WORLD ENERGY COUNCIL | FUTURE ENERGY LEADERS

The Shades of Green

Energy Environmental Sustainability Criteria and Indicators | 2019

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The Council's Future Energy Leaders form a community of exceptional young professionals from across the globe representing the different players in the energy sector, composed of, government, energy industry, academia, civil society and social entrepreneurs. This community of young professionals share a commitment to shape the global energy future.

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ABOUT THE SHADES OF GREEN: ENVIRONMENTAL SUSTAINABILITY CRITERIA AND INDICATORS

The Shades of Green: Energy Environmental Sustainability Criteria and Indicators | 2019 was produced by Market of Ideas- Environmental Issues.

This report stemmed from the observation that defining environmental sustainability of energy is not a simple task or process. It summarises and discusses the most commonly used environmental and energy indicators all over the world among frameworks, ratings and indices paying attention to their practical implications and representativeness. It discusses the shades of green that can be observed when measuring and defining the environmental sustainability.

Drawing on the experiences, studies and sustainability reportings, this report presents and evaluates different approaches to energy environmental sustainability. The report suggests a variety of ways that the "greenness" of energy can be quantified or qualified when looking at the whole life cycle of energy.

FOREWORD, THE SHADES OF GREEN

Our society is facing multiple challenges. Climate change is resulting in accelerated sea level rise, stronger hurricanes as well as more droughts and intense heat waves. Global population growth and demographic change are presenting distinct changes in different regions – The Western world is ageing, whilst birth rates and life expectancies are changing and modifying emerging regions dramatically. All around the world people are leaving the countryside and moving to cities, thus transforming both cities and the countryside alike. These are only a few of the biggest challenges to mention.

The role of energy is crucial when solving these challenges. We need to find ways to fulfil the energy needs of the changing society with solutions that do not burden the environment or increase the amount of greenhouse gases in the atmosphere. Similarly, we need universal access to affordable energy services to provide modern energy to all those who still lack the access to it. We need energy that is accessible and reliable to keep society running.

To reach these goals, we need sustainable energy. Building the sustainable energy system is currently the biggest challenge to the energy sector. To achieve sustainability, we need to know what sustainability means and we need to be able to measure the different aspects of sustainability. Without this knowledge, we cannot even begin to create the right goals needing to be chased.

Before being able to reach sustainability, we need to understand the complexity of the concept, otherwise we could be misled. For example, since climate change is one of the most pressing challenges at the moment, the amount of carbon dioxide create during energy production is measured. Usually in addition to the amount of renewables used in the energy system. However, to really achieve a sustainable energy system, this is not enough. We need to have a wider perspective and include other environmental and social impacts in the review. Also, we need to consider the impacts of the complete life cycle of different energy sources and energy systems. Beginning from ore mines all the way to the customer. If our focus is only on one stage of the life cycle or on one form of impact, we might end up optimising only part of the process. Only by comprehensive thinking can we understand that low-emission might not always mean low impact and renewable does not always mean environmentally benign.

To avoid partial optimisation, it is important to gather more data, acquire more information, and increase our understanding of the implications of sustainable energy. The Shades of Green report by FEL-100 representatives gives a good overview on the concept of sustainability, especially in the environmental sustainability context. Also, it presents different methods to evaluate the sustainability of energy, corporations and countries, and highlights the importance of life cycle analysis.

Knowledge and understanding surrounding the sustainability of energy is crucial to achieve our common goals when considering both climate change mitigation and social welfare. We need to understand the impacts of different energy solutions in all sectors: in the policy making, corporate strategy formulation as well as in our everyday choices. Without understanding, we cannot reach a sustainable energy system.

It is natural that young generations are interested in the future. In the end, they are the ones who are going to be living in it. The Shades of Green report illustrates the enthusiasm of young generation to imagine and share the pathway towards a sustainable tomorrow, and most importantly their willingness to work for it. If someone is going to be able to build the sustainable energy future, it is for sure the Future Energy Leaders.

Pirjo Jantunen
Former Chair of Future Energy Leader's Board

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EXECUTIVE SUMMARY

Environmental sustainability is one of the aspects being used to make decisions on the future energy mix, rank various sources of energy as well as characterise energy and energy systems. Existing reporting, rankings, statistics methodologies and frameworks suggest different visions of defining and measuring the environmental impact of energy. Environmentally sustainable energy is often called “green” and all the various explanations of the “green energy” form “the shades of green”. The authors of the paper summarised existing sources as well as suggested their understanding of energy environmental sustainability and discussed the ways it could be defined and measured.

KEY FINDINGS

Despite the variety of “sustainability” definitions, there is a common understanding that it should be measurable. The review of available publications in the area of energy environmental sustainability and professional experience in the energy field has led the authors to the following key findings:

1. Many shades of green exist for energy and there is a wide range of ways to measure energy environmental sustainability. One of the most commonly used indicators in energy production is the measure of GHG emissions, although many others also exist.
2. Corporate sustainability reporting tools cover wide range of environmental indicators often prioritised according to the opinion of external stakeholders. There is an increasing movement from Corporate Social Responsibility to Creating Shared Values driven by the corporate strategy. Environmental issues entangled with the sustainability pillars are being integrated into company competitiveness, increasing strategies whilst creating social and economic value for the community.
3. To measure how green the energy is, it is useful to look at its entire life cycle – only the full life cycle can demonstrate the true level of environmental sustainability.
4. Renewable energy is not *a priori* sustainable. Environmental impacts of renewable energy sources may be considerable if the whole life cycle is analysed and sustainability criteria should be met to call it “green energy”;
5. Indicators exist to compare, but before making any conclusions, it is important to check the data as differences in methodologies can make similar indicators incomparable.

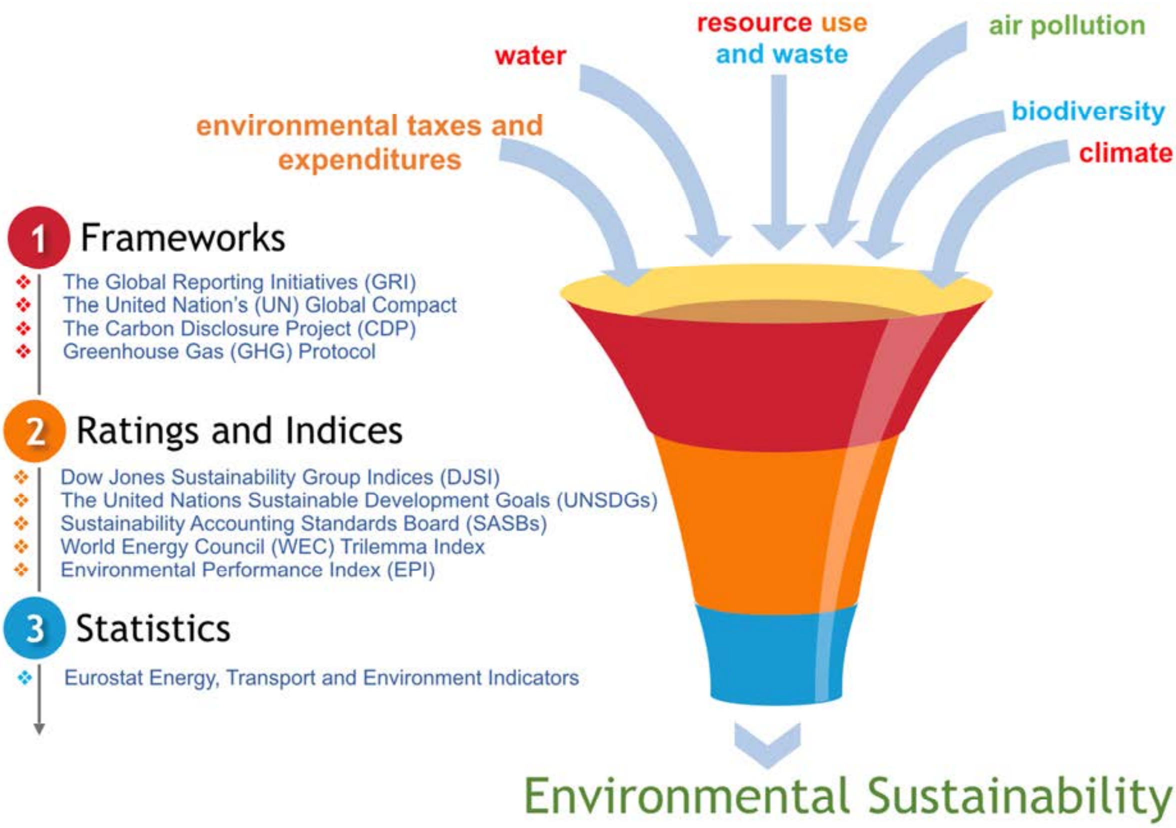
THE SHADES OF GREEN

Many organisations agree that taking care of the environment is important. Is "being sustainable" uncompromising with business objectives? Is being "green" a waste of time in today's competitive world? There are different "shades of green" that can fit with a variety of global and business targets.

