestic value chain integration, as in many other stakeholders groups.

Table 26

Ranking of criteria by future decision-makers

Criterion	*Steps (white cards)*	*Weights (in %(*
Safety	0	21
Electricity systems costs	3	21
On-site job creation	0	11
Technology and knowledge transfer	0	11
Pressure on local water resources	4	11
Use of domestic energy sources	0	7
Local air pollution	1	7
Global warming potential	3	6
Pressure on local land resources	3	3
Domestic value chain integration	0	1
Waste	0	1

Group 5 (local communities)

The ranking of the criteria by local communities (Table 27) shows that global warming potential was ranked as the most important criterion. This was the only group of stakeholders that ranked the global warming potential to be the most important, probably because people on the ground are directly feeling the impacts of climate change. Safety and electricity systems costs were also considered as most important criteria. In this group also environmental criteria such as pressure on water, land and air resources as well as waste were considered much more important than by other stakeholder groups. Domestic value chain integration was the least important criterion.

Table 27

Ranking of criteria by local communities

Criterion	*Steps (white cards)*	*Weights (in %(*
Global warming potential	0	21
Safety	0	21
Electricity systems cost	4	21
Pressure on local water resources	0	8
Local air pollution and health	3	8
Pressure on local land resources	0	5
Waste	2	5
Use of domestic energy sources	0	3

Criterion	*Steps (white cards)*	*Weights (in %)*
Technology and knowledge transfer	0	3
On-site job creation	1	3
Domestic value chain integration	0	2

Group 6 (political decision-makers)

The ranking of political decision-makers (Table 28) showed that criteria that are important for the electricity planning process were considered to be the most important ones. For instance, safety was considered to be the most important criterion because it is the task of the government at the national and local levels to control the risk. But also the use of domestic energy sources and electricity systems costs were considered to be very important criteria, which are essential for energy security policy and also for socio-economic development, which is connected with the electricity prices.

Table 28

Ranking of criteria by political decision-makers

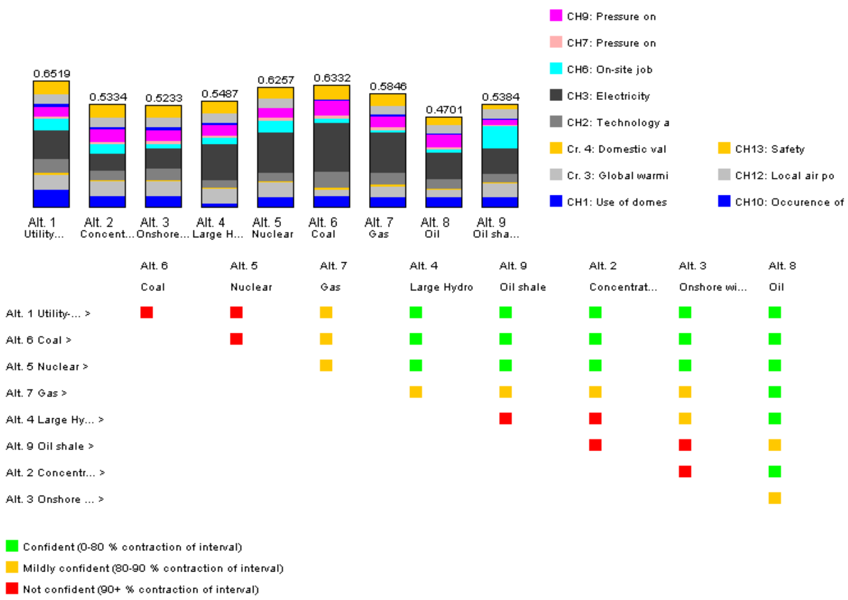
Criterion	*Steps (white cards)*	*Weights (in %)*
Safety	3	26
Use of domestic energy source	0	13
Electricity systems cost	2	13
Domestic value chain integration	0	10
Pressure on local land resources	0	10
Technology and knowledge transfer	4	9
Global warming potential	0	5
On-site job creation	0	5
Local air pollution and health	2	5
Pressure on local water resources	0	2
Waste	0	2

ANNEX 6: Trade-offs of technologies

Group 1 (civil society and NGOs)

