Developing a Taxonomy for Sustainable ICT

An exploratory study of the feasibility of a taxonomy for sustainable ICT

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Abstract

Information and Communication Technology (ICT) can have a role to play in transitioning into a sustainable society but it is important to consider that implementation of an ICT-based solution not always lead to sustainability. Kentaro Toyama (2015) has proposed a framework, what he refers to as “Preliminary Thoughts on a Taxonomy of Value for Sustainable Computing”, to be used for classification of sustainable ICT-projects. A working taxonomy for ICT-projects could provide an explicit evaluative framework to be used for evaluating whether a given project might or might not contribute to sustainability goals. The taxonomy includes three dimensions to consider when classifying ICT-projects:

- Impact - On sustainability
- Intention - Towards sustainability
- Effort - For achieving Impact

This thesis picks up where Toyama left off with the purpose of exploring if the taxonomy is a feasible approach for addressing ICT and sustainability. This is done by first adding a Secondary Level to the taxonomy with the goal of making the classification process more accurate, but more importantly for the purpose of this thesis, enable a more detailed analysis of the overall feasibility of the taxonomy. Four interviews are conducted with representatives from ICT-projects addressing sustainability. As a result of the interviews four problems are identified that have implications for the feasibility of the taxonomy and that need to be considered in any future and further attempts to operationalize it.
Sammanfattning


- Inverkan på hållbarhet
- Intention i förhållande till hållbarhet
- Ansträngning som krävs för att ett projekt ska ha en inverkan.

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1. INTRODUCTION

Information and Communication Technology (ICT) have during recent years become the answer to all the problems and issues that surrounds the topic of sustainability and sustainable development. Given ICT’s ubiquity, wherever a problem can be identified so can an ICT-based solution. There is no doubt that ICT can have a role to play in addressing sustainability, but it is important to consider that implementation of an ICT-based solution do not always lead to sustainability. Kentaro Toyama (2015) has proposed a framework; what he refers to as “Preliminary Thoughts on a Taxonomy of Value for Sustainable Computing”. In this thesis the same taxonomy will be used for sustainable ICT-projects, where Sustainable computing can be viewed as part of Sustainable ICT, so the choice of changing does not affect the design of the taxonomy, but broadens the scope for projects that can be considered for classification. A working taxonomy for Sustainable ICT-projects could provide an explicit evaluative framework to be used for evaluating whether a given ICT-project might or might not contribute to sustainability goals.

1.1 Thesis Purpose

This thesis picks up where Toyama left off with a twofold purpose:

- Adding a Secondary Level to the taxonomy.
- Explore the feasibility of the taxonomy.

It might seem strange to modify the taxonomy before exploring the feasibility of it but there is a reason for doing this. In the Preliminary Taxonomy classification is proposed to be made according to three Dimensions (which will be further explained in section 3.0):

- Impact - On sustainability
- Intention - Towards sustainability
- Effort - For achieving impact

The dimensions can be understood as the Primary Level used for classifying any ICT-project. Connected to each dimension is a Rating System, to be used for rating a project, and which combined constitutes the final classification. In its current state there is no clear protocol for making a classification. Adding a Secondary Level to the taxonomy can make the classification process more accurate, but more importantly for the purpose of this thesis enable a more detailed analysis of the overall feasibility of the taxonomy. It should also be noted that Toyama gives a
definition of sustainability to be used when classifying projects. The definition of sustainability lies at the Root Level of the taxonomy; meaning that the decisions made as to what constitutes sustainability is what ultimately determines the assessment of any given project. Or as explained by Gasparatos and Scolobig (2012), assumptions with regards to how to assess sustainability are value-laden and will affect the outcome of the assessment. The Preliminary Taxonomy is illustrated below in Figure 1, where the Secondary Level to be added is represented by three empty dashed boxes.

figure 1 - Structure of the taxonomy.

The structure of the taxonomy above also gives a good overview of the structure of this thesis; where the Root Level connects to the Background section; the Primary Level to the first part of the Theory section; the Secondary Level to the second part of the Theory section; and finally all added together in exploring the feasibility of the taxonomy as a whole, conducting interviews with ICT-projects addressing sustainability as means for doing that.

1.2 Research Question

The overarching question and aim of this thesis is to explore whether and how the taxonomy can be operationalized. This is done using the following working questions:

- How can a secondary level used for classifying Sustainable ICT-projects according to Toyamas proposed dimensions be constructed?
- Is the taxonomy a feasible approach to classifying Sustainable ICT projects?
• Is there any ICT-project that is sustainable if using the taxonomy for classification?
2. Background

In this section an overview of sustainability and sustainable development is presented. This connects to the root level of the taxonomy and gives historical and theoretical context to the definition used in the taxonomy. It also gives the reader an overview of alternative approaches to sustainability. Secondly, sustainability in connection to ICT will be elaborated.

2.1 Brief History

Given today’s widespread use of the terms sustainability and sustainable development it would not be wrong to assume that what constitutes these two concepts are a straightforward matter. The opposite is more likely to be true. The concept of sustainable development emerged in the mid 1980’s as an attempt to bridge the gap between environmental concerns about the increasingly evident ecological consequences of human activities and socio-political concerns about human development issues (Robinson, 2004). The most commonly used definition of sustainable development is the one found in Our Common Future (also known as the Brundtland-report), a report published by the World Commission on Environment and Development in 1987, stating that:

“Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own needs” (WCED, 1987, p. 45).

Furthermore this laid the foundation for the UN’s Rio Declaration containing 27 principles of sustainable development. Combined, the Brundtland-report and the Rio Summit can be said to have acted as the theoretical framework adopted by Institutions and Organizations across the world. These goals have been revised on several occasions and the most recent version can be found in the 2030 Agenda For sustainable development, consisting of 17 goals (Un.org, 2016).

Although the above definition has been widely accepted, what constitutes “need” will differ depending on several parameters such as point in time, income levels and cultural or national background (Beckerman, 1994). This problem was neatly summed up by Seralgedin (1996) saying that the “definition is philosophically attractive but raises difficult operational questions”. Given the definitions ambiguity alternative terminology addressing the same issues have evolved.
2.2 Sustainability

Sustainability has become an increasingly popular term. If something is sustainable it simply means that it can be maintained at a certain rate or level (oxfordictionaries.com, 2016). According to Hilty (2015), at a minimum, three things must be taken into consideration: The resource used, the function of that resource – that is the service it provides – and the time horizon for which it is meant to provide that function. A resource is then used sustainably if it is able to provide its function over stated time-horizon (Hilty, 2015). This definition can of course be applied to anything, and as pointed by Brown et al. (1987), the meaning of the term must be understood in the context in which it is applied. The term sustainability is sometimes used interchangeably with sustainable development, and although there are not any fundamental differences between the both there is an implied difference in scope which affects the choice of indicator used for assessment.

Sustainability indicators can be divided into two types: Resource-oriented and well-being-oriented. Resource-oriented indicators “reduce the complexity of deeply nested resource systems to simple metrics”(Hilty, 2015), but it still rely on the accuracy of the model of system – where system can be anything from planet earth to someone’s backyard - to be effective.

The well-being-oriented indicators are not as clear-cut, but often economic measurements such as Gross Domestic Product is used. Sustainable development assessment need to use both type of indicators, whereas sustainability considered in terms of resource-use, only need to use a resource-oriented indicator (Hilty, 2015).

2.2.1 The Three Pillars of Sustainability

Sustainability is often divided into three sub divisions referred to as the Three Pillars or the Triple Bottom Line, consisting of social, environmental, and economic sustainability. Each of the three pillars can be said to come with a different set of problems.

Environmental sustainability refers to protection of nature and making sure that we, the inhabitants of planet earth, keep within the biophysical thresholds, which if crossed can result in the loss of inland glaciers, a transition of rainforests to savannas, destruction of tropical coral reefs, desertification of current agricultural land, and a shift in the Indian and African monsoon system. Each of these plays a crucial role in the process of regulating the earth’s climate and staying within the boundaries is crucial for any sort of human development to be possible in the future. (Rockström, 2010)
**Economic sustainability** refers to various strategies that make it possible to use available resources to their best advantage. The idea is to promote the use of those resources in a way that is both efficient and responsible, and likely to provide long-term benefits. A business should use resources in a way that does not compromise the function of resources over time and at the same time return a profit. In more formal terms economic sustainability seeks to keep capital intact, and consumption should be limited to the value added (interest) and not include savings. (Goodland, 2002)

**Social sustainability** refers to the maintenance and development of social capital, which consists in investments and services that create the societal framework. These might be education, law and the institutions needed for promoting and maintaining basic human rights such as free speech. (Goodland, 2002)

The idea is that balance between the pillars should be achieved (Un.org), where sustainability is depicted as the intersection between the three (see figure 2 below). Theoretically the three pillars can be useful in seeing that questions regarding sustainability are not constricted to one area. They are also politically attractive, since it is easier having an economist proposing what is economically sustainable, an ecological expert proposing what is environmentally sustainable and a social scientist proposing what is socially sustainable, than asking each one to consider questions outside their expertise. This approach can lead to trade-off solution (Gibson, 2006), where one “sustainability” is exchanged for another. There do exists alternative suggestions, where for example Gibson (2006) proposes that sustainability should be recognized as an integrative concept where sustainability is not perceived as three separate sectors. Assessment should not be considered “a balancing act or a playing of one issue off against the other”; but should recognize “the interdependent nature of these three pillars” (Drexhage and Murphy, 2010).

