Horizon 2020 Program (2014-2020)

A Framework for Pairing Circular Economy and IoT: IoT as an enabler of the Circular Economy & circularity-by-design as an enabler for IoT

D2.2: Business models for interplay of circular economy with IoT.

†

Abstract:

The adoption of IoT technology to facilitate the working of a circular economy approach is crucial to the success of implementing this form of economic and business model. This is a model which requires organisations in different sectors across the value chain to explore the adoption of disruptive technologies based on increasing the life of an asset, and resorting to reusing, repairing, and remanufacturing mechanisms in the production process. As such, the current project that we are conducting has an invaluable impact on the introduction, implementation and impact of a circular economy model. Therefore, exploring and adopting "A Framework for Pairing Circular Economy and IoT: as an enabler of the Circular Economy & circularity-by-design as an enabler for IoT" is critical to building the business models in this area. This part of CE-IoT D2.2 relating to business models for interplay of circular economy with IoT, focuses on building case studies involving the different members of the consortium.

† *The research leading to these results has received funding from the European Union's Horizon 2020 research and innovation staff exchange programme (RISE) under the Marie Skłodowska-Curie grant agreement No 777855.*

Contractual Date of Delivery	01/05/2020
Actual Date of Delivery	27/04/2020
Deliverable Security Class	Public
Editor	*Khal Soufani, Circular Economy Centre, University of Cambridge*
Contributors	University of Cambridge (UCAM) Cablenet Communication Systems (CBN) Bluesoft Spolka Z Graniczona Odpowiedzialnoscia (BLS) Deloitte Consulting & Advisory (DEL)
Quality Assurance	*Khal Soufani, UCAM*

CE-IoT **Consortium**

ECOLE NATIONALE DES PONTS ET CHAUSSEES (ENPC)	Coordinator	France
THE CHANCELLOR, MASTERS AND SCHOLARS OF THE UNIVERSITY OF CAMBRIDGE (UCAM)	Principal Contractor	United Kingdom
FOUNDATION FOR RESEARCH AND TECHNOLOGY HELLAS (FORTH)	Principal Contractor	Greece
CABLENET COMMUNICATION SYSTEMS LTD (CBN)	Principal Contractor	Cyprus
BLUESOFT SPOLKA Z OGRANICZONA ODPOWIEDZIALNOSCIA (BLS)	Principal Contractor	Poland
DELOITTE CONSULTING & ADVISORY (DEL)	Principal Contractor	Belgium

Document Revisions & Quality Assurance

Internal Reviewers

1. *Khal Soufani, UCAM*
2. *Ellie Wolmark, UCAM*
3. *Patrizia Congedo, UCAM*

Revisions

Version	Date	By	Overview
0.1	18/04/2019	Ellie Wolmark, UCAM	Table of Contents
0.2	27/08/2019	Nic Bryant, Natalia Dziergwa, Baysa Naran, Kris Padget & Atiqah Zaki, Yigit Akar, Rahul Agarwal, Alex Powell, Martin Saigian, Mizuki Isogai UCAM	Sections 2.1, 2.2 & 2.3
0.3	01/10/2019	Youqing Zhao, UCAM Angela Rizzo, UCAM Rouha Hussaina & James Meade, UCAM	Sections 2.4, 2.5 & 2.6
0.4	30/03/2020	Patrizia Congedo, UCAM	Internal Reviews
0.5	20/04/2020	ENPC	Consortium Review
0.6	24/04/2020	Khal Soufani, UCAM	Finalization

Table of Contents

List of Tables

List of Figures

List of Abbreviations

DoW Description of Work

WP Work Package

EU European Union

EC European Commission

M Month

IPR Intellectual Property Rights

IoT Internet of Things

✔ Status: Completed

✔ Status: Started but not completed

DSR - Demand Side Response

IT – information Technology

GCP – Global Consulting Project

CEC – Circular Economy Centre

RISE - Research and Innovation Staff Exchange

PEST - Political, Economic, Social and Technological

SWOT – Strength, Weakness, Opportunity, Threat

EU – European Union

H2020 – Horizon 2020

NPS - National Power System

GW – Gigawatts

TSO - Transmission Service Operator

DSO - Distribution Service Operators

SSR - Supply Side Response

MDM – Metre Data Management

CEP - Complex Event Processor

CRM - Customer Relationship Management

SIM - Subscriber Identity Module

EC- The European Commission

CNS - C.N. Shiacolas Group of Companies

TV – Television

WEEE Cyprus - Waste Electrical and Electronic Equipment in Cyprus

XaaS - As-a-Service

DVD – Digital Versatile Disc

Q2 – Quarter Two

WING - Worldwide IoT Network Grid

MVNO - Mobile Virtual Network Operator

ISO - International Organization for Standardization

OTDR - Optical Time-Domain Reflectometer

CSR – Corporate Social Responsibility

FTTH - Fiber to the Home

EC – European Commission

RESOLVE - Regenerate, Share, Optimise, Loop, Virtualise, Exchange

IRR - Increase in the return rate

ALM - Asset-liability matching

M&A – Mergers and Acquisitions

I4.0 - Industry 4.0

USA – United States of America

FSB - Financial Stability Board

TFCD - Task Force on Climate-Related Financial Disclosure

GMOs - genetically modified ingredients

ESL - excess and surplus lines

P2P - peer-to-peer

HAB – No direct translation – Bluesoft's workforce management platform product

COGS - Cost of Goods Sold

ICT – Information and Communication Technology

RFID – Radio Frequency Identification

GPS – Global Positioning System

IT – Information Technology

US – United States

ESG - Environmental, Social and Governance

BIM - Building Information Modelling

NIS - Network and Information Security

ISO - International Organization for Standardization

ENISA - European Union Agency for Cyber-security

ROI – Return on Investment

CIA - Confidentiality, Integrity and Availability

AI – Artificial Intelligence

3D – Three Dimensional

SVR – Security, Vigilance, Resilience

CIA – Central Intelligence Agency

Executive Summary

The circularity concept is about adding a "re-use/repair/recycle" step to the linear model "take, make, dispose". Circularity tries to put back into the system everything relating to production, distribution, consumption, to extract as much value as possible from the resources we utilize, in the most effective way. The Circular Economy model is one that requires organisations in different sectors across the value chain to explore adopting disruptive technology that is based on increasing the life of an asset, and resorting to reusing, repairing, and remanufacturing mechanism in the production process. The existing economic model helps to produce products that usually can be used just once, producing a large amount of waste; which will affect the earth negatively very soon. There is a need to implement a circular economy approach that applies to all levels of our economic, business, financial, and operational transactions This approach requires the design and implementation of business and financial models that are based on using as little resources as possible for as long as possible, and extract as much value if possible.

Organisations still have to take into consideration cost management and control, but they have to think about the type of business model to adopt and the financial impact - rethinking products and services and designing end user value propositions that offer increased cost efficiency, production effectiveness, and business performance. Despite the importance and potential benefits of the circular economy, the private sector is yet to adopt this new approach at either the strategic or operational level for many different business and sustainability reasons. There is a need to understand and research this model both academically and practically to explore its impact on organisations and society. In order to successfully analyse and adopt a circular economy business model, it is important to identify the different types of enablers that render this approach efficient and effective at all the stages of the value chain of a business.

One of the key enablers to implementing an effective and efficient working circular economy business model in our economic and business system is the *Internet of Things* (IoT). This is a system and an infrastructure of interdependent, interrelated and correlated machines and devices that have the ability and capacity to communicate information and data over the internet without the need for direct intervention by people. The system depends on embedded sensors in all devices and equipment; this can be mobile, electrical devices, vehicles, barcodes, scanners, and anything that is used on a daily basis. These sensors emit data about the current functioning and working state of devices that are being used at all levels. The data is shared over a common platform or infrastructure that use a common language for these devices to communicate with each other. Once the data is sent to a cloud platform the data is analysed and then the important information is extracted to help making decisions on all possible levels input, operational, output, distribution, consumption and utilisation. In general, our economic system has moved and is moving towards adopting smart devices, phones, cars, and cities; all of these will have an impact on our lives.

The adoption of IoT technology to facilitating the working of a circular economy is crucial to the success of adopting this form of economic and business model, hence the current project that we are conducting will have an invaluable impact on the introduction, implementation and impact of a circular economy model. Therefore, exploring and adopting "A framework for pairing Circular Economy and IoT: as an enabler of the Circular Economy & circularity-by-

design as an enabler for IoT" is critical to building the business models in this area. This part of CE-IoT D2.2 relating to **Business models for interplay of circular economy with IoT** focused on building case studies that involved the different members of the consortium. The cases are based on the following:

- Circular economy, internet of things and Bluesoft, the case of the energy sector in Poland, which examined demand side response (dsr).