Figure 27

Preferences of civil society and NGOs

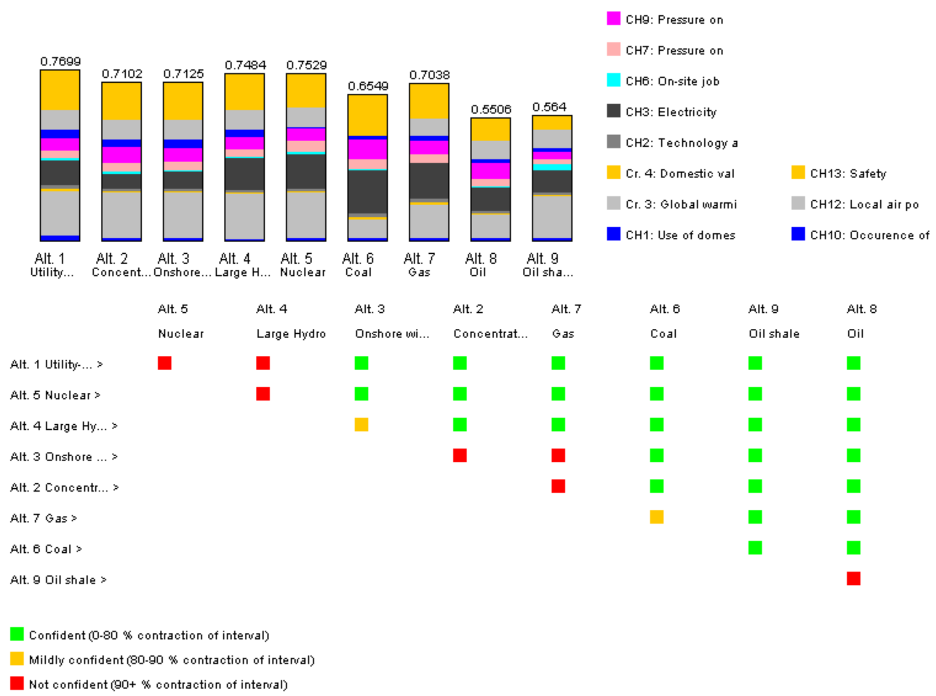


Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 6 Coal" as runner up.
The Alt. 1 > Alt. 6 statement is not confident, since the information provided in this decision basis supports a strict ranking with a degree of 5 %, whereas the reverse statement is not supported.

Group 2 (finance and investment)

Figure 28

Preferences of finance and investment

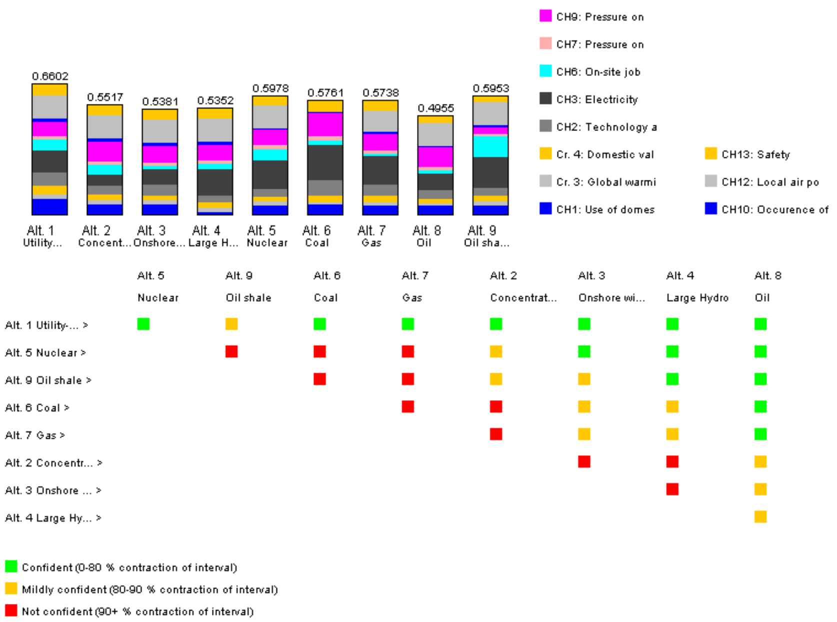


Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 5 Nuclear" as runner up.
The Alt. 1 > Alt. 5 statement is not confident, since the information provided in this decision basis supports a strict ranking with a degree of 7 %, whereas the reverse statement is not supported.