### 2.2.2 Herman Daly and Sustainability

Ecological economist Herman Daly (1990) have proposed a set of principles of what constitutes sustainability, suggesting that it should be understood in terms of how we manage renewable and non-renewable resources (See section 3.2.1 Table 1 for how to classify resources). This is also the theoretical foundation for the definition used in the taxonomy (which will be elaborated in section 3.0). In the case of renewable resources they can be used at the same rate they are being regenerated. In addition to this waste emission rates should equal the assimilative capacities of the ecosystem into which the waste is emitted. Non-renewable resources can never be maintained in a sustainable way (and therefore the use of them can never be considered sustainable), but they can
be used in a “quasi-sustainable” manner where the rate of depletion equals the rate of creation of renewable substitutes (Daly, 1990). Daly’s view is further clarified below under in connection to the description of strong sustainability.

2.2.3 Strong and Weak Sustainability

Any definition of sustainability can broadly be categorized as being either closer to what is called *Weak Sustainability* or *Strong Sustainability*. The difference between the two is how they define the relationship between natural capital and human made capital (see Table 1 section 3.2.1 on how to differentiate between natural and human made capital), and how these are used over time. Proponents of *Weak Sustainability* consider natural capital, such as forests, lakes, and minerals, to be substitutable for human-made capital, counting only the aggregate stock of capital (Hilty, 2008). Generally this means that if the market value of the human-made capital is equal to, or higher than the natural capital, they are considered substitutable. Furthermore, in making policy decisions a proponent of weak sustainability could make the claims that we are not obligated to leave for future generation any particular thing or resource, only the generalized capacity to create the same amount of well-being. Thus weak sustainability considers the general capacity for generating well-being to be the goal and not the resources in themselves. Sustainability here does not have to consider any particular species or piece of land for preservation, but only that the same function are provided or substituted for in the future. Nature can of course be considered to have an intrinsic value, but this can also be understood as a component of well-being. (Solow, 1993)

Proponents of *Strong Sustainability* in contrast, consider natural capital to be non-substitutable meaning that “The total natural capital must be preserved, i.e. industry, as a user of nature, may live only off the ‘interest’ of the natural capital” (Hilty, 2008). Daly (1990) claims that the technologies used for transforming resources and the actual resource used is not substitutable, but rather complementary. A larger fishnet can for example not substitute for a decline in fish stocks. Of course the weak sustainability proponent could make the argument that there is no reason for preserving any particular species of fish, and that this could be substituted for whatever provides the same function. The strong sustainability proponent could add that once we accept that man-made capital and natural capital complementary and not fully substitutable; development is limited by the one in shortest supply, which would be natural capital. To further clarify: The difference between the two is illustrated in figure 2 below. Strong sustainability considers society and the economy to be a subset of the environment, whereas the weak approach considers the three on equal terms. This is of course a simplification of both sides of the argument, and no doubt there
will be more subtleties to both sides, as well as economic technicality, and should be taken as a approximation for getting an overview of the concepts of strong and weak sustainability.

Figure 2 – Strong sustainability (Left picture) and Weak sustainability (right picture).

Where the three-pillar approach lean toward *weak sustainability*, the definition of sustainability used in relation to the proposed taxonomy can be considered as being on the “strong” side of the sustainability spectrum. There are some epistemological uncertainties\(^1\) surrounding both weak and strong approaches to sustainability (Neumayer, 2003), but even so weak approaches have tended to be favored since sustainable development was put on the global agenda in 1987; and though some progress has been made\(^2\) the prognosis is that resource and material consumption in absolute numbers will increase for years ahead, and with that the environmental impacts. The goal of this paper is not to make an argument for either side, but acknowledging that there are differences can be important when applying the applying the taxonomy on ICT-projects. Not all projects are likely to share the “hard” approach of the taxonomy, which can have effects on how the taxonomy can be used or should be constructed.

### 2.3 The Role of ICT

The possibilities of modern information and computation technologies provide hope that sustainability can be achieved. Sachs et al (2015) suggests that the *“Information Age can and should lead to the Age of Sustainable Development, a sixth great wave of sustainable technologies that will make possible the achievement of the Sustainable Development Goals”*. ICT and their applications can have both positive and negative impacts on the environment. There

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\(^{1}\)“That, strictly speaking, both paradigms of sustainability are non-falsifiable implies that neither paradigm can be unambiguously supported by science. However, it does not imply of course that science cannot help in informing policy-making for sustainability” (Neumayer, 2003, p.3-4)

\(^{2}\)Over recent decades both developed countries and emerging economies have made progress in reducing the rate of resource extraction per unit of GDP (OECD, 2008)
will be always be an environmentally negative impact from the use of non-renewable resources in the production of ICT-products. When discussing the impact of ICT it is useful thinking in terms of net environmental impact, which is the sum of all of its interactions with the environment (OECD, 2010).

In the Global e-Sustainability Initiative report from 2015 five areas where the application of ICT-solutions can have an impact on emission rates are presented (see table 1 below).

<table>
<thead>
<tr>
<th>Sector</th>
<th>CO2e Abatement Potential in Gigatons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mobility</td>
<td>3.6</td>
</tr>
<tr>
<td>Manufacturing</td>
<td>2.7</td>
</tr>
<tr>
<td>Agriculture</td>
<td>2.0</td>
</tr>
<tr>
<td>Buildings</td>
<td>2.0</td>
</tr>
<tr>
<td>Energy</td>
<td>1.8</td>
</tr>
<tr>
<td>ICT-enabled</td>
<td>12.1</td>
</tr>
</tbody>
</table>

Table 1 – CO2e abatement potential by sector in gigatons. From Global e-Sustainability Initiative report (p.9)

- **Energy** – ICT can enable the integration of renewables onto the grid and improve efficiency using Smart grids and analytics solutions.
- **Buildings** – Smart building solutions enabled by ICT can reduce energy usage and more efficient energy distribution.
- **Mobility and Logistics** – ICT can enable real-time traffic information, smart logistics and potential for delivery and route optimization.
- **Manufacturing** – ICT can enable more efficient supply chains.
- **Agriculture** – ICT monitoring devices can increase yields and avoid food waste.

In total the solutions can potentially enable a 20% reduction of global CO2e³. Further, their prognosis is that the emissions caused by ICT itself will amount to 1.97% of the total global emission; meaning that the emissions avoided are ten times greater than those caused by the use of ICT. The role of ICT as presented in the report is perhaps best summed up in the foreword by Christina Figueres, writing that: “SMARTer2030 is a narrative and the transformative contribution of ICT about a better future and better living for all” (Global e-sustainability initiative, 2015).

Another report issued by the Swedish Environmental Protection Agency in 2015 explores how

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³ There are other greenhouse gases than carbon dioxide such as methane, nitrous oxide and ozone. The CO2e measure allows for other greenhouse gases to be expressed in terms of CO2; having the concentration of any greenhouse gas being emitted is converted into the equivalent concentration of CO2 (climatechangeconnection.org).
digitisation can contribute to more resource efficient consumption choices and behavior.
The report identifies four fundamental ways in which ICT can promote sustainable consumption. It can replace products, services, and practices. It can intensify the use of product and services. It can increase efficiency and enable the right information to be presented where needed (Höjer, Mober and Henriksson, 2015). The report concludes that given the ubiquity of ICT the potential for it to contribute to sustainable consumption are very large, but that there needs to be environmental control measures, and an ICT-policy promoting sustainable consumption in combination with a strong environmental policy. If not, the potential effects of ICT-applications in terms of reducing consumption can be non-existent or even negative (Höjer, Mober and Henriksson, 2015).

