THE TRANSITION TO A CIRCULAR NETWORK

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Summary

Electronic waste is a complex problem, and it has become one of the fastest growing waste streams due to increased consumption and poor waste management. Especially mobile phones have seen an increase in the amount of waste, which can be attributed to several trends. These trends include fast replacement cycles, difficulty of repair and complex product composition. The increased electronic waste is highly problematic as there are a lot of environmental impacts associated with it. To decrease the electronic waste from mobile phones other tactics such as circular strategies must be used. Circular strategies focus on extending the lifespan by utilized resources and reentering them into the lifecycle again instead of treating it as waste. This project investigates how it is possible to transition to the circular strategies reuse, repair and refurbish by using the Actor Network Theory. This theory focuses on investigating actors in a network, their relations with each other, and how a network can be stabilized through the actors' relations. It has four phases as presented by Michel Callon, and all phases needs to be fulfilled in order to stabilize a network. The first phase is problematization where a collective problem is presented in which actors can relate to. The problematization in this project is that the fast replacement in mobile phones leads to an increased generation of electronic waste, and hence a need for incorporating circularity in phones. Actors who agree with the problematization is thereby included in the attempt to form a network. The next phase is interessement, in which circular strategies are used to create a relation between the actors. The enrollment phase involves the negotiations between the actors in an attempt to clearly define the roles of the actors. The actors who have been identified in this project include the users of circular strategies, repair and refurbishment establishments as well as non-human actors such as policies. The last phase is mobilization which involves the appointing of a representative of the network as a spokesperson for the network. During the analysis it became evident the forming of the network was not durable as several other actors needed to be included in the network for it to be stabilized. Hence, the recommendation to introduce other interests or another problematization in order to engage key actors into the network, which could potentially stabilize it.

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1.0 Electronic waste

Modern society is built around electronic and electrical devices with individuals depending on online services. Online services can be needed in order to be a part of e.g., a workplace or social groups or even in order to get a doctor's appointment. This makes electronic waste (E-waste) the fastest growing stream of waste (TCO certified, 2019) with an estimate of 57,4 million metric ton of waste in 2021 (Forti et. al, 2020). E-waste is defined as discarded (outdated, unwanted, or broken) electronic and electrical appliances such as mobile phones, computers, and copiers (European Parliament, 2020).

E-waste has become one of the fastest growing waste streams and it keeps increasing due to electronics becoming more accessible worldwide. About two out of three Europeans would like to keep their electronic devices for longer if the performance is not significantly affected (European Commission, 2020a), hence hinting at a possible change in the use of electronics. Globally 53,6 million metric ton (Mt) of E-waste was generated in 2019 and only 17,4% of it was officially documented as recycled (Forti et. al, 2020). Since 2014 the officially documented recycled waste has increased by 1,8 Mt while E-waste has increased by 9,2 Mt (Forti et. al, 2020). Hence suggesting recycling activities are not able to keep pace with the increasing generation of E-waste. The low documented recycling rate can further be explained by E-waste being exported illegally, in 2016 10% of E-waste was being exported legally while 10% was being exported illegally (Forti et. al, 2020). Thereby highlighting a system, which does not properly manage E-waste.

Compared to other waste streams, E-waste does not have a significant weight share, but does however has one of the highest CO2 footprints. A study conducted identifying the waste streams in the Capitol Region of Denmark, shows E-waste has the lowest weight with 24.700 ton, but the highest CO2 footprint amounting to 326.000 ton (Thorin, 2020). Thereby showing an immense importance in addressing the waste stream of electronics in order to decrease the environmental impact.

1.1 Electronic waste in mobile phones

Mobile phones in particular have a significant share in the growing E-waste stream. In Europe, the citizens replace their mobile phone on an average of every second year, thus creating 60-80 kg of CO2 equivalent emission per mobile phone (Stupple-Harris, Bego and Droemann, 2021). In Europe there is a purchase of 200 million mobile phones per year, hence releasing 12-16 million kg of CO2 equivalent emissions annually (Stupple-Harris, Bego and Droemann, 2021). Considering the mobile phone market is growing with an 11% increase per year, the problem will only worsen, as more mobile phones will be purchased in the future and thereby increase the amount of E-waste from mobile phones.

2.0 Why is e-waste a problem?

The immediate threat regarding E-waste concerns the pollution associated with improper treatment of the E-waste, however it is important to consider other environmental impacts influenced by E-waste. The section highlights the direct effects of E-waste on the environmental, as well as the influences E-waste has on other stages of a mobile phone, and how this impacts the environment.

E-waste contains a lot of different chemicals that could be harmful to both people and the planet. The chemicals end up in the water, soil, and air if they are not treated correctly when the electronic device is disposed of.
Small electronics are often incinerated in order to extract valuable metals like copper, but this also causes fine particles to be released into the air, which can travel far and can be harmful to both humans and animals. Other metals with higher value, such as silver and gold, are extracted using acids, desoldering, and other chemicals, which releases fumes that can also be toxic. Air pollution can affect some species more than others and can be a threat to biodiversity. It can damage the ecosystem affecting the water quality, soil, and plants (Elytus, n.d.)

E-waste influences the environment due to improper treatment of the waste, however the problem of E-waste also influences the production of new products. The increased volume of E-waste means new products are being purchased as a

replacement for the old products. In the case of mobile phones activities such as extraction, production, packaging and transport are responsible for 72% of the emissions in the lifetime of a mobile phone (Stupple-Harris, Bego and Droemann, 2021). A study conducted by the European Environmental Bureau (2019), suggested that the non-use phase of a mobile phone with a use phase for 3 years was responsible for 51-92% of the total Global Warming Potential for mobile phones. Furthermore, the study revealed that by extending the lifetime of all mobile phone in Europe by a year would save 2.1 Mt CO2 – equal to taking over a million cars of the road. Thus, the high emissions associated with the non-use phase, the expansion of the phone market, and the rapid replacement of phones all fuel the effect E-waste from mobile phones has on the environment. If instead the lifetime was expanded in order to preserve the natural resources, and the value embedded in mobile phones could be preserved, a reduction in E-waste would be experienced.

2.1 The barrier between the linear flow and the circular flow of electronics

E-waste causes a huge strain on the environment, but in order to understand the problem of E-waste, it is important to reflect on how factors in the linear flow influence mobile phones to end up as E-waste. The following section highlights systematic barriers in the electronics industry, which hinders the structure of a more circular flow for mobile phones.

Lack of transparency in value chains

The electronics market faces complex value chains with challenges hindering the transition to a more circular flow. The predominant infrastructure in today's electronic market presents several barriers in a transition from a linear flow to a more circular flow. The lack of transparent value chains for mobile phones dictates barriers in all stages of the value chain, hence obstructing material transparency (World Economic Forum and Pace, 2019). Material transparency is important to ensure ethical sourcing and processing (World Economic Forum and Pace, 2019), thereby driving the market to more ethical products. Furthermore, to overcome the uncertainty of the composition of a product, a more transparent value chain can ensure visibility of

material composition and product condition, hence allowing a seizing of the value of embedded resources through multiple lifecycles (World Economic Forum and Pace, 2019). Lastly, by increasing the transparency in the material flows in the value chains of mobile phones, it is possible to improve waste management systems, and thereby extract value from the products.

Linear product design

The linear product design currently experienced in many mobile phones influence the environmental impact of the phone. Over 80% of the environmental impacts of a product is influenced by the design process (World Economic Forum and Pace, 2019), hence marking the linear product design as a critical phase to improve to ensure a more circular flow. The complex design integrated in mobile phones is based on the purpose for high-performance and low cost (World Economic Forum and Pace, 2019), thereby not considering how an improved circular design can further the longevity of the phone.

Linear lock-in

The development of circular models to decrease the environmental impacts in products is challenging to create in an existing linear system which favors other factors than circularity (World Economic Forum and Pace, 2019). Due to a linear product design, and the lack of management system assessing the potential value in circular models and circular strategies such as reuse and recycling, the linear lock-in is disabling the ability to introduce circular models on the same basis as linear models. A reused Iphone retains 48% of its original value, whereas the components of a recycled Iphone only retains 0.24% of its value (World Economic Forum and Pace, 2019), in which the introduction of an assessment management system could address the value and condition of used phones, thus promoting the potential for integration into a new lifecycle.

Insufficient waste management systems

Waste management systems with proper infrastructure are often unavailable in lower-income countries resulting in 90% of waste being dumped or burned (World Economic Forum and Pace, 2019), thereby not utilizing the value of the waste.

Furthermore, collection schemes and waste management systems and infrastructure are challenging to implement in these areas due to a lack of data on the waste streams (World Economic Forum and Pace, 2019). Globally, more than 80% of E-waste is not documented for recycling (Forti et. al, 2020), likely due to the E-waste being landfilled, incinerated or informally processed, highlighting the need for proper waste management systems which can support the use of circular models.

Ineffective sorting and processing infrastructure

To achieve a high quality of recovered materials, waste streams must be separated and sorted to ensure uniform material streams, and to avoid cross contamination (World Economic Forum and Pace, 2019). Manual disassembly has in many cases in electronics aided to a recycling rate of 90%, whereas mechanical disassembly has a recycling rate of 60%, (World Economic Forum and Pace, 2019), thereby illustrating the effectiveness of a proper processing infrastructure. However, the lack of current material standardized and a complex composition of materials in products, makes it difficult to identify and properly sort the waste, and the cost associated with the technology and infrastructure to ensure high recovery rates are high (World Economic Forum and Pace, 2019).

3.0 Lifecycle of mobile phones

The different phases in the lifecycle of mobile phones have challenges, which all contribute to the increasing generation of E-waste. Hence, it is relevant to consider the full life cycle as illustrated in Figure 1. The following section highlights different problems in the lifecycle of a mobile phone, hence illustrating several factors leading to the generation of E-waste.