- Cablenet communications systems ltd, where the case is built to examine the circular economy at cablenet. the example addressed relates to waste reduction, service models, procurement process, modern lifecycle, smart asset management, and network infrastructure components.

- Cyber security for CE-IoT and CE-IoT consortium collaboration framework: a case study on cyber security as an enabler of CE-IoTbased on findings at Deloitte and framework for collaboration within CE-IoT value chain

- Bluesoft as a loyalty platform provider.

- Bluesoft: focus on smart insurance contracts.

- Circular economy in industrial construction: how IoT can reduce industrial construction waste.

1 Introduction – Circular Economy and IoT

1.1 The Circular Economy

Many studies mention that the economic model we all depend on in our life usually uses the available resources on the earth to create products and services, and that to maximize profit and satisfy consumers, firms utilise the earth's natural resources like steel, aluminium, copper, together with water, energy and the skilled labour needed to produce goods. The existing economic model helps to produce products that usually can be used just once, producing a large amount of waste, which will affect the earth negatively very soon. (Esposito, et al., 2018).

Moreover, it is important to add that we face two major problems; the first one is the extraordinary increase in demand for a limited supply of resources. The second one is the huge amount of waste produced whilst creating products/services, which, inevitably may destroy the earth's resources quickly. Thus, coupled with the earlier problems, there is a necessity to find a suitable economic model that will help to solve this problem (World Economic Forum, et al., 2014, Pagoropoulos, et al., 2017).

It is evident that there is a need to shift to a circular economy approach; however, its success depends on how companies and policymakers will react. The term "circular economy" (CE) has a long history, multiple definitions, and distinctive developments in different global contexts (Hopkinson, et al., 2018)

Circularity tries to put back into the system everything relating to production, distribution, consumption, to extract as much value as possible from the resources we use, in the most effective way. The main idea that stands behind the concept of CE is to decrease the use of resources as much as possible, for as long as possible, reuse as much of the components as possible, extract as much value from those resources in the most effective way possible, and then recover and regenerate as much of those materials and products at the end of their useful life when and if possible (Soufani, 2018).

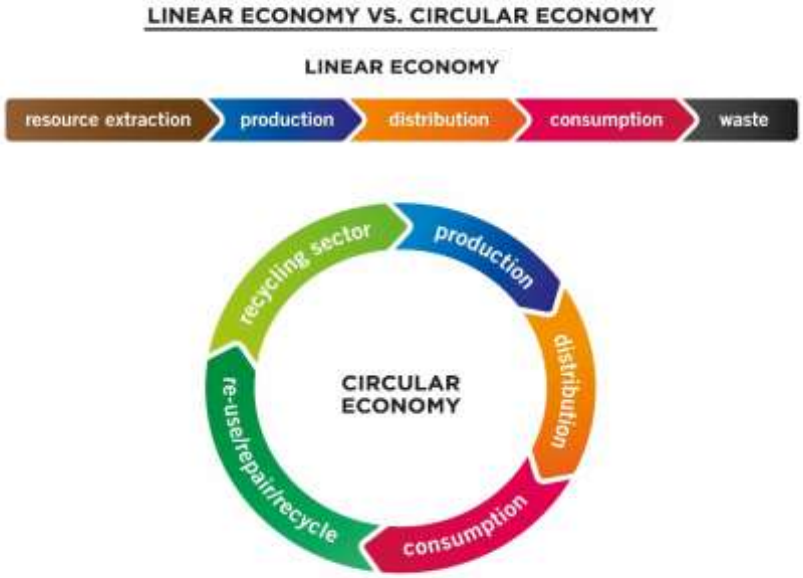

Figure 1. Linear vs Circular Economy

The circularity concept is about adding a "re-use/repair/recycle" step to the linear model "take, make, dispose". Circularity tries to put back into the system everything relating to production, distribution, consumption, to extract as much value as possible from the resources we utilize, in the most effective way. The CE is a disruptive, innovative economic model that forces the incumbent model to rethink and change the production and consumption chains we are used to. It relates to government policy, businesses and consumers, it is restorative or regenerative by design, structure, and objective: products, components, and materials should continuously add, recreate, and always preserve value (Soufani, 2018). It represents a systemic shift that builds long-term resilience, generates business and economic opportunities, and provides environmental and societal benefits (The Ellen MacArthur Foundation, 2017).

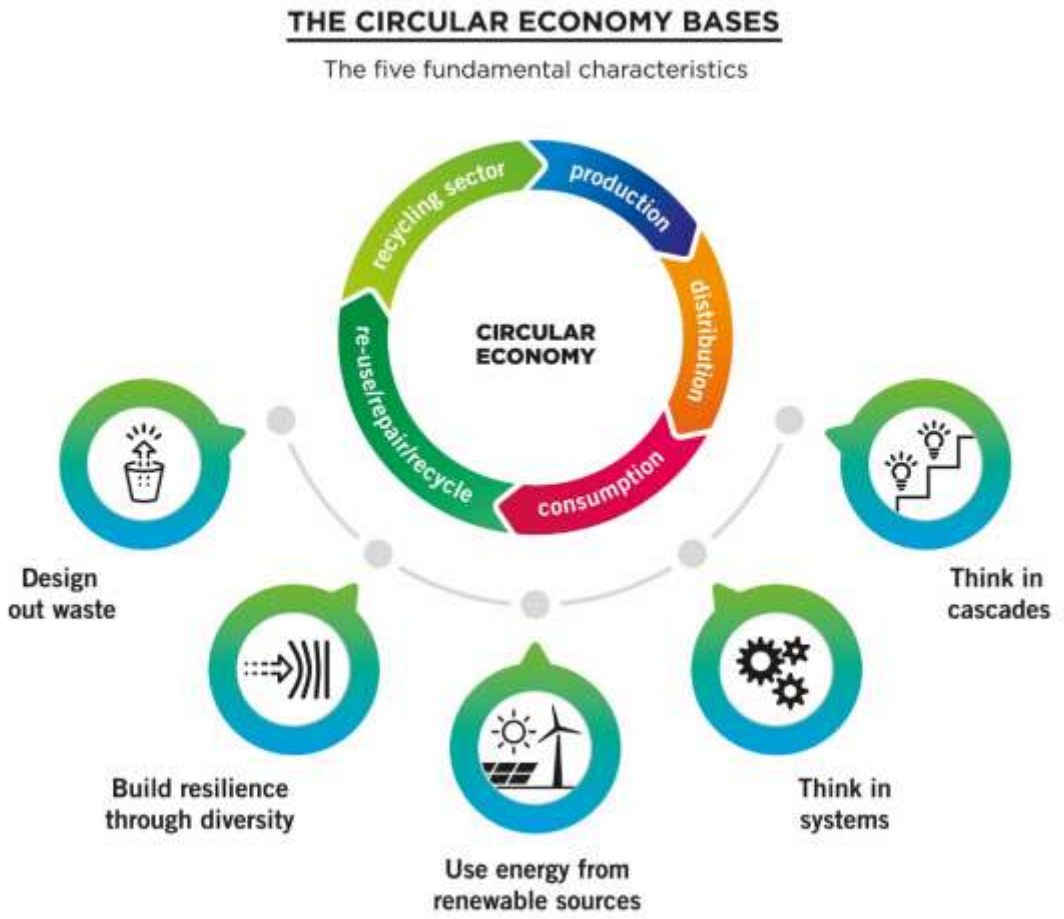

Figure 2. Five fundamental bases of Circular Economy

In CE terminology we find two material categories: Biological materials/nutrients like food, fibres, timber, that should be sustainable and exceed the rate of extraction, and technical materials/nutrients like metals, minerals, fossil fuels that should cycle infinitely (Weetman, 2017).

CE implementation requires encouraging companies, right from the start, when they are designing a product to have in mind that they will have to bring back the product, reuse some of the components, reuse some of the materials, to avoid as much as possible the more complicated process of recycling afterwards.