2.3.1 Green in ICT and Green by ICT
A useful way to understand the role of ICT is to consider both the effects that ICT can have in itself, which Hilty et al. (2011) refers to as “Green in ICT”, and also consider the effects ICT can have on the life cycles of other products and processes. Green in ICT includes the direct energy consumption of ICT-equipment and resource use in the production process. Murugesan (2008) has suggested four aspects of ICT to consider that can be understood as “Green in ICT”:

- **Green use.** Reduce the energy consumption of computers and other information systems and use them in an environmentally sound manner.

- **Green disposal.** Refurbish and reuse old computers and properly recycle unwanted computers and other electronic equipment.

- **Green design.** Design energy efficient and environmentally sound components, computers, servers, and cooling equipment.

- **Green manufacturing.** Manufacture electronic components, computers, and other associated subsystems with minimal or no impact on the environment.

Green By ICT instead considers the effects ICT have on other products and processes. ICT can be used for more efficient management of certain processes, which was. For example heating and cooling systems in buildings can be managed using intelligent technology for monitoring and decision making (Hilty et al. 2011). In summary a comprehensive analysis of the effect of ICT in terms of sustainability need to consider both aspects, and should balance greenhouse gas emissions resulting from the development, production and operation of ICT products against emissions reductions attributed to the application of these ICTs to improve energy efficiency in other products and services life cycles.
2.3.2 Decoupling and Dematerialization

Decoupling and Dematerialization are terms often used when discussing the potential effects of ICT. Decoupling refers to the changing ratio between two sustainability indicators. Assuming that maximizing well-being, or maintaining functionality of a service, while minimizing resource use is the goal; decoupling is simply increasing or sustaining current levels of well-being, or functionality, while decreasing resource use. Dematerialization is a “special case” of decoupling where a material resource is substituted for an immaterial (Hilty, 2015) (See section 3.2.1 Table 1 for how to classify resources). Wherever ICT can facilitate the replacement of physical products and processes there is potential for dematerialization. One example is the use of teleconferencing equipment for conducting meetings that can replace traditional business travel. Another example is that of digital streaming services of music and video replacing previous practices using physical media. On a higher level dematerialization and decoupling in connection to ICT is probably better understood as a change in the value creation process in the digital economy, with software becoming the paradigm (Hilty et al, 2011), which could lead to a less resource intensive economy.
3. Theory

The theory section consists of two parts. In the first part Toyama (2015) proposed taxonomy (henceforth Preliminary Taxonomy) is presented in more detail. This means that each of the three dimensions: Impact, Intention, and Effort, used for classification are presented, and also the suggested Rating System for each of these. The second part of this section concerns the first working question posed in the introduction:

- How can a secondary level used for classifying sustainable ICT-projects according to Toyama’s proposed dimensions be constructed?

Here a secondary level is added to the each of the dimensions, meaning that additional theory will be added not originally presented in Toyama (2015) paper.

3.1 Preliminary Taxonomy

This section presents Kentaro Toyama (2015) preliminary taxonomy without any alterations or considerations beyond those made in his original proposal. The structure of the preliminary taxonomy can be viewed in Figure 3 below. First the definition of sustainability in the preliminary taxonomy is presented. This is followed by an explanation of each of the three dimensions and their suggested rating system. It should be noted that the three dimensions are considered as conceptually independent and assessment for each dimension is done as such. In the last part an example is given of how the taxonomy can be used for classification.
3.1.1 Sustainability as Resource Equilibrium

Toyama suggests that sustainability should be understood in terms of resource consumption and replenishment, meaning that sustainability is the point of equilibrium where resource consumption is equal to resource replenishment. This is a generalization of the principles of sustainable development suggested by Herman Daly (1990) explained in the background section. Toyama gives a set of examples regarding resources. Resources according to Toyama can be thought of as:

- Natural resources such as fossil fuels or minerals.
- Clean water and clean air as opposed to polluted water or air.
- Regions with inhabitable climate as opposed to inhospitable climate.

He further notes that most sustainable ICT-projects will undoubtedly consist of, and use more than just one resource, in which case a system of resources will need to be considered.

3.1.2 Impact

The impact dimension according to Toyama (2015) “focuses on the nature of actual sustainability impact”, where sustainability impact here should be understood as any impact relevant in the context of the taxonomy, furthermore, an example of how the impact can be understood and assessed are given in section 3.1.5. A scaling of impact in form of levels from -3 to 1 is suggested. This is what has been referred to as a Rating System in the introduction.

Below is the rating system for the Impact dimension.

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![Figure 3 - Structure of the preliminary taxonomy.](image-url)
Impact Rating:

- **Level -3**: Adversely affects sustainability. Increases the rate of net resource depletion.
- **Level -2**: Maintains status quo without affecting movement toward or away from sustainability. The net rate of resource depletion is unaffected.
- **Level -1**: Decreases the rate of net resource depletion, but does not take things toward a sustainable equilibrium. The rate of resource depletion is still positive.
- **Level 0**: Achieves a sustainable equilibrium in and of itself, but does not move things toward increased sustainability. Net resource depletion is zero.
- **Level 1**: Contributes to movement toward a globally sustainable equilibrium. Actively move things toward net resource replenishment.

3.1.3 Intention

This dimension refers to the intention of those responsible for a given ICT-project to address sustainability in terms of the definition presented above. The motivation behind this dimension is that intention is “important to consider in the context of sustainability projects, because ultimately, sustainability can only be reached by a global shift in intention” (Toyama, 2015).

Intention Rating:

The following rating system for the intention dimension is proposed:

- **Class A**: Genuine intention to move things toward increasing sustainability.

- **Class B**: Neutral, indifferent, or half-hearted intention to move things toward sustainability, yet also without negligence or active intention to be adverse to sustainability.

- **Class C**: Intention to move things in a direction that runs counter to sustainability, or negligence toward an incidental effect that runs counter to sustainability.

To differentiate between class C and B Toyama uses the legal concept of *Negligence*, which can be defined as: “the failure to meet a standard of behaviour established to protect society against unreasonable risk” (Encyclopedia Britannica, 2016).

Toyama (2015) explains a Class C-project as follows: *Class C intention includes situations in which whether or not an activity is “intended” to be*
unsustainable, it is one that a hypothetical, reasonable person can nevertheless see to run counter to sustainability.

For example: Higher levels of greenhouse gases – such as carbon dioxide – in the atmosphere are the cause of ongoing climate change. Higher levels of greenhouse gases in the atmosphere have been caused by human activities such as burning fossil fuels (epa.gov, 2016). If a project would be initiated with the goal of increasing the emissions of carbon dioxide into the atmosphere, those responsible would be considered negligent and the project would be regarded as a Class C project.

3.1.4 Effort

According to Toyama (2015) this dimension should be understood as the effort required for a project to have its impact. Effort here refers to human effort on either individual or societal level. He proposes the following three levels to be used as a rating system for the effort required:

**Effort Rating:**

**Unlikely:** Requires significant or sustained effortful activity that people are unlikely to take up without a considerable external impetus.

**Effortful:** Requires moderate or medium-term effortful activity that some people or some societies might be able to muster.

**Effortless:** Requires almost no significant change in behavior among people or societies.

3.1.5 How to use the taxonomy

The following are one example presented by Toyama (2015) on how the taxonomy could be put to use, this will be referred back to in the upcoming analysis.

**Intelligent thermostat:** Consider a thermostat that applies machine learning to determine a household’s power usage habits as they go about their regular lives and automatically regulates appliances in order to reduce total energy usage. Such a project might be classified as a Level -1, Class A, Effortless project (shorthand: -1/A/Effortless) since the intention is clearly toward greater sustainability; the use of the device decreases the rate of resource consumption but does not replenish it; and relatively little effort is required of the user (other than to purchase and install the device).
3.2 Developing a Secondary Level

The preliminary taxonomy presented above includes three dimensions, which can be viewed as the primary level of the taxonomy, and a rating system for each of the dimensions. In this section an additional level will be added to each of the dimensions, a secondary Level (see figure 4 below). The secondary level can provide a more precise way of addressing the three dimensions, hence enable a more accurate classification of ICT-projects when using the taxonomy, but also, as mentioned in the introduction (section 1.0), enable a more detailed analysis of the overall feasibility of the taxonomy in upcoming parts of this thesis, where an example of how to use the final developed taxonomy can be found in the upcoming section 6.5.

Figure 4 - Structure of taxonomy with secondary level.

3.2.1 Sustainability and Resources

The secondary level of the impact dimension will be based on theory using a slightly different definition of sustainability than the one in the preliminary taxonomy. The definition used is not in conflict with Toyama (2015) definition in the previous section but rather complementary. The definition used considers the resource used, the function of that resource – that is the service it provides – and the time horizon for which it is meant to provide that function. A resource is then used sustainably if it is able to provide its function over a stated time-horizon (Hilty, 2015). This definition can include the constraint that resource consumption should equal resource replenishment as proposed by Toyama (2015). If for example a non-renewable resource y enables a
function x then it is easy to see how function x cannot be sustained using resource y, hence cannot be considered sustainable.