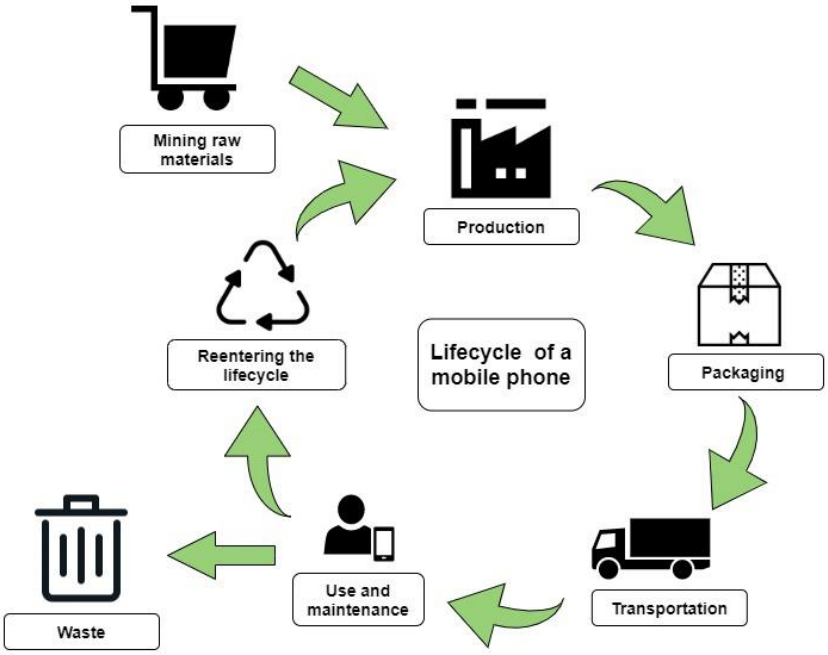


Figure 1: An illustration showing the lifecycle of a mobile phone.

Extraction of raw materials

A mobile phone is a highly complex product, and contains many different raw materials such as plastic, metals, ceramics and glass, including up to 16 rare earth metals (Stupple-Harris, Bego & Droemann, 2021). Some of these materials can be critical raw materials, which is defined as a raw material which has a high risk associated with the supply (Ministry of Environment and Food of Denmark, n.d.). Hence, the extraction and mining of critical raw materials poses a problem since the processes of mining critical raw materials is often associated with dangerous chemicals, which pollute the environment. Furthermore, the mining of some critical raw materials occurs in conflict related and high-risk areas, where conditions of armed conflict and violations of human rights are common, and the critical raw materials are traded by armed groups (Cordella, Alfieri and Sanfelix, 2020). Hence, the production of new mobile phones relies on critical raw materials, which can have high risk associated with the supply. However, some manufactures are working towards a more transparent and due diligence supply chain with brands such as

Fairphone ensuring the acquisition of critical raw materials are fair trade certified (Cordella, Alfieri and Sanfelix, 2020).

Design and production

The design and production phase is essential to the longevity of a phone, and the design choices can determine performance, quality of parts, aesthetic, durability, the level of disassembly, supply and recyclability (Cordella, Alfieri and Sanfelix, 2020). Many phones experience a short longevity due to the design choice, which thereby makes it difficult to prolong the lifetime. It provides an unnecessary consumption of resources to make new phones, and the design can in most cases be a driver to the replacement of phones. Phones are being replaced due to a breakage of the screen, battery degradation, or camera dysfunctionality, which is the direct result of the design choices of the manufacturers (Stupple-Harris, Bego and Droemann, 2021). A study by Cordella, Alfieri and Sanfelix (2020) outlined 78% of EU citizens replaced phones, which could have been avoided through a better and more durable design. Hence, to reduce the generation of E-waste the design of a phone should be improved, and include better repairability, better durability and easier disassembly as an aim for an extended lifespan.

Packaging

The packaging of a new phone protects the phone during transport. Mobile phones are often wrapped in cardboard and plastic. The packaging is meant to protect the phone in order to secure safe transportation and avoid breakage. This requires more resources for packaging, and it also results in more waste when the phone is unpacked (Ministry of Environment and Food of Denmark, n.d.).

Transport

As mentioned, a mobile phone contains raw materials from all over the world. Some raw materials are mined in Africa, China and South America, then transported to Asia, where they are processed to create materials used in the production of the mobile phone. The phone is then transported to Europe for consumers to buy it (Ministry of Environment and Food of Denmark, n.d.).

Transportation often causes air pollution and emits CO_2, which contributes to global warming. Much of the transport takes place by ship, but in special cases the phones are flown by plane to Europe, and this is a mode of transport that produces a particularly high level of pollution and emits a high amount of CO_2 (Ministry of Environment and Food of Denmark, n.d.).

Use and maintenance

The average use of a phone for citizens in the EU is approximately 2 years before it is replaced (Stupple-Harris, Bego and Droemann, 2021). The lifespan of a phone is in stark contrast to other electronic devices, such as washing machines (11.4 years), laptops (4.5 years), and vacuum cleaners (6.5 years) (Stupple-Harris, Bego and Droemann, 2021). Phones require regular software updates in order to maintain proper functionality, however most phones are not able to receive updates after 2-3 years, hence the lifespan of the software is often far shorter than the longevity of the hardware leading many users to replace their phones (Stupple-Harris, Bego and Droemann, 2021). The short life span of mobile phones is leading to a rapid replacement rate (State of Green, 2018), with users seeking to replace their phone due to the launch of newer models and features, loss of performance, or breakage of the phone (Cordella, Alfieri and Sanfelix, 2020). The short life span of mobile phones results in an increased production of new mobile phones, which further strain the environment. It was in publication shown an increase of the use phase of a mobile phone by one year, would lead to a 25% reduction of the environmental emissions, thus implying the life span is a critical factor to consider (Cordella, Alfieri and Sanfelix, 2020).

The choice on whether to repair, or replace an old phone is a dilemma many users face and can be based on many factors such as price, type of phone, expected lifetime, functionality, and emotional attachment (Cordella, Alfieri and Sanfelix, 2020). Furthermore, repairing a phone can be a viable solution in order to extend the lifetime, however many users does not seek repair due to the difficulty of repair. A study conducted by Cordella, Alfieri and Sanfelix (2020) states that two thirds of the users experiencing a faulty phone does not even attempt to have it repaired, due to the difficulty and the associated cost. For the user, it is possible to extend the lifetime

of a phone with options such as repair, however to drive the phone market to a longer lifetime on average, factors such as design and repairability must be improved.

Incineration and landfill

Mobile phones and other electronics contain valuable raw materials which after becoming E-waste, can be recovered. However, an amount of the E-waste becomes incinerated or ends up in landfills. A statistic from DPA (2019) showed 140.000 ton electronics were marked as waste with only 72.000 ton being properly collected. Hence, there is a disconnection between the generation of E-waste and the collection of E-waste. This can be due to the lack of data in the area, direct resale, the collection of E-waste from unauthorized collectors or improper sorting of the E-waste. Furthermore, part of the E-waste also ends up in other countries that do not have proper treatment of E-waste or environmental regulations, in which it can be harmful to the environment when sent to incineration or landfill (Ministry of Environment and Food of Denmark, n.d.).
The non-recyclable parts of the phone can either be landfilled or incinerated and converted into energy.

Recycling

Many of the raw materials in a mobile phone can be recycled if the phone cannot be utilized by other circular strategies. This saves extraction of new raw materials in the mines (Ministry of Environment and Food of Denmark, n.d.). A mobile phone consists mainly of plastics and aluminum, however the rare earth metals in the phone are the main elements for the residual value of the mobile phone, hence the aim for recycling is often to obtain the rare earth metals (Cordella, Alfieri and Sanfelix, 2020).

The lifecycle of a mobile phone depicts a variation of challenges and barriers in each phase, which can hinder the circularity of a phone. Some of these challenges are embedded in the phone itself, while others are due to external factors. To achieve a more circular use and manufacturing of a phone, it is important to improve all of the lifecycle stages for the phone.

3.1 Causes of a short product life

The short product life contributes to immense environmental impacts, highlighted by the study conducted by the Cordella, Alfieri and Sanfelix (2020). in which it was illustrated how an increase of the use phase of a mobile phone by one year, would lead to a 25% reduction of the environmental emissions. Thus, the problem regarding a short life span of a mobile phone is crucial to consider when investigating the environmental impacts associated with the generation of E-waste.

Four categories have been identified as the reasons leading to a short lifespan of mobile phones. The four categories are mechanic expiration, functional expiration, emotional expiration and economic expiration. The following section aims to group the causes for E-waste into the four categories.

Mechanic Obsolescence

Mechanical obsolescence is defined as the breakage of a component's hardware due to poor quality, extended use or easily breakable such as the screen of a smartphone, the camera, or the casing.

Mechanical obsolescence is experienced in many phones today and can be a cause for the malfunction of phones. In a study conducted by Watson et al. (2017), it was revealed 40% of Nordic users choose to replace their phone due to their current phone not functioning properly. Poor quality of parts, and a design choice to not use durable parts can cause the phone to break easily, hence leading to mechanical obsolescence. For example, a low performance of the battery coupled with the design of mobile phones obscuring an easy replacement of degraded parts often results in consumers seeking a new product. The mechanical obsolescence and the difficulty of repair of mobile phones is a reason for the increase of E-waste. In the design of mobile phones, a smart design is often valued higher than the repairability and easy disassembly of a phone (Daalgaard, n.d.), enabling the throw-away culture currently depicted on the phone market. It further fuels the increased consumption of new mobile phones, in which consumers often favor a quick replacement of a phone,

instead of dealing with the warranty and security issues of a repair (Baldé, et al., 2017).

Functional obsolescence

Functional obsolescence is when the hardware and software are no longer compatible due to software upgrades, in which older models of mobile phones no longer have the same ability to get the same upgrades as newer models. 13% of Nordic users replaced their phone, due to wanting the latest software (Watson et al., 2017), hence highlighting a rapid advancement in software development, in which older software becomes outdated. Functional obsolescence is also partly caused by manufactures, who publish a new feature and thereby nudge the user to obtain a new model which support the new feature (Proske et al., 2016).