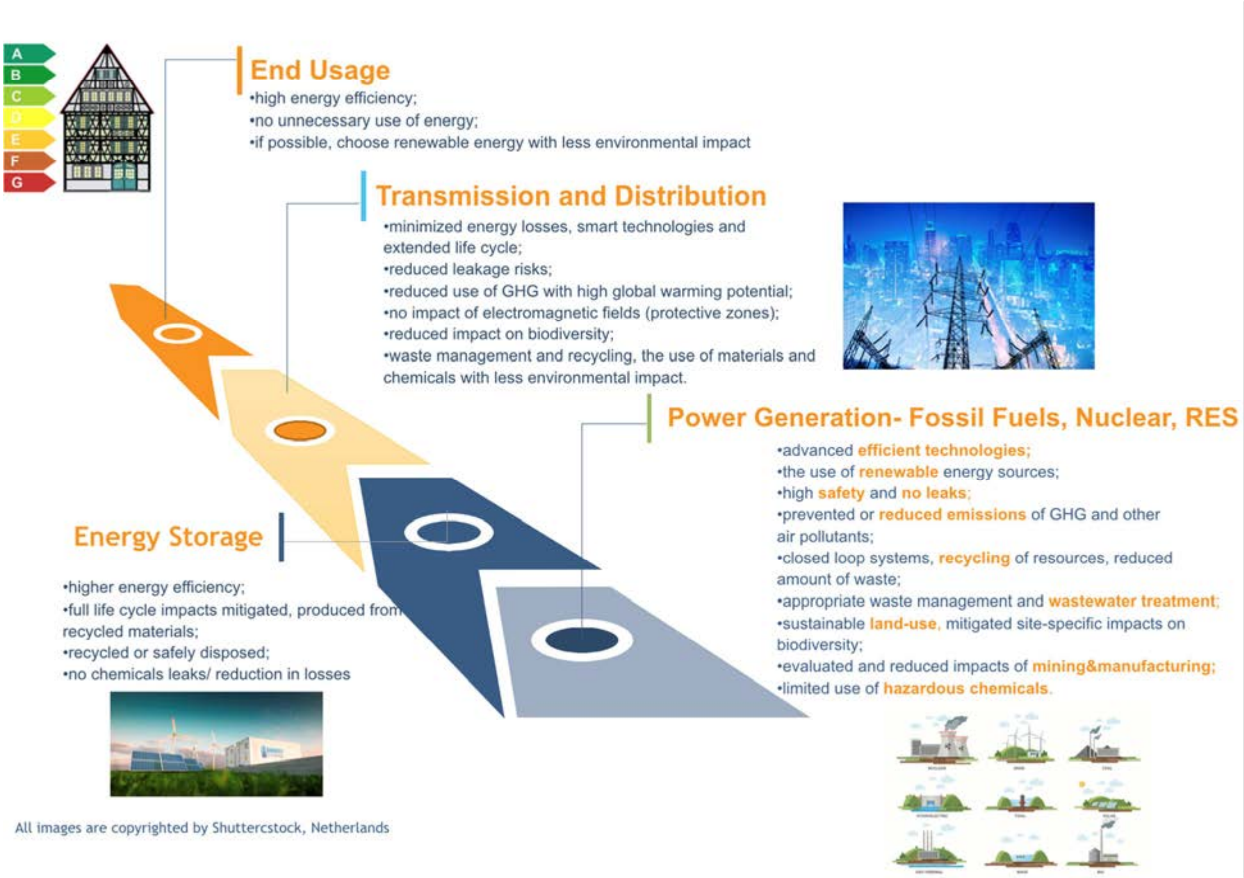
Sustainability themes included in reporting frameworks, standards, ratings and indices vary from only taking into account impacts on climate to also considering other aspects, such as impacts on biodiversity and water, resource use and waste - different shades of green.

Environmental sustainability is one of the aspects being used to make decisions on the future energy mix and rank various sources of energy. What are the "measurement units" of energy environmental sustainability? Which source of energy is more or less "green"?

A sustainability report gives information on a company's performance and commitment to its sustainable development. How easy is it to actually compare the numbers given in different reports? One group of data regarding greenhouse gas emissions does not simply answer the sustainability question or indicate its ranking. The data and life cycle stages taken into account can vary between reports.



ENVIRONMENTALLY SUSTAINABLE ENERGY



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WHICH ONE IS THE GREENEST?

	Company 1		Company 2	Company 3	Company 4
	0.06 ton CO_2/MWh*		0.4 ton CO_2/MWh*	0.015 ton CO_2/MWh*	0.03 ton CO_2/MWh*
Company Profile	Energy Generation and Distribution		Energy Generation and Distribution	Energy Generation	Energy Generation and Distribution
Year of the report	2017		2015	2017	2017
CO_2 emissions covered by indicator					
	Energy Generation … Yes Auxiliary Process … Yes Distribution Losses … No		No information available	Power Generation … Yes Auxiliary Process … No Distribution Losses … No	Energy Generation … Yes Auxiliary Process … Yes Distribution Losses … Yes

*Based on annual reports of actual companies from the same market area, all located in Northern Europe

IMPLICATIONS FOR THE ENERGY SECTOR

Which source of energy is more or less "green"? Driven by the view on future perspectives, legal platforms, as well as social and economic aspects, the question surrounding the growing importance of environmental concerns often arises in the energy sector. There is no simple answer to this question. As an example, the environmental impact of energy is being evaluated using such tools as the World Energy Council Trilemma Index and the World Energy Scenarios by using different "shades of green". This report suggests ways that the "greenness" of the energy can be quantified or qualified looking at the whole life cycle of energy.

Environmental indicators and criteria provide an opportunity for decision-makers and energy-suppliers to compare energy sources from a consumer perspective. However, the variety of methodologies can lead to a certain range of results due to the following different approaches: the boundaries of the data the indicator includes (activities and life cycle stages covered), environmental areas covered and prioritization of environmental impacts.

The importance of an environmental performance evaluation in the energy sector is related to the access of financial instruments such as EU funds, green bonds or international bank loans.

RECOMMENDATIONS

- The focus on GHG emissions for evaluating environmental impacts on the energy sector has its reason – the urgent global impact of GHG emissions and the potential effects on our climate. Although, to provide a broader view, it is important to expand the range of relevant indicators and environmental impacts being used for energy and energy systems evaluation (e.g. impact of biomass on air quality or impact of hydro on fish resources etc).
- Energy generation is the most frequently evaluated stage of the energy life cycle. When considering emissions, it means defining renewable energy as "zero emission" technology, making all the renewable energy sources equal from an environmental point of view. This approach limits the choice between more or less sustainable renewable energy. Expanding analysis with manufacturing, transportation and the waste management of renewable technologies ensures a truer picture of environmental performance.
- One of the limitations with expanding environmental evaluation of the energy is the lack of global comparable data for all regions. EU energy statistics are a good example of data that covers most energy environmental aspects and tends to reflect the full life cycle. Improving quality and reliability of energy statistics is one of our recommended future developments.

Introduction

INTRODUCTION

In the last two decades, the concept of sustainability has gained increasing prominence across the globe. Whilst understanding of sustainability varies, the most commonly accepted definition comes from the Brundtland Report[1] which states that "Sustainable development is development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs". A more exact definition has been given by Szekely and Knirsch[2] as they define sustainability for corporations as "sustaining and expanding economic growth, shareholder value, prestige, corporate reputation, customer relationships, and the quality of products and services". According to the United Nations (UN) there will be around 11.2 billion people living on Earth by the year 2100[3]. Population rise means that there will be a higher demand of supplies like water, energy and other natural resources. Fortunately, we are in a generation where more and more people are being informed about the need to be sustainable for the sake of next generations. Even most companies are convinced that being a sustainable corporation is something that they must address to improve their brand value and reputation.

There are many prejudgments about corporate sustainability. Although many organisations agree with the idea that taking care of the environment is important, they may also assume that "being sustainable" will compromise business objectives. Being "green" can be seen as a waste of time in today's competitive world. However, sustainability can take many different forms meaning how corporations respond can be made in a personalised and strategic way. There are different "shades of green" that can fit with as many business targets as needed. For example, some organisations aim to reduce the environmental impacts of their products whilst others use radical innovations that result in a complete change in their business model. There is no set of rules for how a company can "go green". What works and what doesn't work depends on the "shade of green" a firm is aiming for: a "light green" strategy of reducing environmental damage will have different implications than a "dark green" strategy which may aim at producing in a sustainable way. "Shades of green" is basically the way that an organisation would prefer to apply sustainability strategy into their business models.

Despite the variety of definitions, there is a common understanding that to define how a corporation is doing with respect to sustainability, it should be measurable[4]. This has been the key motivator for the development of corporate sustainability reporting tools (SRTs), which like sustainability, is also known with various terminology e.g. corporate social responsibility (CSR) reporting, sustainable development (SD) reporting, triple bottom line (TBL) reporting, non-financial reporting, and environmental, social and governance (ESG) reporting[5]. Each reporting tool addresses a different aspect of the three pillars of sustainability. The three pillars include: economic, social, and environmental factors.

The historical background of such reporting is interesting. Marlin and Marlin[6] suggest that the first phase of CSR reporting was between the 1970s and 1980s. Here, the focus was merely on the reporting of a

[1] WCED – World Commission on Environment and Development, 1987. Our Common Future. Oxford Univ. Press, Oxford.
[2] Szekely, F., Knirsch, M., 2005. Responsible leadership and corporate social responsibility: metrics for sustainable performance. Eur. Manag. J. 23 (6), 628e647.
[3] World population projected to reach 9.8 billion in 2050, and 11.2 billion in 2100, 2017, https://www.un.org [Accessed in December 2018]
[4] Ozdemir, E.V., Hardtlein, M., Jenssen, T., Zech, D., Eltrop, L., A confusion of tongues or the art of aggregating indicators e reflections on four projective methodologies on sustainability assessment. Renew. Sustain. Energy Rev. 15 (5), 2385e2396. 2011
[5] Siew, R. Y. A review of corporate sustainability reporting tools (SRTs). Journal of environmental management, 164, 180-195. 2015
[6] Marlin, J.T., Marlin, A.T. A Brief History of Social Reporting, 2003

corporation's compliance regarding environmental management. There is no real linkage to corporate performance. Then, in the 1990s, a paradigm shift to reporting on occupational health and safety (OHS) or community-based activities can be observed, followed closely by the institutionalisation of the triple bottom line concept. The triple bottom line emphasises a wide spectrum of values and measures a corporation's performance across the three main pillars of sustainability.

Most companies view sustainability reporting tools as an opportunity to benchmark and improve sustainability performance. However, some view them as a waste of time, effort, money, and resources with no positive bottom-line impacts. Sustainability reporting requires companies to gather information about processes and impacts that they may not have measured before. This new data, in addition to creating greater transparency about firm performance, can provide firms with the knowledge needed to reduce their use of natural resources, increase efficiency and improve their operational performance. In addition, sustainability reporting can prepare firms to avoid or mitigate environmental and social risks that might have material financial impacts on their business whilst delivering better business, social, environmental and financial value. In turn, creating a virtuous circle[7]. The Business Review article, “Creating Shared Value”, by Michael Porter and Mark Kramer introduced the concept of using corporate policies and practices to enhance the competitiveness of a company in 2011. This concept encouraged increased competitiveness whilst simultaneously advancing social and economic conditions in the communities that the company sells and operates in. There is an increasing movement from Corporate Social Responsibility (CSR) to Creating Share Values (CSV). To understand the difference between CSR and CSV, Table 1 shows the baseline of these two concepts for comparison.