As mentioned by Toyama (2015) there will most likely not only be one resource to take into consideration but a system of resources, where resources can be divided into subcategories shown below in Table 2. It is the character of a given ICT-project that decides what resources can be considered for possible consumption and replenishment. Furthermore the necessary demarcations in terms of resources of a sustainable ICT-project will differ in time and space, depending on the character and scope of the project.

<table>
<thead>
<tr>
<th>Classification</th>
<th>Material</th>
<th>Immaterial</th>
</tr>
</thead>
<tbody>
<tr>
<td>Natural</td>
<td>Renewable:</td>
<td>Climate regulation</td>
</tr>
<tr>
<td></td>
<td>Wood</td>
<td>Song of a bird</td>
</tr>
<tr>
<td>Non-renewable:</td>
<td>Minerals</td>
<td></td>
</tr>
<tr>
<td>Human-Made</td>
<td>Machines</td>
<td>Scientific knowledge</td>
</tr>
<tr>
<td></td>
<td>Integrated circuit</td>
<td>Algorithms</td>
</tr>
</tbody>
</table>

3.2.2 Impact - Secondary Level

The secondary Level for the Impact dimension will be based on Hilty's (2015) LES-framework. LES denotes Life-Cycle Impact, Enabling Impact, and Structural Impact. All three levels (not to be confused with levels in the taxonomy) in the LES-framework are non normative. The reason for using the LES-framework is that it is specifically concerned with the impacts of ICT and provides theory for understanding the effects of ICT adding up to the impact.

At all three levels of the framework there is potential for different effects. The aim of this thesis is not to go into detail of the potential effects of ICT, but showing the vast number of effects should give the reader some insight into the complexity of making an accurate impact assessment. The aim of this thesis is not to try to quantify effects on any on the three levels, but it is worth mentioning that on the first level the effects are hard, but at least possible to quantize with
reasonable result using life-cycle assessments, as done by for example Malmodin et al. (2014). On
the enabling and structural level on the other hand the effects are not as obvious and harder to
quantize.

3.2.2.1 Life-Cycle Impact – Direct Impact of ICT

ICT will have environmental and social impact during its production and disposal. In addition to
this ICT-hardware and infrastructure will consume energy throughout the use phase, which is also
part of its life-cycle. Any impact caused during the life-cycle is referred to in the LES-model as
Life-Cycle Impact (Hilty, 2015). The life-cycle moves through the following four phases:

1. Production of raw materials
2. Production of ICT-Hardware
3. Recycling of ICT-Hardware
4. Final disposal of Residues

The use of any ICT-application will take place after the ICT-hardware has been produced and
before it has been recycled, that is, between phase 2 and 3.

3.2.2.2 Enabling Impact – Indirect Impact of ICT

In the LES-framework, actions that are enabled by the application of ICT fall under the category of
enabling impact. The change enabled by ICT can take place in one of the following categories:

- **Production** (Organizational change),
- **Consumption** (Behavioral change),
- As an effect of Technological change itself.

In this thesis these will be referred to as Change Categories.

Hilty (2015) suggests that any enabling impact of ICT is a case of substitution, where substitution
here means that an ICT-application substitutes for a non ICT-application. For example email can
be said to substitute for traditional mail.

There are three types of substitutions that can have an enabling impact:

- Process optimization – Substituting an immaterial for a material resource
- Media Substitution – Substituting one material resource for another.
- Externalization of control – Substituting one immaterial resource for another.

Each will be explained in more detail below.
Process optimization

Process optimization can occur in any of the three change categories mentioned above. To explain the optimization process Hilty (2015) uses the concept of information, where “all processes that have a purpose can be optimized by making use of information”. Information in that sense is of course rather vague but can be understood as any information useful to the function of a given process. The goal of any optimization process is to reduce the amount of resources used while maintaining functionality. A process optimization can occur in organizations as well as households. An example of the former might be an organization using ICT for evaluation of their supply chain performance, where the data gathered enables analysis that includes all activities in a supply chain and the life-cycle of a product (Rizzoli et al. 2015). An example of the latter might be a mobile application enabling energy consumption feedback for households, providing tools for lowering energy consumption while maintaining the same standard of living.

Media substitution

As the name implies a media substitution is the substitution of one medium for another. Every Media Substitution occurs in the Technology Change category. Furthermore all immaterial resources need a material medium. A digital service can substitute for a non-material service – as in the case of email and mail – but the digital service still requires material in form of infrastructure and hardware for the user and service to operate on. This means that a substitution of an ICT solution for a non-ICT-solution does not automatically constitute dematerialization, something that must be assessed for each case.

Externalization of control

With any process that uses information as an input there is the possibility to externalize control over that process. Any device connected to the Internet could in principle be controlled by an external source, that is, a source that is not in direct physical contact with the device. Hilty (2015) uses the example of heating systems. In this particular case externalization could for example enable energy savings by regulating the temperature of households from an external source, where traditionally the residents of the household would regulate the heat themselves.

With Information control being externalized there is of course the possibility of misuse. Hilty (2015) have identified two potential effects that can be explained by the external control of information:

- **Obsolescence** – if the provider of an external information resource has a monopoly of that resource and stops providing it, obsolescence will occur. In the case of the heating system, the information-processing device connecting the system and making its information available for external control can be rendered obsolete if a software-update stops support
Emerging risks – External control depends directly on a functioning ICT-infrastructure. In the example of the heating system an attack on the infrastructure enabling that externalization of control would have an effect on the function of that system. This overlaps with the risk of obsolescence given that the system can’t be used if the infrastructure it depends on is not functioning.

3.2.2.3 Structural Impact – Socio Economic Impact of ICT

Structural Impact divides into economic structure and change of it; and potential change of the Institutional structure.

Hilty (2015) have identified two economic structural changes connected to wider adoption of ICT-applications: Dematerialization and the Networked Economy. Dematerialization should be understood as it was defined in the background section, that is, a “special case” of decoupling where a material resource is substituted for an immaterial resource (Hilty, 2015).

The Networked Economy refers to a new mode of production of goods and services where application of ICT blurs the line between producer and consumer in the value creation and production process; enables open innovation and more resource efficient business models\(^4\)– as for example Airbnb\(^5\), a marketplace community where people can list their homes for other people to rent as vacation accommodation. Where production traditionally have been centralized, with firms owning the capital for creating goods and services, ICT enables a decentralized structure where consumers now can organize in networks utilizing the ICT-infrastructure. This can have an effect on sustainability, given its impact on resource use in the production of any service.

ICT could also affect the Institutional structure indirectly. Hilty (2015) uses the example of ICT’s role in environmental monitoring and research. ICT-systems for generating environmental information could be used in policy decision-making processes.

3.2.2.4 Impact – Secondary Level Summary

In summary the secondary level of the impact dimension consist of:

- Direct Impact
- Enabling Impact

\(^4\) [http://www.technologyreview.com](http://www.technologyreview.com)
\(^5\) [Airbnb.com](http://www.technologyreview.com)
• Structural Impact

These should be understood as they were explained in the sections above. They are not however suggestions for measurement, but the theory behind each of these can be useful in understanding the different aspects of ICT’s potential impact, and enable a more accurate assessment.

3.2.2 Intention - Secondary level

The perhaps biggest difficulty is, as highlighted by Toyama, to differentiate between a project that have “half-hearted” (class B) intention and those that have intentions neglecting effects that a hypothetical reasonable person could see are negative in terms of sustainability (Class C). What constitutes a hypothetical reasonable person in a sustainability context is not obvious and could be a proponent of either strong sustainability or weak sustainability (these were explained in section 2.2.3).

Given how sustainability in connection to the taxonomy has been defined, the secondary level will address how well a project can account for what it is seeking to sustain. If a project describes itself as explicitly sustainable or have motives that are implicitly sustainable it should be able account for:

• What it is sustaining.
• How it is being sustained.
• Why they are seeking to sustain it.

The What is based on Dobsons (1996) question “What is to be sustained?”. The How and Why are based on Browns (1987) recommendation that “Sustainability may be defined broadly or narrowly, but a useful definition must specify explicitly the context as well the temporal and spatial scales being considered”, where the How and Why refers to the context aspect. This means that the What, How, and Why constructs the secondary level of the intention dimension.

