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DEVELOPMENT OF A DECISION SUPPORT TOOL (DST) FOR SOCIAL SUSTAINABILITY ASSESSMENT OF ENERGY TECHNOLOGIES

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This thesis is submitted in partial fulfilment of the requirements for the degree of Master of Science

ABSTRACT

Social sustainability is the least investigated of the three dimensions of sustainability. With increasing interest in social aspects, new tools and techniques for social assessment have been developed recently. This thesis investigated existing social sustainability tool/techniques and their applicability to energy technologies. Energy technologies have been analysed in order to identify existing energy technologies and the presence of potential positive and negative social impacts. It was analysed that energy technologies have both positive and negative social impact. Tools and techniques for social sustainability assessment shall be used for providing deeper analysis of social aspects.As a result, 53 tools and techniques for social sustainability assessment were identified and evaluated with taking into account their characteristics and application. Out of these tools and techniques, 8 were considered to be applicable to energy technologies. The analysis of energy technologies can be conducted from project, plan, facility or product perspective. The aim of this thesis is to help the decision maker to select the most appropriate tool/technique for social assessment. Thus, the Decision Support Tool (DST) in form of a Decision Tree (DT) has been developed.

Keywords: social sustainability, social sustainability assessment tools and techniques, Decision Support Tool, Decision Tree, social impact

Word count: 7106

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LIST OF ABBREVIATIONS

CSR	Corporate social responsibility
CSRR	Corporate Sustainability & Responsibility Research
DST	Decision support tool
DT	Decision tree
EIA	Environmental impact assessment
EMS	Environmental management system
ESIA	Environmental and social impact assessment
HIA	Health impact assessment
HRIA	Human Rights Impact Assessment
ISAE	International Standard on Assurance Engagements
LCA	Life cycle assessment
OHSAS	Occupational Safety & Health Administration
SA	Sustainability appraisal
SEA	Strategic environmental assessment
SIA	Social impact assessment
SIA	Social Impact Assessment
SIGMA	Sustainability Integrated Guidelines for management
TA	Technology assessment

This thesis has been prepared in the format used for scientific papers appearing in the "*Renewable & Sustainable Energy Reviews*".

Development of a Decision Support Tool (DST) for Social Sustainability Assessment of Energy Technologies

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Social sustainability is the least investigated of the three dimensions of sustainability. With increasing interest in social aspects, new tools and techniques for social assessment have been developed recently. This thesis investigated existing social sustainability tool/techniques and their applicability to energy technologies. Energy technologies have been analysed in order to identify existing energy technologies and the presence of potential positive and negative social impacts. It was analysed that energy technologies have both positive and negative social impact. Tools and techniques for social sustainability assessment shall be used for providing deeper analysis of social aspects. As a result, 53 tools and techniques for social sustainability assessment were identified and evaluated with taking into account their characteristics and application. Out of these tools and techniques, 8 were considered to be applicable to energy technologies. The analysis of energy technologies can be conducted from project, plan, facility or product perspective. The aim of this thesis is to help the decision maker to select the most appropriate tool/technique for social assessment. Thus, the Decision Support Tool (DST) in form of a Decision Tree (DT) has been developed.

1 Extended introduction

1.1 The concept of social sustainability

The concept of sustainability and sustainable development was first introduced in 1987 by the Brundtl and report, which defines sustainable development as:“Development that meets the needs of the present without compromising the ability of future generations to meet their own needs”(WCED, 1987, p.15). There are identified three dimensions of sustainability, namely environmental/ecological, economic and social.

Whilst environmental sustainability includes ecosystem integrity or biodiversity and economic sustainability includes growth, development or productivity (Khan, 1995), the social sustainability concept and objectives often differ from authors.

Many authors consider the social dimension, also known as social sustainability or social pillar, as a dimension with vague meaning and objectives. Out of all three dimensions, goals of social sustainability have the most problematic aspirations for measurement. Social sustainability is difficult to measure and quantify due to problems with an objective definition and identification of all issues (Assefa and Frostel, 2007; Barr, 2008; Dempsey et al., 2011). Overall, there is the need of greater understanding of social pillar (Murphy, 2012).

Table 1 presents some interpretations of social sustainability issues and objectives.

Table 1.Social sustainability issues and objectives

Author	Social sustainability aspects/issues/objectives
Murphy (2012)	Equity, awareness for sustainability, participation and social cohesion.
Khan (1995)	Empowerment, equity, accessibility, participation/sharing, cultural identity and institutional stability.
Assefa and Frostel (2007)	Adequate provision of social services which include education, health, political accountability and participation, gender equity, fairness in distribution and opportunity.
Rogers et al. (2007)	There are 10 social dimensions of sustainable development: Poverty reduction, participatory development, consensus building, nongovernment organizations, gender and development, involuntary resettlement, indigenous peoples, social exclusion, social analysis and social development indicators.
Åhman(2013)	Social cohesion, quality of life, basic needs and equity, sense of place, education, social capital, integration and diversity.

Deeper analysis of social sustainability literature with focus on different views of social sustainability is provided by Murphy (2012).

Even the social sustainability is not always treated as other dimensions(Murphy, 2012), presence of linkages between three pillars is unquestionable. Khan (1995) stated that achieving the one sustainability without the others is not possible. However, Goodland (2008) believes there are stronger linkages between environmental and economic sustainability, and the social sustainability should be separately defined in sociological terms. Murphy (2012) stated that the linkages between social and environmental dimensions are

particularly undeveloped and he demands for clearer links with the environmental dimension.

Contradictions between these dimensions may also arise. An example of the contradictions between environmental and social sustainability arises in the case of poverty alleviation at the expense of short-term environmental degradation. However, the objectives of environmental, economic and social sustainability must be achieved in both short-term and long-term period of time (Khan, 1995).

Model of sustainable development is usually presented as three circles model illustrating three dimension of sustainability. However, Giddings et al. (2002) presented Nested sustainability model in order to critique of three circles model. Three circles model and its alternative are presented in Figure 1.

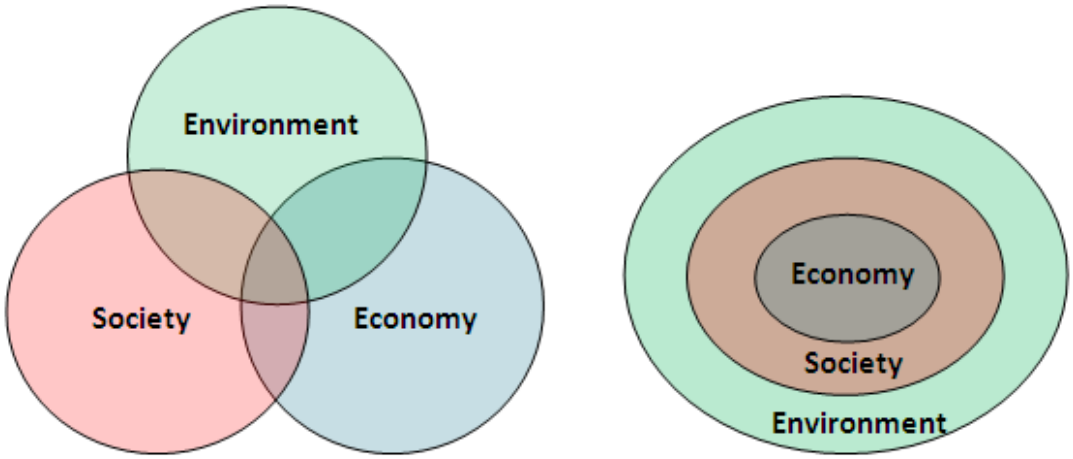

Figure 1. Three circles model vs. Nested sustainability model (Source: Giddings et al., 2002, p.189 and p.192)

Figure 2 shows the consideration of social dimension compared to other sustainability dimensions during the time in three circles model. Although the social dimension was taken into consideration in sustainability agenda from 1980s, it was not equally considered until 2000s. Social sustainability was dominated by environmental and also by economic dimension probably due to the fact that principles of sustainable development were developed from the environmental movement (Colantonio, 2007).