Group 3 (academia)

Figure 29

Preferences of academia

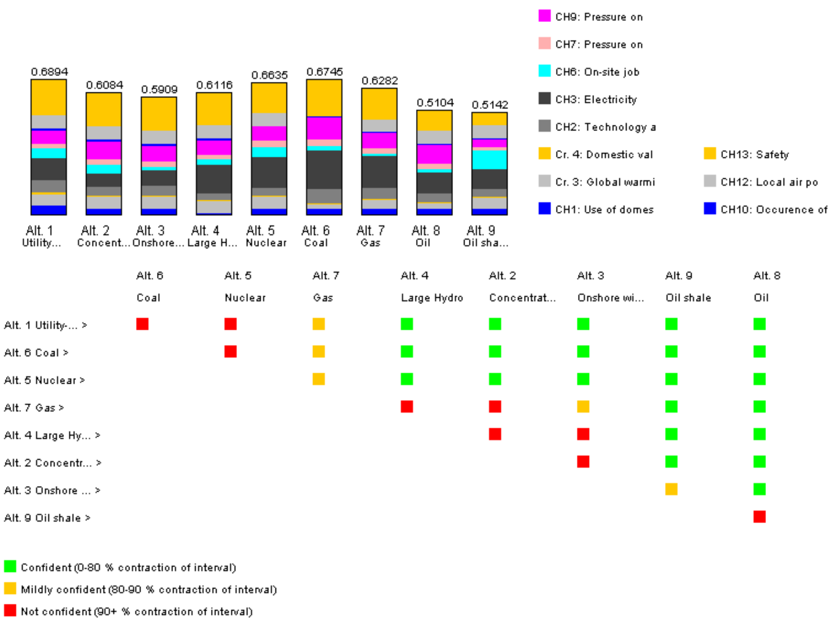


Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 5 Nuclear" as runner up.
The Alt. 1 > Alt. 5 statement is confident, since the information provided in this decision basis supports a strict ranking with a degree of 21 %, whereas the reverse statement is not supported.

Group 4 (future decision-makers)

Figure 30

Preferences of young leaders / future decision-makers

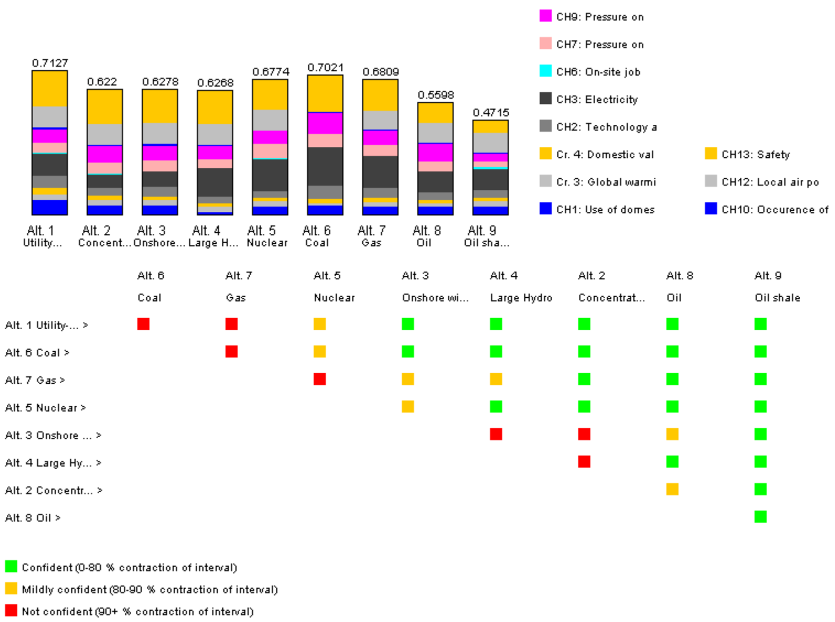


Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 6 Coal" as runner up.
The Alt. 1 > Alt. 6 statement is not confident, since the information provided in this decision basis supports a strict ranking with a degree of 4 %, whereas the reverse statement is not supported.