Currently, we live in a linear economy model, based on "take-make-dispose" philosophy, where products are increasingly becoming commodities, and resource scarcity is becoming a reality. To remain competitive in this economic environment and to achieve sustainable growth, companies are increasingly shifting their business model to enhance resource efficiency and sustainability. In this context, the concept of the Circular Economy has attracted attention in recent years. (Pagoropoulos, et al., 2017). According to the Morlet A, et al., the Circular Economy is characterized as an economy that is restorative and regenerative by design and which aims to keep products, components and materials at their highest utility and value always, distinguishing between technical and biological cycles. It is conceived as a continuous positive development cycle that preserves and enhances natural capital, optimizes resource yields and minimizes system rinks by managing finite stock renewable flows. (2016).

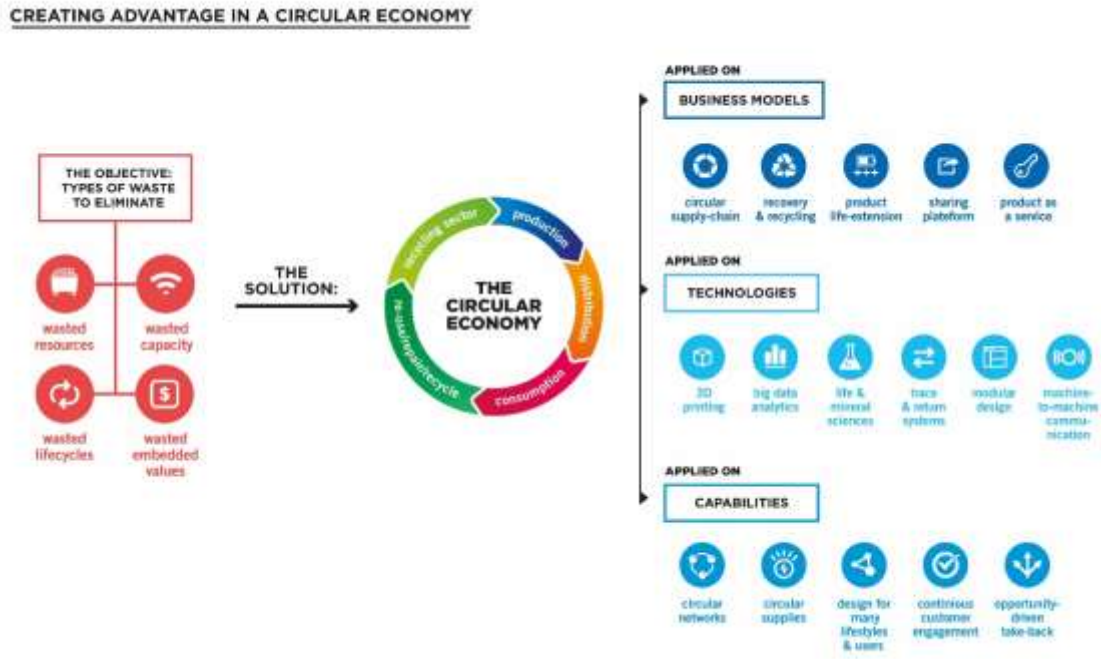

Figure 3. Creating advantage in a Circular Economy

1.2 Development of IoT

Although it might differ from the standard definition, we consider IoT movement as the democratization of automation technologies. Most IoT products are connected sensors, some with limited abilities to interactive with environment, all of which have been available in the industrial environment for years. But because they were too expensive, too large and consume too much power, mass adoption was not possible until recently. This is not in any way trying to undermine the importance of IoT, as massive data collections have only become possible with this technology, and with more data there is a better chance to get a correct result. In

weather forecasting for example; daily measurements have grown from 1200 a day in 1987, to 215 billion a day in 2017 (Shukman, 2017), the weather forecast can now therefore predict 5-7 days in the future, far better than the next day forecast available in 1987 (Ravilious, 2015). Of course, measurements alone did not cause this huge improvement, the new forecasting models and computing powers played very important roles too.

1.3 Literature review

IoT plays a significant role in the enablement of circular economy principles. The extension of internet connectivity into physical devices and objects allows devices or assets to communicate with each other and provides information about the location, components, or gives a historical record of utilization of assets, transforming the assets to "intelligent assets", defined as physical objects that are able to sense, record or communicate information about themselves and/or their surroundings. (Morlet A, et al., 2016).

As previously stated, most IoT products are connected sensors, some with limited abilities to interactive with environment. Now that mass adoption is possible the economic benefit of adopting the technology will further improve, many researches and studies shows that by 2025 there will be more than 75 billion installed IoT devices worldwide, 3 times higher than the current number.

For this introduction we centre our review around 2 industry reports: Accenture's Circular Advantage ('Accenture-Circular-Advantage-Innovative-Business Models Technologies-Value-Growth.pdf', 2014), and Vodafone's IoT Barometer 2019 report (Vodafone IoT Barometer 2019, 2019). Both reports heavily focus on digital technologies including IoT; in Accenture's report (published in 2014), the importance of new circular economy model is highlighted, and further discussion centres around business models that utilise the CE concept. The report suggests digital technology allows companies to be customer centric, and then provides a few successful case-studies. The common theme of these cases are companies using digital technology to help them either serve their customers better or offer a new innovative business model. This is echoed by Vodafone's report 5 years later, suggesting that companies trying to use IoT to provide value, need a sophisticated plan outlining how to use such technology. The take-away for us here is that IoT alone will not be able to provide huge value, but it can act as an enabler, or amplifier to boost the right business strategy.

Another interesting point in the comparison of these two reports is that Accenture called for collaboration and cooperation in order to maximize the adoption, so in 2019 Vodafone found that 92% of all companies who adopted IoT bought products/services with IoT built in rather than develop them in house, echoing the need highlighted in the earlier report. Another industry report regarding IoT has suggested that even within IoT technology itself, an ecosystem has been established (2019 Trends in Internet of Things | CompTIA, 2019).

2 IoT enabled Circular Business Models – cases studies

2.1 Case Study – Bluesoft

2.1.1 Executive Summary

In the era where resource scarcity is becoming reality, the call for replacing linear economy principles of make-take-dispose with circular economy principles is becoming ever more urgent. Poland's energy sector is one where circular economy principles may have a substantial impact. Volatility in both power generation and electricity demand engenders inefficiencies in the form of power generation, asset utilisation, and costly electricity system continuous adjustments and balancing. As power supply must currently follow power demand, the power generator's assets are highly utilised in peak hours and less so in non-peak hours. Furthermore, the volatile nature of consumers' electricity usage makes it near-impossible for power providers to supply exactly the right amount of electricity to contract with power generators. Since the electricity system must be kept in balance at any given point in time, system adjustment and balancing is very expensive, costing the sector 12 billion PLN annually.

Demand Side Response (DSR) is a principle and model where power demand follows power supply instead of the other way around. The advent and development of Internet of Things (IoT) has enabled the automatic implementation of DSR in Poland's energy sector. With IoT, power providers and transmission infrastructure owners can create smart meters and smart grids which measures real-time electricity usage of consumers and automates electricity usage of the users by switching it off when there's a surge of demand and lack of supply. Along with monetary incentives, a smart protocol called *IoT Load Control* will allow a smart allocation of electricity load, minimising discomfort for users who relinquish full control of their electricity usage to DSR providers.

BlueSoft, one of Poland's top IT solutions and software providers, is well positioned to offer the IT architecture of such a solution to Poland's energy sector. With 15 years of experience in the IT sector, strong relationships with electricity utility companies, and its business capabilities, BlueSoft is primed to offer such a model and reap the first-mover advantage of proposing the implementation of DSR. Aside from providing new revenue streams for energy providers and replacing the expensive go-to-market operation for electricity system balancing, we also believe that DSR promotes circularity principles by curtailing excessive energy demand, promotes energy savings, and better asset utilisation over the long-term.

2.1.2 Project Background

This Global Consulting Project (GCP) forms part of a research grant won by the Circular Economy Centre (CEC) at Cambridge Judge Business School. The grant is run by Marie Skłodowska-Curie Actions and Research and Innovation Staff Exchange (RISE) in the Horizon 2020 Programme, the largest European Union programme concerning scientific research and innovation so far, aiming to bring about world-class science and technology in Europe.

This GCP is one of the first deliverables led by CEC within the project entitled: "Business models for interplay of circular economy with IoT (CE-IoT).", by providing a case study on BlueSoft. BlueSoft, the company the team was seconded to, is a leading IT solutions and software provider in Poland and Europe. As a consortium partner of the CE-IoT project, BlueSoft contributes expertise in the key areas of Big Data and Machine Learning along with cloud and architecture competencies. Being a partner of this project, BlueSoft is looking to gain

from the GCP team's expertise developing a new business model appropriate for the organization within circular economy space.