It has been revealed leading companies in the mobile phone market use the tactic planned obsolescence with countries such as France, Israel and USA investigating the issue (BBC, 2018). Planned obsolescence is a design strategy which limits the mobile phones' use phase by slowing down the performance of older models, hence nudging the consumer to invest in a new product (RAVPower, 2018) Companies argued that the slowing performance of older models was intended to counter the decline of battery life of old phones. Despite advances in the development of batteries used in mobile phones, the constant use and charging of the battery wears on the physical battery, hence over time the battery will perform at a lower level (RAVPower, 2018).

Emotional obsolescence

Emotional obsolescence occurs when the mobile phone is still functional, but the user is replacing it with a newer or better model.

Fast-fashion electronics is an aspect which leads to increasing amounts of E-waste. The term fast-fashion contributes to the notion in which a consumer is replacing a functioning product with a newer model due to a variety of reasons. These reasons can include technological advances and wanting the newest updates, as well as

fulfilling a social aspect (Baldé, et al., 2017). The constant release of new models of phones enables consumers to continually purchase new products in order to stay up to date with the latest technological advances. Furthermore, the purchasing of new products can be supported by the social aspect in which there is a certain social status and recognition associated with having the latest model (Baldé, et al., 2017). Thereby adding to the rapid replacement and consumption of mobile phones, which in turn increase the level of E-waste.

Another problem seen in the creation of E-waste in mobile phones occurs in the user perception, which can influence the users' disposal of used mobile phones as well as their consumption of new products. Misconception can lead users to disregard sustainable strategies such as refurbished and reused phones in favor of new products. The user perception is important in order for the current linear economy of take-use-dispose to transition into a circular economy in which the product via circular strategies can reenter into the lifecycle. The misconception of refurbished and reused mobile phones can be related to the users' lower willingness to pay due to the perception of high risk and low quality of the refurbished and reused phones (Weelden, et al., 2016). Refurbished and reused phones can be perceived as a high risk and low quality, as the user can be uncertain about the functionality as well as the quality of the product. A study conducted by Weelden, Mugge and Bakker (2016), showed a lack of understanding for the refurbishment process is further hindering the user's willingness to pay for a refurbished product, and hence limit the success of refurbished products. The study highlighted four main barriers for users buying refurbished products: Lack of awareness, misconception of refurbishment concept, lack of availability, and lack of the thrill of newness (Weelden, Mugge and Bakker, 2016). These factors influence the user's willingness to buy refurbished products but can be improved by the availability of information for the user. The user perception further ties together with the 'hibernation' of mobile phones in the user's homes, meaning when the user acquires a new phone, the old product is often stored in the household regardless of it is functioning or not. The functioning share of hibernated phone in private homes, are often used as a back-up solution, if an occasion occurs in which there is a need for a replacement phone (Schischke et al., 2021). Furthermore, hibernated phones are also stored in private homes, due to a concern for the data security risk, in which the user fears the leaking of private data if

the old phone is resold (Schischke et al., 2021). By storing an old mobile phone in the home, the product gradually loses its value, instead of reentering the phone into a lifecycle. An old mobile phone could be reentered into the lifecycle by either reuse, refurbishment, repair or recycle. By utilizing these strategies, the phone could reenter the lifecycle and potentially limit E-waste.

Economic obsolescence

Economic obsolescence happens when the mobile phone is in need of repair, but the user chooses to obtain a new phone due to low difference between the expenses associated with repair and with obtaining a new phone.

Limitations on repair guides and spare parts provided by the manufacturer complicates the repairing of mobile phones (Mashhadi, et al., 2016), which can result in a longer repair process for the customer due to increased costs and resources of a more difficult repair, which in turn can increase the price of a repair. This is due to the difficulty of All these factors can in turn discourage the customer from seeking repair, and hence a new product is purchased instead due to the economic expenses associated with repairing a phone compared to purchasing a new phone.

4.0 Measures to promote circularity in mobile phones

Several measures exist with the overall goal of promoting sustainable products, and thereby decrease the environmental impact of mobile phones. The following chapters focus on relevant legislation in a European context, which all promote circularity in phones.

4.1 Legislation

4.1.1 WEE Directive

The WEEE directive (Waste Electrical and Electronic Equipment) is essential to the management and disposal of mobile phones and other electronics. The WEEE Directive covers the EU rules concerning the management and disposal of mobile phones in an environmental perspective, hence opting for safe disposal of mobile phones as well as limiting the quantity of waste. The directive aims to ensure proper waste treatment as well as reduce resource consumption by design (Danish Producer Responsibility, 2018).

The directive compels Member States to adopt appropriate measures to minimize the disposal of WEEE and to ensure proper treatment of disposed electrical equipment. The directive further aims for the achievement of a high level of a separate collection of WEEE (EU Directive 2012/19/EU, 2012). The measures Member states should incorporate allows for a more thorough and more effective waste treatment. Several measures are put forth by the directive concerning private households, these include:

1. Member States should implement systems allowing end-users to return electronic waste free of charge by ensuring availability and accessibility of necessary return facilities.

2. The distributor supplying a new product is responsible for the ability to return such waste on a one-to-one basis free of charge.

3. Distributors should provide for the collection of small electronic equipment (25 cm) at retail shops with sales areas of 400 m2 free of charge.

4. Producers are allowed to implement take-back systems for WEEE from private households provided the take-back systems fall in line with the objectives of the Directive.

5. WEEE that present health and safety risk to personnel due to possible contamination can be refused for return. The Member States are required to make a separate collection system for such WEEE.

(EU Directive 2012/19/EU, 2012).

Another objective in the WEEE Directive is to minimize waste from electronic equipment, hence the directive has a focus on product design. In article 4 of the directive, it is stated that Member States should encourage cooperation between producers and recyclers to promote measures such as product design focusing on the facilitation of reuse, disassembly and material recovery in WEEE (EU Directive 2012/19/EU, 2012). Furthermore, the directive compels Member States to take appropriate measures to ensure ecodesign is applied in products. Hence, under the directive, producers are not allowed to implement design features which can prevent sustainable measures in the Member State. (EU Directive 2012/19/EU, 2012).

The WEEE Directive therefore aims to obtain the objectives through producer responsibility, which essentially means the polluter should be responsible for the product after ended use (Danish Producer Responsibility, 2018). Hence, the producer and importer are responsible for the collection and for an environmentally friendly treatment of a proportional share of the products they are placing on the market. The producer will impose the cost in the EEE, hence affecting the cost for the consumer and for businesses.

The WEEE Directive is categorized as a ‘minimum’ directive, meaning each Member States has the ability to impose national specific measures in order to facilitate the implementation of the directive, and thereby adapt to provisions to the directive to specific national conditions (Danish Producer Responsibility, 2018). However, the measures are to be in compliance with the directive and must not contradict the objective in the directive.

4.1.2 The RoHS Directive

Electric and electronic equipment contains substances which can be hazardous if released to the environment. The RoHS Directive focuses on this and has the purpose of avoiding hazardous substances in EE equipment. The RoHS Directive

aims to prevent risk to human health as well as the environment by prohibiting substances in EEE such as heavy metals and flame retardants (EU Directive 2011/65/EU, 2011). The directive restricts substances which can be substituted by safer alternatives. The RoHS is restricting 10 substances which have been deemed harmful (EU Directive 2011/65/EU, 2011).

4.2 Ecodesign and Energy Label in mobile phones

The following section will present the Ecodesign Directive and the EU Energy Label, as they are essential to a new initiative proposed by the European Commission. The initiative is named *Environmental impact of mobile phones and tablets* with the intention to minimize the environmental impact from mobile phones and tablets by proposing regulations to the Ecodesign Directive, and the Energy Labelling Regulation. It is still in the initial phase with feasibility studies being done to assess how additions to the Ecodesign Directive and the EU Energy Label can include the utilization of resources in phones and tablets. The initiative is planned under the Circular Economy Action Plan 2020 and aims to ensure tablets and mobile phones are designed to be energy efficient and durable, easy repairable by users, and can be reused and recycled (European Commission, n.d.).

4.2.1 The Ecodesign Directive

In order to achieve higher sustainability across the EU, the European Commission has implemented a directive to increase energy efficiency in energy-related products. The Ecodesign Directive is a framework for setting ecodesign requirements for all energy-related products within EU Member States. An energy-related product is a product with an impact on energy use. The directive improves the product's environmental performances by providing consistent rules for household appliances in the EU (European Commission, n.d.a). These rules act as minimum mandatory requirements for the energy efficiency of these products.
The purpose of the directive is to reduce energy consumption and other environmental impacts as stated in the article 2, 12. directive (Directive of establishing a framework for the setting of ecodesign requirements for energy-related products, 2009) "Any change to the environment wholly or partially resulting

from a product during its life cycle" (EU Directive 2009/125/EC, 2009). The directive was established in 2005, but amendments was made in 2009. By setting requirements for the energy use of energy-related products, the directive removes the most environmentally damaging and least energy efficient products on the market. Furthermore, the directive strives to improve the material efficiency which is an approach set out in the Commission's Communication of 18 June 2003 entitled 'Integrated Product Policy - Building on Environmental Life-Cycle Thinking'. This aims to minimize the environmental impact of products by assessing all stages of the life cycle and taking action where it is most effective (European Commission, n.d.). The Ecodesign Directive is focused on the design phase, based on the pollution caused throughout the life stages and is implemented in EU countries through product-specific regulations. All EU member states are required to use mandatory energy labelling which complement the Ecodesign requirements.

4.2.1 Energy labelling Regulation

Energy efficiency is an essential way for the EU to achieve carbon neutrality by 2050. When improving energy efficiency, it will reduce emissions and lower energy costs for citizens and businesses. The EU Energy label is a measure to boost energy efficiency of electric appliances. It acts as a guide for consumers to make informed choices when buying energy-related products (European Commission, 2020).