Table 1: Comparison between CSR and CSV

Bases	Corporate Social Responsibility (CSR)	Created Shared Values (CSV)
Motivation/focus	Corporate reputation	Competitive advantage
Main driver	External stakeholders	Corporate strategy
Approach	Reactive and defensive	Proactive
Measurement	Spending, standard ESG metrics	Social and economic values
Business benefits	Risk reduction and goodwill	New business opportunities
Social benefits	Successful projects	Large scale, sustainable chain
Value	Doing good	Economic and social benefits relative to cost
Type	Citizenship, philanthropy, sustainability	Joint company and community value creation
Profit definition	Separate from profit maximisation	Integral to profit maximisation
Motives	Discretionary in response to external pressures	Integral to competing strategy

[7] EY and Boston College Center for Corporate Citizenship. Value of Sustainability Reporting, 2016

Budget	Impact limited by company's footprint	Realign the entire company's budget
Agenda	Defined by external reporting and personal preference	Company's specific and internally guidelines
Person (s) in charge	Typically led by CSR, marketing, corporate communications, external/public/ government affairs, community relations, sustainability and foundation departments	Typically led by CEO, senior executive team and individual champions across the company in close collaboration with corporate affairs and sustainability departments

Source: Porter, Kramer, (2011). Creating shared value: How to reinvent capitalism - and unleash a wave of innovation and growth[8]; Ozdemir, Hardtlein, Jenssen, Zech, Eltrop (2011), A confusion of tongues or the art of aggregating indicators e reflections on four projective methodologies on sustainability assessment[9].

The scope of this report is to discuss how environmental sustainability in energy production can be measured, summarised and analysed by different corporate SRTs and to show the indicators and criteria used. The subsequent sections will discuss the dimensions of energy environmental sustainability as well as explore, the wide spectrum of corporate SRTs in frameworks, ratings and indices. Frameworks typically refer to principles, initiatives or guidelines provided to corporations to assist them in their disclosure efforts. Ratings and indices are third party evaluation of a corporation's sustainability or ESG performance. For energy companies, sustainability reporting and high-level environmental performance is not only related to its reputation but also to its attractiveness for consumers following “the green trend”. It also opens financial opportunities and sometimes is a binding requirement to access financial sources. Some examples can be seen below:

- European Investment and Reconstruction Bank (EIB) Environmental and social standards[10] which are applied to EIB borrowers and project promoters;
- Growing interest for the Green bonds – bonds whose proceeds are used to finance eligible projects with proven positive environmental impact audited by the third parties;
- EU funds available for the projects complying with EU climate and environmental policies.

There are plenty of environmental indicators and sustainability criteria used worldwide to characterise the environmental impact of energy. This report summarises and discusses the most commonly used environmental and energy indicators all over the world within frameworks, ratings and indices paying close attention to their practical implications and representativeness. In the scope of this booklet, reviews are made to develop common perspectives in terms of environmental energy sustainability.

[8] Porter, M., & Kramer, M. R. Creating shared value: How to reinvent capitalism - and unleash a wave of innovation and growth. Harvard Business Review, 89(1/2), 62–77. 2011
[9] Ozdemir, E.V., Hardtlein, M., Jenssen, T., Zech, D., Eltrop, L. A confusion of tongues or the art of aggregating indicators e reflections on four projective methodologies on sustainability assessment. 2011
[10] European Investment Bank. Environmental and Social Standards Overview, 2018

ENVIRONMENTAL REPORTING AND RANKING METHODOLOGIES

1. OVERVIEW OF METHODOLOGIES

As discussed in the introduction section, no matter what "shade of green" a company is aiming for the way that they show their approach also matters. Sustainability is not a uniform "shade of green" with a one-template-fits-all solution. For corporations, they can look to define what green is for them by following different principles that can be found in the section below.

This section provides an overview of the most well-known frameworks, ranking, and sustainability reports showing their relevant qualities such as type and environmental sustainability themes. The subsequent sections will explore the wide spectrum of corporate SRTs environmental frameworks, standards, ratings and indices. Frameworks typically refer to principles, initiatives or guidelines given to corporations to assist them in disclosure efforts. Ratings and indices are third party evaluations of a corporation's sustainability or ESG performance.

Table 2: 10 well-known sustainability frameworks and their qualities summarised from environmental sustainability perspective.

Methodology	Range (global, regional, state, cities, organisation, corporate)	Type (reporting, ranking, principles, statistics)	Environmental sustainability themes included
FRAMEWORKS			
The Global Reporting Initiative (GRI)	Corporate	Reporting	Overall environmental aspects, impacts on climate, water and biodiversity, resource use and waste
The United Nation's (UN) Global Compact	Global, State, Cities, Organisations, Corporate	Principles	Overall environmental aspects
The Carbon Disclosure Project (CDP)	Corporate, Cities	Reporting	Impacts on climate
Greenhouse Gas (GHG) Protocol	State, Cities, Organisations, Corporate	Reporting, principles	Impacts on climate
RATINGS AND INDICES			
Dow Jones Sustainability Group Indices (DJSI)	Corporate	Ranking	Biodiversity, impacts on climate and water, resource use and waste[11]
The United Nations Sustainable Development Goals	Global, State, Cities, Organisation, Corporate	Principles	Overall environmental aspects, impacts on climate and biodiversity

[11] DJSI's sustainability assessment is based on CSA (Corporate Sustainability Assessment) by RobecoSAM

Methodology	Range (global, regional, state, cities, organisation, corporate)	Type (reporting, ranking, principles, statistics)	Environmental sustainability themes included
Sustainability Accounting Standards Board[12]	Corporate	Reporting	Impacts on climate, water and biodiversity, resource use and waste
WEC Trilemma index	State	Ranking	Impacts on climate and resource use
Environmental Performance Index	State	Ranking	Impacts on climate, water and biodiversity, resource use and waste
STATISTICS			
Eurostat Energy, Transport and Environment indicators	Global, Regional, State	Statistics	Impacts on climate, resource use and waste, water resources, biodiversity, chemicals

2 FRAMEWORKS

THE GLOBAL REPORTING INITIATIVE

GRI is an independent international organisation that was founded in 1997 with intention of creating a globally applicable sustainability reporting framework. GRI helps businesses and governments understand and communicate their impact on critical sustainability issues. GRI reports are produced in more than 100 countries. According to the GRI guidelines, a typical report should address the following areas: vision and strategy; corporation profile; governance structure and management systems; GRI content index; performance criteria (economic, social and environmental)[13]

THE UNITED NATIONS GLOBAL COMPACT

UN's Global Compact was launched in 2000 by the United Nations as a call to companies everywhere to align their operations and strategies with ten universally accepted principles in the areas of human rights, labour, environment and anti-corruption. With 9,500 companies and 3,000 non-business signatories based in over 160 countries it is the largest corporate sustainability initiative in the world. Environmental principles are underlined as following: Principle 7: Corporations should support a precautionary approach to environmental challenges; Principle 8: Undertake initiatives to promote greater environmental responsibility; Principle 9: Encourage development and diffusion of environmentally friendly technologies.[14]

[12] Sector: Renewables & Alternative Energy sector, industry: Wind Technology & Project Developers. SASB includes different sustainability accounting standards for 79 industries in 11 sectors.
[13] G4 Sustainability Reporting Guidelines, Global reporting Initiative, 2015, www.globalreporting.org
[14] Business solutions to sustainable development, UN Global Compact progress report, 2017

THE CARBON DISCLOSURE PROJECT

In 2000, the Carbon Disclosure Project (CDP) was launched by an UK-based organisation to encourage corporations to disclose their greenhouse gas emissions. CDP has accelerated the climate change mitigation initiative by providing quantitative information about greenhouse gas emissions, water use and climate change strategies on a global scale. The carbon disclosure score assesses a corporation solely on the quality and completeness of their disclosures. CDP claims that these scores are not an indicative measure of corporate performance because it does not make any judgment on a corporation's action to mitigate climate change.[15]

THE GREENHOUSE GAS PROTOCOL

The GHG Protocol provides a global standardised framework for corporations to quantify and report on their emissions. GHG Protocol arose when the World Resource Institute (WRI) and World Business Council for Sustainable Development (WBCSD) recognised the need for an international standard for corporate GHG reporting in the late 1990s. The first edition of the Corporate Standard was published in 2001 but is continually updated with additional guidance that clarifies how companies can measure emissions from electricity and other energy purchases, as well as account for emissions throughout their production chains. GHG Protocol also developed a suite of calculation tools to assist companies in calculating their greenhouse gas emissions and measure the benefits of climate change mitigation projects[16].

3. RATINGS AND INDICES

DOW JONES SUSTAINABILITY GROUP INDICES (DJSGI)

DJSGI (1998) are a group of benchmarks that track the stock performance of companies in terms of economic, environmental and social criteria. The indices provide an engagement platform for companies which want to take on sustainable best practices and serve as benchmarks for investors who want to take into account sustainability considerations in their portfolios[17].

THE UNITED NATIONS SUSTAINABLE DEVELOPMENT GOALS (SDG)

SDGs, also known as global goals, officially came into force on the 1st of January 2016. They are a universal set of goals that aim to end all forms of poverty, fight inequalities and tackle climate change, whilst ensuring that no one is left behind. SDGs are not legally binding, but governments are expected to take ownership and establish national frameworks to achieve the goals. Each goal has specific targets to be achieved over the next 15 years[18].

SUSTAINABILITY ACCOUNTING STANDARDS BOARD (SASB)

Sustainability Accounting Standards Board (SASB), a registered non-profit organisation in the United States, was officially launched on 4 October 2012. SASB's stated mission is to develop and disseminate industry specific accounting standards for material sustainability issues for integrated reporting. The SASB

[15] Renard Y.J. Siew. A review of corporate sustainability reporting tools (SRTs). Journal of Environmental Management 164 (2015) 180-195

[16] Greenhouse Gas Protocol, https://ghgprotocol.org [Accessed in July 2018]

[17] Principles for Sustainable Insurance Become New Insurance Industry Assessment Criterion of the Dow Jones Sustainability Indices, www.unepfi.org [Accessed in July 2018]

[18] The Sustainable Development Agenda, www.un.org [Accessed in July 2018]

standards are suitable for disclosure in standard filings but are broadly applicable and relevant globally for companies looking to report on material environment, social and governance (ESG) issues[19].