3.2.3 Effort – Secondary level

Effort will be exchanged for Likelihood of Adoption (LoA) used in diffusion of innovation theory, which seeks to explain how, why and at what rate new ideas and technology spread (investopedia.com, 2015). The point of this thesis is not to go into any depth of diffusion of innovation theory but to explore the feasibility of the taxonomy, borrowing concepts from diffusion of innovation theory as a means for doing that. The reason for the change is that the amount of effort required for any ICT-project/service is arguably not a useful way to approach the question regarding if or not a project will have an impact. A project could have a high adoption
rate while still being perceived as effortful according to Toyamas (2015) suggestion. A high adoption rate might imply that the effort required is low, and there might be a strong correlation between successful projects and those projects perceived as effortless, but theoretically this does not have to be the case, and will depend heavily on how effort is defined. Instead of getting the definition for effort right, focusing on likelihood of adoption allows for that process to be bypassed without compromising the goal of this dimension of the taxonomy.

The secondary level used to investigate the likelihood of adoption of a sustainable ICT projects will be based on Rogers (1995) *Perceived Attributes of Innovation*.

- **Relative advantage** - The degree to which an innovation is perceived as being better than the idea it supersedes. The degree of relative advantage is often expressed as economic profitability, social prestige, or other benefits” (Rogers, 1995, p. 212).

- **Compatibility** - The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 1995, p. 224)

- **Complexity** - The degree to which an innovation is perceived as relatively difficult to understand and use” (Rogers, 1995, p. 242).

- **Trialability** - The degree to which an innovation may be experimented with on a limited basis” (Rogers, 1995, p. 243). A trial is a way for a potential user to alleviate any hesitancy or doubt that they might have.

- **Observability** - The degree to which the results of an innovation are visible to others”(Rogers, 1995, p.244)

It should be noted that each of these are defined as the degree to which an innovation includes any of the attributes, and detailed assessments of that are possible as shown in Moore and Benbasat(1991) and Venkatesh and Davis (2000). Here they will not be considered in such detail, but used as a foundation for discussing the likelihood of adoption. For example considering questions like: Does project x have relative advantage to project y? Is project x consistent with the existing values, past experiences, and needs of potential adopters? And so forth.

**Rating system**
Having switched *Effort to Likelihood of Adoption* an adjustment for the rating system is also needed. The new rating system is shown below.

A - Likely
B - Possible
C - Unlikely

### 3.3 Final Taxonomy

The final taxonomy should be understood as final for this thesis, and not necessarily final and ready to be used. Below in figure 5 is the taxonomy now including the *secondary level* for each dimension.

This is also the “answer” to the first working question of this thesis: 

*How can a secondary level used for classifying sustainable ICT-projects according to Toyamas proposed dimensions be constructed?* It should be noted that the secondary levels don’t affect the rating system for each dimension (with the exception of the likelihood of adoption dimension). They suggest an additional level to consider before moving on to rating a project, where for example impact now can be viewed on three levels: Direct Impact, Enabling Impact and Structural Impact. Furthermore the secondary level of the impact dimension contains a lot more additional theory in comparison with the other two dimensions. This was not intended, but not surprising given the importance of understanding the impact, and as pointed out by Toyama (2015) the impact of a project is arguably what matters most in the context of sustainability.

![Figure 5 - Structure of final taxonomy](image)
4. Method

This thesis started from the preliminary taxonomy proposed by Toyama (2015), consisting of the definition of sustainability at the Root level, the Dimensions and a Rating System for each dimension. First a pre-study was performed as a means to gathering material for adding a Secondary Level to the taxonomy. The result of this (presented in Developing a secondary level section 3.2 and finalized in the section prior to this called Final Taxonomy) is to be seen as the answer to the first of the working questions posed in the introduction of this thesis:

- How can a secondary level used for classifying ICT-projects according to Toyamas proposed taxonomy be constructed?

The next step of this thesis was to address the remaining two questions, those being:

- Is the taxonomy a feasible approach to classifying sustainable ICT projects?
- Is there any ICT-project that is sustainable if using the taxonomy for classification?

This was done by performing interviews with projects addressing sustainability. The interview and recruitment process is explained below.

4.1 Choosing projects

There were two criteria when trying to find projects to use for evaluating the feasibility of the taxonomy. The projects should:

1. Address sustainability questions.
2. Have a clear connection to ICT.

The process of identifying potential projects to be interviewed was done using Google search on keywords such as sustainability and ICT. It also included using prior knowledge of companies using ICT to address sustainability, as well as recommendations from the supervisor of this thesis. All contact with potential participants was done through mail.

Below a short description for each of the projects interviewed are given along with a motivation for how they met the criteria. Since the goal of the interviews was to explore the feasibility of the taxonomy and not evaluate the projects, they are all presented anonymously. Each project have
been given an alias below which will also be used in the upcoming result section.

**Project EnergyApp:**
A start-up company providing a mobile app that allows households/users to get an overview of their energy consumption by gathering data from smart meters, analyzing the data, and visualizing it. The company website explained that the company was started “in order to achieve a more sustainable energy consumption”.

**Project ChargeCar:**
A start-up company providing an electrical vehicle charging system. The system consists of smart power sockets communicating with a cloud server that sends the information to a user controlled mobile application. The system also included a web service presenting the user with statistics and payment information. This project was found through the website of an incubator focusing on technology start-ups, where it was listed under the category *Sustainability*. Furthermore, on their website they partially marketed themselves toward real estate companies looking to profile themselves as *sustainable*.

**Project Scenario:**
A research project that resulted in a web-based interactive design prototype presenting scenarios for a sustainable society in the year 2053. In the description found on the project's website one of its goals was explained as “normalizing sustainable lifestyles”.

**Project Certification:**
A non-profit organization and third party sustainability certification for IT products. The motivation for this project qualifying is self-explanatory.

### 4.2 Semi-Structured Interviews
For data collection semi-structured interviews were conducted. All of the interviews except one were held in person, where the remaining interview was conducted over phone. The phone interview was planned to be conducted using Skype, but due to some technical difficulties and lack of time the choice of phone had to make due. There was one representative from each project participating in the interviews, with the exception of Project Certification where there were two. The time of the interviews varied between 25-45 minutes. In total there were 18 questions prepared (these can be viewed under *Interview framework, section 4.2.1*). The questions were mapped out according to the three dimensions in the taxonomy. In addition to this there was one category of questions addressing sustainability at what has been called the *root level* of the taxonomy. The structure of the questions was based on judgment and
was not considered absolute in the sense that a question could provide information only for the
dimension under which it had been organized in the interview framework. Neither was it deemed
-crucial that all the questions were asked in the order they had been placed in the interview
framework, or asked at all. If for example the first question lead to an answer that also addressed
the second question (or any other), that question could be disregarded.

4.2.1 Interview framework

Impact

- What is the main goal of your product/service?
- What methods does the product/service employ in order to reach that goal?
- What are the effects of using your product?
- Are there any other effects the product/service might have that are beyond the direct control of you as product/service
  providers? (Can the product/service have unintended effects?)
  - Was this considered during the development process?

Intention

- What problem does the product/service intend to solve?
- How does the product/service intend to solve the problems in the way of reaching that goal?
- Why is it important that this problem is addressed?
- How is the product/service intended to be used?

Effort/Likelihood of Adoption

- What is the demand for the product/service?
- What are the user segments for the product/service?
- What are the requirements for using the product/service? (Technical knowledge, hardware etc.)
- What are the advantages of using your product/service against other options available?
- Is there a possibility to test the product/service before committing to it?

Sustainability

- What is sustainability for you and how does that relate to the product/service?
- How does the product/service encourage work towards sustainability?
- How is the product/service (itself) sustainable?
- Is there anything else you would like to add?

4.3 Method for analysis

To analyse the information gathered from the interviews a type of thematic analysis used.
Thematic analysis can be described as a “method for identifying, analyzing and reporting patterns
within data.” (Braun and Clark, 2006, p. 79). More specifically the thematic analysis used for data
analysis in this paper, is a deductive a priori template approach as described by Crabtree and Miller
(1999), where the theory is predefined and the data gathered from the interviews are interpreted according to predefined concepts.

Here the template is the developed taxonomy as it has been presented in the theory section; the categories are the three dimensions; and the concepts are those found under the secondary level of each dimension.
5. Result

The result will be presented under the categories used in the interview framework, which are also the dimensions in the taxonomy, with the exception of the Sustainability category (section 5.1). Since not all questions were asked explicitly during all of the interviews, the result under each category will be the aggregated data deemed relevant for the given category. A lot of the data could be interpreted as being relevant for more than one category and in those cases the choice was made to include them under both categories.

5.1 Sustainability

Three out of four participating projects referred to the three-pillar approach in understanding sustainability, if not directly then indirectly by mentioning social, economic and environmental aspects. However, only Project Certification used it explicitly as a foundation for its work with sustainability, pointing to the UN’s definition saying that: “We have included sustainability according to the UN’s definition, and the UN defines sustainability as environmental, economic, and social. Those are the three pillars.”