Therefore, this GCP aims at identifying and developing an innovative framework of interplay between circular economy principles with IoT which BlueSoft can commercially leverage to generate direct value for its customers, end-users, and possibly the wider public. The core focus is on the development of novel circular economy business models enabled by IoT sensors, turning assets into "smart" or "intelligent" assets. The integration of these assets into an open and circular-by-design business models will allow for better data gathering which can support the enforcement of the business models itself. Lastly, the GCP will also aim at analysing the commercial aspect of the proposed model (e.g. high-level IT architecture which can be offered by BlueSoft, socio-economy-political analysis, etc).

2.1.3 Circular Economy, Internet of Things, and Bluesoft

This section explains the context of the GCP project, by explaining the key concepts and players; Circular Economy, Internet of Things (IoT), and BlueSoft.

Circular Economy

Currently, we live in a linear economy model, based on "take-make-dispose" philosophy, where products are increasingly becoming commodities, and resource scarcity is becoming a reality. To remain competitive in this economic environment and to achieve sustainable growth, companies are increasingly shifting their business model to enhance resource efficiency and sustainability. In this context, the concept of the Circular Economy has attracted attention in recent years. (Pagoropoulos, et al., 2017). According to the Morlet A, et al., the Circular Economy is characterized as an economy that is restorative and regenerative by design and which aims to keep products, components and materials at their highest utility and value always, distinguishing between technical and biological cycles. It is conceived as a continuous positive development cycle that preserves and enhances natural capital, optimizes resource yields and minimizes system rinks by managing finite stock renewable flows. (2016)

Internet of Things

IoT plays a significant role in the enablement of circular economy principles. The extension of internet connectivity into physical devices and objects allows devices or assets to communicate with each other and provides information about the location, components, or historical record of utilization of assets, transforming the assets to "intelligent assets", defined as physical objects that are able to sense, record or communicate information about themselves and/or their surroundings. (Morlet A, et al., 2016).

BlueSoft

BlueSoft is a company in Warsaw, Poland, with 15 years of experience in the IT industry, providing a full range of IT services and dedicated software across verticals: telecommunication, energy & utilities, pharmaceutical, logistics, banking, and insurance. BlueSoft primary services are IT system integration, Cloud Services, Consulting services, and Big Data and advanced data management. As a part of the RISE project and with its extensive experiences and competencies in the IT and Big Data management, BlueSoft was looking for IoT-enabled Circular Economy business model where BlueSoft can create new forms of value to their customers.

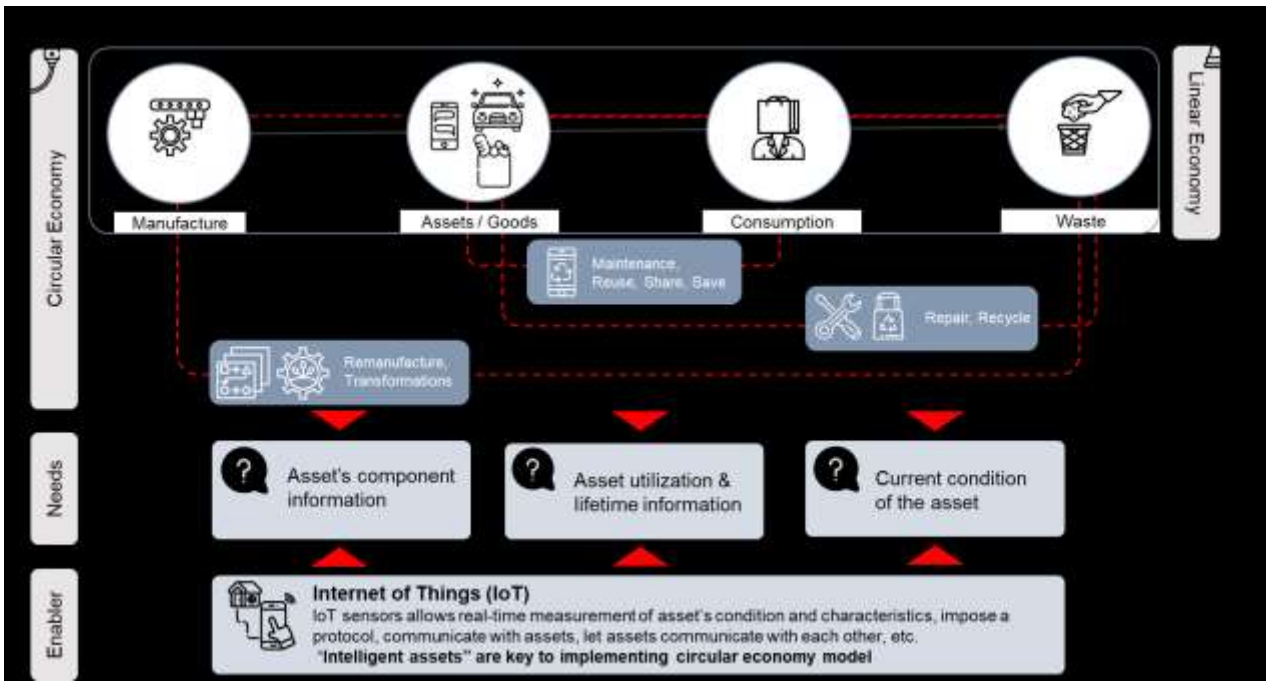

Figure 4. Circular economy, and its interplay with IoT

2.1.4 Methodology

The project was divided into three phases. The first phase was to gain a deeper understanding of circular economy principles, BlueSoft business operations, and existing challenges faced by each industry that is serviced by BlueSoft. The second phase was to generate and filter ideas based on the principles uncovered in the phase one. The third phase was a deep-dive research and business development focusing on the chosen idea.

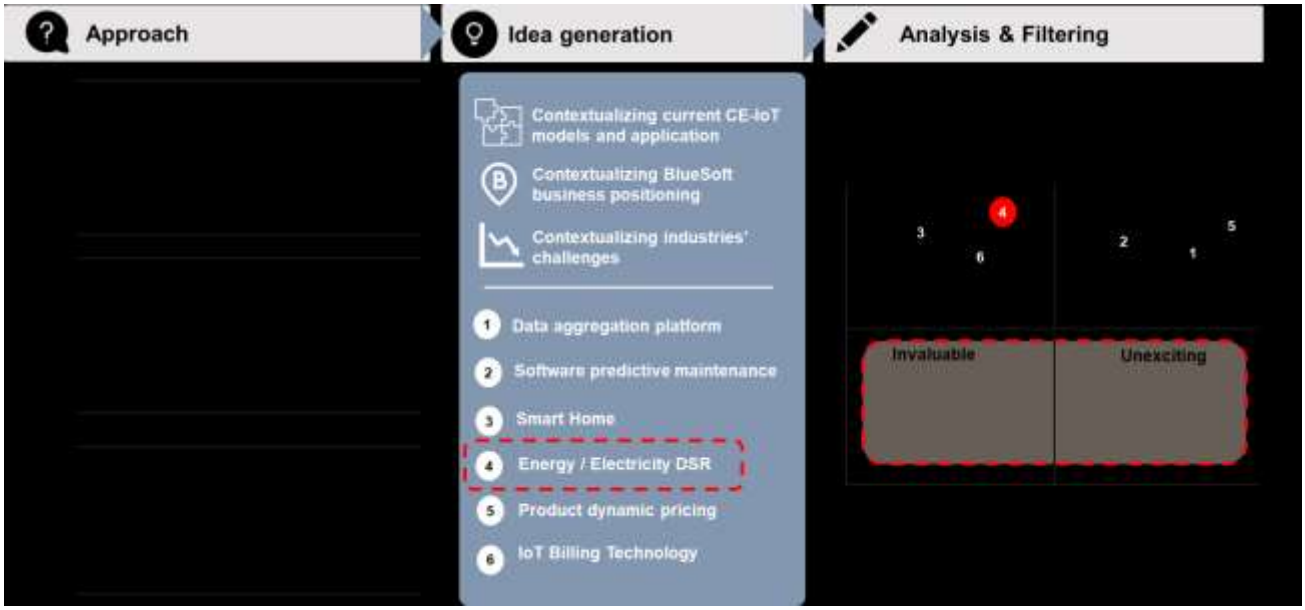

Figure 5. GCP Methodology Phase 1 & Phase 2

We understood early on that the ability to contextualise current CE-IoT model applications, BlueSoft business positioning, along with putting them in a bigger picture of which industry's specific challenges such model can be of use, are all imperative to achieve this GCP's objective. With such understanding, the team generated many ideas. We filtered these ideas with two metrics of value for customers and feasibility. Six ideas were shortlisted which we believe will provide higher value for BlueSoft and its customers (Figure 2). We presented these ideas to BlueSoft leadership team, and, based on that discussion, decided to proceed with one prospective idea: The application of Demand Side Response (DSR) in Poland's energy (electricity sector). Having selected the DSR, the team advanced the research and interviews to develop more a concrete idea which could be applicable to BlueSoft. The team studied several related areas such as the electricity market in Poland, mechanism of the DSR, and IT/IoT system architecture, as well as deeper analysis of PEST or SWOT.