WORLD ENERGY COUNCIL TRILEMMA INDEX

The Trilemma Index tool was first produced in 2011 in partnership with Oliver Wyman. The tool is an interactive index that assesses the sustainability of national energy policies. It ranks countries on their ability to provide sustainable energy through 3 dimensions: Energy security, Energy equity (accessibility and affordability) and Environmental sustainability. The ranking measures the overall performance in achieving a sustainable mix of policies and the balance score highlights how well a country manages the trade-offs with "A" being the best.[20]

ENVIRONMENTAL PERFORMANCE INDEX (EPI)

Since 2012, the EPI has ranked almost all countries (180) on 24 performance indicators across ten issue categories covering two dimensions of environmental performance: environmental health and ecosystem vitality. These metrics provide a way to see at a national level how close countries are to meeting established environmental policy goals. The EPI offers a scorecard that highlights the best and worst environmental performance by countries and gives insight on best practices and guidance for countries[21].

4. STATISTICS

EUROSTAT ENERGY, TRANSPORT AND ENVIRONMENT INDICATORS

The “Energy, transport and environment indicators” (2018) book provides statistics produced mainly by the European Statistical System. It provides information on where the European Union stands and where current trends may lead in the areas of transport, energy and environment policies. It therefore contributes to making better informed decisions in these closely related areas.[22]

[19] Gilman K., Schulschenk J. Sustainability Accounting Standards Board, www.ey.com [Accessed in July 2018]
[20] The World Energy Council’s Energy Trilemma Index, https://trilemma.worldenergy.org/ [Accessed in July 2018]
[21] Environmental Performance Index, https://epi.envirocenter.yale.edu/ [Accessed in July 2018]
[22] Eurostat Energy, Transport and Environment Indicators report (2017 edition). Eurostat Statistical Book, 2017

ENERGY ENVIRONMENTAL SUSTAINABILITY

1. THE IMPORTANCE OF ENVIRONMENTAL SUSTAINABILITY FOR THE ENERGY SECTOR

The world faces the challenge of meeting the needs of a still-growing human population as well as facing the challenge of trying to do it sustainably – that is, without affecting the ability of future generations to meet their needs. Energy plays a pivotal role in this challenge and supply is a main factor in the rate of a country's economic development. Understanding that we live in an interconnected and global matrix of energy production and consumption is thus becoming increasingly important.[23]

Sustainable energy is an energy production that can last for the foreseeable future and can be maintained for a consistent period of time. Sustainable energy practices must rely on resources that can continue to supply our needs. Interpretations of this concept have been primarily based on the three-pillar approach, which distinguishes between environmental, social, and economic dimensions of sustainable development. It is important to understand the direct interactions between energy and other needs such as food, water, fuel, clean air and also some of its indirect interactions with climate and ecosystems. The goal must be to improve energy accessibility and affordability while reducing environmental harm.

There are a host of challenges and potential inadvertent consequences that are associated with the transition to clean and affordable energy as well as opportunities that hugely benefit sustainability goals. The main obstacle for sustainable development and sustainability is that their transformation and operationalisation is still at the practical level[24].

The accomplishments of civilization have largely been achieved through the increasingly efficient and extensive harnessing of various forms of energy to extend human capabilities and ingenuity[25]. However, energy use can generate undesirable by-products and emissions that can result in degradation of nature and severe health issues. The concept of 'sustainability' thus, becomes increasingly important. Alongside looking to achieve its long-term temperature goal, the Paris Agreement also looks at the need for equitable action, poverty eradication and sustainable management of natural resources. The United Nations' Sustainable Development Goals provide 17 goals that elaborate the multiple dimensions of sustainable development (Figure 1). 'The World in 2050' initiative endeavours to demonstrate how the objectives of sustainable development within planetary boundaries can be met. These objectives look at ensuring prosperity, social inclusion, and good governance for all. New strategies and investments require companies to disclose their responsibility for sustainability.

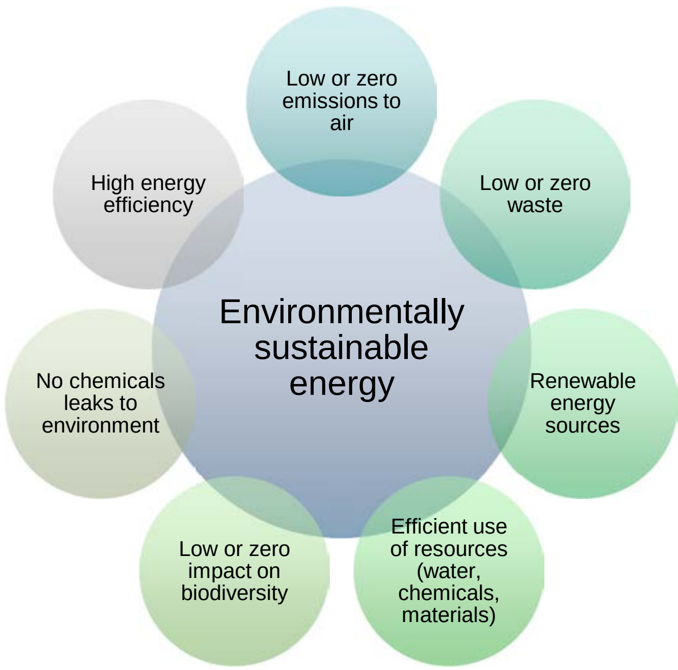
[23] Is the energy industry meeting its sustainability goals? 2018, www.weforum.org [Accessed in December 2018]
[24] Pavlovskaia E. Sustainability criteria: their indicators, control, and monitoring (with examples from the biofuel sector). Environ Sci Eur.2014; 26(1): 17
[25] GEA, 2012: Global Energy Assessment - Toward a Sustainable Future. International Institute for Applied Systems Analysis, Vienna, Austria and Cambridge University Press, Cambridge, UK and New York, NY, USA

Figure 1: Key dimensions of the sustainability based on UN Sustainable Development Goals

Source: FEL-100 Environmental Issues project, based on United Nations (2018), Sustainable Development goals.

This section focuses on the sustainability of the environmental pillar of energy which contributes to the quality of the environment on a long-term basis and suggests environmental sustainability criteria for different sources of energy and energy related processes.

Figure 2: Energy Environmental Sustainability



Source: FEL-100 Environmental Issues project

2. ENERGY ENVIRONMENTAL SUSTAINABILITY CRITERIA

The creation of sustainability criteria ensures sustainability in the long-term and contributes to securing financial investments. This section reviews energy sustainability criteria with a focus on the energy sources used in the World Energy Scenarios[26].

For the best possible sustainability protection, it is desirable that the sustainability criteria for a product and its production are applied at the earliest stage of its development[8].

Environmental impact assessments and/or life cycle assessments are completed at the early stage of an energy project to provide an opportunity to develop a truly sustainable project from an environmental point of view. Defining system boundaries and flows are crucial - the system needs to be defined with care in order to include all components. This includes energy, material, water, and communication flows that consider the environmental impacts of manufacturing and the end-of-life-cycle-phase by ensuring materials are recycled.

2.1. MAIN ENERGY TECHNOLOGIES FOR POWER GENERATION

Fossil fuels

A 'fossil fuel' is a generic term for a non-renewable, carbon-based energy source. These include solid fuels such as coal (incl. lignite), natural gases and oils from plants and animals that lived millions of years ago. These have then undergone transformation through chemical and physical processes[27].

The use of fossil fuels reduces environmental sustainability by its definition. As most fossil fuel resources are finite, it is not possible to save these resources for future generations if we only continue to use non-renewable energy sources. There are standards and reference documents which contain quantified values for pollutant emissions and energy efficiency as well as defining the best practice in reducing environmental impact of industrial processes. Best Available Technique (BAT) Reference Documents (BREFs) created by the European Integrated Pollution Prevention and Control Bureau for certain groups of technologies that include energy generation by large combustion plants[28]. According to EU Directive 2010/75/EU the BAT conclusions (containing emission limit values) must be adopted by large combustion plants[29] within 4 years of publication. The main criteria are listed as below:

- Actual energy efficiency meets the levels of the best available technologies
- Carbon capture and storage technologies are implemented for CO_2 intensive fuels (if economically, technically and environmentally feasible)
- Emissions of air pollutants (NOx, SO_2, PM and other) are prevented or minimised to the levels of the best available technologies

[26] World Energy Scenarios by the World Energy Council, https://www.worldenergy.org [Accessed in August 2018]
[27] Eurostat Environmental Data Centre on Natural Resources, Fossil fuels, https://ec.europa.eu/eurostat [Accessed in August 2018]
[28] Best Available Techniques (BAT) Reference Document for Large Combustion Plants, JRC Science For Policy Report, 2017
[29] Installations with a total rated thermal input of 50 MW or more, gasification of coal or other fuels in installations with a total rated thermal input of20 MW or more, disposal or recovery of waste in waste co-incineration plants for non-hazardous waste with a capacity exceeding 3 tonnes per hour or for hazardous waste with a capacity exceeding 10 tonnes per day

- Environmental impacts of fuel extraction, transportation and storage are evaluated and mitigated
- Reduced use of water, chemicals and other resources, recycling and appropriate water treatment
- High safety and potential environmental impacts of accidents mitigated.

In Regulation with European Parliament and the Council, the Internal Market for Electricity, Article 23: Design principles for capacity mechanisms enforced that Generation capacity for which a final investment decision has been made after (OP: entry into force) shall only be eligible to participate in a capacity mechanism if its emissions are below 550 gr CO2/kWh. Generation capacity emitting 550 gr CO2/kWh or more shall not be allowed to take part in the capacity mechanisms for up to 5 years after the enforcement of this regulation.

Nuclear energy

According to the World Energy Council's future World Energy Scenarios, nuclear energy plays an important role in the future energy mix. Nuclear energy is a well-developed energy source capable of providing large amounts of energy. The question surrounding the sustainability of nuclear energy often arises because of the potentially significant environmental and social impacts of this source of energy. This could be caused by accidental leaks during the extraction process or the management of end-life waste. Development of nuclear technologies provides opportunities to mitigate significant impacts and increase the sustainability of this source using the following steps:

- Reduced use of uranium;
- Recycling of the used fuel and reduced amount of radioactive waste;
- Safe and careful final disposal of spent nuclear fuel;
- Reduced use of water and other resources, recycling and appropriate water treatment;
- Mitigation of uranium mining environmental impacts;
- High safety, radiation protection and minimised potential impacts of industrial accidents.

Nuclear energy from fission of uranium and plutonium can also be considered as a sustainable nuclear technology[30].