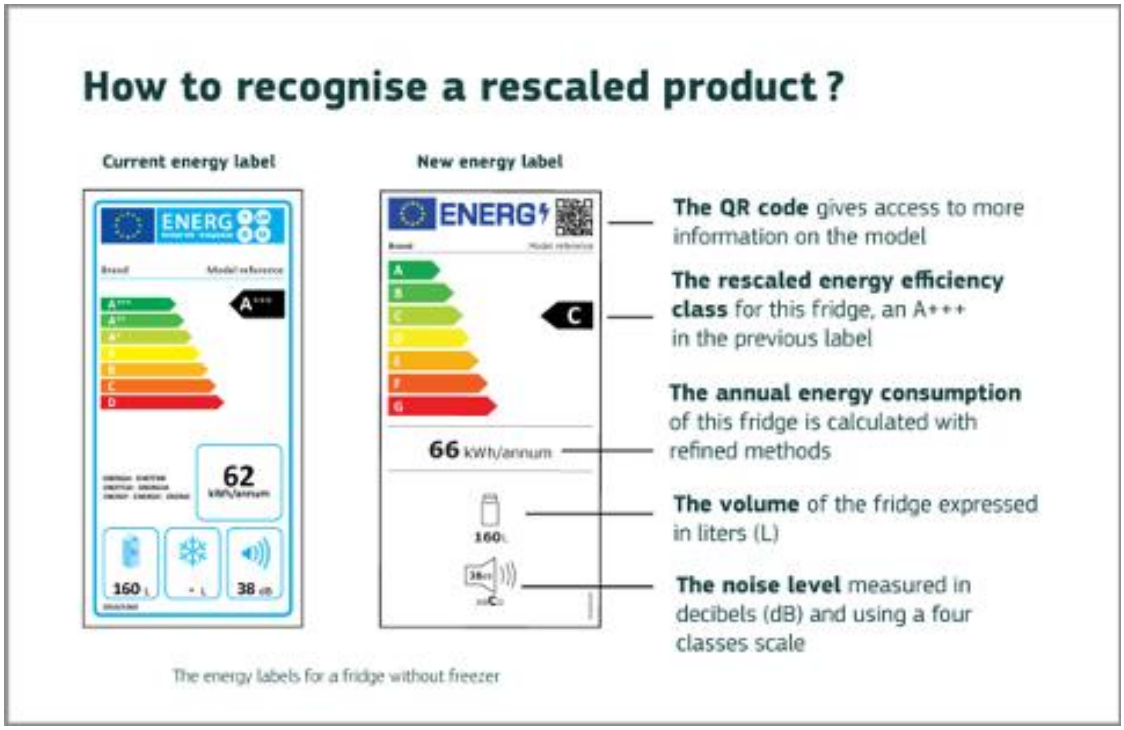


Figure 2: Illustration of the new and the old energy label (European Commission, 2020).

At the end of 2020 the energy label was renewed due to the fact that the category “A” was no longer enough to describe the most energy efficient products. The categories “A+”, “A++” and “A+++” were added to the classification system, and at the same time some of the lower categories were phased out. The new energy label has a simpler scale that goes from A to G and is language neutral as illustrated in Figure 2.

4.2.3 Environmental impact of mobile phones and tablets

The initiative currently in the process of being formed focuses on avoiding waste and obsolescence by improving the design in mobile phones to ensure better material efficiency, reparability, end-of-life treatment, and energy use during the lifetime of a mobile phone (Tecchio et al., 2018). In an outline presenting the initiative, it was described how challenges in the lifetime of a phone was of concern for the environment. These challenges were identified as an increase in the power demand, storage capacity, materials used for manufacturing, hibernation of used phones, and rapid replacement cycles (Tecchio et al., 2018).

The legal basis for the initiate includes measures to increase energy efficiency in the EU Energy Labelling Regulation, and measures in the Ecodesign Directive. The initiative could potentially be regulated at EU level, as it was assessed a national level regulation could present obstacles to the free movement of products across national borders (Tecchio et al., 2018). By implementing EU wide regulation, the policy is thought to help reduce environmental impacts stemming from resource and energy use, production, and use of the products. The initiative will focus on reducing the carbon footprint of mobile phones and tablets by addressing the whole lifecycle of these products with a special focus on extending the lifetime. Initial measures were proposed to support the objective, these includes making products more durable, better repairability, reducing waste and achieving higher rates of recycling and reuse (Tecchio et al., 2018). An impact assessment and a preparatory study was conducted to assess how regulations to the Ecodesign Directive and Energy Labelling Regulation could be achieved. Five scenarios were studied, in order to assess how best to incorporate regulations. The five scenarios are:

- option 1 – no action (business as usual)
- option 2 – self-regulation
- option 3 – mandatory specific and/or generic ecodesign requirements
- option 4 – energy labelling according to the Energy Labelling Regulation
- option 5 – a combination of ecodesign requirements and energy labelling. (Tecchio et al., 2018).

Option 1 was assessed as having a slightly positive influence, due to current market trends which would increase material efficiency. One of these markets trends is partly declining markets, which points to slowed down replacement cycles (Schischke et al., 2021). Another market trend pointing to increased material efficiency, is the increased price for a mobile phone, which can extend replacement cycles as well as increase the reuse rate (Schischke et al., 2021).
However, other market trends in option 1 highlight a negative effect for environmental emissions, such as new products concepts, and a shift to high-end devices will cause increased manufacturing emissions (Schischke et al., 2021). An assessment of the mobile phone market suggests the positive effects for option 1 are

dominant, but however not enough to achieve the EU policy Goals (Schischke et al., 2021).

Option 2 concerning self-regulation focuses on a new regulation under advisement – the EcoRating, which will be implemented in 2021 by major telecommunication companies throughout Europe. The EcoRating can possibly have the same effect as a voluntary agreement and will rate mobile phones on the basis of repairability, durability, reusability, upgradability, reusability, recyclability, use of hazardous substances, use of recycled materials, and packaging (Schischke et al., 2021). However, EcoRating is led by telecommunication operators, and does not include phone manufactures, thereby not covering the whole market, but is estimated to cover 25-40% of the market (Schischke et al., 2021). Furthermore, the option does not include design-specific requirements, hence the effect of the option is not ensured to receive a positive market response.

Option 3 concerns specific or generic Ecodesign requirements and can lead to mandatory change in the mobile phone market, in which the user's role is critical, since they are the determining factor in the success of the market shift (Schischke et al., 2021). The option identified the measures which should be addressed in mandatory Ecodesign requirements. These measures are: Easier repairability (by the user) and reusability, operating system support, battery lifetime, battery endurance, ease of data transfer and data security, unbundling of accessories, protective shell, and water and dust protection (Schischke et al., 2021). This option was assessed as having a positive effect and will in 2030 see a 23% decrease in cost for the consumer, 35% less in material use, and 19-23% less critical raw materials in the mobile phones compared to option 1 (Schischke et al., 2021).

Option 4, the implementation of mandatory regulation to the Energy Labelling on mobile phones will move the market to more energy efficient products. The extend of the effect depends on the users' consumption patterns, but due to the familiarity with the established Energy Label, consumers are thought to have an easy transition. The option 3 implements regulations regarding battery endurance, and will potentially cause declining sales of phones, due to a longer battery life (Schischke et al., 2021). The regulations to the Energy Label are anticipated to have a positive

effect, and likely to improve 3-6% for economic and material indicators, and a 6-11% improvement for social and environmental indicators (Schischke et al., 2021).

Option 5 includes a combination of Ecodesign and Energy Label regulations, which in the year 2030 is likely to achieve the same positive effects as option 3. However, with a combination of the Ecodesign and Energy Label, the effects are likely to be implemented faster, and thus in the years leading up to 2030, will have a better impact. Furthermore, due to the familiarity with the Energy Label, it is expected to cause a more positive market response and experience a 28-42% decrease in environment impacts (Schischke et al., 2021).

In summary the initiative *Environmental impact of mobile phones and tablets* is proposing scenarios, which will improve the environmental impacts, and hence assist the Circular Economy Action Plan in achieving climate neutrality by 2050 (Tecchio et al., 2018). The proposed causes of action for the options differ, and thus depending on the chosen option, will have a varying positive impact on the environment.

5.0 Certifications as motivators for mobile phones

Certification for mobile phones has the purpose to highlight which products are sustainable and thereby giving the consumer the opportunity to make an informed choice. Furthermore, the certifications have the ability to drive businesses to create more sustainable products, and thereby achieve a higher standard in the product than proposed by directives and regulations. Relevant certifications, which act as drivers for the mobile phone market as well as verification for sustainable products are described in the following section.

5.1 TCO Certified

TCO Certified is a third-party international sustainability certification, which focuses on IT products. The certification is a label ensuring the mobile phone fulfill certain requirement during its lifecycle: Manufacturing, use and end of life (Schischke et al., 2021). For the manufacturing phase, the certification focuses on the socially responsible manufacturing and environmental management system with criteria

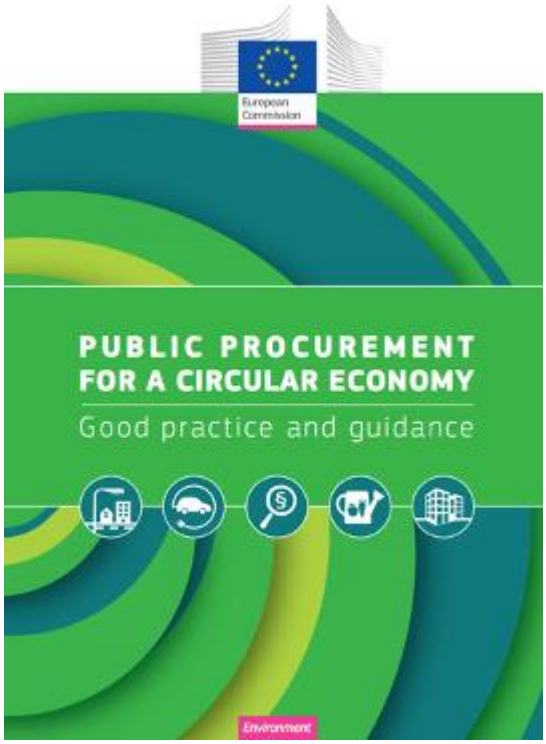
concerning a transparent supply chain, responsible sources minerals, energy efficient indicators etc. (TCO Certified, 2019). In the use phase of the phone, the certification focuses on climate, extended lifetime, health and safety, and emissions (Schischke et al., 2021). The criteria regarding the use phase includes battery replaceability, service manual, availability of replacement parts, product durability etc. (Schischke et al., 2021). In the end-of-life phase, the certification has criteria concerning the reduction of hazardous material and substances, as well as design for recycling (Schischke et al., 2021). Hence, the TCO Certification has high standards in order to award a phone the certification, and no phone has yet to achieve the updated requirements put forth in the newest TCO Certification update from 2019 (Schischke et al., 2021).