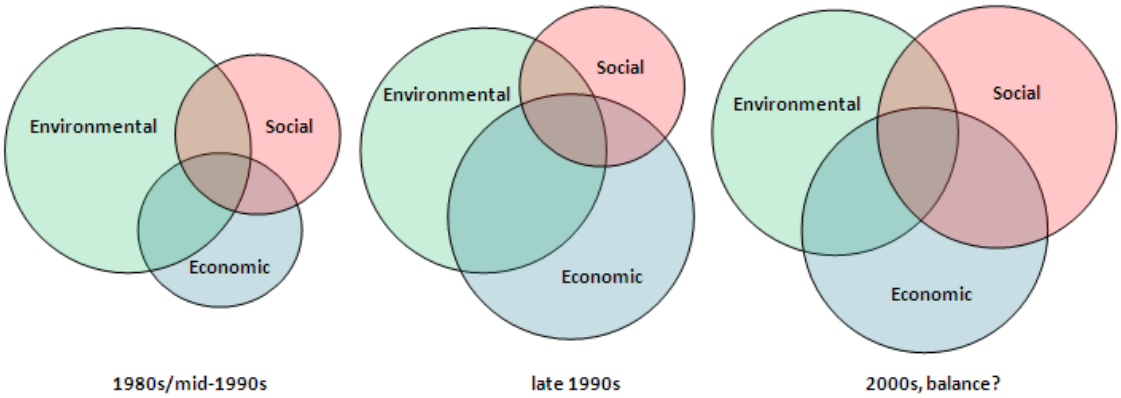

Figure 2.Consideration of social dimension during the time (Source: Colantonio, 2007, p.4)

1.2 Aim and objectives

The aim of the project is to develop a Decision Support Tool (DST) to determine the most appropriate tool/technique for social sustainability assessment of energy technologies.

The objectives are:

- To identify and evaluate the available tools/techniques for social sustainability assessment and select those that are applicable to energy technologies.
- To identify and evaluate the energy technologies and their social impacts.
- To develop a Decision Support Tool (DST) that aids in the selection of the most suitable tool/technique for social sustainability assessment of a given technology.

1.3 Energy technologies and social sustainability

Although some research studies have looked at social sustainability and social sustainability assessment (Murphy, 2012; Colantonio, 2007; Benoît and Vickery-Niederman, 2010), there has been only few studies focused on social sustainability assessment of energy technologies or energy system. Most of them were aimed at only one ingredient of social sustainability such as social acceptance.

According to Assefa and Frostel (2007) the energy technologies are important group of technologies that should be subjected to sustainability assessment due to decision making about the alternatives and their potential contribution to climate change.

Difficulties with understanding of terms: energy source, form and technology may occur. Energy source refers to an input that is represented by combustible, thermal or kinetic fuel in order to generate heat or electricity(OECD/IEA, 2005). Energy coming from the energy source enters into the energy system and then is transformed from one form to another e.g. biogas, electricity. The energy technology do the process of transformation and also storing and transportation(Gritsevskyi, 2008).

Technologies play an essential role in societal system. Technologies can have a positive impact on society in the case of job creation or improvement of living conditions (Lehmann et al., 2013). From the social view, energy technologies help to improve living conditions by providing energy. In developing countries the development of new energy technologies can bring significant improvement to energy security (Gritsevskyi, 2008).

Social sustainability assessment of technologies is essential during decision making related to technology implementation and contributes to development of more sustainable technologies (Lehmann et al., 2013).

1.4 Decision support tool (DST)

Rakus-Andersson (2009, p.1) defines decision making as a task that:“arises from the need to select the best possible course of action (or a set of optimized actions) from a set of alternative”. To make the best decision is the basis of each project and plan.

A decision support tool (DST) is analysis, procedure or guidance that supports a decision (Sullivan et al.,2000).A DST supports decision making based on complex information and can be in written the form of guidance, model, data or software (Liu et al., 2012).

Distinctions between the terms within decision making are essential for understanding and development of a DST. Important terms in decision making are: decision support information, decision support tool (DST) and decision support systems (DSS). Figure 3shows a conceptual framework for information use and differences between these terms.

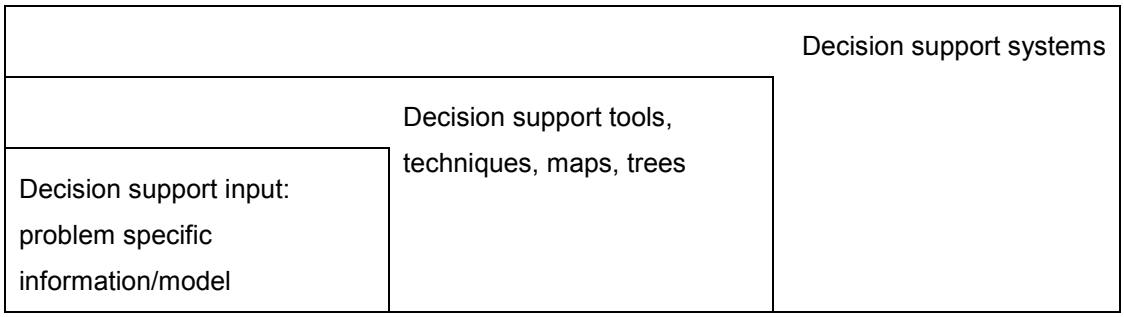

Figure 3. Decision Support Information, Tools and Systems (Source: Sullivan et al., 2000, p.16)

Figure 3shows the superiority of a DST of a decision support input and superiority of a DSS of a DST. The decision support tools, techniques, maps and trees represent the middle part of a decision making process.

Currently does not exist any DST for social sustainability assessment that would help a decision maker to select the most suitable tool or technique from the set of tools and techniques. Creation of a DST for social sustainability assessment is an emerging task. There is an importance to develop DST within social sustainability assessment due to increasing number of emerging tool/techniques for social sustainability assessment. There have been identified dozens of tools and techniques for assessing social sustainability which is caused by increasing interest in social sustainability.

Main objective of the DST is to provide the tool for selection of the most appropriate social sustainability tools/techniques with taking into consideration applicability to energy technologies.

Benefits of using a DST within social sustainability assessment are to:

- Reduce time of decision making process,
- Avoid inappropriate selection of tool/technique for assessment, and

- Provide information about selected tool/technique and recommendations.

Institute for Manufacturing (2014), which provides new ideas and approaches to modern industrial practice, identified more than seventy DSTs that are classified under following categories: Information Control, Paradigm and Simulation Models, Way of choosing, Representation Aids and Processes.