Renewables

Biofuels

Bioenergy can be produced from a variety of biomass feedstocks, including forest, agricultural and livestock residues, short-rotation forest plantations, energy crops, the organic component of municipal solid waste, and other organic waste streams. Through a variety of processes, these feedstocks can be directly used to produce electricity and heat, or can be used to create gaseous, liquid, or solid fuels. The range of bioenergy technologies is broad, and the technical maturity varies substantially[31].

The EU has created a set of sustainability criteria[32] to ensure that the use of biofuels (used in transport) and bioliquids (used for electricity and heating) is done in a way that guarantees real carbon savings and

[30] Brook B.W., Alonso A., Meneley D.A., Misak J., Blees T., van Erp J.B. Why nuclear energy is sustainable and has to be part of the energy mix, Sustainable Materials and Technologies, Volumes 1-2, December 2014, p.8-16

[31] Renewable energy sources and climate change mitigation. Special report of the intergovernmental panel on climate change, IPPC, 2012

[32] Biofuels sustainability criteria, European Commission, https://ec.europa.eu/energy [Accessed in August 2018]

protects biodiversity. Only biofuels and bioliquids that comply with the criteria can receive government support or count towards national renewable energy targets. The main biomass sustainability criteria developed by EU are listed below:

- GHG emission saving: to be considered sustainable, biofuels must achieve greenhouse gas savings of at least 35% in comparison to fossil fuels. This savings requirement rose to 50% in 2017. In 2018, it rose again to 60% but only for new production plants. All life cycle emissions are considered when calculating greenhouse gas savings. This includes emissions from cultivation, processing, and transport.
- Land-Use Criteria: Biofuels cannot be grown in areas converted from land with previously high carbon stock such as wetlands or forests.
- Material Criteria: Biofuels cannot be produced from raw materials obtained from land with high biodiversity such as primary forests or highly biodiverse grasslands.

Hydro

Hydropower harnesses the energy of water moving from higher to lower elevations, primarily to generate electricity. Hydropower projects include dam projects with reservoirs, run-of-river and in-stream projects which all vary in project scale[31]. Some of US Renewable energy standards do not accept hydropower as a renewable energy due to the environmental impacts this energy source might cause[33]. How sustainable this technology is will often be linked to its impact on its natural water basin and in turn, the social consequences (flooding, population settlements and displacement).

In July 2018, the International Hydropower association published the Hydropower Sustainability Assessment Protocol. The Protocol is a sustainability assessment framework for hydropower development and operation. It enables the creation of a sustainability profile for a project via a performance assessment using important sustainability topics[34].

Environmentally sustainable hydro energy must meet the following criteria[34]:

- Healthy, functional and viable aquatic and terrestrial ecosystems in the area affected by the hydropower facility that are sustained over the long-term;
- Erosion and sedimentation associated with operating facility do not present ongoing problems for environmental, social and economic objectives of the facility;
- Water quality in the area affected by the operating hydropower facility is of a high quality;
- GHG emissions are evaluated and demonstrated to be consistent with low carbon power generation; and
- Resilient to climate change and provides contribution to climate change adaptation measures.

Wind

Wind energy harnesses the kinetic energy of moving air. Electricity is produced from large wind turbines located on onshore (on land) or offshore (sea or freshwater sources)[31]. The main environmental impacts of

[33] Energy Independence Act (EIA or I-937), Washington State Department of Commerce, https://www.commerce.wa.gov *[*Accessed in August 2018]
[34] IHA Hydropower Sustainability Assessment Protocol, July 2018

wind power production are noise, shadow flicker, possible effects to animals and changes in the landscape. The impacts and their scale are highly dependent on the site location and its surroundings such as housing and nature as well as layout planning. Therefore, correct site selection, thorough environmental impact assessments and layout planning play a key role in the development phase.

Environmentally sustainable wind energy is generated by avoiding, mitigating or compensating all the potential negative impacts:

- Mitigating site-specific impacts on biodiversity including wildlife mortality, alteration of vegetation and loss of habitat
- Technical solutions and layout planning to reduce the impact of noise, shadow flicker and vibration
- No impact on protected land or protected landscapes
- Evaluating and mitigating life cycle impacts including assessment on the environmental impacts of balancing

Solar

Solar energy technologies harness the energy of solar irradiance to produce electricity. Currently, there are two main technologies employed, photovoltaics and concentrating solar power technologies[35].

The potential environmental impacts associated with solar power include land use, habitat loss, water wastage and the potential use of hazardous materials in manufacturing. All can vary greatly depending on the technology. The scale of the system can range from small, distributed rooftop PV arrays to large utility-scale PV and CSP projects. The choice of technology also plays a significant role in the level of environmental impact[36]. Environmental sustainability of solar energy can be increased by:

- Using lower-quality lands for utility-scale solar systems: brownfields, abandoned mining land, or existing transportation and transmission corridors[37]
- Reducing environmental impacts during the manufacturing phase, including the use of hazardous materials and instead, using recycled materials.

Geothermal

Geothermal energy uses accessible thermal energy from the Earth's interior. Heat is extracted from geothermal reservoirs using wells or other means[31]. Although geothermal energy is considered a renewable resource and the emissions are lower when compared with fossil fuel power plants, there are still aspects of geothermal energy that can be harmful to the environment. Sometimes, when transforming energy from the geothermal wells, the process releases greenhouse gases that have been trapped in the earth's core. These gases include carbon dioxide, hydrogen sulphide, methane, and ammonia[38].

[35] Roger A. Pielke, Sr. Climate Vulnerability, Volume 3, Newnes, 2013, 512 p.
[36] Environmental Impacts of Solar Power, Renewable Energy, www.ucsusa.org [Accessed in August 2018]
[37] Renewable Energy Projects at Mine Sites, United States Environmental Protection Agency, https://semspub.epa.gov [Accessed in August 2018]
[38] Berrizbeitia Luis D. Environmental Impacts of Geothermal Energy Generation and Utilization, 2014

Eliminating environmental impacts ranks geothermal energy among the most environmentally sustainable energy sources. The following provisions can lead to lower environmental impacts[39]:

- Close-loop water systems reducing contamination risk and emissions to the air
- Reduced water consumption, recycling cooling water
- Increased energy efficiency

Ocean

Oceans are a source of renewable energy, with the potential to contribute to a more sustainable energy supply in the future. Technologies to harness ocean power are still at the early stages of development although ocean-wave and tidal-current technologies, which obtain energy from the movement of the waves and tides, are among the most developed of the ocean-energy systems[40]. The most common environmental impacts of wave energy are coastal erosion, impact on eco-system, noise and potential for chemicals to leak[41]. Appropriate placing of wave farms is an essential precondition to minimise the environmental effects[42] therefore reducing environmental impacts of wave energy that would mainly focus on:

- Finding optimal sites that will allow for construction and operation with low impact on the eco-system
- Minimising chemicals leak risks

2.2. ENERGY STORAGE

Energy storage is a crucial tool for enabling the effective integration of renewable energy whilst unlocking the benefits of local generation and a clean, sustainable and resilient energy supply. The technology continues to prove its value to grid operators around the world who must manage the variable generation of solar and wind energy. However, the development of advanced energy storage systems (ESS) has been highly concentrated in select markets, primarily in regions with highly developed economies.

The increase in energy storage popularity is expected to continue following the growth in development of the renewable energy sector. Recently, many countries have witnessed significant growth in renewable generation, but energy storage has yet to take hold. This is expected to change in the coming years as ESS prices continue to decline and project developers gain experience efficiently building, integrating, and monetising ESSs alongside renewable plants.

Energy storage systems provide a wide array of technological approaches for managing a power supply. This is with the hope that they will create a more resilient energy infrastructure and bring cost savings to utilities and consumers. Some of the main technologies currently being deployed around the world are:

- Solid State Batteries - a range of electrochemical storage solutions, including advanced chemistry batteries and capacitors

[39] Environmental Impacts of Geothermal Energy, Renewable energy, Union of Concerned Scientists, www.ucsusa.org [Accessed in August 2018]
[40] Science for Environment Policy. Environmental impacts of ocean-energy systems: a life-cycle assessment, European Commission, 2016, Issue 471
[41] Environmental Impact of Wave Energy, Alternative Energy Tutorials, http://www.alternative-energy-tutorials.com [Accessed in November 2018]
[42] Riefolo L., Lanfredi C., Azzellino A., Vicinanza D. Environmental Impact Assessment Of Wave Energy Converters: A Review. International Conference on Applied Coastal Research SCACR, 2015

- Flow Batteries - batteries where energy is stored directly in the electrolyte solution for a longer cycle life, and quicker response times
- Flywheels - mechanical devices that harness rotational energy to deliver instantaneous electricity
- Compressed Air Energy Storage - using compressed air to create a potent energy reserve
- Thermal - capturing heat and the cold to create energy on demand
- Pumped Hydro-Power - creating large-scale reservoirs of energy with water.

Energy storage sustainability criteria strongly depend on the technology used, but the general criteria can be defined as follows:

- Achieving high energy efficiency and minimising the losses of stored and converted energy
- Reducing environmental impacts of manufacturing (selection of materials) and end-of life (recycling, reducing amount of hazardous waste) phases
- Minimising chemicals leakage risks.

With an increasing focus on EV production, smart grids and storage batteries have the potential to offer a viable solution for storing intermittent energy supplies associated with renewable energy. At this stage, it is becoming imperative to re-evaluate all incentives associated with storage throughout the supply chain, re-examining all the potential markets and lowering barriers to entry. Providing certainty in the market will drive investment and result in the outcomes we desire – a reliable and resilient network fed from renewable sources. Energy storage will act as a key enabler in this transition process, bringing us increasingly closer to a more sustainable future.

2.3. ENERGY TRANSMISSION AND DISTRIBUTION

Energy generation, whether by conventional or renewable energy sources, needs to result in transmitted and distributed energy to ultimate end users. Throughout this process, a significant number of environmentally sensitive components and processes are incorporated. The international, rapidly increasing demand for energy means that adopting sustainable measurers to minimise the environmental impacts not only in generation, but also in transmission and distribution, is of paramount importance. Improvements in the efficiency of energy transmission and distribution systems directly translate into the effective use of conventional and non-conventional energy resources and therefore are directly linked with reducing negative impacts on the environment.