Group 5 (local communities)

Figure 31

Preferences of local communities

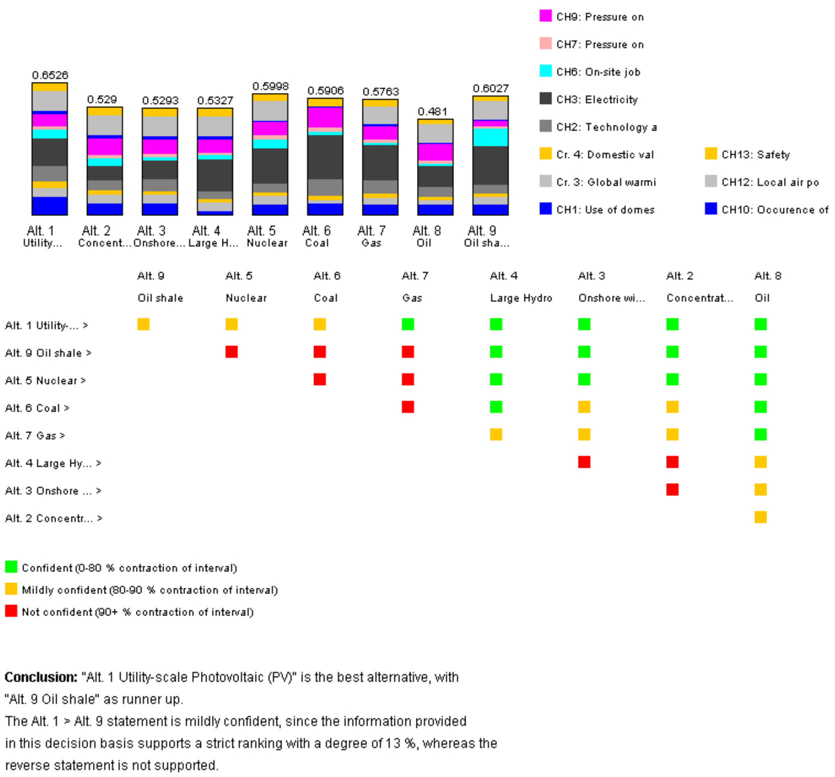


Conclusion: "Alt. 1 Utility-scale Photovoltaic (PV)" is the best alternative, with "Alt. 6 Coal" as runner up.
The Alt. 1 > Alt. 6 statement is not confident, since the information provided in this decision basis supports a strict ranking with a degree of 3 %, whereas the reverse statement is not supported.

Group 6 (political decision-makers)

Figure 32

Preferences of political decision-makers



ANNEX 7: Individual preferences

Figure 33
Satisfaction with the final criteria ranking

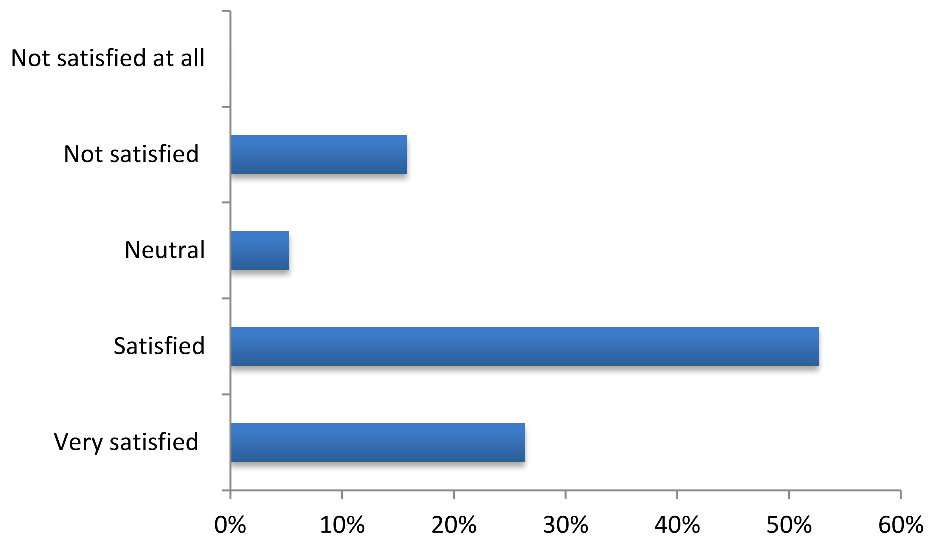


Figure 33 shows the level of satisfaction with the final criteria ranking. The respondents were asked "How satisfied are you with the final ranking of criteria?" It shows that the majority of respondents were satisfied and very satisfied with the results. However, almost 20 per cent were not satisfied with the results of the final ranking.