2.1.5 Energy Sector in Poland

Energy, specifically the electricity, sector in Poland follows a competitive-market principle as per EU directives. The function of fulfilling electricity needs for Poland's 38 million citizens and its industries are fulfilled by private parties. The continuity and stability of electric supply is guaranteed by a group of electric supply entities creating the National Power System (NPS). There are four main subs-systems creating the NPS:

1. **Power Generators**
   Responsible for generating power through owning and operating power plants. There is currently 40 Gigawatts (GW) electricity capacity installed in Poland.
2. **Transmission Service Operator (TSO)**
   Responsible for owning and maintaining the transmission network infrastructure at national level (high-voltage cables). There is only one TSO in Poland, a fully state-owned enterprise, PSE S.A.
3. **Distribution Service Operators (DSO)**
   Responsible for owning and maintaining the transmission network infrastructure at regional level (typically medium and low-voltage cables).). DSOs are also responsible for electricity transmission from national grids to end customers. There are around 160 in Poland.
4. **Retailers**
   Responsible for providing electricity services to end customers (households and industrial users). End-to-end business process of electricity provision to customers.

Poland's electricity sector uses a "Supply Side Response (SSR)" system, in which the power generated follows what is being demanded. The electricity produced by generators is transmitted on a national level by the TSO. It then supplies the power on regional level to DSOs, who supply the energy to the Retailers who are the primary point of contact for the customers. As infrastructure owners and managers, the TSO and DSOs do not deal with the customers directly. The retailers supply the electricity to the consumers and are responsible for electricity bill payment collections. To run their business profitably, retailers typically secure a long-term contract with the power generator companies at a minimum price, then based on forecast and seasonality, secure a short-term contract at relatively higher price to fulfill the actual demand that happens during electricity transmission.

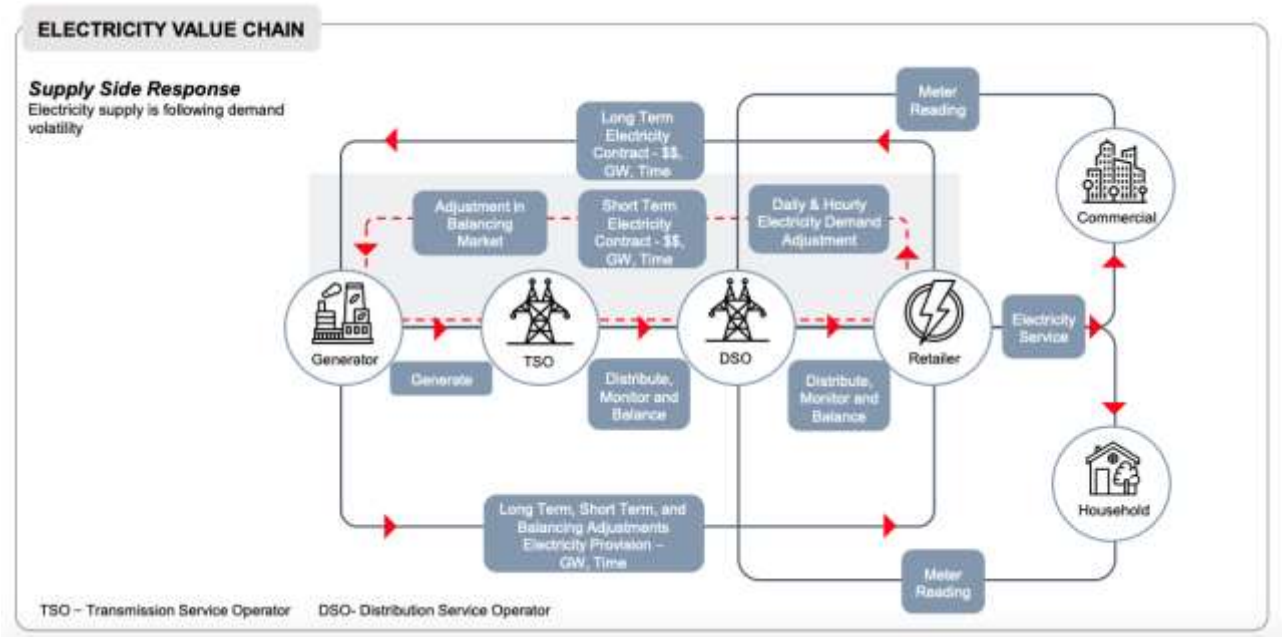

Figure 6. Electricity players and value chain in Poland

There are two important principles in any electricity sector in the world: 1) electricity can't be stored once generated, and 2) the system must be kept in balance at all time, meaning electricity produced has to equal electricity being consumed at any given point in time. These two principles and given that there is volatility on both supply side (power generation) and demand side (retailers) makes system balancing and adjustments a continuous and expensive process. Currently, system balancing and adjustment is done through market operation, where parties with surplus or deficit electricity go to day-ahead market (one day prior to transmission), intra-day market (one hour prior to transmission), and balancing market (fifteen minutes prior to transmission). The urgent nature of adjusting and balancing makes transacting in these markets expensive (wider spread between bid and offer). This issue, on top of the retailers' method of securing long-term contracts for known usage and filling the gap of demand last minute, generates immense impact on the electricity system. Approximately 31% of the total electricity consumption in Poland (TGE, 2016) is traded on the day-ahead and intra-day market due to demand volatility which costs approximately 12 billion PLN. In order to capture this high monetary opportunity, a Circular Economy Solution of Demand Side Response (DSR) has been explored.

2.1.6 Demand Side Response (DSR)

Demand Side Response is a program established to motivate changes in consumer electricity usage by multi-tier pricing or reward-based incentive program to lower peak demand. A decrease in peak demand usage would not only allow for asset utilization optimization for generators (higher demand in non-peak hours) but it will also reduce CO2 emission through lower energy use in the long term.

To understand the concept of DSR in its current state we refer to Figure. 4. The consumers enter into an agreement with the retailers agreeing to curtail their power supply as per retailer requirements. Typically, during peak hours, the retailer would call the customers to request a lower usage. The customer would oblige (otherwise face penalty) and either reduce the power consumption or shift the usage to off peak hours. For example, the customer may choose to shut

down the laundry and do it later. As a result, the retailers can balance the consumption based on the power supply. The customers get monetary rewards for participating in the program.