Project EnergyApp said that, “sustainability is a really broad topic. It can mean lots of different things” and that the question concerning what sustainability meant was too general. Though, went on saying "that it is perhaps possible to speak of sustainability in a clear way if you can make clear demarcations and connect it to specific actions”.

Project Scenarios definition was based on energy consumption and an even distribution of energy across the globe.

5.2 Impact

None of the projects talked directly about the impacts of their respective product/service but gave answers that could be interpreted as the effects that their product/services could have. Furthermore one of the questions under Impact in the interview framework was aimed at what indirect effect the projects might have. This question proved hard to get any deeper answers on and indirect effects was not something that any of the projects except one had considered at any length.

Project Scenario aimed to provide people with visions of different alternatives for sustainable futures, showing that there are potential sustainable futures that can be attractive and do not have to
lead to technological regression. Project Scenario said that lots of visions of the future available either come in form of scientific articles or thick books; and that the purpose of the project was best described as informing and communicating visions of sustainable futures in a way that makes them more concrete and accessible to the general public. Project Scenario did not think that their solution would have any considerable effect saying that “Honestly I think this have a pretty small effect, and partly because it’s isolated, without any clear context”.

Project Certification said that any IT-product meeting the criteria of their certificate they considered as being better than other available products on the market with regards to sustainability; and that these criteria considered every aspect of a products life-cycle, including environmental, social and economic aspects. Project Certification further mentioned that although they considered the whole life-cycle of a product it was hard for them to have an equal impact during the whole life-cycle saying that, “there are some ways in which you could place demands in the recycling process and during waste management, but it is much easier placing demands on production, the design and the distribution of the product. Once the product has left the control of the brand [here referring to the producer of the certified product] and reached the customer it is hard for us to control recycling and waste management”. Project Certification said that although there are some demands that could be placed at the these stages it is much easier to do so during the production, design and distribution-phase of a product, since at these stages they had a contract with the producer, which they did not have with the buyers of these products. With regards to indirect effects the same project said that they were mainly concerned with the “Greening of IT”, the process of making the products themselves more sustainable and not the processes in which they were used.

Project ChargeCar talked about the impact in terms of what they hope to achieve saying that, “Because the existing infrastructure is way to inefficient and demands too much of the user, it’s important that there are more user friendly solutions [referring to how it their solution would enable users to charge their vehicles where they usually stand parked (at home or work), not having to spend time at a charging station] available to make possible a greater diffusion of electrical vehicles and making the option of buying an electrical car more attractive”. The same project also said that the indirect effects of using their service could be to save time and money.

Projects EnergyApp said that their service helped households lower their energy consumption without use of additional hardware and summed up the potential effects of their project as energy efficiency and engagement. The same project explained how through a combination of data analysis and visualization they could get people to become more involved in their energy
consumption which could lead to a change in behavior saying that, “We use visualization, but we also use techniques from social psychology to get people to change their habits and behaviors and enable them to actually lower their energy consumption”

5.3 Intention

All of the projects could account for how their products/services worked and how they were intended to be used and why they considered it important. But in terms of what the projects hoped to achieve in terms of sustainability and what should be sustained there were a wide range of answers, from ambiguous to fairly detailed. Project EnergyApp gave several explanations referring to their intentions “If you’re looking at the development with the climate and the questions we are facing today, it is extremely hard to solve these problems. Now the development is heading in a positive direction and we are trying to be one of the actors who continue the global development around the climate, climate questions, and so forth”. The same project also said, “We really just want to supply more information regarding households energy consumption, which can hopefully lead to it decreasing.

Two projects mentioned law and policy frameworks. Project Certification explained the difficulties in achieving some of their goals given that they were bound by laws and policy frameworks that were beyond their control, but that in terms of sustainability they tried to push their product/service as far as they could, explaining how if the laws are the ground rules for how to compete, their product went beyond the ground rules doing more than demanded, while also trying to continuously improve according to new research. Project EnergyApp said that “Our thought is to use the technology, policies and information [referring to the data they gathered to deliver their service] available today and empower the end-consumer.

Project ChargeCar said that the goal of their product/service was to enable a greater diffusion of electrical vehicles but did not connect it to why that was important in terms of sustainability, and explained how their product/service provided a more time and cost-efficient alternative. Project Scenario said that they wanted to change the narrative with regards to what sustainable development can mean.

5.4 Likelihood of Adoption

Most of the interview data that could be interpreted as being related to the likelihood of the projects being adopted where in all cases very general, where the projects mainly considered their product/service in comparison to available alternatives of similar kind.
None of the projects thought that their product required any special hardware or technical knowledge to be used. Two of the projects mentioned that they had tough competition but that they thought they were better than the alternatives.
One project said that they were better than their alternatives with regards to sustainability, but that their service put higher demands on the user.
Project ChargeCar referred to their advantages being ease of use and time and cost-efficiency when explaining why people would use their service.
One project said that they operated in a very “conservative and undigitized industry” and that that lowered the possibilities of their service reaching a larger crowd. The same project also required their users to be connected to one of their partner companies.
One of the projects had a hard time defining for whom their product was actually for, saying that during their work with the product they hadn’t really decided.
6. Analysis

In this section the result from the interviews will be connected to the developed taxonomy to see if the dimensions and the proposed secondary level were useful in interpreting the data gathered from the interviews. Further this section will be used as a foundation for an attempt to answer the two questions presented in the introduction of this thesis, that is:

- Is the taxonomy a feasible approach to classifying sustainable ICT projects?
- Is there any ICT-project that is sustainable if using the taxonomy for classification?

As explained in the theory section the dimensions of the taxonomy are meant to be conceptually independent; meaning that an impact assessment can be made independently of the intention and likelihood-dimension. As a result of the choice of method for data gathering the distribution of information corresponding to each of the three dimensions are not clear cut, but blend together, where most data could be understood as important for discerning the validity, or lack thereof, for any of the three dimensions. The perhaps biggest difficulty was in trying to draw a clear line between the intention and the other two dimensions; where some of the answers interpreted as connected to the intention dimension touched upon questions of potential impacts and the likelihood of the project having an impact. The problem of separating the three dimensions, in this case, is perhaps an artifact of the choice of method, but it is worth mentioning because the relationship between the Impact dimension and the Intention dimension are such that it will likely complicate things when trying to classify a project no matter how. I will call this the Intention Dimension Problem and return to it in under Implications for the taxonomy (Section 7).

6.1 Impact

As was mentioned under section 3.2.4 a vast majority of the theory added in creating the secondary levels could be connected to the Impact dimension. This is further reflected in the presentation of the result, where a majority of the data gathered from the interviews was connected to the impact dimension. Although the exact type of impact could be discerned the secondary level proposed were clearly useful as a way of getting at the boundaries of a project and also for interpreting the answers given in terms of different types of impact.

The secondary level for the impact dimension consisted of:

- Direct impact
All of the participants talked about what impacts or effects their respective projects potentially could enable. One clear example of this was project Chargecar explicitly stating that one of the goals of their service was to enable a diffusion of electrical vehicles. Of course moving from a project having an impact to having an enabling impact might seem trivial, but given that this corresponds well to Enabling Impact in secondary level of the taxonomy, focus can move to the change categories connected to Enabling Impact:

- Production (Organizational change)
- Consumption (Behavioral change)
- Effect of Technological change itself

Having established the change category the type of substitution can be decided, where there were three types of substitutions that could have an enabling impact:

- Process optimization – Substituting an immaterial for a material resource
- Media Substitution – Substituting one material resource for another.
- Externalization of control – Substituting one immaterial resource for another.

This can allow for a more accurate assessment by pointing to the right boundaries for investigation. If for example - as was the case in two of projects interviewed - a project is seeking to enable a behavioral change and constitutes a process optimization, the process of making an impact assessment becomes more focused. This would just be the first step of an assessment and does not really get at what the actual impact of a given project can be. This requires further work, but getting the demarcations right is a crucial first step in making an accurate impact assessment. This will be labeled The Boundaries Problem and be returned to under section 7. The example used above of projects Chargecar also hints at the potential for a structural impact.

6.2 Intention

The intention dimension referred to “whether there is any intention among the people responsible for a project, technology, policy, or system to address sustainability.”

The secondary level of intention were explained as “given how sustainability has been defined in this paper this will be taken to mean that if a project describes itself as explicitly sustainable or have motives that are implicitly sustainable it should be able account for:

- What it is sustaining.
- How it is being sustained.
• Why they are seeking to sustain it.