A choice of a DST´ design depends on many factors. The most important factor is a nature of input information. The input information represents information about the individual tools/techniques for social sustainability assessment. Input information are in verbal form because there are no numeric data available.

Analytical Hierarchy Process (AHP), one of the most used Multiple Criteria Decision Making (MCDM) methods, cannot be used because it uses comparison scales and inputs are measured as the weight, price or time (González-Prida et al., 2014).Taking into account nature of the input information these comparison scales are not available. SWOT analysis is used for organisation's assessment of its strengths, weaknesses, opportunities and threats. This DST is not suitable for social sustainability assessment as well.

Because of the properties of an input information, the most appropriate DST is a decision tree(DT) presented in the Representation Aids category. The Representation Aids category includes tools and techniques that aid visualisation of the problem space or the data (Institute for Manufacturing, 2014).The DT represents a rational approach which is used for selection of the best option from all alternatives. The DT uses the classification of input information as well as the visualization.

1.4.1 Decision Tree (DT)

The decision tree is group of steps arranged in a logical order(Sullivan et al., 2000). The methodology of a decision tree is based on principle of elimination answers by asking sub questions(Scragg, 1997). Decision tree is often classified as a technique for data mining (Pathak and Pal, 2013).

The design of a DT is in the form of a diagram with use of branching lines and nodes. There are two types of the nodes namely chance nodes and decision nodes (Haimes et al., 1989). Pathak and Pal (2013, p.333) stated that: “to construct a decision tree for each outcome class, the original instances in the training data set are categorized into two revised classes: yes (Y) and no (N)”.

Pathak and Pal (2013) also defined two types of splitting criteria, binary and multivariate. Splitting criteria represents extraction of input information from a table. Multivariate splitting that is considered to be more complicated that binary splitting. It uses several attributes within one node while binary splitting uses two attributes. The value obtained from binary splitting that uses for the division of the attribute in two mutually exclusive and exhaustive sub-domains is used for attribute comparison.

The important component for development of a decision tree is a data set. In case of selection of the most appropriate tool or technique the table with tools/techniques for sustainability assessment can be used.

DTs as well as other DSTs support decision making. The decision tree has widespread use in many fields such as environment, healthcare or finance.

The advantages of using a decision tree are following:

- The DT is easy to understand and self-explanatory,
- It can use both numeric and nominal input, and
- DTs can handle datasets in any size that may have errors or missing values (Pathak and Pal, 2013).

2 Methodology

The research methodology includes six steps within three phases that are directed to accomplish aim and objectives of this research study.

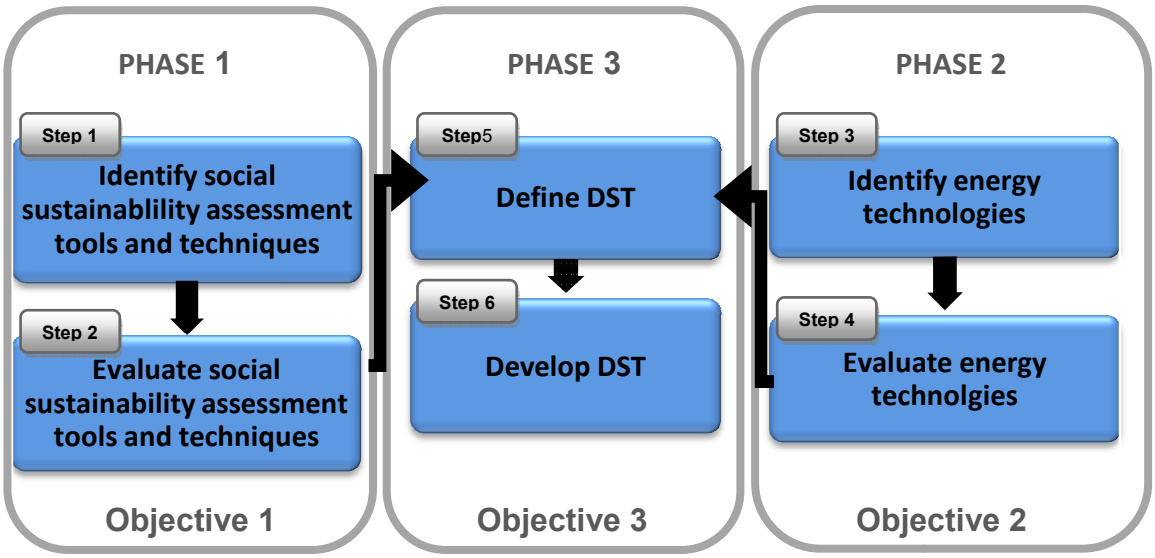

Figure 4. Research methodology diagram

The first phase of research methodology, presented in Figure 4, involves the first step and the second step. This phase focuses on social sustainability assessment tools and techniques. The first step consists of gathering data from appropriate literature in order to identify the social sustainability assessment tools and techniques. This step is followed by evaluation of social sustainability tools and techniques. Phase 1 represents the first mentioned objective of the thesis.

The second phase that represents the second objective relates to energy technologies. The third step, within the second phase, is defining existing energy technologies followed by their evaluation. The identification of energy technologies includes the diagram of available energy technologies with main classification into renewable and non-renewable energy technologies. The evaluation will show potential positive and negative social impact of energy technologies.

After identification and evaluation of assessment tools/techniques and energy technologies follow the steps related to DST namely definition and development of the DST. The definition of a DST includes criteria for selection and description of selected form of a DST. The development of a DST comprises the development of a diagram. Phases 1 and 2 constitute crucial information needed to accomplish Phase 3 that demonstrates the last objective.

3 Results and Discussion

3.1 Review of social sustainability assessment tools and techniques (Phase 1)

With regard to transition to sustainability, sustainability goals have to be assessed. The number of tools and techniques that can be used for sustainability assessment is increasing (Ness et al., 2007). These tools and techniques help the decision makers decide which actions they should take in order to contribute to sustainable development.

Firstly, it is important to know a distinction among terms: tools, techniques, methodologies and methods. These terms are commonly used related to sustainability assessment. According UNEP/SETAC (2009), an assessment tool is any instrument used to perform a procedure. These tools can use different methodologies that are classified as the sets of methods. A technique is a set of procedures needed to perform a task.

Based on sustainability tool/technique research, social sustainability can be evaluated through variety of tools and techniques. During the overview the social sustainability assessment tools and techniques, following factors have been considered:

- The focus on social aspects,
- The level of assessment, and
- The nature of tool/technique.

The original hierarchy of tools and techniques presented by UNEP/SETAC (2009) has been kept and then updated with other levels, tools and techniques identified in appropriate literature.

Figure 5showsthe different levels of assessment that represent the object of a tool application: project, intervention or facility, product, organization, community and sector/country level (UNEP/SETAC, 2009; Štreimikiene et al., 2009). These different tools and techniques have different goals and use various disciplines in the assessment (UNEP/SETAC, 2009).

Tools and techniques are further differentiated according to the tool/technique nature within individual levels. There are analytical tools, procedural and management tools, monitoring tools, communication tools and reporting tools. Analytical tools assess the object in systematic and logical way. Procedural and management tools represents tools used for managerial purposes. The communication tools refer to stakeholder´s communication and finally the reporting tools represents tools with reporting purpose.