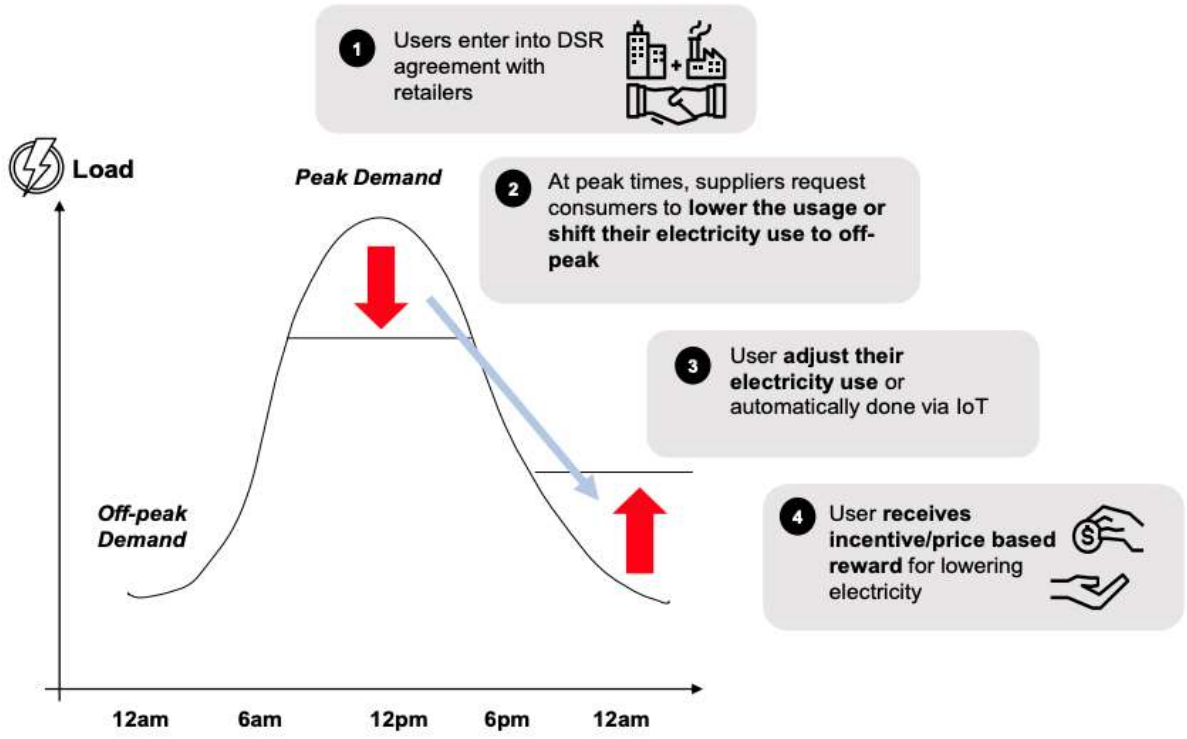

Figure 7. DSR Working Mechanism

The concept of DSR fulfills multiple purposes as shown in Figure. 5. Due to reduction in power usage at peak hours, the peak load is reduced. This means that the required production capacity decreases. The consumption of the same power during non-peak hours (Valley Filling) results in generators running at optimum level leading to better asset utilization. The process results in load shifting making the demand curve flatter and the production more stable. In the long run, the process would also lead to energy conservation as the consumers may not use the power in off peak hours later.

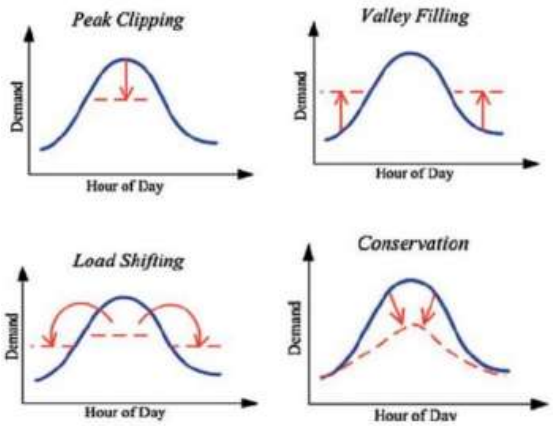

Figure 8. Effects of DSR

2.1.7 Proposed Solution

As described, consumers are requested by retailers to curtail power supply during peak hours. The process is non-automated and requires intervention from multiple parties making it inefficient. The proposal attempts to eliminate this deficiency through the introduction of IoT in the system as shown in Figure. 6. Since the DSO controls the meter, we have proposed the DSOs to be the entity to control the DSR. The DSOs receives short- and long-term requests from Retailers making them aware of the energy consumption forecasts in a region. As a result, the Generators supply the DSOs with the requested power. Now, as the retailers update their forecast in real-time and request for the required power to DSO, instead of following the demand, the DSOs will now curtail the consumption in such a way that it follows the supply.

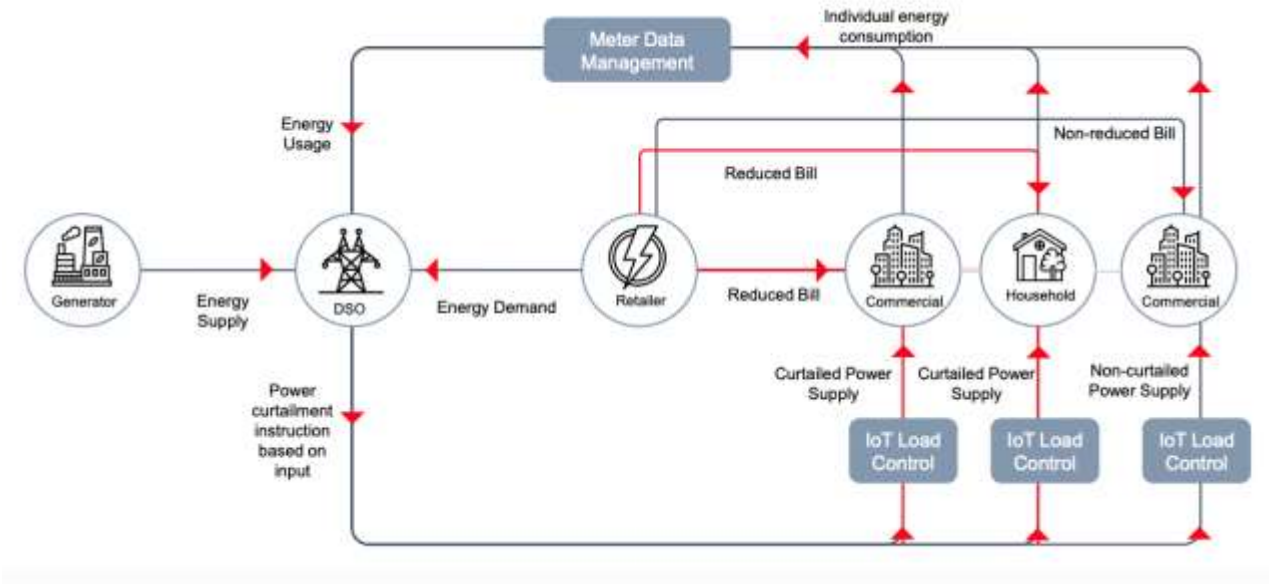

Figure 9. Proposed IoT Solution

An IoT load control device needs to be installed for the mechanism to work. It is an intelligent asset protocol that will determine the essential vs non-essential load consumptions, communicate with other intelligent assets to determine energy shortfall and surplus and, based on supply and demand, take remedial actions. In the figure shown, the power supply is less than demand which results in curtailed power supply to the 1st and 2nd commercial and household while the 3rd commercial entity gets non-curtailed supply. This distribution of power will be determined by the technology embedded in the system. The meter data management software records the individual energy consumption and provides retailers with the reduced or non-reduced electricity bills based on the curtailment throughout the month.

2.1.8 IoT Load Control

In the proposed solutions above, IoT will allow for a system which enables electricity load control; IoT Load Control. IoT Load Control allows an operator to remotely connect and disconnect electrical devices from the electrical network. The method of control can loosely be categorised into three distinct groups:

- **Circuit control** – night circuits, which are on a second metre, could be retrofitted with an IoT smart metre which can be used to turn off and on power to everything connected to that circuit
- **Appliance control** – Smart appliances with IoT chips embedded directly in them could be remotely controllable. Alternatively, devices without IoT could be controllable via a socket adapter
- **Micro-grid control** – small areas in the electrical grid, such as a residential or office block, could be disconnected from electrical grid and to use a short-term battery supply or generator

These three methodologies for IoT control allow for a range of loads to be controllable, allowing the operator of a DSR system to disconnect a single residential boiler or an industrial facility depending on the need.

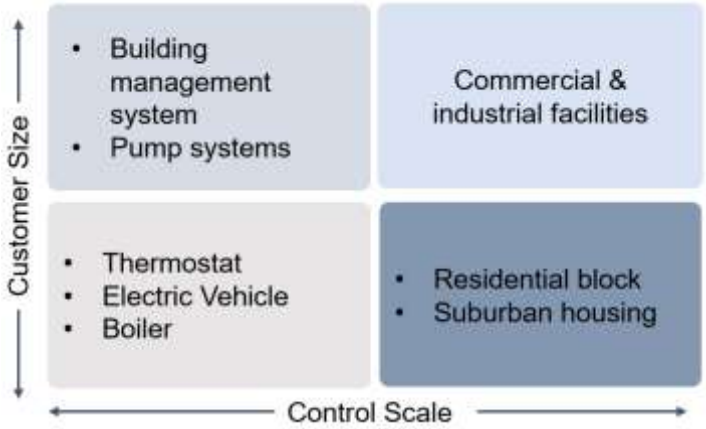

Figure 10. IoT Load Control range examples

A future key objection from the public that we foresee is that they do not want a DSR system to be able to remotely turn off their electricity. It takes away control and could interrupt their lives. To avoid this, it is recommended that only non-essential, interruptible, load be controllable via DSR such as boilers. If boilers are turned off for short periods a consumer is unlikely to notice as the existing hot water can readily be consumed.