Given that none of the projects shared the definition of sustainability proposed as a foundation in the taxonomy, but leaned toward the Three Pillar approach\(^6\) or some other idea of sustainability (an issue which will be further elaborated under section 7) as in the case of project chargecar, to say that they specifically accounted for what they intended to sustain would be incorrect. None of the projects answered in terms of what they intended to sustain but rather what change they sought to enable. A perhaps more reasonable interpretation would be to say that some of the projects had a view of sustainability that to a greater or lesser extent correlated with the one given in the taxonomy. Also, difficulties arose in trying to separate the intended impact from intention toward sustainability, which can have implications for the overall structure of the taxonomy. This will be considered part of what was labeled the Intention Dimension Problem two sections above and returned to in section 7.

6.3 Likelihood of adoption

In the preliminary taxonomy effort were explained as the requirements for a project to have its impact, where effort referred to human effort. During the development of the secondary level, effort was exchanged for likelihood of adoption; with the motivation that the former was to elusive, with the latter addressing the same problem but from a more manageable perspective. Regardless what one chooses to call this dimension the result indicates that it’s important to decide at what stage a project should be in to qualify for classification. At a user level a service could be identified as easy to use, compatible with current values, not demanding any behavioral change and so forth; but as exemplified by one of the participants during the interviews the stages before a service even reaches the user are important to consider, with the participant saying that they operated in a “conservative and undigitized industry” which lowered the possibilities of their service reaching a larger crowd. A further example of external factors affecting the likelihood of impact was the mentioning of policy frameworks. This raises the question as to what stage a project can, or should, be considered for classification and to what extent external factors will affect likelihood of a project getting adopted. I will call this Project Stage and External Factors Problem and return to it under Section 7 below.

\(^6\) The Three Pillar approach here refers to the view that sustainability can be viewed as the intersection between environmental, economic, and social sustainability, as explained in section 2.2.1
6.4 Sustainability as a Resource equilibrium

Certain patterns emerged around the concept of sustainability itself; how the projects viewed sustainability in relationship to their projects; and how this conflicts with the definition of sustainability used as a foundation in the taxonomy.

Sustainability in the taxonomy was understood in terms of resource consumption and replenishment, where sustainability is the point of equilibrium where resource consumption is equal to resource replenishment. As mentioned earlier under Intention section 6.2, the projects interviewed leaned toward the three-pillar approach or some other idea of sustainability. This does not have to be a problem in terms of classifying projects. A project being classified does not have to agree upon what constitutes sustainability, but it highlights the problem of reconciling a “three-pillar reality” with a taxonomy taking a resource approach. This will be labeled the Sustainability definition problem and will be further discussed below in section 7.

6.5 How to use the developed taxonomy

In section 3.1.5 one example of how to use the taxonomy were presented, taken from Toyama’s (2015) paper. To further clarify the result from the interviews one new example will be given below. This time using the developed taxonomy and one of the projects that participated in the interviews.

**Project Chargecar:**

The direct impact of the charging system is the use of raw materials in the production phase of the power socket, and the energy consumption of both the power socket (since it was connected to a cloud server) and the cloud server used to control the distribution of energy during the use phase. Recovering and recycling of old devices was not discussed during the interview and is therefore not known. As to enabling impact project Chargecar can potentially have an effect on user behaviour in the context of charging electrical vehicles, enabling the users to charge their cars where they usually stand parked for longer times (at home or work) as opposed to visiting a charging station. During the interview project Chargecar expressed that this might save the user both time and money. Furthermore project Chargecar can be identified with enabling two types of substitution:

**Process optimization** - Substituting an immaterial for a material resource.

Using their smart power sockets one cars could be charged where traditional power sockets only allows for one car at a time to be connected and charged. Furthermore it enables the car owner to charge the car where they usually park their car, instead of taking time of for finding a charging
station and waiting while the car recharge (which can take up to 30 minutes). The smart power socket connects to a cloud server running software for efficient distribution of energy between the connected cars, allowing for several vehicles to use the same socket.

Externalization of control - Substituting one immaterial resource for another.
It is the externalization of control of the charging process and energy distribution that enables the process optimization. One negative aspect might be that the use of the Chargecar system requires a working connection between the smart power socket and the cloud service that distributes the energy between the cars connected to the Chargecar power socket. If a connection is not available or there were to be issues with the server running the software needed, the function of the service will be affected.

Furthermore Project Chargecar considered their product and service as a component in larger electrical vehicle ecosystem, saying that:
“Because the existing infrastructure is way to inefficient and demands too much of the user, it’s important that there are more user friendly solutions [referring to how it their solution would enable users to charge their vehicles where they usually stand parked (at home or work), not having to spend time at a charging station] available to make possible a greater diffusion of electrical vehicles and making the option of buying an electrical car more attractive”.

With this in mind the total impact is uncertain. Considered as a part of a bigger electrical vehicle ecosystem it is clear that availability of charging solutions are needed to make electrical cars a strong competitor to fuel driven cars; and that Chargecars solution can be one way of achieving this. However, this does not imply that the neither the charging solution nor electrical vehicles are sustainable in terms of resource consumption and replenishment. Most likely the Chargecar charging solution is less resource intensive than the current system where charging stations are used, since it makes use of existing infrastructure and power sockets available in every building. A level -1 rating seems appropriate, meaning that project Chargecar decreases the rate of resource depletion but does not move things toward a sustainable equilibrium.

The intention of the project is somewhat unclear. If assuming that the diffusion of electrical vehicles is always a good thing, than the intention to make this possible can be considered a good thing, but it does not necessarily have to imply a genuine intention toward sustainability as it has been defined in the taxonomy. A Class B rating, meaning neutral or indifferent intention toward sustainability seems more reasonable. Project Chargecar expressed a want for a more efficient charging solution as a means for saving time and money, where their product and service could enable a change in user behavior, which in turn could facilitate an efficiency improvement and savings in both money and time.
It seems possible that the charge car product and service will be adopted. In terms of relative advantage it is clearly more user friendly and considerate of user behavior in the context of cars then the currently available charging systems. During the interviews project Chargecar stressed easy of use and the non-complexity of the service. In terms of compatibility with current values, fuel driven cars are still the norm and it is possible that a widespread adoption of electrical vehicles are still years in the future, which can obstruct the diffusion of project Chargecars charging solution. In terms of trialability (testing of a product before committing) and observability (if the use of a product is visible to others), the project was still in an early stage of implementation and none of the answers given during the interviews could be used to make a fair assessment of these. In summary the classification of project Chargecar using the developed taxonomy as a foundation would be -1/Class B/Possible. This means that it is possible that the service is adopted but that this depends on factors outside the control of project Chargecar. The intention toward sustainability is neutral at best and it seems reasonable to believe that it would lead to decrease in resource consumption but not achieve equilibrium since it does not replenish resources.

It is worth comparing this to the example of the intelligent thermostat given by Toyama (2015) and presented in section 3.1.5. There are some parallels between project Chargecar and the intelligent thermostat in that they both use data for process optimization. It is also clear that adding an additional level to the taxonomy makes the assessment process, if not more accurate, more nuanced. Of course both Toyamas example and the example given above are speculative and a real assessment would require a more developed method, but even so the developed taxonomy provides useful tools for reasoning about the three dimensions which were previously not available.
7. Implications for the taxonomy

The overarching question and aim of this thesis was to explore whether and how the preliminary taxonomy can be operationalized, using the working questions as a means for doing that. There were a number of problems highlighted in the analysis above that can have implications for the process of making an assessment using the taxonomy and its overall design, which affect its feasibility.

The problems identified are presented below in the order they appear in the section prior to this one, with a short recapitulation of their meaning:

- **Intention Dimension Problem (section 6.0)**
  The connection between the Impact dimension and the Intention dimension are such that it will likely complicate things when trying to classify any project.

- **Boundaries Problem (section 6.1)**
  The problem of drawing the right boundaries when assessing an ICT-project.

- **Project Stage and External Factors Problem (section 6.3)**
  The question concerning the stage in which a project can, or should be considered for classification and to what extent external factors affect the likelihood of a project getting adopted need to be addressed.

- **Sustainability Definition Problem (section 6.4)**
  The problem of reconciling a Three-Pillar approach with a taxonomy taking a resource approach.

The Intention Dimension Problem, the Boundaries Problem, and the Sustainability Definition Problem are to a large extent connected, where the Intention Dimension Problem and Boundaries Problem stem from the Sustainability Definition Problem. This is perhaps easiest understood by viewing the structure of the taxonomy below in figure 6. The definition problem connects to the Root Level of the taxonomy, where the intention and boundary problem connects to the Primary level. With the problems identified in mind I will now attempt to answer the question posed in the beginning of this thesis.
7.1 Answer to the working questions

In this section I will attempt to answer the working questions, those being the following:

- Is the taxonomy a feasible approach to classifying sustainable ICT projects?
- Is there any ICT-project that is sustainable when using the taxonomy for classification?