There is a fine line between individual tools. Some tools and techniques are included in more than one category and many tools can be substituted or complemented by others. Knowledge of characteristics, differences and connections among tools are essential for the development of the decision tree.

Project, intervention or facility level covers social sustainability assessment tools and techniques suitable for the whole project assessment from initial steps to the end of the project. The development of a power plant can be included into this level with taking into consideration life stages of a power plant including mining, construction, installation/commissioning, operation, maintenance, decommissioning, recycling and disposal. Main characteristics and application information are shown in Table 2.

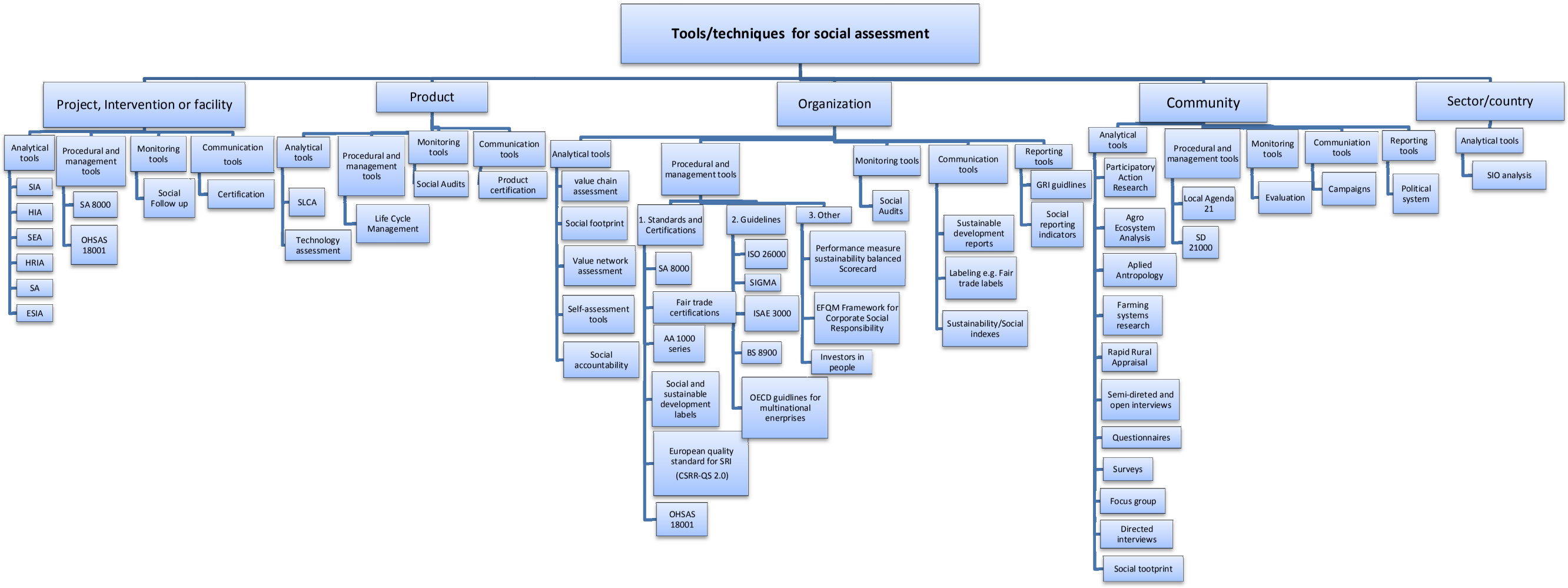

Figure 5. Tools and techniques for social sustainability assessment

(Adapted from UNEP/SETAC, 2009;The World Bank/NTF, 2013;Štreimikiene et al., 2009)

Table 2.Social sustainability assessment tools/techniques on project/intervention or facility level

Project, Intervention or facility			
Tool type	**Tool/technique**	**Main characteristics**	**Application and limitations**
Analytical	Social Impact Assessment (SIA)	➢ Is the systematic appraisal of impacts on individuals and community quality of life by proposed project, plan, policy or programme (Burdge, 2004) ➢ Provides quantitative and qualitative social indicators (UNEP/SETAC, 2009)	➢ Is often compulsory in large development projects (UNEP/SETAC, 2009) ➢ Can be part of EIA and then creates triple bottom line (TBL) (Sheate, 2009)
	Health Impact Assessment (HIA)	➢ HIA uses participatory, qualitative and quantitative techniques ➢ It helps to make decisions about possible alternatives, improvements to prevent injuries and diseases as well as promotes health (WHO, 2014)	➢ Assess projects, plans and policies in different economic sectors (WHO, 2014)
	Strategic Environ-mental Assessment (SEA)	➢ Contributes to strengthen commitments of society to sustainable development, green economy and efficient management of resources (Partidário, 2012)	➢ Can be applied in development of programs, plans and policies ➢ Applied in Long-term strategic perspective Partidário, 2012)
	Human Right Impact Assessment (HRIA)	➢ Aim of HRIA is to understand, identify and manage impacts in human rights field ➢ Can improve company and product reputation, relations with stakeholders, workers´ motivation and productivity, contribution to sustainable development and corporate social responsibility (CSR) etc. (Lenzen and d´Engelbronner, 2009)	➢ Is used for stakeholders monitoring performance of an organization ➢ Suitable for multinational enterprises ➢ Can be done ex ante or ex post (Lenzen and d´Engelbronner, 2009)
Procedural and management	SA 8000	➢ Focuses on workers´ rights in organizations and enterprises	➢ Is used for facility assessment ➢ Can be used in a SLCA (UNEP/SETAC, 2009)
	Occupational Safety & Health Administra-tion 18001 (OHSAS 18001)	➢ Is American standard focuses on risks and accidents ➢ Aims to reduce environmental risks and improve health and safety of workers ➢ Takes into account other standards such as British standards BS 8800 ➢ Is compatible with ISO 14001 and ISO 9001 (AFNOR, 2006)	➢ Uses to know continuous improvement within health and safety of workers (AFNOR, 2006)

Tools and techniques within the product level are connected with production and consumptions of goods and services. With focus on energy technologies, products can be represented by products such as wind turbines or solar panels. Product related assessment tools/techniques are used for social sustainability assessment of a specific product. Detailed information are included in Table 3.

Table 3. Social sustainability assessment tool/techniques on the product level

Product			
Tool type	**Tool/technique**	**Main characteristics**	**Application and limitations**
Analytical	SLCA	➢ Assessment through product life cycle ➢ Assess production and product ➢ Considers economic (to some extent) and social aspects (UNEP/SETAC, 2009) ➢ Provides basis for communication and reporting (UNEP/SETAC, 2009) ➢ Based on functional unit ➢ Supports decision making	➢ Is commonly used in engineering (Basurko and Mesbahi, 2014) ➢ Important decision support tool in developing countries during developing projects (Lehmann et al, 2013) ➢ Suitable for comparative technology analysis and for addressing social impact of technology implementation through social indicators (Lehmann et al, 2013)
Monitoring	Social audits	➢ Assess social, environmental and economic limitations and benefits of an organization ➢ Information and details about financial and non-financial resources are shared with public through any public platform during the social audit ➢ Aims to enforce transparency and accountability as well as provide the ultimate users of projects and services (Eavani et al, 2012)	➢ Used for checking working conditions of workers and preventing abuse and exploitation of workers ➢ Requires stakeholder´s involvement ➢ Often used in developing countries (Eavani et al, 2012)

The organization level of assessment includes tools that assess a corporate impact. These tools are used for social assessment of an organization as a whole. They can assess the behaviour, operations or activities of an organization. Tools within this level cannot be used for assessment of individual projects or specific products. For further information see Table 4.