5.2 EPEAT

EPEAT ecolabel is a global rating system for electronics – including mobile phones, which started in 2003. To get a device registered in EPEAT, the product must meet certain required and optional criteria throughout the whole lifecycle (Schischke et al., 2021). The EPEAT ecolabel awards three types of rating based on the products ability to meet a combination of required and optional criteria. To obtain a bronze-rating, the product must meet all of the required criteria. To obtain a silver-rating, the product must meet all of the required criteria, as well as at least 50% of the optional criteria. Lastly, to be awarded a gold-rating, the product must meet all of the required criteria, and at least 75% of the optional criteria (Schischke et al., 2021). For mobile phones, the some of the required criteria include compliances with the ROHS Directive on hazardous substances, service support, end-of-life processing, recyclable plastics, take-back systems, and battery removability etc. (Schischke et al., 2021). As of May 27th 2020, the EPEAT ecolabel has 54 mobile phones registered from brands such as Apple, Samsung, Google and LG (Schischke et al., 2021).

5.3 Green Public Procurement

Green Public Procurement (GPP) is a voluntary instrument for public authorities to choose environmentally friendly goods, services and works and therefore contribute to a sustainable consumption and production. The purpose of this is to make the EU more resource efficient by stimulating the demand for **sustainable** goods and services (European Commission, n.d.e). These could otherwise be difficult to get onto the market which makes GPP a stimulus for eco-innovation. GPP includes clear and verifiable environmental criteria for products and services in the process of public procurement. These criteria, and guidance hereof, are developed by The European Commission and a number of European countries (European Commission, n.d.e).



(European Commission, n.d.e).

The guide “Public Procurement for a Circular Economy” is an approach to GPP with focus on "the purchase of works, goods or services that seek to contribute to the closed energy and material loops within supply chains, whilst minimizing, and in the best case avoiding, negative environmental impacts and waste creation across the whole life-cycle" (European Commission, n.d.f).

The guidance covers mobile phones and presents a set of measures, which is aims to ensure a sustainable guidance in the purchase of mobile phones. The CPP guidance has a list of specific requirements such as availability of repair and spare parts, recyclable design, information about recycling, plastics marketing, recycled content and information to the consumer (Schischke et al., 2021). The CPP presents guidelines, however many Member States have implemented national regulations going beyond these guidelines, and have specific legislation and requirements (Schischke et al., 2021).

5.4 Blue Angel

Blue Angel is an ecolabel originating in Germany. The Blue Angel label has a wide range of product groups, with mobile phones being one of them. The Blue Angel ecolabel aims to protect the environment, reduce energy consumption, increase resource efficiency, and avoid harmful substances and waste (DE-UZ 106, 2017). In order for a mobile phone to be awarded the Blue Angel label the following objectives must be met to a certain standard:

The Blue Angel label (DE-UZ 106, 2017).

- Product longevity
- Low user exposure to electromagnetic radiation
- Design that supports maintenance and recycling
- High-value (secondary) batteries
- Compliance with fundamental social standard

(DE-UZ 106, 2017).

To meet the objectives certain measures must be taken such as ensuring the availability of spare parts, an easy and secure deletion of data, extended durability of the battery, software updates, recyclable design etc. (DE-UZ 106, 2017). The Blue Angel label promotes a high environmental standard for mobile phones with a focus on the whole lifecycle, yet no mobile phone has been awarded the certification (Schischke et al., 2021).

6.0 Circular strategies

Circular strategies are important, in order to utilize resources. The concept of circular economy uses circular strategies by utilizing materials and obtaining the most value by keeping materials in use for as long as possible. Circular economy further avoids waste by extending the lifespan of products (Christiansen et. al, 2019). A transition to a circular economy is an opportunity to become more sustainable and to contribute to the sustainable development goals set by the UN. Furthermore, the transition will also contribute to meeting the objectives of the 2030 Sustainable Development Agenda.1 (Christiansen et. al, 2019).

The waste hierarchy was introduced to manage waste and illustrates how to reach the best environmental outcome by a ranking of strategies in which prevention of waste has the highest priority and landfill has the lowest priority. The different strategies are set up as a hierarchy, as illustrated in Figure 3, to achieve the greatest possible value for the material.

The two systems illustrate two approaches to the management of waste. The waste hierarchy is representing a system, in which the linear management of waste such as disposal and recovery are given a considerably amount of attention in contrast to circular economy. In circular economy the focus is on circular strategies, which can prevent the generation of E-waste and utilize the resources more efficiently, whereas the waste hierarchy includes circular as well as linear strategies. Furthermore, the ideology of the waste hierarchy is to achieve the highest form of waste management. Prevention is the top priority and is the only strategy being treated as non-waste, whereas several linear strategies are present and correlated to the direct treatment of waste. Thereby the waste hierarchy can be perceived as more focused on waste instead of the prevention of waste causing more linear strategies to be used.

Prevention

The highest priority in the waste hierarchy is prevention, which through design, repair, reuse and remanufacturing strategies can prevent waste. Prevention is essential for circular economy, as it builds on the notion to maintain products in the lifecycle for as long as possible (EMF, n.d.). Designing durable phones ensures the phone has a longer lifetime. The prolonged lifetime of a durable phone further ensures it can be reused between users. The strategy of repair prolongs the lifetime of the phone, thus slowing the resource flow, and discourages the user from buying a new phone. Reuse as a strategy entails the product are sold or passed on without first having been collected as waste, and thereby slows the replacement cycle for the new user.

Figure 3: Waste hierarchy in the EU (European Commission, n.d.g).

Preparation for reuse

This level deals with products that can be used again with only a few and simple actions, such as function check, cleaning or upgrades. This appears as a solution at the top of the hierarchy, as it is an environmentally better solution than recycling, where the product undergoes different processes in order to extract and recover materials. Examples of preparation for reuse can be the replacement of individual components in electronics so that it is functionally again (The Danish Environmental Protection Agency, n.d.).

According to the Danish waste declaration §3 nr. 19 the preparation for reuse is defined as any recovery operation in the form of inspection, cleaning or repair, in which products or product components that have become waste are prepared in order for them to be reused (The Danish Environmental Protection Agency, n.d.).
In a Danish context, preparation for reuse must be handled by the company itself or by a collector / waste processor (The Danish Environmental Protection Agency, n.d.).

Recycling

If the product cannot be reused, or in other ways be reentered into the lifecycle it can often be recycled. This is, as mentioned before, done by degrading or comminuting

the products, after which substances or materials are recovered from the degraded products. These materials can either be used in manufacturing new products. Unlike reuse, recycling is about extracting the resources in the waste (The Danish Environmental Protection Agency, n.d.a). Recycling is placed lower in the hierarchy than reuse due to the energy use associated with recycling, and the lower quality of the recycled materials as well as the limited number of times the material can be recycled. An example of waste recycling could be sorting plastic into different types and remelting it into new products or melting disposable batteries into smelters for the production of stainless steel (The Danish Environmental Protection Agency, n.d.a). Recycling is the least desirable strategy in circular economy and should be the last solution as it does not extend the lifetime of the product, but instead treat the product as waste.

7.0 Delimitation

The problem analysis had the purpose to outline the context of E-waste in mobile phones, and what current measures are being utilized to promote a reduction in E-waste. As described E-waste in mobile phones are a growing problem with many factors contributing to this problem. Hence, the problem analysis pinpointed the most prominent factors for this problem in an attempt to outline the complex landscape of E-waste in mobile phones. The problem analysis is based on research regarding the topic of E-waste in mobile phones, which have provided this report with coverage of the current trends and issues in the area. This project seeks to contribute with an understanding of some of these issues, and investigate the user's role in the utilization of circular strategies, and hence investigate how a transition to a more circular use of mobile phones can become reality.
Due to the broad scope in the problem analysis the scope has to be limited in order to conduct a concise and in-depth analysis. Hence, moving forward, it is important to indicate certain boundaries for the research, and how these limitations affect the project.

The research conducted with this project has the aim to investigate how the circular strategies can be utilized in mobile phones, and hence disengage from the linear economy in which these strategies are not prioritized. Moving forward the term circular strategies will cover reuse, repair, refurbishment and recycling. In the project the focus will be on the user, as they are the deciding factor in how the mobile phones are handled after use, meaning the user determines if the phone gets repaired, reused, recycled, stored etc. Hence, the scope is limited to the use and the end phase of a mobile phone as this is the phases in which the user is a part of. It became evident through the problem analysis, that the design phase plays an imminent part in the later phases of a mobile phone, as the design phase determine elements such as reparability, material efficiency etc. However, due to the user being the main focus the design phase is outside the scope and will not be regarded in the analysis.

To assess how the user can utilize circular strategies, this project aims to analyze a transition to a circular oriented network, and how the transition can become

stabilized. Therefore, the project will answer the following research question:

How can E-waste be reduced by a transition to circular strategies and how can this transition become stabilized?

8.0 Methods and theory

The research question will be answered using the theory Actor Network Theory (ANT), which will investigate relevant actors in a network favoring circular strategies, and how their relations can stabilize a network. By using this theory, non-human actors are included in the analysis, and will be prescribed the same value as human actors. The theory is the foundation for the analysis in which the empirical data is supplied by interviews, literature and a survey. Hence, the research design is framed by the ANT, which will act as the guideline for the analysis.

8.1 Methods for data collection

8.1.2 Interview

In order to gain knowledge regarding circular strategies in E-waste, interviews have been conducted within the field in a practical context. The interviews conducted have contributed with empirical data concerning the stakeholders' experiences and perceptions of the issue.