Energy transmission and distribution sustainability criteria can be defined as follows:

- Minimised system energy losses (lines and transformers)
- Eliminated risks of oil leakage form transformers
- Reduced use and minimised leakage of greenhouse gases (SF_6)
- Managed impact of electromagnetic field (protective zones)
- Reduced or managed impact on biodiversity (protected areas and species (including mitigation measures to reduce impact on birds), sustainable management of protected zones)
- Waste management and recycling, the use of materials and chemicals with less environmental impact

2.4. ENERGY USE

The end of the energy life cycle is the stage that may not have any direct environmental impacts. It is sometimes thought that this stage forms the basis of the whole life cycle and we can say that the life cycle of energy starts from the demand defined by energy end-users. Industrial, household and commercial energy consumers are indirectly responsible for overall energy sustainability during its full life cycle and can impact it in the following ways:

- Increasing energy efficiency and reducing unnecessary use of energy
- If possible, choosing to use a renewable energy with less environmental impact

The implementation of these two simple points is not as easy as it sounds. It is a complex system impacted by consumers, their behaviour, their level of knowledge, energy availability, infrastructure, energy markets, technology markets, geographical location and climate.

A various choice of energy providers is not always available for households. This all depends on each country regulatory scheme, market design and available fuel resources. It is also dependant on whether electron or the molecules sourced from a common system can be tracked back to its “black”, “grey” or green origin[43]. Energy poverty can also affect users when they are impacted by 3 factors such as energy costs, low revenues and poor habitation’s energy efficiency.

Apart from creating physical opportunities to increase the sustainability of energy consumption, one of the key issues is changing consumers’ behaviour by educating them in the field of energy efficiency and energy environmental sustainability.

Environmental indicators can help consumers make a quantified evaluation on the environmental sustainability of energy. The following section will touch the practical side of this issue, how energy consumers can receive information on energy environmental impacts and whether it is possible.

3. ENERGY ENVIRONMENTAL SUSTAINABILITY - CONCLUSIONS

Sustainability is determined by three different parameters: environmental sustainability, social sustainability and economic sustainability. Renewable energy technology can lead to reduced greenhouse gas emissions but for a complete analysis it is important to oversee that the whole production chain is sustainable. For instance, it is not always obvious that the production of wind turbines and solar cells is sustainable, that the materials have been sourced in a sustainable way, or that the industries are capable of recycling the technology in the future. Renewable sources such as wind, solar, geothermal, biomass, and hydropower also have environmental impacts, some of which are significant. The specificity and intensity of environmental impacts vary depending on the technology used, geographic location, and a number of other factors. By understanding the current and potential environmental issues associated with each renewable energy source, we can take steps to effectively avoid or minimise these impacts as they become a larger portion of our electricity supply.

[43] Greenpeace published for France a comparative analysis of electricity supplier “green electricity offers” and rankling them per “real” green footprint based on 3 criteria: company’s original sourcing from renewable assets , CO_2 emissions, and share of nuclear, https://www.guide-electricite-verte.fr/ [Accessed in December 2018]

It is imperative to navigate through evolving policy and regulatory frameworks across countries and regions, whilst being innovative in how we generate power. This will not only achieve progress but also maintain balance. Energy technology is constantly being improved. In the future, entirely new technology and improvements of today's technology may play an important role. However, to save the climate, renewable energy needs to be scaled up quickly and current technology will have to make up a large part of this expansion. Depending on the technologies we choose, the demand will increase for different materials and elements that may come from more or less rare resources. The extraction of these resources can create environmental problems, usually in poorer parts of the world, that means their future availability is often uncertain.

Truly sustainable energy systems require the creation of sustainable industries, which not only produce large amounts of renewable energy technology, but also help maintain a working system on a longer time scale in a resource efficient way.

INDICATORS

1. ENVIRONMENTAL INDICATORS AND ENERGY SECTOR

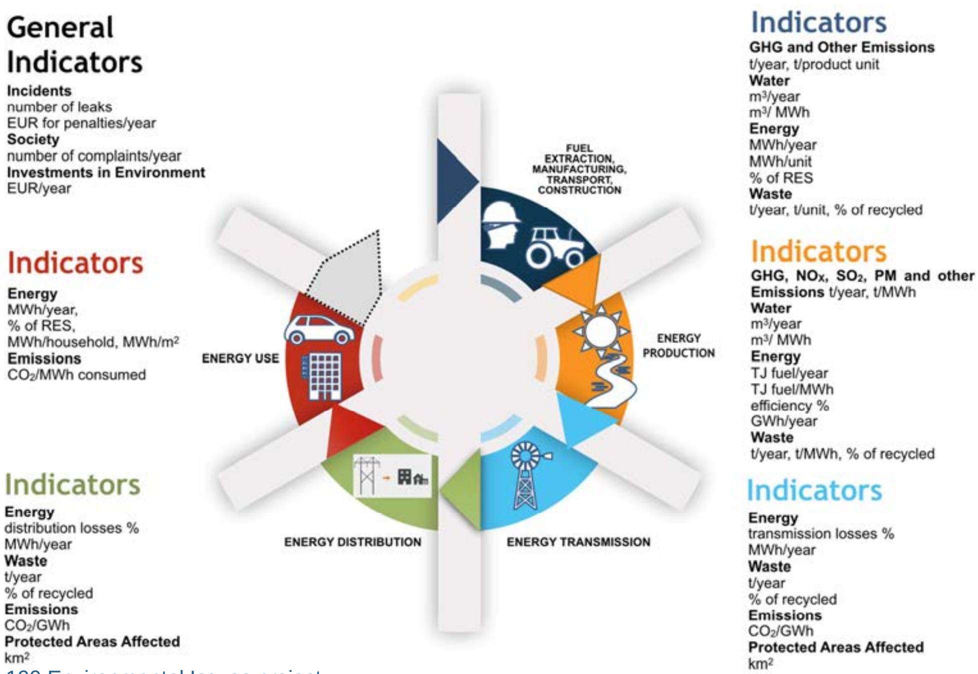
The environment is a complex. Its overall state is very difficult to measure, since it is impossible to measure every single variable. Therefore, a critical question is how we can define what is sustainable using measurement and assessment tools available today. An environmental indicator is a quantitative parameter that provides a practical way to assess and track the state of the environment or assess the sustainability.

An environmental indicator is a parameter, or a value derived from parameters, which points to/provides information about/describes the state of a phenomenon/environment/area with a significance extending beyond that directly associated with a parameter value.

-OECD[44]-

Indicators provide a practical way to track the state of the environment over time. An effective indicator must meet characteristics reflecting the problem and criteria to be considered. Its main purpose is to show how well the system is working[45]. A variety of indicators can be used depending on the scope of assessment. Choosing good and representative indicators is a key component of a good sustainability assessment.

Figure 3: Examples of indicators used in different phases throughout the life cycle of energy starting from fuel extraction and manufacturing to energy use and consumers.



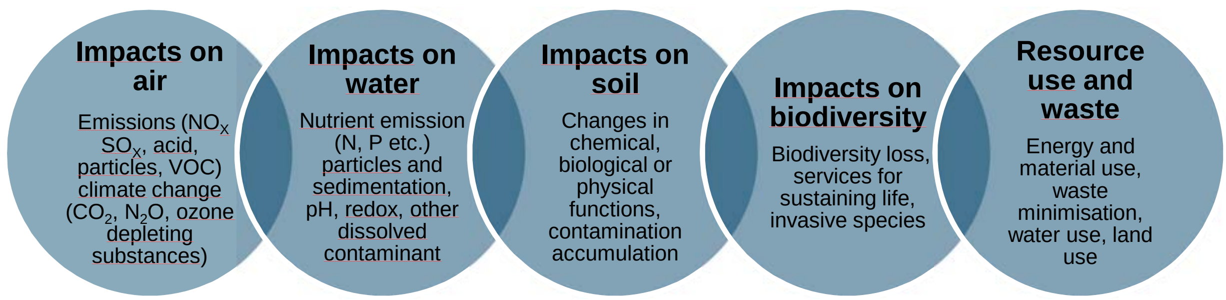
Source: FEL-100 Environmental Issues project

[44] OECD Core Set of Indicators for Environmental Performance Reviews. A synthesis report by the Group on the State of the Environment, OECD. 1993
[45] Afgana N.H., Carvalhoa M.G., Hovanovb N.V. Energy system assessment with sustainability indicators. 2010.

In all stages of the energy production cycle, from fuel extraction and manufacturing to energy production, pressures on the environment are created. Pressures vary from local household level to national and global level. Different indicators can also be used at different stages and levels which will evaluate the impacts of specific energy systems. Figure 3 shows examples of indicators from all the phases discussed.

Besides phases of use, indicators can also be grouped based on the ecosystem and environmental functions. Figure 4 shows indicators used to measure impacts on air, water, soil, biodiversity and resource use and waste.

Figure 4: Different environmental indicators grouped emphasising ecosystem and environmental functions.



Source: FEL-100 Environmental Issues project

2. DISCUSSION: INDICATORS IN PRACTICE

Indicators are the base and core of sustainability reports, ratings, rankings and statistics. The next chapter will discuss, from an indicator perspective, the comparability of companies' sustainability reports, the use of sustainability reports as the basis of sustainability rating and the comparison of country rankings and statistics.

2.1. COMPARABILITY OF SUSTAINABILITY REPORTS

An energy company's sustainability report will often include a variety of statistics as well as their reported emissions. They give information on the company's performance and commitment to the sustainability development. The reports share information to both internal and external stakeholders. Sustainability reporting is an initiative that comes from the business; it comes from the inside, not from outside – i.e. from governments. It is motivated by the desire to maintain competitiveness and maximise the effectiveness of management as well as company resources. It is not a mandatory exercise by law, but rather by the requirements of society and consumers. It is effective because it is voluntary. However, one question that arises from this is how easy it is to compare the numbers given in different reports.

Table 3: Annual CO_2 emissions per produced unit of energy from chosen four energy companies with focus area in Northern Europe and what is included in their emission intensity numbers

	Company 1 Sustainability and Annual Report, 2017	Company 2 Sustainability Report, 2015	Company 3 Annual Report, 2017	Company 4 Responsibility Report, 2015
Type of company	Energy generation and distribution company	Energy generation and distribution company	Energy generation company	Energy generation and distribution company
Annual CO_2 emissions reporting per MWh from reporting year	0.06 t/-CO_2MWh group overall 0.25 t-CO_2/MWh CHPPs	0.40 t-CO_2/MWh group carbon intensity	0.014 t-CO_2/MWh	250 g-CO_2/kWh (0.025 t-CO_2/MWh)
What is included in CO_2 emissions reporting?	Emissions from facilities that participate in the EU ETS[46], from non-participating facilities and energy generation related supporting process emissions. Emissions from transport were reported separately.	Information on what is included in not given in the report.	Power generation	Emissions of energy production and co-owned production by the total energy sold. Production and distribution losses have been taken into account. In 2017, the calculation was specified by including in the emissions of electricity used in heat pumps and district heat pumping.