Figure 34

Satisfaction with the final criteria ranking of technologies

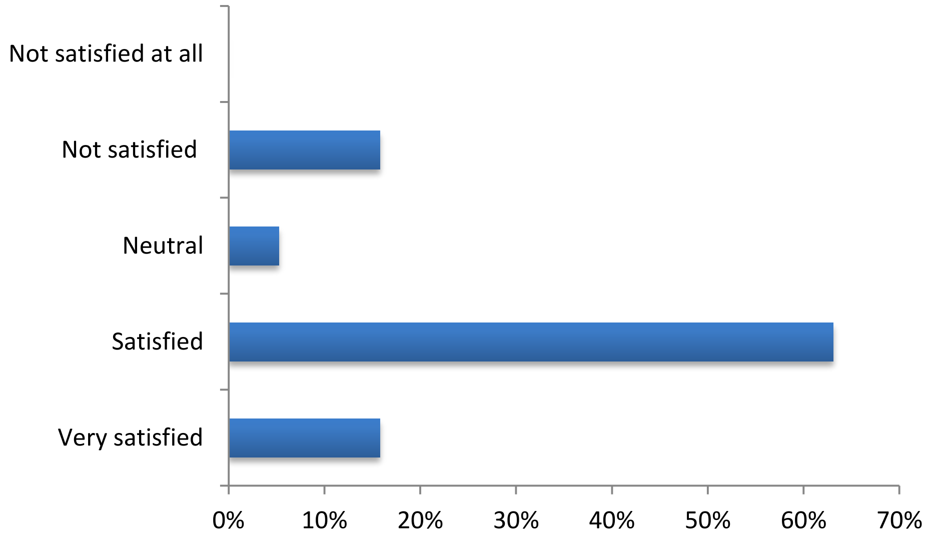


Figure 34 shows how satisfied the participants were with the final ranking of technologies. The respondents were asked the question "How satisfied are you with the final ranking of technologies?" It shows that the majority of stakeholders were satisfied and very satisfied with the final ranking of technologies. However, the share of stakeholders who were not satisfied is also around 20 per cent.

Figure 35

Individual ranking of technologies

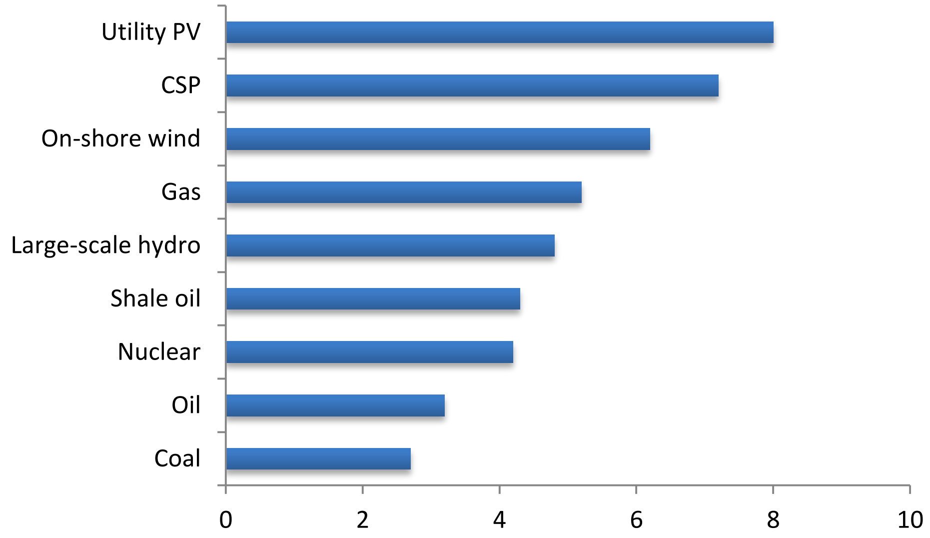


Figure 35 shows individual ranking of technologies when respondents were asked during the survey to rank technologies by themselves. The question was "How will you rank technologies individually?" It shows that renewable energy sources such as utility PV, CSP and onshore wind were ranked as the most favorable technologies. At the same time nuclear, oil and coal were ranked as the least favorable technologies.