Based on this, an interview guide has been designed. This has acted as a semi-structured approach in order to achieve comprehensive information in all areas of the topic. This gives the informant the opportunity to go beyond the interview guide and therefore come up with new aspects of the topic. This creates room for deviation, which may lead to knowledge regarding new areas of the topics. (Brinkmann and Tanggaard, 2015).

To achieve well thought out answers, this guide has been sent to the informant before the interview was conducted, in order to give the informant time to elaborate on the answers (Brinkmann and Tanggaard, 2015).

The interview guide was created based on a set of objectives from which the interview questions originate from.

The interview is a way of achieving a more nuanced and detailed data for the analysis to supplement the questionnaire survey (Brinkmann and Tanggaard, 2015).

The interview guide was similar to ensure knowledge within the same area, but customized for each informant based on their part in the E-waste network.

8.1.3 Survey

To collect data concerning the users of mobile phones, the quantitative method of survey was used. The survey had the aim to reflect the behaviors of the users based on questions regarding their experience and needs with several categories including electronics, textiles and bulky waste. Since the interest of this project is with electronics, and more specifically mobile phones, the categories textiles and bulky waste will not be explored further.

The survey was constructed as part of the project Affald og Ressourcer på Tværs (Across waste and resources), which the researcher was a part of. The design and distribution of the survey was done by Norstat, which is a company specializing in data collection, and hence has a large panel of participants. The survey was conducted with 1005 participants all ranging in demographic ensuring a broad perspective of the responses. By using this quantitative method, the possibility to include a large number of participants ensures a larger generation of data, hence marking it as a viable method for data collection on a large target group. The target area for the survey was the Capitol Region with participants from all municipalities.

The survey was constructed by a series of questions enquiring as to the obtaining and repair of electronics. The first section of questions regarded the acquisition of several groups of electronics such as computers, mobile phones, kitchen appliances, tools, and televisions. The participant had the possibility to answer the questions seen in figure 4 for each individual group of electronics. Furthermore, the survey was constructed in such a way, in which the survey redirected the participant based on the previous answer. For example, if the person marked ‘new’ in question 2 for mobile phones, the participants would be redirected to answer question 3b for mobile phones.

Question nr.	Question
1.	Have your household received or bought electronic or electric products within the years 2019-2020?
2.	Were the products new or used?
3a.	Why did you acquire a used product?
3b.	Why did you acquire a new product

Figure 4: Illustrates the questions from the survey.

The second part of the survey was relating to user's behavior regarding repair of electronics. The same set up was used in which the participant had the possibility to answer the questions seen in figure 5 for each individual group of electronics. Similarly to section one, the user was redirected based on the previous answer, hence ensuring the participant answered questions relevant to their experience and needs.

Question nr.	Question
1.	Have your household in the years 2019-2020 experienced one of the following products break down?
2.	How old was the product when it broke down?
3.	Did the product get repaired?

4a.	Why did your house get the product repaired, or are planning on getting the product repaired?
4b.	Where did the product get repaired?
4c.	Why did the product not get repaired?

Figure 5: Illustrates questions from the survey.

The survey was an instrumental tool to collect data and ensured a vast amount of data from the users in the Capitol Region. However, with this quantitative method, there are limitations in the form of not acquiring in-depth answers, since the participants only had the option to choose some preconstructed answers, not allowing the participants to explain further. The basis of the survey being web-based further removed any opportunities for enquiries about certain answers.

8.2 Actor Network Theory (ANT)

Actor Network Theory: Introduction

Actor Network Theory (ANT) was first presented by Bruno Latour and Steve Woolgar in the publication “Laboratory Life: The Social Construction of Scientific Facts” from 1979. The publication focused on the behavior and activities within a laboratory, creating the theoretical foundation for the Actor Network Theory, which stated scientific and technological aspects had a close relation to the social and natural. These relations thus create a series of connections between humane and non-humane actors in a collected network. As stated in the name, both ‘actor’ and ‘network’ are important terms in the theory, hence ANT studies a collective network in which value is prescribed to both humane and non-humane actors (Kroustrup & Olesen, 2007). The theory therefore focuses on human relations, but also on relations to phenomena and artefacts.

The concept of a network

A network consists of actors and the interrelations between them, hence creating a collective network. As the actors in ANT mainly are relevant in terms of their relations, an actor can be said to be an individual network in a bigger collective network. This point of view can make it difficult to distinguish between an actor and a network, however the focus is on the relations between the actors in the network, hence the actor in itself is not of great significance. One of the main focuses in ANT is how the relations between the actors differs in the network, and how the relations can be perceived differently depending on the actor in the network. Furthermore, the network can be perceived and understood differently depending on the position in the network, hence influencing how the actors and their relations is perceived (Kroustrup & Olesen, 2007). The network is therefore not objective but is subjective to the individual actor. Hence, this is important to keep in mind when assessing a ANT network.

Translation process: How to form a stabilized network

Michel Callon describes in the text *Some elements of a sociology of translation: domestication of the scallops and the fishermen of St Brieuc Bay* (1984) the four moments of translations, which is a series of terms to describe and analyze the translation process and the stabilization of a network. A stabilization can occur for a whole network or for individual relations, however it is important to note, that a stabilization is not a permanent fixture and can be changed. The analysis will take its point of departure in Callons four translation moments, and it will investigate how these can be support the stabilization of the actors and the network. The four stages are problematization, interessement, enrollment and mobilization.

9.0 Analysis

The following chapter contains an analysis based on the Actor Network Theory presented in section 8.2. A more in-depth description of the different phases are presented when used in the analysis in order to provide a more overall understanding of the concepts. The empirical data collected for this thesis are the main contributor in the identification of the actors presented in the analysis. Hence, the analysis aims to identify what actors are needed to create a network, and how the relation between these actors can support the stabilization of the network. Furthermore, the analysis will investigate which factors can influence the translation to a stabilized network for circular strategies for a mobile phone.

Delimitations of the network

The network investigated in this report is centered around mobile phones which have the ability to utilize circular strategies to improve the circularity of the phone. The focus will be on a mobile phone in its use phase, and its end phase, thereby not focusing on the production, transportation, and packaging of the mobile phone. The network therefore consists of actors which have established a relation to the mobile phone in the use phase, or the end phase. The aim with the analysis is to investigate how E-waste can be reduced by utilizing circular strategies, and thereby create a network, which favors circular strategies as opposed to a network, which takes its departure in linear strategies. Thereby the analysis focuses on how the relations in this network are established, and how they potentially can be stabilized. The transition to a new network will be analyzed by using Michel Callon’s four phases.

1. Phase - Problematization

The first phase in a transition as stated by Michel Callon is the problematization stage. The problematization stage includes the mapping and definition of the actors in the network. The stage encompasses the finding of the *obligatory passage point,* which is a point all actors must pass through to be part of the network, and to realize their *matters of concern.* The obligatory passage point is put forth by an actor, who makes a collective problematization, which all actors must agree with, and by doing so secure a place in the network (Callon, 1984). Each actor has their individual goal, but to obtain this goal, they must first pass through the obligatory passage point, thereby forming an alliance with the actor who made the problematization in order to be part of the network, and by doing so fulfill their matters of concern (Callon, 1984;Latour, 2004).

The term *matters of concern* covers human context and values, and as Latour (2004) describes it, *matters of concern* conveys actions, thoughts and meanings based on the values and feelings of humans. Hence, the goals are dictated by their matters of concern. Latour (2004) uses matters of concern to move towards a more subjective interpretation of the world, in which he states that by doing so, a more accurate representation of the reality is presented because the matters of concerns include and can convey the context the actor is part of. Latour's take on matters of concern corresponds well with Callon's four stages in the translation process, and the term matters of concern will therefore be used to map actors in the network. By using matters of concern, the mapping of the actors will include the needs and concerns of the actors providing a more comprehensive mapping of the network. Furthermore, the matters of concerns of the actors will likewise provide a deeper insight into the following stages of Callons four stages of translation by providing knowledge regarding what needs must be met in order for the actor to be enrolled into the network. Thereby, matters of concern become an important element for the stabilization of the network (Latour, 2004).

Mobile phones have a growing share in the E-waste fraction and causes environmental impacts due to factors such as a short lifespan, fast-fashion and low repairability. This analysis will investigate how a network favoring circular strategies

in mobile phones can be created and stabilized. In order to establish this network actors who can contribute to such a network needs to be identified, as well as their matters of concern. This analysis takes its point of departure in the problematization that the current trend in mobile phones causes an increasing amount of E-waste, and hence is an environmental concern which is the basis for pursuing more circularity in mobile phones. Thus, actors who utilize circular strategies such as reuse, repair, refurbish and recycling can be said to have passed the obligatory passage point, as these strategies work towards the reducing of E-waste in mobile phones. Hence, for actors to become part of the network, they need to want to find a solution to the problem of mobile phones becoming E-waste. Each actor has different goals, and matters of concern, however the following actors have been identified as being essential for the stabilization of the network.

Mobile phones

Mobile phones act as a non-human actor in this network, and are the main artefact which the network is centered around. In this analysis, the mobile phone is defined as a smartphone, which has the ability to utilize circular strategies such as reuse, repair, refurbishment or recycling. Mobile phones have a relation to all other actors in the network, and is a required actor for other actors to pass through the obligatory passage point.

The users of mobile phones

The users of a mobile phones can be separated into two groups as they have different goals and matters of concern. The first group is users who currently utilizes circular strategies such as repair, reuse or refurbishment. These users have through their actions already established a willingness to limit the environmental impacts of mobile phones either directly or indirectly. The second group are users who do not utilize circular strategies. The following section will via the data collected through the survey investigate the matters of concerns of the different user groups.