Source: Publicly available reports of the companies, summarised by FEL-100 Environmental Issues project team (2018).

Based on the data in the table above as well as other reports studied for the comparison, it could be said that it is very difficult or near impossible to compare the companies with one chosen sustainability indicator. The main reasons for this are that the used units and functions vary within the statistics.

Unit variation such as t-CO_2/MWh and g-CO_2/kWh still allows comparison, but only after the extra effort of conversion. For the table above, only reports that included company's emissions per produced unit of energy (emission intensity) were included. Many of the company reports studied only reported a total amount of emissions. Therefore, the comparison of sustainability is difficult between these kinds of reports as the reader needs to put in more effort to do the calculations, assuming that the numbers can be found and are comparable, which is often not the case.

[46] Combustion plants with total rated thermal input exceeding 20 MW

Another issue is the variation in functions included in the reporting or the total lack of information on what is included. Calculation methods for emissions are different in all four companies included in Table 2, or the information is given in an undetailed manner. It is also sometimes possible that the information is difficult to find, for example it can be found some other part of the large report as the actual numbers.

Discussion: It is impossible to compare the sustainability of companies just based on their annual or sustainability reports, as often units vary and therefore making them near- uncomparable. Only few companies publish relative indicators such as emissions intensity which are in theory comparable and representative. Even then, the comparability is not guaranteed as data included varies.

2.2. SUSTAINABILITY REPORTS AS A BASIS FOR SUSTAINABILITY RATING

Publicly available sustainability reports are often used as an evaluation source by the third parties. The following example provides a short comparison of some indicators used in GRI as well as the indicators used in the Oekom Sustainability rating.

Table 4: Comparison of Oekom Sustainability Rating and GRI indicators

Indicator subgroup	Oekom Sustainability Rating	Global Reporting Initiative (GRI)	Conclusions
Greenhouse gas emissions	-GHG emission intensity (t/GWh) and change over years -GHG emission reduction targets and action plans -Estimate on company's GHG inventories and calculation methods (scope, activities and gases included)	-GHG emissions intensity - Direct GHG emissions -Energy indirect GHG emissions - Other indirect greenhouse gas emissions -Reduction of GHG emissions	Both measure GHG intensity and this allows comparison based on this indicator. GRI does not require specifying calculation measures
Solid waste	- Waste intensity (t/GWh) and change over years - Strategy and measures taken to promote recycling of waste components	- Total weight of waste by type and disposal method	Oekom measures amount of waste per produced unit of energy but does not differentiate the types of waste produced. GRI's waste reporting tells nothing about waste intensity itself, just total weight. Methodology of waste accounting can differ among countries and waste intensity could be representative only if waste from operations not related to energy life cycle are excluded

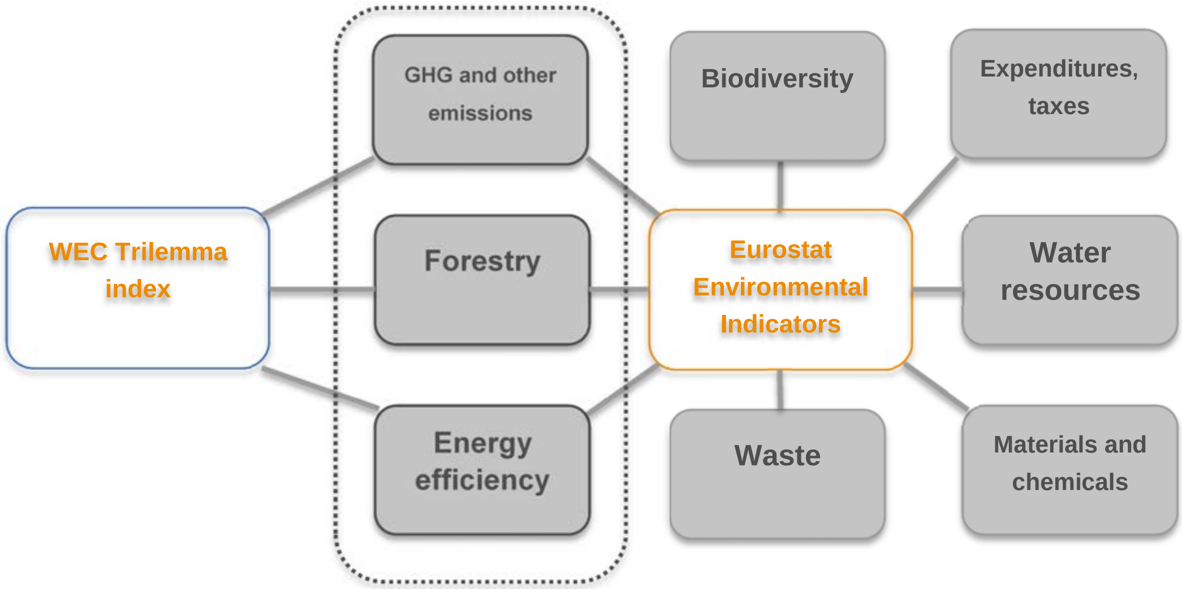
Discussion: It can be concluded that GRI is an appropriate framework to follow one company's performance from year to year. However, to be able to use this data for any kind of ranking, deeper analysis of the report will be necessary to make a conclusion on the company's progress. Any change in company's operations (e.g. changes in structure, new projects) or changes in calculation methodologies can make environmental indicators incomparable and lead to wrong performance conclusions.

2.2. COUNTRY RANKINGS AND STATISTICS

Environmental indicators are widely used to assess a country's environmental ranking based on their overall performance. Regional and country environmental statistics aim to encourage progress towards approved targets or provide the basis for analysis and decision-making. Country rankings use certain methodologies for prioritising and weighting indicators forming the total result for each country. Statistics are also based on the most representative indicators, though it usually includes a wider range of indicators that are not prioritised and country ranking is performed for each impact area or even indicator.

Next, let us discuss two energy sector country ranking and statistic methodologies as well as indicators used to characterise the energy sector.

Figure 5: The groups of indicators covered by Trilemma Index and Eurostat Energy, Transport and Environment Indicators 2017.



Source: FEL-100 Environmental Issues project

Trilemma Index indicators[47]:

- Final energy intensity;
- Efficiency of power generation and T&D;
- GHG emission trend;
- Change in forest area;
- CO_2 intensity;
- CO_2 emissions per capita;
- CO_2 from electricity generation.

[47] World Energy Council (2017), World Energy Trilemma Index 2017

The Eurostat Energy, Transport and Environment Indicators report (2017 edition)[22] includes a wide range of environmental indicators both generally and sector-specific. Some environmental indicators provide specific data for the energy sector and can be used to create environmental profiles for a country's energy sector:

- CO_2 emissions of energy sector;
- Domestic and imported CO_2 emissions induced by final use of products;
- Emissions of acidifying gases (ammonia (NH_3), nitrogen oxides (NOx), sulphur dioxide (SO_2));
- Emissions of ozone precursors (nitrogen oxides (NOx), non-methane volatile organic compounds (NMVOC), carbon monoxide (CO), methane (CH_4));
- Waste generation and treatment;
- Production and consumption of renewable energy;
- Energy intensity (the ratio of Gross Inland Energy Consumption to Gross Domestic Product);
- Distance to energy efficiency target;
- Energy taxes.

Discussion: The Trilemma Index focuses on three environmental areas. However, these do not cover all the environmental areas impacted by energy processes. The Trilemma Index uses both energy sector indicators as well as some general indicators related to overall environmental impacts on the country. Eurostat includes a wide range of indicators and covers all the main environmental areas. Still some areas, for example, energy efficiency do not include more specific indicators. This is because the efficiency of power generation focuses more on general trends and progress towards energy efficiency targets.

3. INDICATORS - CONCLUSIONS

When comparing measuring tools and indicators, it shows how important it is to understand what they consist of before making conclusions and decisions. Even for the indicators that have been determined appropriately, it may not be a fair benchmark to compare companies since the baseline behind the indicators may be different. The quality of indicators and data sources are key functions when making a comparison. One set of statistics showing greenhouse gas emissions does not simply answer the sustainability question or show whether it ranks well. The data and life cycle stages considered can vary between reports. Taking into account the whole life cycle of energy is of great importance as otherwise the true sustainability can remain unclear.

Unfortunately, indicators used to rank countries in the energy field currently only focus on certain environmental areas. Expanding the range of indicators would better demonstrate energy sector environmental performance, though the question of availability, quality and comparability of data all over the world is still crucial.

Conclusions

CONCLUSIONS

The environment is one of the three main pillars of sustainability. As the concept of sustainability gains prominence across globe, decision makers, investors and individuals will also give it more importance. This results in the need for understanding what sustainable means is increasing. Country, city, company specific, and global sustainability rankings as well as principles, reporting and statistics are used as a basis for decision making and give information about sustainability using different shades of green. These shades were the spark and interest behind this report: how can energy sustainability be measured and how do these methodologies compare?

What are the “measurement units” of environmental sustainability? Simply, there is no unified approach in measuring it. At a global, regional and state level, GHG emissions are often the only indicator of environmental performance used to assess environmental impacts. Expanding the range of relevant indicators and environmental impacts being used for energy and energy system evaluation would provide a broader view and also show the importance of environmental data availability, quality and comparability.

To address the three pillars of sustainability (economy, environment, and social), corporate social responsibility strategies are used with the help of sustainability reporting tools to make operations measurable. There is an increasing movement from ‘Corporate Social Responsibility’ to ‘Creating Shared Values’ driven by the Corporate Strategy. Together, environmental strategies and sustainability pillars are being integrated into company-wide targets to create social and economic value in the community that the company operates in. Sustainability reporting and high-level environmental performance of energy companies not only relates to its reputation and attractiveness for consumers following “the green trend”. It also opens financial opportunities and sometimes is a binding requirement to access financial sources.