2.1.9 IT Architecture for DSR

The proposed architecture for our DSR model is based on the current high-level model used by DSOs to remotely monitor electricity consumption, shown in Figure 8.

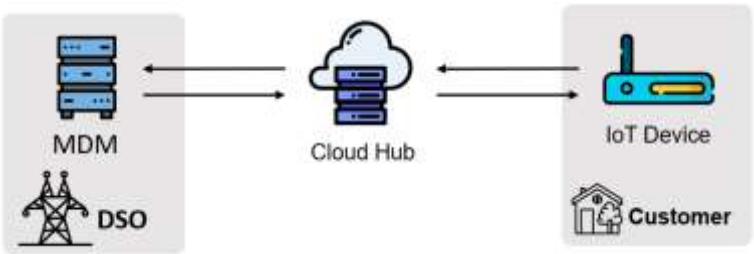

Figure 11. current architecture

The proposed architecture, in Figure 9, shows a complex event processor that allows for real time analysis of electricity consumption and issues load control commands to IoT devices.

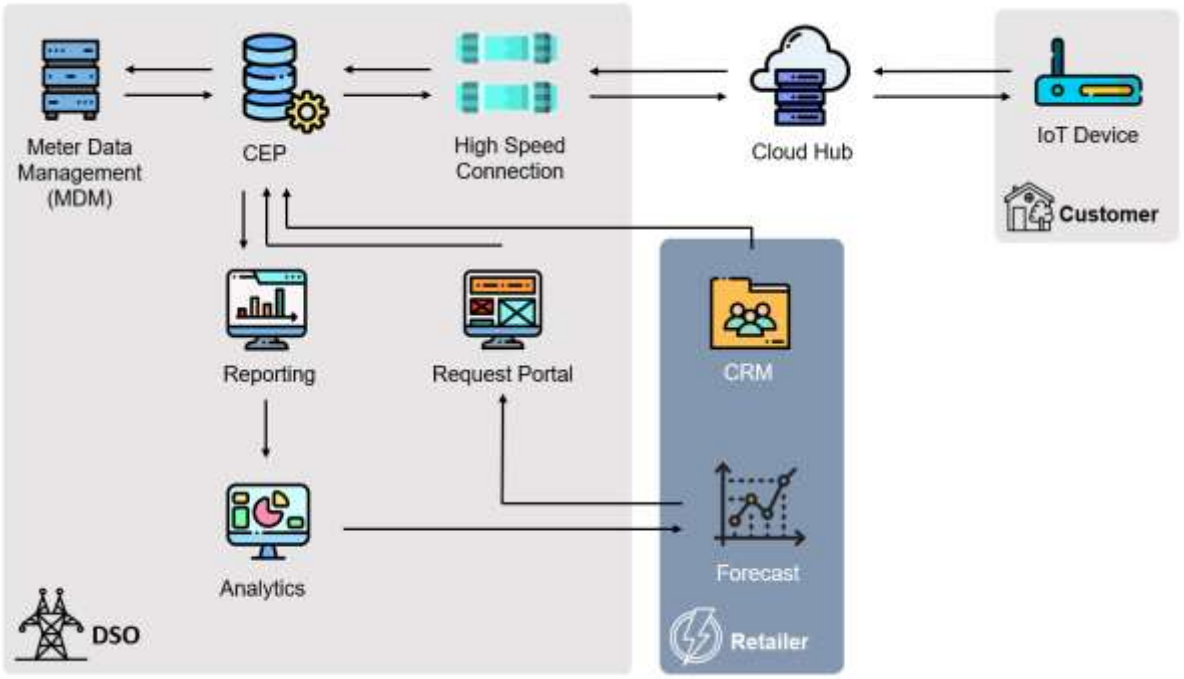

Figure 12. Proposed architecture

Architecture operational flow model:

1. Smart meter communicates usage information
2. Information is processed by Complex Event Processor (CEP), data is sent to MDM for storage and to reporting and analytics engines
3. Retailer uses analytics to compare and predict energy usage
4. Requests are made to reduce load via a portal that communicates with CEP
5. CEP communicates with IoT device based on customer information from MDM and Customer Relationship Management (CRM)

2.1.10 Revenue Model for DSR Provider

DSOs are the ideal electrical sector entity to provide a DSR service as they own the existing energy transmission and measurement infrastructure. DSOs are also motivated to implement such a system as there is a potential revenue stream. Moreover, reduced electrical loads would lower the level of infrastructure investment they are required to make.

The DSR service could be sold by the DSO to electrical retailers as an alternative to the expensive short-term electrical markets. As shown in Figure 3, if the DSR was priced such that after a retailer pays for the service and pays the incentive to the end customer, the cost is lower than the spot price, so for the equivalent electricity the retailer will purchase the DSR service instead of the energy. DSOs will be incentivised to provide DSR at low prices, since the cheaper they make the service, the more often a retailer will choose to use it over paying to make electrical purchase decisions in the market.

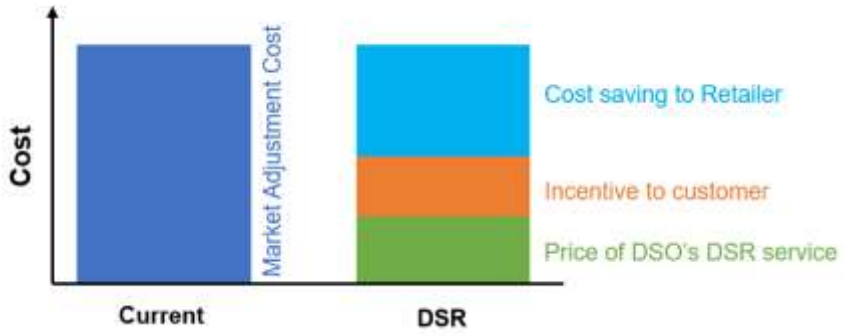

Figure 13. Value proposition of DSR for retailers

2.1.11 Opportunity for Bluesoft

BlueSoft, as an IT services provider, has an opportunity to design, implement and manage the proposed DSR service. The potential revenue for BlueSoft comes from developing the DSR service in partnership with a DSO, integrating the system into the DSO's IT infrastructure, and finally managing and maintaining the system on an ongoing basis. The DSR service could be sold to multiple DSOs within Poland and to equivalent organisations in markets with similar electrical sector structures, such as the UK, Scandinavia, Australia, New Zealand, and some US states.

BlueSoft is well placed to develop such a solution. It possesses many of the technical skills required to build the service, and strong relationships with key players in energy sector, including the DSOs. However, there are some specific areas of expertise that BlueSoft does not currently have, including IoT hardware skills and experience with Multi-Agent Service design, which has been identified as a key technology for load control (Dimeas and Hatziargyriou, 2005)

The scale of spending on the short-term electrical market (12 billion PLN, TGE, 2016) means that the potential incentive for DSO and retailers to create such a service is high, allowing BlueSoft to charge a premium for the service. However, as there are no unique skills or assets required to build a DSR service, other IT firms may also consider developing such a service.

Figure 14. SWOT

2.1.12 Benefits

DSR can provide benefits to all the parties in the electrical system as well as enhancing the circularity of the system:

1. End customers are incentivised to sign up for the DSR service to receive a lower energy bill or other monetary incentives from their electrical retailer.
2. The retailers will use the DSR service provided by the DSO as it allows them to avoid the costly short-term electrical market, providing potentially massive savings.
3. The DSOs will want to provide the DSR service because it provides a new revenue stream and reduces their spending on electrical transmission infrastructure.
4. Generators will benefit as one of the effects of DSR is reduced peak power consumption and few fluctuations in demand, which is costly, allowing them to better manage their asset utilisation.

The overall effect is a net reduction in the energy consumed, which in Poland's case means a reduction in fossil fuel consumption. It will also allow for better utilisation of existing assets as well as promoting the adoption of more renewable energy sources. One of the challenges of renewable energy sources such as wind or solar is the extremely variable and unstable output. This means that only countries with an abundance of renewable energy sources have them as a major part of the generation capability (Statistics Poland, 2016). Through DSR, these fluctuations can be absorbed by tailoring the demand to the variation, thus reducing the risk to generation companies that they cannot meet demand.