Table 4. Social sustainability assessment tools/techniques on the organization level

Organization			
Tool type	**Tool/technique**	**Main characteristics**	**Application and limitations**
Analytical	Social footprint	➢ Is used for measurement and reporting social sustainability of an organization ➢ Assess impact on anthro capital which includes social, human and constructed capital (SO, 2013)	➢ Measures and reports impact of an organization on anthro capital relative to thresholds, standards and norms (SO, 2013)
Communication	Sustainable development reports	➢ Is corporate or organizational report made by a company to reflect its contribution to sustainable development ➢ Is written in way that can be comparable with financial corporate reporting ➢ Including measurement of economic, environmental and social aspects of sustainability (GRI, 2014)	➢ Include collection of data, communication and responses ➢ Used for making the report (GRI, 2014)
	Labelling e.g. Fair trade labels	➢ Products need to respect conditions for fair trade (WFTO, 2011)	➢ Used for labelling of fair trade products
Reporting	GRI guidelines	➢ Provides sustainability reporting framework ➢ Includes economic, environmental and social aspects (UNEP/SETAC, 2009)	➢ Is used by many enterprises to provide information for assessment of socio-economic aspects (UNEP/SETAC, 2009) ➢ used for enterprise reporting

Procedural and management	**Standards and certification**		
	Fair trade certification	➢ Products need to respect conditions for fair trade (WFTO, 2011)	➢ Application is under the monitoring system for fair trade products (WFTO, 2011)
	AA 1000 series	➢ Account Ability´s standards provides management systems of organizations ➢ Is used for improvement of performance from sustainability point of view (UNEP/SETAC, 2009)	➢ Can be used for organization of any size, for every region as well as for all sectors e.g. public sector (UNEP/SETAC, 2009)
	CSRR-QS 2.0	➢ Includes the collection of CSR data, Socially Responsible Investments (SRI) activities (analysing, researching, ranking, screening, risks and opportunities assessment, etc.) and reporting all results to stakeholders ➢ Assess both environmental and social issues (Association for ICS & RR, 2006)	➢ Focuses on the operational requirements of products and services related to SRI ➢ Aims to improve quality management systems, facilitate assurance processes, form a basis for verification procedures and simulate transparency
	Guidelines		
	ISO 26000 - Social Responsibility	➢ Represents organization´s responsibility for impacts of its activities and decisions on the environment and the society (TUVRheinland, 2012) ➢ taking into account stakeholders´ expectations, society health and the welfare	➢ must be integrate through organization, practices in relationships and it must comply applicable law and international norms of behaviour (TUVRheinland, 2012)
	SIGMA	➢ Contribute to sustainable development by understanding sustainable principles through planning, monitoring, delivering and reporting sustainable development strategy ➢ Includes consideration of all three dimensions ➢ includes the holistic management of social, natural, manufactured, human and financial capital of an organization and includes exercise of accountability through transparency and responding to stakeholders	➢ Suitable for organizations of any sector (BSI, 2003) ➢ Is built on triple bottom line (TBL) concept ➢ Refers to other sustainable development frameworks such as ISO 14001, the ISO 9000 series, OHSAS 18001, Investors in People and AA 1000 framework (BSI, 2003)
	OECD guidelines for multinational enterprises	➢ Includes voluntary principles and standards ➢ Aims to ensure that company´s operations are consistent with government policies, mutual confidence with societies, improving climate, improving the foreign investments and contribution to sustainable development (UNEP/SETAC, 2009)	➢ Is used for multinational enterprises to implement best policies practice for sustainable development (UNEP/SETAC, 2009)

	BS 8900	➢ Help to implement decision-making structure to support sustainability within the organization ➢ Is British social responsibility standard ➢ Supports development of ISO 26000 (AFNOR, 2006)	➢ Helps companies to connect with other standards such as GRI Guidelines, AA1000 and ISO 14000 Series (AFNOR, 2006)
	(ISAE 3000)	➢ Aims to provide and establish principles and procedures of assurance engagement for professional accountants IFAC, 2005)	
	Other procedural and management tools		
	Performanc e measure sustainabi-lity balanced Scorecard	➢ Incorporates social and environmental aspects in management system of an organization	
	EFQM Framework for CSR	➢ Represents responsibility of enterprises to contribute to sustainable development ➢ Integrate environmental and social concerns in operations of the organization as well as in their stakeholders interactions CEC (2002) ➢ Focuses on positive relations and impact between society and business and its operations, enterprises and citizens (UNEP/UN, 2005) ➢ There are differences in CSR interpretations due to regional differences (UNEP/SETAC, 2009)	➢ Can be used by private and public sector in their operations - policy making, management and production processes (UNEP/SETAC, 2009) ➢ Helps advance CSR in management system

Community level comprises such tools and techniques that can assess the social impact on the community at local or national level. These tools and techniques are focused on perception of residents. Tools and techniques within community level are presented in Table 5.

Table 5. Social sustainability assessment tools and techniques on the community level

Community			
Tool type	**Tool/technique**	**Main characteristics**	**Application and limitations**
Analytical	Participatory Action Research	➢ Is public research of health ➢ Is based on data collection, reflection and action that improves health	
	Agro Ecosystem Analysis	➢ Is strict framework with interdisciplinary interaction (Conway, 1985) ➢ The results are system properties such as stability, productivity or sustainability	➢ In workshop environment ➢ Defining the objectives by participants, relevant analysis and boundaries and then these information are analysed in term of time, space and decisions (Conway, 1985)
	Applied Anthropology	➢ Solving problems of humans by gathering information from anthropology	
	Farming systems research	➢ Relates to agricultural production ➢ Focuses on farming and its interaction between farms and social, natural and economic aspects ➢ There are three characteristics: interdisciplinary, participatory approach and system thinking	➢ Applied on farm scale
	Rapid Rural Appraisal	➢ Represents the bridge between methods of research such as focus group or depth interview and formal surveys (FAO,2009)	➢ To obtain information and formulate hypotheses about life in rural areas ➢ Carried by team of members from different disciplines (FAO,2009)
	Semi-directed and open interviews	➢ Includes open-ended questions	➢ Is used to know the community perception
	Questionnaire	➢ I used for collecting information from a large number of individuals ➢ Includes structured groups of questions	➢ Is used to know the community perception