Figure 36

Individual ranking of criteria

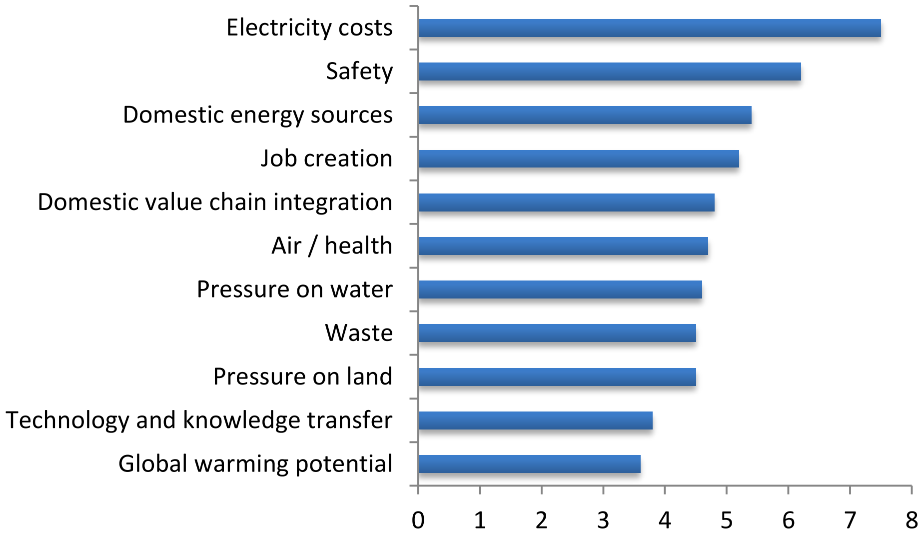


Figure 36 shows the individual ranking of criteria. The respondents were asked: "How will you rank criteria individually?" The majority of stakeholders ranked criteria, which are relevant for national energy security such as electricity costs, safety and the use of domestic energy sources, as the most important criteria.

To the question "Would you agree to provide your government with ranking developed during the final workshop as a recommendation for Jordan's energy policy?" More then 94 per cent of all respondents answered "yes" and five per cent were undecided.

bicc \
Internationales Konversionszentrum Bonn
Bonn International Center for Conversion GmbH

Pfarrer-Byns-Straße 1, 53121 Bonn, Germany
+49 (0)228 911 96-0, Fax -22, bicc@bicc.de

www.bicc.de
www.facebook.com/bicc.de

Director for Research, Professor Dr Conrad Schetter

Director for Administration, Michael Dedek

Germanwatch
Kaiserstr. 201
D-53113 Bonn
Germany

+49 (0)228 / 604 920

www.germanwatch.org

AUTHORS

Dr Nadejda Komendantova is a research scholar at IIASA and a senior research scholar at ETH Zurich

Professor Love Ekenberg is a senior research scholar at IIASA and a professor in computer and systems science at the Stockholm University

Leena Marashdeh is a research assistant at the School of Engineering at the University of Jordan

Professor Ahmed Al-Salaymeh is a chaiman of the Mechanical Engineering Department at the School of Engineering at the University of Jordan

Professor Mats Danielson is a vice president of the Stockholm University, senior researcher of the DecideIT Research Group and a professor in computer and systems sciences

Dr Joanne Linnerooth-Bayer is a director of the Risk and Resilience program at IIASA

CONTRIBUTING AUTHORS: Jomana Tanbour is a research assistant at the School of Engineering at the University of Jordan, Jenan Irshaid is a research assistant at IIASA, Johana Spiegelhofer is a program support officer at IIASA, Dr. Aron Larsson is a senior researcher at the Preference Inc, Prof. Jussi Karlgren is an adjunct professor at the Royal Institute of Technology in Stockholm and one of the founding partners of Gavagai

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