What can first be said is that no matter the definition of sustainability any assessment of effort/likelihood of adoption is not affected, and given that this is the case I will address the Project Stage and External Factors Problem first and then address the remaining three problems.

What became clear is that a decision needs to made as to what stage of implementation a project should be in to be considered for classification given how this will affect the assessment and the Effort/LoA-Dimension in the taxonomy. The projects interviewed in this thesis were all at different stages of implementation, where two of the projects interviewed were at a fairly early stage. If using the secondary level to understand the likelihood of them getting adopted, or estimating the effort needed, then they could be classified as being effortless or as being likely to be adopted due
to their ease of use. But this is only considering their respective services from a user perspective where in reality the most limiting factors are external ones affecting the project at the stage before even reaching the user. This was highlighted by two of the projects participating in the interviews, mentioning policy frameworks and industry norms. Furthermore, in his paper Toyama (2015) uses smartphones to exemplify how the taxonomy could be used. If assessing projects that are already proven to be successful, such as the smartphone, the classification process would be trivial using either the likelihood of adoption or effort approach. If the choice is made only to focus on projects at an early stage of implementation then the likelihood of adoption approach that was suggested as a secondary level can be useful, given that the attributes (see attributes under figure 6 above, and further section 3.2.3) suggested do take this into account, where for example *Compatibility* considers “The degree to which an innovation is perceived as consistent with the existing values, past experiences, and needs of potential adopters (Rogers, 1995)” . Of course this approach would need to be further developed, but can be considered a pointer to a possibly useful direction.

The remaining problems identified were the *Sustainability definition Problem*, the *Boundaries problem* and the *Intention Dimension Problem*. The first two are of course general problems for any discussion concerning sustainability assessment, and as mentioned in the beginning of this thesis, the choice of definition is always value-laden and will affect the outcome of any assessment (Gasparatos and Scolobig, 2012). In this case the choice of definition affects the three dimensions differently (where as mentioned above, the Effort/LoA-dimension is not affected at all) and depending on how one chooses to address the problems it can have different implications for the taxonomy as a whole.

Sustainability in the taxonomy was defined as a resource equilibrium, which was explained as the point where resource consumption equals resource replenishment. This is not an unreasonable approach for assessing an ICT-projects potential impact. Any difficulties likely to arise in using a resource-based approach such as the one in the taxonomy is not as much in making an assessment as in identifying what resources to consider for assessment, hence what boundaries to draw. As mentioned, resource-oriented approach “*reduce the complexity of deeply nested resource systems to simple metrics*” (Hilty, 2015), but still rely on the accuracy of the model of system to be effective. The secondary level suggested for the impact dimension in the taxonomy was useful for getting a clearer picture of what impacts are available for consideration but also highlighted the issue of drawing the correct boundaries, and as such is still a long way from being useful in making an accurate assessment.

Problems likely to arise due to addressing sustainability from a resource perspective is to come to terms with the seeming discrepancy between sustainable use of a resource or a set of resources on a
smaller clearly demarcated level, and what adds up to sustainability on a higher level. Take for example Project EnergyApp participating in the interviews. Given that their service was concerned with enabling people to get a better overview of their electricity consumption and providing tools for decreasing the same consumption, it seem reasonable to say that the boundaries for an impact assessment should be drawn around energy consumption within households using this application. Further, it is not unreasonable to believe that people might decrease their energy consumption using this app. Yet if taken into consideration that included in the scope of the project was to “be one of the actors who continue the global development around the climate, climate questions, and so forth”, an argument could be made for assessing the total environmental impact of a household using the application, which would affect the boundaries.

With that said, no matter the accuracy of the boundaries, in a best-case scenario their service would never reach a classification better than -1 using the rating system for the Impact dimension, which translates into being classified as not sustainable, albeit, the best of three ratings for non-sustainability. It’s hard to see how any ICT-application would reach a higher classification than -1 given that they all require the usage of non-renewable resources.

As explained by Hilty (2015), a digital service can substitute for a non-material service – as in the case of email and mail – but the digital service still requires material in form of infrastructure and hardware for the user and service to operate on. This means that a substitution of an ICT solution for a non-ICT-solution does not automatically imply dematerialization, and in the case that an ICT-solution constitutes a dematerialization it would still only be able to receive a -1 rating. This would not be factually wrong given that ICT will use some amount of non-renewable resources, but it raises questions with regards to how to rate different levels of impact and the feasibility of the taxonomy. A taxonomy where every project can only be assessed on levels of unsustainability is arguably not a feasible one, and an adjustment of this need to be considered in any further attempts to operationalize the taxonomy.

Furthermore, the problem identified as the Intention Dimension Problem is to a high degree connected to the Sustainability Definition Problem. The problem arises in trying to keep the Intention dimension independent from Impact, where intention in the theory section was explained as “whether there is any intention among the people responsible for a project, technology, policy, or system to address sustainability”(Toyama, 2015). The intention of those responsible for any ICT-project addressing sustainability is of course of importance, but if a project don’t share the sustainability definition of the taxonomy it is hard to see how the intention dimension would add anything above and beyond what is given by making an impact assessment. In the secondary level

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7 A -1 rating was explained in section 3.1.2 as: “Decreases the rate of net resource depletion, but does not take things toward a sustainable equilibrium. The rate of resource depletion is still positive”(Toyama, 2015) where the rating scale went from -3 to 1.
of intention I suggested that any project under assessment should be able to account for:

- What it is sustaining.
- How it is being sustained.
- Why they are seeking to sustain it.

This seems reasonable if sustainability is considered in terms of resource consumption and replenishment. But if for example - as was the case with Project Certification – a Three-Pillar approach (economic, social and environmental sustainability) is used, Intention toward Sustainability is a lot harder to come to terms with, and as mentioned (Intention section 6.2) all the projects explained their intentions in terms of what change they intended to enable.

This does not mean that a project being assessed need to share the definition of sustainability, but it indicates that problems might arise in assessing clearly well-intended projects that don’t share the same definition of what constitutes sustainability.

### 7.2 Method Critique

Semi-structured interviews and the process of analyzing the gathered data depend in general on asking the relevant questions and drawing the right or plausible conclusions from the gathered data. The data gathered was useful, but as was mentioned above, a lot of the answers could be interpreted as connecting to more than one of the dimensions, where the perhaps biggest difficulty arose in trying to draw a clear line between the intention dimension and the other two dimensions, where some of the answers interpreted as connected to the intention dimension touched upon questions of potential impacts and the likelihood of the project having an impact. In retrospect the interviews might have gained from having a more structured approach, the semi-structure interviews resulted in answers that at times were less relevant than hoped for when constructing the interview framework. Furthermore the time of the different interviews varied to some extend which might be a reflection of the structure of the interviews, where some of the participants found it easier talking freely about their projects than others. It might also reflect the writer of this thesis limited experience in conducting longer interviews. A set of more specific questions might have provided more specific answer, for easier matching with the taxonomy as well as comparison between the different projects.
7.3 Conclusion

This thesis has explored the feasibility of a taxonomy for sustainable ICT as proposed by Kentaro Toyama (2015). What can be concluded is that the taxonomy in its current state is not a feasible approach for assessing sustainable ICT-projects. With the resource approach and current rating system used for the impact dimension no application of ICT can reach a classification that would be regarded as sustainable. Furthermore it is hard to see that the Intention Dimension will add anything beyond an accurate impact assessment considering that lots of projects are likely not to share the definition of sustainability used in the taxonomy. Both of these problems and the decision as to what stage a project should be in to be considered for classification need to be addressed in any future and further attempts to operationalize the taxonomy. With that said there is still a need for understanding the relationship between ICT and sustainability; and although the taxonomy in its current state is not feasible does not mean it cant be adapted using the findings in this paper. Overall the result from this thesis can be used as a stepping-stone for future attempts to further develop this taxonomy or as an aid in understanding the difficulty in the overall complexity in making an assessment with regards to ICT and sustainability. Preferably future research should consider focusing on just one of the dimensions. One suggestion is to only consider the intention dimension and how to understand the intentions of those projects that are involved in sustainability work but addressing the issue from a three pillar perspective and not from a resource perspective as the one proposed in the taxonomy. Another suggestion is to further investigate how to understand the effort/likelihood of adoption dimension and the stage a project should be in to be considered for assessment.
8. REFERENCES


829-845.


Toyama, Kentaro. (2015)"Preliminary thoughts on a taxonomy of value for sustainable computing." First Monday 20.8