	Surveys	➢ Is used for collecting and analysing information/data from individuals or units such as households in a systematic way	➢ is used to know the community perception
	Focus group	➢ Is group interview ➢ Focuses on communication between participants of research and generate data (qualitative) about specific group of population	➢ Application includes assessing needs of community, collecting data and information for development of questionnaires etc.
	Directed interviews	➢ Is face to face interview	➢ Asking for specific questions within specific time
Procedural and management	Local Agenda 21	➢ Refers to Agenda 21 ➢ Is strategy of local authority that help to achieve sustainable development goals at the local level ➢ Main goal is to improve quality of life ➢ Focuses on all three dimensions - economic, social and environmental (SE, 2012)	➢ Strategy following discussions with local citizens about their opinions of improvements within the locality (SE, 2012) ➢ Is based on community participation and co-operation
	SD 21000	➢ Is French social responsibility standard ➢ Promote consideration of the sustainable development in companies´ strategies and during development of their policies ➢ Offers a management system to implement ➢ Aims to help with the development of organization´s strategy that will take into account operation of companies and global effect on the life as well as provide recommendations to meet sustainable development goals and integrate its management into CSR goals (AFNOR, 2006)	➢ Is French guide on sustainable development management for companies (AFNOR, 2006)
Moni-toring	Evaluation	➢ Presents various possibilities how to evaluate the project or plan	➢ Is process that examines project critically from all possible perspectives with use of the pros and cons
Commu-nication	Campaigns	➢ Are series of activities intended to achieve desired goals ➢ are information based, media and communication based	➢ Refers to public-awareness strategies e.g. public health campaign

3.2 Energy technologies (Phase 2)

3.2.1 Identification of existing energy technologies

This paper is focused on social assessment of energy technologies thus all existing energy technologies need to be identified. Following 9 technologies were identified from appropriate literature: solar, wind, biomass and waste, geothermal, hydroelectric, ocean, nuclear, fossil fuels and Carbon Capture and Storage (CCS) energy technologies. Diagram of energy technologies presented in Figure 6providesdetailed information about subdivision of these technologies.

At the beginning, energy technologies were divided into two groups: Renewable and non-renewable energy technologies. Renewable energy technologies use renewable energy sources and non-renewable energy technologies use non-renewable sources such as coal or gas. EU Commission (2013) defined renewable energy source as follow “Renewable energy sources are defined as renewable non-fossil energy sources: wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogases”.

The term ‘renewable’ is often connected with the term ‘inexhaustible’. However the nuclear energy technology is classified as non-renewable due to uranium use as a source of energy, Cohen (1983) thinks that it can be considered as a renewable. He took into consideration the reactors that can be fuelled by replenished uranium from seawater.

The biomass technologies are also questionable. In case of using wood from forests and woodlands as a fuel the biomass energy technology should not be considered as a renewable (Gritsevskyi, 2008).

Even though the Carbon Capture and Storage (CCS) technology has been included in energy technology diagram it has not fulfil the definition of energy technology is presented in Section 1.4, CCS does not generate electricity or heat but it mitigates negative impact of some non-renewable energy technologies by capturing and storing CO_2 (CCSa, 2014).

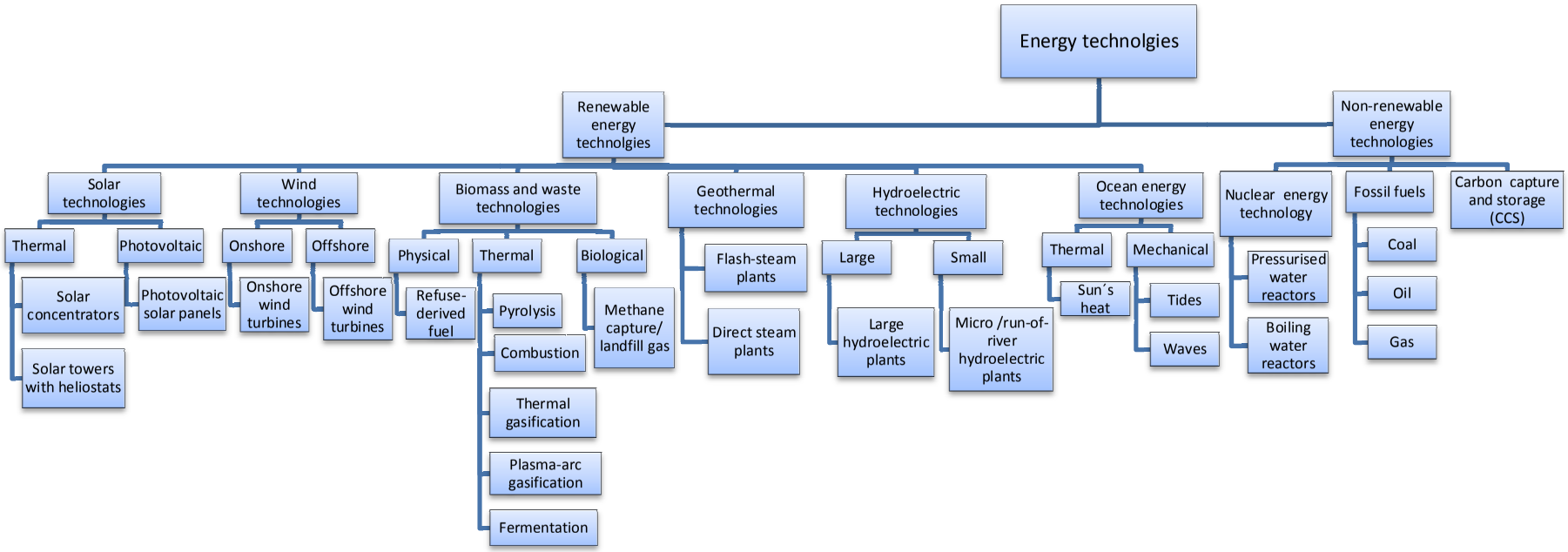

Figure 6. Energy technologies diagram

(adapted from Demirel, 2012; Renewable Energy World, 2014; Ngo, 2010; Gritsevskyi, 2008)

3.2.2 Overview of the potential social impact of energy technologies

The research of social aspects, indicators and factors has been conducted to express potential social impact of solar, wind, biomass and waste, geothermal hydroelectric, ocean, nuclear fossil fuels and CCS energy technologies. Several social aspects, indicators and factors have been selected and the potential positive or negative social impact is shown in Table 6.

Table 6. Social impact of energy technologies

Energy technology / Social aspect/indicator	Health	Aesthetics	Noise	Job creation/ provision of employment[a]	Energy[b] security
Solar	-	- -/-	0	+/++	+
Wind	?	-	-/0	+	+
Biomass and waste	?	-	-	+	+
Geothermal	-	-	-	+	+
Hydroelectric	-	- -	?	+/++	+
Ocean	-	-	-	+	+
Nuclear	- -	-/- -	-	+	++
Fossil fuels	- -	- -	?	+	++
CCS	+	?	?	?	?

(adapted from Carrera and Mack, 2009; Pappas et al., 2012; Maxim, 2014; Lewis et al., 2011; Dickson and Fanelli, 1995;Pires et al., 2011)

[a] considering Number of employees per unit of electricity produced (job-years/GW h)

[b] considering average capacity of plant/project (in MW)

Score	Assessment of impact
+ +	potential significant positive impact
+	potential positive impact
- -	potential significant negative impact
-	potential negative impact
0	no impact
?	gaps in evidence

Social impact can be measured through social indicators. The levels of social impact, presented in Table 6, are predominantly based on researches that evaluate social indicators such as health and aesthetics(Carrera and Mack, 2009) or visual disturbance or noise of energy technologies. Remaining aspects/indicators, job creation and energy security, use data from studies on characteristics of energy technologies such as number of employees employed per unit of electricity produced or average capacity of plant/project (Maxim, 2014).Furthermore, studies on ocean, geothermal and CCS technologies have been used as well (Lewis et al., 2011; Dickson and Fanelli, 1995; Pires et al., 2011).