Users inside the network

The survey investigated the experiences and needs of users of mobile phones, thus providing an understanding of their practices. The survey included 830 people, in which 530 people answered to have bought or received a new mobile phone in the years 2019-2020. Out of the 530 people, 90 participants acquired a secondhand phone for various reasons. The main reason given was the financial gain by buying a used phone, for which the price is significantly reduced as opposed to buying a new phone. This shows that the financial aspect is important and can be the deciding factor when it comes to mobile phones. The economic aspect was not the only reason for people choosing a secondhand phone, the second most common reason given described how a secondhand phone was able to sufficiently meet the needs of the user. Thus, part of the group is highly aware of their own needs and can thereby assess what needs they have for a phone. Other reasons given for buying a secondhand phone was that is it more environmentally friendly, hence showing a matter of concern which includes the environment. These reasons given for pursuing circular strategies in mobile phones are in line with the goal of achieving solutions to limit E-waste in mobile phones, hence the actors are through their actions and values part of the network.

Another group who has utilized circular strategies, are users who have had a mobile phone repaired, or are planning to get their mobile phone repaired are part of the group of users who are in line with the problematization. These users have given several reasons for choosing to get their mobile phone repaired as opposed to buying a new phone. The main reason again is the financial aspect, in which users state the expense for obtaining a new phone as opposed to have the old one repaired is too much, and therefore they choose the more circular strategy of having their phone repaired. Interestingly enough, the second most popular reason for having the phone repaired is to avoid waste by disposing of the product. Furthermore, other reasons given were the sentimental value of the phone, and the unavailability of a corresponding product. Hence, this group of users already practice circular strategies which reduce the E-waste of mobile phones, and the group thereby have an interest in being part of the network.

Hence for both groups of users who have utilized circular strategies, the economic element is the most important factor and is thus their matter of concern. In order to maintain these users in the network, it is important to take their matters of concern into consideration, and ensure they are addresses in order for the actors to contribute to the stabilization of the network.

Users outside the network

The other group of users include people who does not make use of circular strategies, and thereby does not pass the obligatory passage point. Due to the nature of the problematization, a broader network with more actors is seen as beneficial, as doing so will ensure more actors getting involved with circular strategies, and a larger number of mobile phones will extend their lifespan. However, for this group to be included, the network needs to meet their matters of concerns, in order for them to align their interests with the network. It is important to understand how the network can transit to meet the matters of concern in order to expand and stabilize the network. Experiences and needs were expressed in the survey from user groups who did not prioritize circular strategies, hence the following paragraph will focus on these elements in order to understand how the network can expand and include these actors.

The survey showed a majority of the participants choose not to repair their phone, or to buy a secondhand phone. Out of the 530 people who bought or received a phone within the years 2029-2020, 440 of them acquired a new phone. The main reason for getting a new phone was due to the users wanting the latest model. Furthermore, uncertainties such as reliability and warranty regarding secondhand phones were popular reasons for users disregarding secondhand phones. 319 of the participants in the survey experienced breakage of their mobile phone in 2019-2020 with 144 participants seeking repair, leaving 175 participants to refrain from repairing their malfunctioning mobile phone. The main reason for refraining from repairing the mobile phone was due to it being too expensive, or the products being too damaged to repair. Another matter of concern uncovered through an interview with an informant highlighted how the use of circular strategies need to be accessible for the

user. The user emphasized how they had several phones in ‘hibernation’ in their home and wished for an easy solution for the discarding of the phones. Hence, the user needs to easily be able to utilize circular strategies otherwise they will choose not to make use of these strategies.

Hence, for the user groups currently not involved with circular strategies several matters of concern needs to be met, in order for these actors to become part of the network. Firstly, the repair cost needs to be lowered, and thereby increasing the willingness to repair. Furthermore, the availability of newer models of phones needs to be available as secondhand phones, or the user needs to change their interest, and information regarding the reliability and warranty of secondhand phones needs to be accessible.

Repair and refurbishment establishments

Repair and refurbishment establishments who specializes in the repair and resale of mobile phone have been identified as an actor in the network. They are included in the network as they utilize circular strategies and thereby have an interest in the problematization. Repair and refurbishment establishment seek to extend the lifespan of mobile phones by repair and reuse, thus decreasing the amount of E-waste in mobile phones through extended use. During an interview with Greenmind, it became evident, that their matter of concern was related to the increasing difficulty with repairing the phones due to increased costs of spare parts, more complex phones and tactics from manufactures discouraging repair.

”You know, it gets slightly more difficult to repair each year, but that also means the technicians gets better, and our skills gets better. So it’s not, as an example, that it takes more time to change a screen on the new phones than it did on the older phones, but it is just becoming more difficult.” (Greenmind, 2021)

It is by Greenmind described how more complex products can limit the rates of repair, which needs to be taken into consideration when discussing reduction of E-waste. Furthermore, Greenmind directs the focus to the need for improving skills regarding repair due to more complex products, and it is thus highlighted how newer

phones require specialized repair, which to some extend could exclude repairs made by private consumers.
Furthermore, Greenmind highlighted tactics put forth by some manufacturers, which complicates repairs for mobile phones. In order to reduce E-waste in mobile phones, repair and reuse needs to be fully utilized, however it was highlighted how in the newer models of Apple's Iphone, the repair process was made more complicated.

"Apple for instance, they have made it so that for Iphone 11 and up… If you don't buy the screen directly from them and calibrate it through their tool, then the phone gives a message saying an unoriginal screen has been mounted on it, and that you need to hand it into an Apple authorized [repair shop] to have it looked at. " (Greenmind, 2021)

This tendency can potentially disrupt the repair market as the manufacturer sees it as beneficial to avoid repairs, in order for the costumers to replace their products instead of extent the lifespan.
Furthermore, the same is true for spare parts, which in this network is a non-humane actor. Spare parts are an important element to repairs, and the availability of spare parts is in direct correlation with the rate of repairs. Therefore are spare parts an actor in the network, and is through its relations to the other actors in the network part of the stabilization. Greenmind describes how Apple control the spare parts to the newer models of the Iphone.

"It makes it hard for a third-part repairer like us, to provide cheap repairs because the spare parts we buy, it is the manufacturer that decides the price of them, and the manufacturer is not interested in getting their products repairs, so they keep the price falsely high on those spare parts. " (Greenmind, 2021).

The manufacturer hence controls the price for spare parts, and by doing so, controls the repair market, evidently forcing third-part repairers to adjust to the conditions and price level controlled by the manufacturer.
The repair and refurbishment establishments' matters of concern centers around their goal to provide the user with circular strategies and hence, their matters of

concern is the availability of spare parts, the relation with the manufacturer, and the potential to provide efficient and low cost repairs.

Ecodesign Directive

The Ecodesign Directive is a non-humane actor, who have an effect on the relations in the network. Legislation such as the Ecodesign Directive aims to promote circularity in phones, and thus becomes an actor which have a goal in alignment with solving the problematization. Furthermore, the Ecodesign Directive act as a policy-based approach to increasing the circularity in phones, thus supporting Repair and Refurbishment establishments, as well as users utilizing circular strategies. However, concerns have been voiced regarding policies being too ineffective, for example by Greenmind, who was dissatisfied with manufacturers tactics making it more difficult to repair mobile phones. Hence, the Ecodesign Directive needs ramifications (See section 4.2.3.), which can promote circularity in mobile phones in order to stabilize the relation between repair shops and policies.

The first translation phase identified different actors interested in the network by having interest aligned with the problematization. The actors do not necessarily have an interest in decreasing the growing amount of E-waste, however their goals are in alignment with the solution to the problematization, hence the actors build a relation with other actors in the network, as they have passed the obligatory passage point. This point became evident as they all have goals which are intertwined with use of circular strategies.

2. Phase – Interessement

The second phase in the translation process is the interessement phase, which aims to strengthen the link between the various actors. To strengthen the link between the interest of the actors, there needs to be a cohesion in the network, which pinpoints the actors position in the network (Callon, 1984). To do so, Callons introduces the term interessement devices, which is an actor or artefact in the network which creates a collective connection between the actors. Furthermore, the interessement device also serves as a 'shield' from other networks, and thereby ensures the actors are not involved with other networks (Callon, 1984). This phase is used to align interests between the actors, so they are willing to enter into the network.

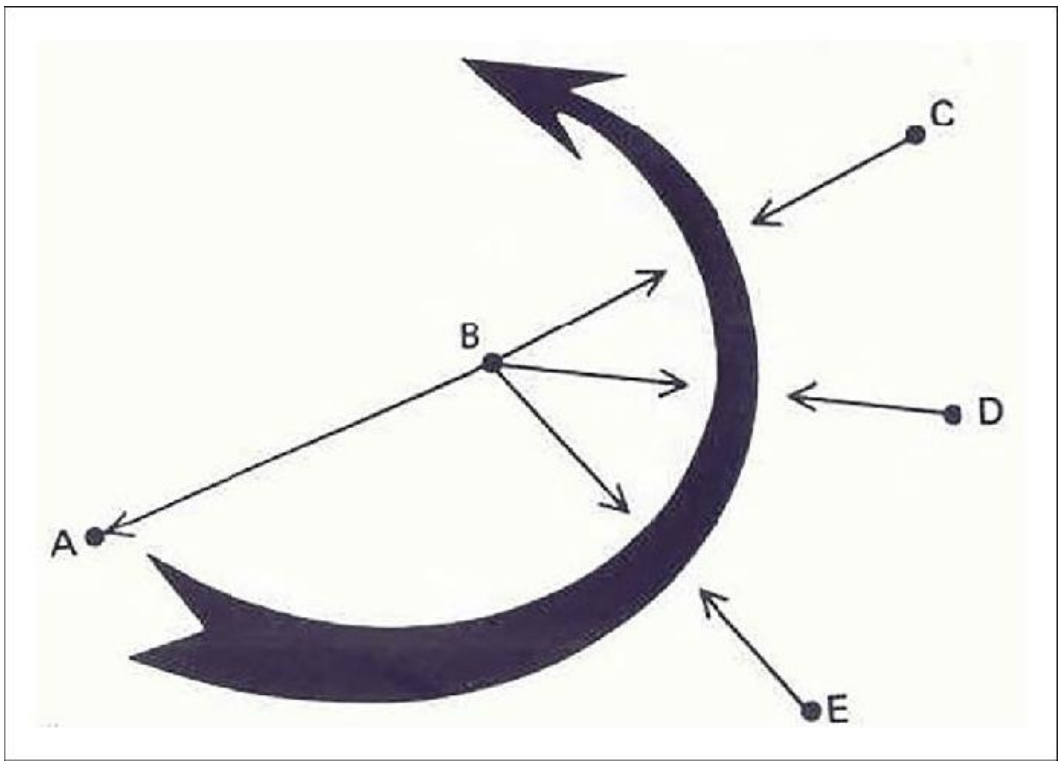


Figure 6: Illustration of interessement through interessement device (Callon, 1984).