MANY SHADES OF GREEN EXIST FOR ENERGY AND THERE IS A WIDE RANGE OF WAYS HOW TO MEASURE ENERGY SUSTAINABILITY

There is a wide spectrum of corporate SRTs in frameworks, ratings and indices. Frameworks typically refer to principles, initiatives or guidelines provided to corporations to assist them in their disclosure efforts. Ratings and indices are a third-party evaluation of a corporation's sustainability or ESG performance. Their range varies from organisation and corporate level, cities and state level to global. Sustainability themes included also vary from only considering impacts on the climate to also considering other aspects, such as impacts on biodiversity and water, resource use and waste. Therefore, they all result in different shades of green.

TO MEASURE HOW GREEN THE ENERGY IS, IT IS USEFUL TO LOOK AT ITS WHOLE LIFE CYCLE - ONLY FULL LIFE CYCLE DEMONSTRATES TRUE LEVEL OF ENVIRONMENTAL SUSTAINABILITY

Pressures on the environment are created in all stages of the energy production cycle, from fuel extraction and manufacturing to energy production and finally, its end. The sustainability assessment is not complete if any of these phases are left out. Using the life cycle approach when evaluating renewable energy environmental impacts allows for the comparison of energy sources without putting them in one common “zero-emission” category.

RENEWABLE ENERGY IS NOT A PRIORI SUSTAINABLE – CHECK HOW IT IMPACTS THE ENVIRONMENT IN ALL STAGES OF ITS LIFE CYCLE AND IF IT MEETS SUSTAINABILITY CRITERIA

The words “renewable energy” and “sustainable energy” are often used interchangeably. When looking at sustainable electricity sources, we commonly identify solar, wind, hydro, geothermal and bioenergy. However, not everything renewable is sustainable, and in turn not everything which is sustainable is necessarily renewable. Even renewable resources can become unsustainable. If a resource is used up faster than it can regenerate, it will eventually be entirely depleted despite its renewability. Conversely, a non-renewable resource can be sustainable if it's used in moderation. Again, if used without caution, these may be depleted in a short time. If the evaluation of energy sources focuses on GHG emissions, decisions based on this indicator may lead to negative impacts on other areas of the environment such as biodiversity, air and water quality, waste management.

INDICATORS EXIST TO COMPARE, ALTHOUGH BEFORE MAKING ANY CONCLUSIONS IT IS IMPORTANT TO CHECK THE DATA INCLUDED, DIFFERENCES IN METHODOLOGIES CAN MAKE SIMILAR INDICATORS INCOMPARABLE

Some methodologies do use environmental indicators that have similar measurement units. As an example, t GHG emissions per MWh of electricity should theoretically be comparable for any source of electricity. In practice however, even when the indicators have been determined appropriately, it might not be achievable create a benchmark between countries, companies or technologies since the baseline behind the indicators may be different. Quality of indicators and data sources are key functions when trying to develop a fair comparison of sources in the energy sector.

LIST OF TABLES AND FIGURES

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REFERENCES

1) WCED – World Commission on Environment and Development, 1987. Our Common Future. Oxford Univ. Press, Oxford.
2) Szekely, F., Knirsch, M., 2005. Responsible leadership and corporate social responsibility: metrics for sustainable performance. Eur. Manag. J. 23 (6), 628e647.
3) World population projected to reach 9.8 billion in 2050, and 11.2 billion in 2100, 2017, https://www.un.org [Accessed in December 2018]
4) Ozdemir, E.V., Hardtlein, M., Jenssen, T., Zech, D., Eltrop, L., A confusion of tongues or the art of aggregating indicators e reflections on four projective methodologies on sustainability assessment. Renew. Sustain. Energy Rev. 15 (5), 2385e2396. 2011
5) Siew, R. Y. A review of corporate sustainability reporting tools (SRTs). Journal of environmental management, 164, 180-195. 2015
6) Marlin, J.T., Marlin, A.T. A Brief History of Social Reporting, 2003
7) EY and Boston Collоge Center for Corporate Citizenship. Value of Sustainability Reporting, 2016
8) Porter, M., & Kramer, M. R. Creating shared value: How to reinvent capitalism - and unleash a wave of innovation and growth. Harvard Business Review, 89(1/2), 62–77. 2011
9) Ozdemir, E.V., Hardtlein, M., Jenssen, T., Zech, D., Eltrop, L. A confusion of tongues or the art of aggregating indicators e reflections on four projective methodologies on sustainability assessment. 2011
10) European Investment Bank. Environmental and Social Standards Overview, 2018
11) Sector: Renewables & Alternative Energy sector, industry: Wind Technology & Project Developers. SASB includes different sustainability accounting standards for 79 industries in 11 sectors.
12) G4 Sustainability Reporting Guidelines, Global reporting Initiative, 2015, www.globalreporting.org
13) Business solutions to sustainable development, UN Global Compact progress report, 2017
14) Renard Y.J. Siew. A review of corporate sustainability reporting tools (SRTs). Journal of Environmental Management 164 (2015) 180-195
15) Greenhouse Gas Protocol, https://ghgprotocol.org [Accessed in July 2018]
16) Principles for Sustainable Insurance Become New Insurance Industry Assessment Criterion of the Dow Jones Sustainability Indices, www.unepfi.org [Accessed in July 2018]
17) The Sustainable Development Agenda, www.un.org [Accessed in July 2018]
18) Gilman K., Schulschenk J. Sustainability Accounting Standards Board, www.ey.com [Accessed in July 2018]
19) The World Energy Council's Energy Trilemma Index, https://trilemma.worldenergy.org/ [Accessed in July 2018]
20) Environmental Performance Index, https://epi.envirocenter.yale.edu/ [Accessed in July 2018]
21) Eurostat Energy, Transport and Environment Indicators report (2017 edition). Eurostat Statistical Book, 2017
22) Is the energy industry meeting its sustainability goals? 2018, www.weforum.org [Accessed in December 2018]
23) Pavlovskaia E. Sustainability criteria: their indicators, control, and monitoring (with examples from the biofuel sector). Environ Sci Eur.2014; 26(1): 17
24) GEA, 2012: Global Energy Assessment - Toward a Sustainable Future. International Institute for Applied Systems Analysis, Vienna, Austria and Cambridge University Press, Cambridge, UK and New York, NY, USA
25) World Energy Scenarios by the World Energy Council, https://www.worldenergy.org [Accessed in August 2018]
26) Eurostat Environmental Data Centre on Natural Resources, Fossil fuels, https://ec.europa.eu/eurostat [Accessed in August 2018]
27) Best Available Techniques (BAT) Reference Document for Large Combustion Plants, JRC Science For Policy Report, 2017
28) Brook B.W., Alonso A., Meneley D.A., Misak J., Blees T., van Erp J.B. Why nuclear energy is sustainable and has to be part of the energy mix, Sustainable Materials and Technologies, Volumes 1-2, December 2014, p.8-16
29) Renewable energy sources and climate change mitigation. Special report of the intergovernmental panel on climate change, IPPC, 2012
30) Biofuels sustainability criteria, European Commission, https://ec.europa.eu/energy [Accessed in August 2018]
31) Energy Independence Act (EIA or I-937), Washington State Department of Commerce, https://www.commerce.wa.gov [Accessed in August 2018]
32) IHA Hydropower Sustainability Assessment Protocol, July 2018
33) Roger A. Pielke, Sr. Climate Vulnerability, Volume 3, Newnes, 2013, 512 p.

34) Environmental Impacts of Solar Power, Renewable Energy, www.ucsusa.org [Accessed in August 2018]
35) Renewable Energy Projects at Mine Sites, United States Environmental Protection Agency, https://semspub.epa.gov [Accessed in August 2018]
36) Berrizbeitia Luis D. Environmental Impacts of Geothermal Energy Generation and Utilization, 2014
37) Environmental Impacts of Geothermal Energy, Renewable energy, Union of Concerned Scientists, www.ucsusa.org [Accessed in August 2018]
38) Science for Environment Policy. Environmental impacts of ocean-energy systems: a life-cycle assessment, European Commission, 2016, Issue 471
39) Environmental Impact of Wave Energy, Alternative Energy Tutorials, http://www.alternative-energy-tutorials.com [Accessed in November 2018]
40) Riefolo L., Lanfredi C., Azzellino A., Vicinanza D. Environmental Impact Assessment Of Wave Energy Converters: A Review. International Conference on Applied Coastal Research SCACR, 2015
41) Greenpeace published for France a comparative analysis of electricity supplier “green electricity offers” and rankling them per “real” green footprint based on 3 criteria: company’s original sourcing from renewable assets , CO_2 emissions, and share of nuclear, https://www.guide-electricite-verte.fr/ [Accessed in December 2018]
42) OECD Core Set of Indicators for Environmental Performance Reviews. A synthesis report by the Group on the State of the Environment, OECD. 1993
43) Afgana N.H., Carvalhoa M.G., Hovanovb N.V. Energy system assessment with sustainability indicators. 2010.

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PROJECT TEAM

Alona Bolonina (Head of Environmental Management Unit, Latvenergo AS, Latvia); Lolita Carry (Chief of Staff to ENGIE Executive Vice-President, ENGIE, France); Keii Gi (Researcher, Research Institute of Innovative Technology for the Earth, Japan); Cansu Karaca (Project Engineer, Energy and Environmental Systems Research Development – ENVIS, Turkey); Aanchal Kumar (Officer, Energy Efficiency Services Limited, India); Tharindu de Silva (Electrical Engineer, Lanka Electricity Company (Private) Limited, Sri Lanka); Ilona Välimaa (Environmental expert, ÅF, Finland)

PROJECT MANAGEMENT

Alona Bolonina (Head of Environmental Management Unit, Latvenergo AS, Latvia); Ilona Välimaa (Environmental expert, ÅF, Finland)

WORLD ENERGY COUNCIL CONTRIBUTORS

Emily-Jane Godfrey (Operations Coordinator); Oskar Gehrmann (Member Services Intern); Barry Kermisch (Senior Director of Communications, Digital and Platforms) and Michelle Arellano (Member Services Manager)

WORLD ENERGY COUNCIL FUTURE ENERGY LEADERS BOARD

Nuno Silva (FEL Chair), Portugal; Andrei Covatariu (FEL Studies Committee), Romania; Sultan AlShaaibi (FEL Studies Committee), Oman; Andreas Formosa (FEL Studies Committee), Cyprus