The most of social aspects/indicators of energy technologies relate to quality of life such as health, aesthetics and noise. Almost all energy technologies have negative social impact on the health, noise or aesthetics. CCS technology has a positive social impact due to capturing CO_2 (CCSa, 2014).

Even though renewable energy technologies such as solar, wind or biomass were evaluated as those technologies with negative impact on health (Carrera and Mack, 2009),they still can have positive social impact in case of implementing these technologies instead of non-renewable alternatives such as fossil fuels energy technologies. According to Akella et al. (2009) the improved health is one of the social benefit of renewable energy system.

Refer to social impact of wind energy technology, there are differences in noise disturbance of onshore and offshore energy technologies. There is no noise disturbance of offshore wind farms and the level of noise disturbance of onshore wind farms depends on the distance of local community (Pappas et al., 2012). The aesthetics differ in assessment of solar energy technologies. Visual disturbance is higher if solar panels are situated self-standing than they are situated on roof top(Pappas et al., 2012). All energy technologies contribute to job creation and energy security in some extent.

For a more comprehensive and accurate results of social impact are needed detailed information the plan/project and characteristics of energy technology such as place or size of power plant. Social sustainability assessment

tools/techniques, presented in Section 3.1, shall be used for deeper analysis of social aspects.

3.3 Development of a DST (Phase 3)

To select the most appropriate tool/technique is a challenge. Thus the DST will be developed to help the decision maker to select the most appropriate tool/technique. Available forms of the DST were discussed in Section 1.4 as well as some benefits of its use. A DT was selected as the best choice from all alternatives. Before starting the development of the DT, the set of tool/technique applicable to energy technologies has to be identified.

3.3.1 Selection of social sustainability assessment tools/techniques applicable to energy technologies

After identification and evaluation of social sustainability assessment tools/techniques and existing energy technologies, tools and techniques suitable for assessment of energy technologies need to be selected.

As mentioned before social sustainability assessment tools/techniques are divided into five levels: project, intervention or facility, product, community, organization and sector/country level. These levels refer to the object of an assessment. Since the tools/techniques within community level assess the community, tool/techniques within organization level are used for assessment of the corporate impact and tools/techniques within sector/country level assess the country or sector, such tools/techniques are not relevant for application to energy technologies. Even though some tool/techniques within the community level can be used in other social sustainability assessment tools. Tools and techniques within the community level can be also used in order to find out the social acceptance of energy technologies.

For the selection of social sustainability assessment tools/techniques, Table 7 was created. Table 7 includes following information criteria for selection: sustainability dimension, level of analysis, social aspects and overview of applied case studies. These information are useful not only for selection of

tools/techniques suitable for energy technologies but also for development of a DT.

Some social aspects can be assessed within several tool/techniques but in different extent. For example HRIA is focused on human rights, one of the social aspects, in bigger extent than ESIA that assess all social aspects, including human rights(The World Bank/NTF, 2013).

There is possibility to use a combination of several tool/techniques for sustainability assessment. SLCA can be used separately or as a complement of LCA (SEAT, 2010). SLCA assess only social impact but together with LCA can assess both, social and environmental impact.

Table 7. Social sustainability assessment tools/techniques for energy technologies

Tool/ Tech-nique	Focus - Sustainability dimension	Levels of analysis	Social aspect	Case studies related to energy technologies	Appli-cable to en.Tech-nology
SIA	Social dimension	Program/policy/projects/plans level	All social aspects	SIA for proposed Valleydora Photovoltaic power plant free state province in 2012	Yes
HIA	Social dimension	Project/plan/ policy level	Health impacts	HIA of integrated wood processing and electricity generation plant in Newbridge	Yes
SEA	Environmental, economic and social dimensions	Program/policy/plans level	All social issues	SEA of the Offshore Renewable Energy Development plan in Ireland	Yes
HRIA	Social dimension	Corporate/ country/site/ product level	Human rights	N/A	No
SA	Environmental, economic and social dimensions	Plan/programme/project level	All social aspects	N/A	No
ESIA	Environmental, economic and social dimension	Project/plan/ policy level	All social aspects	MTKVARI hydroelectric Power plant project	Yes
SA 8000	Social dimension	Facility level	Worker´s rights	Dahanu Thermal Power Station	Yes
OHSAS 18001	Social dimension	Facility level	Occupational health and safety	Dahanu Thermal Power Station	Yes
SLCA	Social and economic dimension but economic only to some extent	Product level	All social aspects	N/A	Yes
TA	Environmental, economic and social dimensions	Project/plan level	All social aspects	Solar Thermal Technology Assessment – U.S. Department of Energy	Yes
Social Audit	Environmental, economic and social dimensions	Facility/Product/company level	All social aspects	N/A	No

From Table 7there were identified eight social sustainability assessment tools/techniques applicable to energy technologies. Social sustainability tools/techniques that can be used for assessment of energy technologies are SIA, ESIA, TA, SA 8000, OHSAS 18001, SEA, SLCA and HIA. The applicability to energy technologies was clarified by existing case studies and information about their application.

Human Rights Impact Assessment (HRIA), Sustainability Appraisal (SA) and Social audit are not applicable to energy technologies. HRIA is used for stakeholders monitoring in the human rights field(Lenzen and d´Engelbronner, 2009). SA is conducted during preparation and developing phase of a Local Plan and Social audit assess sustainability benefits and limitations of an organization or of the production facility (Eavani et al., 2012). The audit is predominantly focused on working conditions of employees. Due to these information the possible application to energy technologies was rejected.

3.3.2 Development of a DT for social sustainability assessment of energy technologies

The simple DT in Figure 7provides step-by-step guidance for selection of tool/technique.

The DT is drawn starting on the top and moving down. The decision nodes, chance nodes together and the branching lines have been used for the development of a DT. Chance nodes are represented by round shape and decision nodes have square shape. Binary splitting criteria has been chosen for an extraction of information from a Table 7 with use of questions and sub questions.

DT starts with making sure that the decision maker knows what social sustainability assessment is and if the decision maker wants to assess social sustainability assessment of energy technologies. Other questions and sub questions ask for sustainability impact and object of the assessment.

The DT should not be used itself but together with other information provided by this study. The decision maker can use the DT in the first phase of the decision making and then use other information about the individual tool or technique. The results of a DT are illustrated by decision nodes. The decision nodes include recommended tool/technique or group of tools/techniques. The DT works under the assumption that the decision maker is deciding according following criteria: dimension focus, level of assessment and focus on chosen social aspect.

As an example of use the DT in practice the case study of Health Impact Assessment (HIA) in New bridge can be used. HIA was used for assessment of Integrated Wood Processing Plant in 2000. Main input information include the object of the assessment - power plant. The main priority was evaluate the health impact (Las, 2000).

The DT starts with questioǹ Do you want to undertake social sustainability assessment of energy technologieś. The decision maker has to be sure that he knows what is meant by terms`social sustainabilitý and`energy technologý.