The network is supported by the interessement device *circular strategies* which is a non-human actor, and act as a shield from other strategies involving the purchase of mobile phones. The users who prioritize circular strategies are doing so due to several reasons. Hence, the circular strategies ensures that this user group can have their matter of concern fulfilled, and thus shields them from other networks which could have an interest in mobilizing them in their network. The relation between this

user group and circular strategies is through this stage undergoing a negotiation to align their interests, and thereby strengthen the relation. Likewise, the repair and refurbishment establishments are utilizing circular strategies and thus have an interest in this network as it can be perceived as a way to ease their matter of concern. By using circular strategies as a barrier from other networks, the repair and refurbishment establishments can enter into negotiations with other actors in the network, and thereby potentially secure support for their matter of concern. For example, the repair and refurbishment establishments can strengthen their relation with the users over a shared interest of decreasing the cost of repair, and since both actors are interest in circular strategies, this interesse device create a barrier shielding them from other networks.

The Ecodesign Directive has an interest in making mobile phones more sustainable, and thus can realize this wish through circular strategies. However, it should be noted that the Ecodesign Directive has a broader scope, and thus also focuses on the design process in order to increase the material efficiency among other things. Hence, the directive seeks to utilize circular strategies, but depending on the chosen approach for the new initiative (see section 4.2.3), could potentially be part of other networks. Therefore, to ensure the Ecodesign Directive becomes involved in this network, other actors have to enter into negotiations, and thereby attempt to align the interests. Through the interessement device, the relations become stronger to the network, as it acts as a barrier from other network, which is an important step to reach stabilization within the network.

Users who do not utilize circular strategies do not have an interest in the network as they do not have to be part of the network in order to use and acquire mobile phones. This group of users have matters of concerns such as the cost of repair and the unavailability of newer phone models which the network of circular strategies does not fulfill. Thus, this user group seek involvement in other networks, which can meet their wishes. Hence, there is a need for other interessement devices to entice this user group to enter into the network.
The non-humane actor spare parts are crucial actor in the network as it is essential to the accomplishment of repairing and refurbishing a phone. However, as spare

parts in large are controlled by an actor outside the network – the manufacturer, the actor spare parts is not shielded, and thus can destabilize the network.

Through the second phase is became evident how the interessement device *circular strategies* became a common interest shared among the actors in the network. By being shieled from other networks, the actors' relations to each other become stronger, and therefore increases the chance of stabilizing the network. However, if the interessement device did not work sufficiently in shielding the actors from other networks, the network would be fragmented, as the actors could be mobilized in other networks. Hence, this is an important part of the translation process and is crucial to the success of stabilization.

3. Phase – Enrollment

The third phase is enrollment, which can only be reached if the interessement is successful. The enrollment involves a clear definition of the actors roles in the network, and should be in alignment with the problematization. This phase is based on the negotiations in the interessement phase, which ensures participation and acceptance of the actors' positions in the network, and their prioritization of the problematization. The roles in the network cannot be defined and stabilized without the shielding from other networks. Henceforth, the enrollment phase ensures clear definitions of the roles, and thereby it becomes more evident how the network can be stabilized with the actors in the network (Callon, 1984).

The enrollment phase differs depending on the actor, due to them having individual roles in the network. For the users already invested in circular strategies, the role is clearly defined. As mentioned earlier, this user group utilizes circular strategies mainly due to the financial gain, hence they become actors in the network, as they have been persuaded to seek either repair, refurbishment or reuse by the lowered expense as opposed to acquiring a new phone. The actor is especially important in the network, as they are the driving force behind the consumer use of circular strategies. An important note to keep in mind is the possibility of part of this user

group becoming disengaged with the network if the financial gain disappears. A spokesperson from Greenmind highlighted the fact, that due to the increasing repair cost caused by an increased cost of spare parts and manufacturers forcing repairers to use their tools, the difference between buying a new phone and seeking repair is decreasing.

"But now when you go down and buy a phone for 8000-9000 kr., and it then costs 3000kr. to get the screen replaced, then we are looking at something, where you almost lay 30% of the total price just to repair that one thing. Whereas you beforehand put down 15-20% of the total price [to get it repaired]. The higher the repair price is contra the total value from new, or what the product is worth secondhand, the less inclined are you to get it repaired." (Greenmind, 2021).

With the increased repair costs, it is possible to potentially see a shift in the user group who currently utilized circular strategies, which would move them away from the network, and seek other networks to fulfill their need for a mobile phone. Hence, the user group is a defined actor in the network, but the relation to circular strategies can become weakened if the network does not continue to shield from other networks.

The repair and refurbishment establishments are enablers in ensuring the availability of circular strategies, and thereby has a clearly defined role as the provider for the handling of repair, refurbishment and reuse. They are part of the network as they have been encouraged to utilize circular strategies to increase the circularity in phones. Thereby, they have a strong relation to other actors in the network, as they are dependent on their interest in circular strategies. The repair and refurbishment establishment Greenmind states how they throughout their business endeavor have increased their use of circular strategies, which illustrates how they have strengthened the link with other actors in the network, and thereby have had the opportunity to expand.

"We started 10 years ago with only reapairing Iphones, and then we expanded the repairs in the portfolio, and now er buy and sell the products as well." (Greenmind, 2021).

Through the quote it becomes visible how Greenmind is a product of the increasing potential in utilizing circular strategies, and thereby is an established actor in the network.

The Ecodesign Directive was identified as an enrolled actor in the network and has the individual role to promote circular strategies in mobile phones through policy. Thereby, the Ecodesign Directive is strengthened through its prioritization of promoting circular strategies, which in turn secures the interests of other actors in the network. The current Ecodesign Directive does however have a limited impacts on the circular strategies in mobile phones, as it has yet to specifically target mobile phones as a product group. However, with the current initiative (see section 4.2.3.) the Ecodesign Directive has the potential to become an even stronger actor in the network and could potentially create relations to actors outside the network, and thereby expand and stabilize the network.

The third phase is only successful if the interessement is reached. It was showed how the users outside the network, and spare parts are not being properly shielded from other networks. Hence, to ensure a proper transition, these two actors need to be involved in the network through other interessement devices. If these interessement devices are not present, then the network would not be able to stabilize.

4. Phase – Mobilization

The last phase in the translation process is according to Callon the mobilization phase. In this phase it is decided who is the representative for the actors in the network. It is often the strongest actor in the network who assigns this role either to itself or to some other actor in the network. The mobilization is the last step to a stabilization of a network, whereas the appointed representative ensures the actors in the network gets a voice, and that their matters of concerns are met (Callon, 1984).

The role of representative for the network is in this case the users inside the network. They obtain the role of representative as they are one of the main drivers for solving

the problematization. The users have the ability to influence other actors outside the network, and in the process ensure the network becomes more stabilized, as other actors align their matters of concern with the problematization.
Hence, in order to reduce E-waste in mobile phones through the use of circular strategies, the users can implement changes by supply and demand, in which the users can influence the advancement of circular strategies. Furthermore, the users also have the power to influence policies, but they do however also need to recruit users outside the network, in order to create a stronger network.

To transition from a linear use of mobile phones to a more circular use of mobile phones, the four stages mentioned needs to be fulfilled. However, in this case, there are still progress to be made, as the network has not been fully stabilized for the actors involved.
The construction of the network also has an influence on the mobilization, for example if a policy or other legislation was in the process of being implemented, it would act as the main representative of the network. Thereby, should the initiative mentioned in section 4.2.3. become a reality, then the policy would be an actor, which has a strong initiative to stabilize the network, as it would act as a shield from other networks.

10.0 Discussion and conclusion

The project had the aim to answer the research question: How can E-waste be reduced by a transition to circular strategies and how can this transition become stabilized?

The analysis investigated how a transition to a network favoring circular strategies could be created and what processes needed to be fulfilled in order to stabilize the network. The analysis identified the main actors of the network, and investigated what interest the individual actor had, and how these interests could be aligned to the problematization of the network.

The solution for the problematization was to reduce E-waste in mobile phones through circular strategies, which then became the obligatory passage point, whereas the actors needed to pass through in order to become part of the network, and build relations with the other actors in the network.

The interessement phase demonstrated how an intessement device could strengthen the network by shielding the actors from other networks, and thereby strengthen the relations between the actors. However, it became apparent that the interessement device *circular strategies* did not shield all actors from outside networks. Users outside the network did not share an interest in with the interessement device resulting in an exclusion from the network. However, as users outside the network is seen as an important actor, to further stabilize the network, a different interessement device should be utilized. Likewise did spare parts not become a part of the network, and could not be shielded by the interessement device. Spare parts are an important element in circular strategies, but are controlled by an actor from an outside network – the manufacturer, hence an interessement device which can shield spare parts are needed for the network to be stabilized.

The enrollment phase aimed to have clearly defined roles for the actors. This was possible with actors such as users inside the network and with repair and refurbishment establishments. However, even though these roles are clear, they could potentially become destabilized as other actors can affect their role. For

example, if the financial gain disappears for the users, then they would seek other networks, which then again would affect weaken the relation with the other actors in the network, and destabilize the network.

Lastly, the mobilization phase is the final phase in the translation, in which the users inside the network were appointed representative of the network. As showed in the analysis, the users have the ability to gain influence on actors outside the network, which would ensure a much stronger and more stabilized network. However, the transition is not yet possible, as there is a need for stronger relations in the network, as well as the inclusion of actors such as spare parts and users outside the network.

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