Then follows the question`Do you want to assess also environmental impact and/or economic together with social sustainability assessmenť. Several tools/techniques considered to be applicable to energy technologies can assess social aspects as well as economic and environmental aspect. The answer for this question would be negative.

Questions̀ The object of assessment is only a device of energy technology component in term of a product e.g. solar paneĺ and`The object of assessment is power plant project, intervention or facility´ refer to the level of assessment. Energy technologies can be recognized from several perspectives i.e. product, power plant project, plan, facility perspective. Since the object of the assessment is wood processing power plant, the answer for the first question would be negative and then positive for the second question.

Following questions̀ Focus on workers´ rights onlý and`Focus on health only´ are asking for the specific social aspect/indicator. Social sustainability

assessment tools/techniques that are applicable to energy technologies can be focused on human/workers rights, health or on all social aspects. Taking into consideration the preferences of decision makers, the result of this case study example is the proposal to use HIA or OHSAS 18001. Whereas OHSAS 18001 is standard focused on health and safety of workers (AFNOR, 2006), the HIA is the technique focusing on health of all stakeholders (WHO, 2014). Thus the final decision would be upon the decision maker.

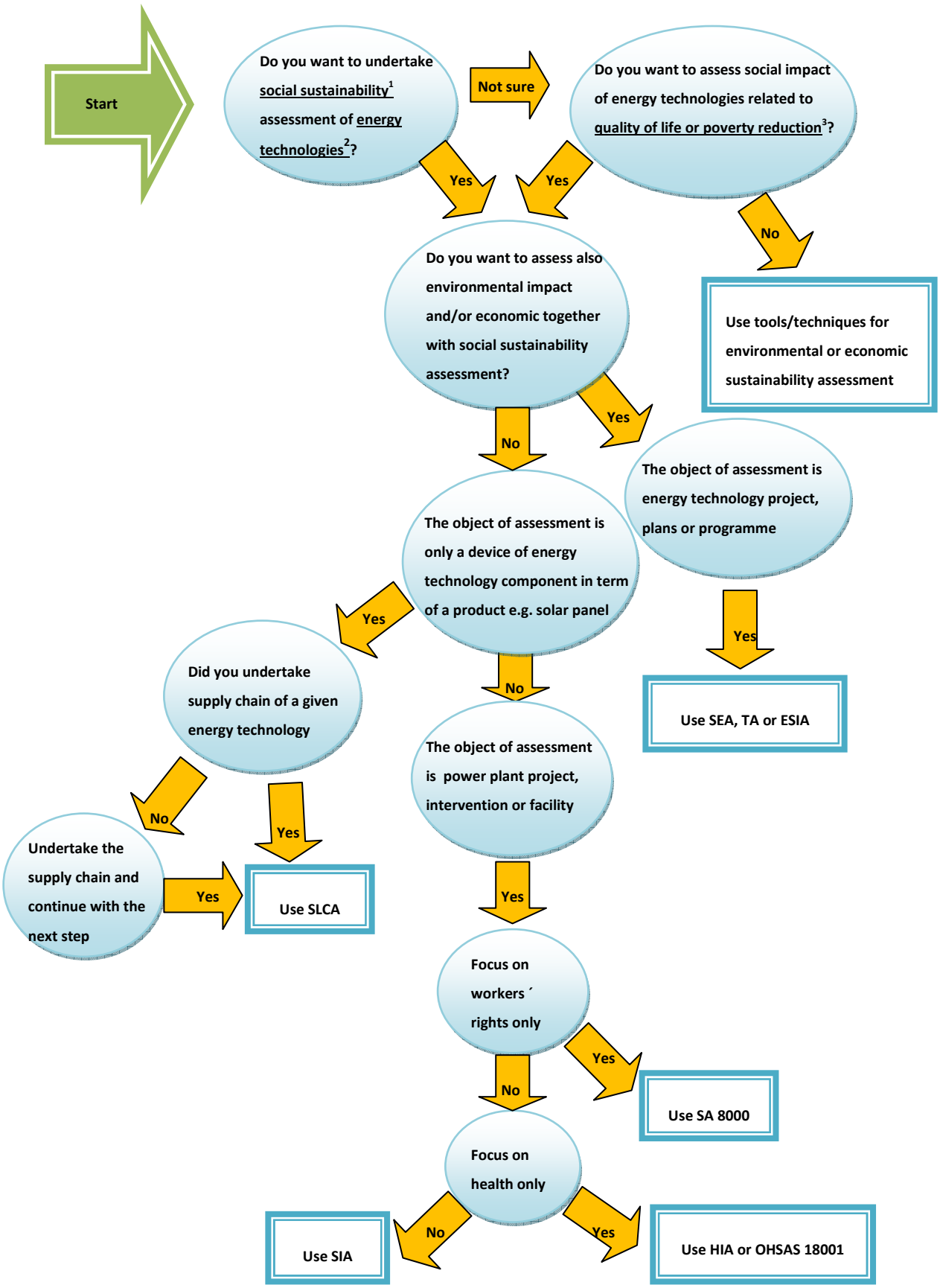

Figure 7. DT for social sustainability assessment of energy technologies

Table 8.DT explanatory notes

1	Social sustainability relates to following social aspects: Social cohesion, quality of life, basic needs and equity, sense of place, education, social capital, integration and diversity (Åhman, 2013).
2	Energy technologies are technologies that generate heat or electricity. There are solar, wind, biomass and waste, geothermal hydroelectric, ocean, nuclear fossil fuels and CCS energy technologies.
3	Quality of life can include social aspects such as health, safety, aesthetics or noise and the poverty reduction includes job creation.

The presented DT was developed for the purpose of support decision making in sense of selecting the most appropriate tool and technique from all possible alternatives. The DT is self-explanatory, easy to understand (Pathak and Pal, 2013) and fast tool. Because of these properties, the DT can be even used by non-expert in field of sustainability science.

4 Conclusion

This thesis focuses on social sustainability assessment of energy technologies through identification and evaluation of social sustainability assessment tools/techniques and existing energy technologies.

The social sustainability assessment tools/techniques and energy technologies were investigated in two phases in order to gain the information about the applicability of tools/techniques to energy technologies. The third phase comprises the development of a Decision Support Tool, in form of a Decision Tree that can help the decision maker to select the most appropriate tool or technique.

The social sustainability assessment tools/techniques can be used for assessment from project/plan or facility, product, organization, community and country perspectives.

It was analysed that energy technologies have both positive and negative social impact. Tools and techniques for social sustainability assessment shall be used for providing deeper analysis of social aspects.

As a result, 53tools and techniques for social sustainability assessment were identified and evaluated with taking into account their characteristics and application. Out of these tools and techniques, 8 were considered to be applicable to energy technologies. The analysis of energy technologies can be conducted from project, plan, facility or product perspective.

The presented DT supports the decision making in sense of selecting the most appropriate social sustainability assessment tool or technique from all possible alternatives and time reduction during the decision making process.

5 Recommendations

Finally more future research on social sustainability tools and techniques is necessary due to updating current list of tools and techniques.

Once the DT becomes fully developed, it should be tested in order to support its utility and the validity. However before that stage is reached, many challenges remain and further research is needed.

Further development of a DT can by supported by questionnaires including questions about the decision maker´s criteria and preferences during the selection of social sustainability assessment tool/technique.

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