2.1.13 Challenges

Although the proposal of IoT in DSR augments Circular Economy, improves asset utilization, reduces energy consumption and promotes the usage of renewable energy, it has some challenges in implementation:

1. **Latency**: Communications and data processing are characterized by latency. Latency in data transfer reduces time to insight, which slows time to action for business and responses to the data.
2. **Bandwidth:** Even when each device is sending small amounts of data, a large number of devices will need a hefty bandwidth.
3. **Cost:** Sending large amounts of data is costly. Processing data at the edge reduces the network-related costs.
4. **Security**: The practice of data communication channels involves the fact that data is exposed to attacks and security breaches. These risks strengthen the case for securing and analysing data at the edge.
5. **Duplicity**: duplicated data is a fact for Big Data / IoT applications. The complexity and cost of supplementary storage and other assets is a challenge.
6. **Data Corruption:** Various factors (attacks, faults) can lead to data corruption. Considering that data quality for Big Data and IoT is already low, supplementary corrupted data is an issue.
7. **Compliance:** Regional and country compliance regulations can restrict or complicate data transfer.

2.1.14 Recommendation

DSR is one of the most effective circular economy models in overcoming electricity volatility, inefficiencies, and cost in Poland's energy market. The continuous advancement in technology innovation such as IoT enables the implementation and efficacy of this model. With its business capabilities and established network with industry players, BlueSoft should consider taking the first mover advantage to establish the standard for DSR in Poland.

Though it is too early to begin full development of a DSR service BlueSoft should monitor the political situation at local and EU levels to anticipate changes of legislation. BlueSoft should also identify partners in the IoT field to better understand the technology landscape to help the creation of a DSR service in the future. Finally, BlueSoft should use its existing relationships to approach DSOs to embark on small scale DSR trials to build and validate the business case for full development.

2.1.15 Bibliography

Dimeas, A., Hatziargyriou, N., 2005. *A MAS architecture for microgrids control*. p. 5 pp. https://doi.org/10.1109/ISAP.2005.1599297

Morlet A, et al., 2016. *Intelligent Assets: Unlocking the Circular Economy Potential*. EllenMacArthur Foundation.

Pagoropoulos A, et al., 2017. *The emergent role of digital technologies in the Circular Economy: A review*. Procedia CIRP 64 (2017) 19-24.

Statistics Poland, 2016. *Energy statistics in 2016 and 2017* 52.

2.2 Case Study – Cablenet

2.2.1 Introduction

Circular economy is a new wave of thinking that disrupts the traditional 'make-use-dispose' approach of doing business to transition into reducing waste and making the most out of materials and processes. This case study was prepared in conjunction with the Global Consulting Project on "Business models for interplay of circular economy with Internet of Things (IoT)", undertaken by University of Cambridge Master of Business Administration candidates, under the Circular Economy Centre (CEC) of Judge Business School together with Cablenet Communication Systems Ltd (Cablenet).

The main objective of the project was to stimulate knowledge sharing between CEC and Cablenet with an overarching goal of exploring novel circular economy business models and circular-by-design IoT architecture. Through a series of interviews with Cablenet employees, consultation with subject-matter experts, and secondary research, a bespoke circular economy framework was developed for Cablenet. It is built upon their existing circular economy practices (as identified by the project team) and can be used to identify future opportunities to incorporate circular practices. The bespoke framework is designed to enable Cablenet to further capture and develop circular business models and opportunities within its operations. The framework is configured around four main areas: new business models, circular design, enablers, and reverse logistics. Key existing circular economy practices were identified, and solutions were formulated to enable the company to embrace further opportunities. It was key to develop solutions that do not require major capital or material investment, as the company operates on a lean cost structure and prioritizes customer acquisition and network investment. Therefore, the solutions developed built upon existing capabilities. The project focused on the following areas:

- understanding the business operations of Cablenet to determine potential areas to introduce circular practices;
- exploring how Cablenet has adopted circular practices in its operations, and whether there is any IoT interplay involved;
- determining whether Cablenet has created new forms of value by transitioning to circular business practices;
- identifying the best practices in circular economy, especially those using digital resources as enablers of circular product-service business models;
- formulating Cablenet's circular economy / corporate social responsibility strategy; and
- defining further IoT related opportunities for Cablenet and the challenges and opportunities of the implementation of the business model.

Circular Economy 101

The genesis of circular economy goes to the root of how humans live and treat resources. As humans, we mostly adopt a linear approach in managing resources; this basically means we take, we make, and we dispose (Ellen Macarthur Foundation, 2011). A new phone comes out, we buy it and dispose of the old one; when a modem breaks down, the user would most likely throw it away. Each time we do this, we are eating into a finite supply of resources which often produces toxic work; this way of living will not work in the long term (Ellen Macarthur Foundation, 2011). Given this, individuals, corporations and governments collectively need to work together to adopt a more circular approach in managing resources.

So, what does being circular mean? It boils down to three key principles - maintain, return and minimise; we need to maintain the value of our product, materials and resources for as long as possible, we need to return our product, materials and resources into the product cycle at the end of their use and minimise generation of waste or utilisation of resources (Eurostat, 2019). By applying these principles to operations, we are essentially closing the loop in supply chains, thus, prolonging the value of every single resource that we have chosen to utilise. If everyone adopts a more circular approach in managing resources, consumption of new resources would decrease as the utility of existing product, materials and resources would be fully maximised to satisfy our needs before new ones are introduced to the supply chain (Eurostat, 2019).

Figure 15. Key principles of Circular Economy

Below are some examples of circular practices (Eurostat, 2019):

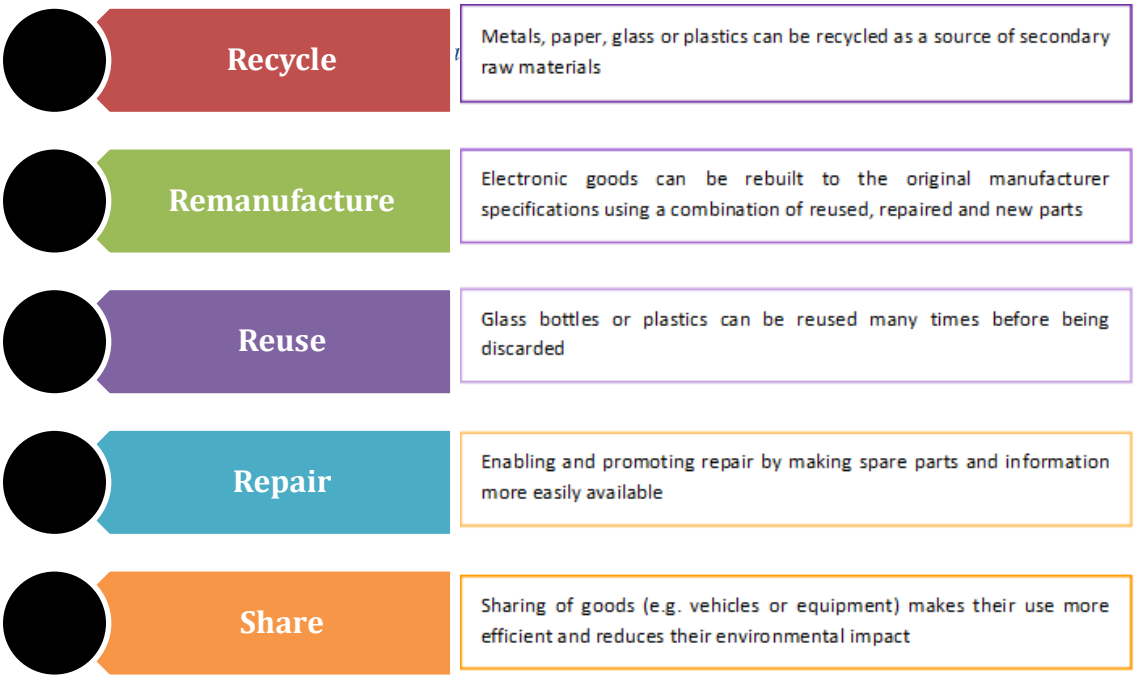

Figure 16: Examples of circular practices

For an example, a beverage manufacturing company that sells carbonated drink in bottled glasses would create the beverage, bottles and bottle caps. The finished product would be delivered to various distribution channels, and subsequently sold to consumers who would then dispose of the bottle cap and bottle upon consuming the beverage, and these wastes would then go to a landfill. This method of operation is the linear approach described earlier; the value of product, materials and resources are not extended beyond their initial use. In a circular economy, several aspects of the company's operation would be different. Among others, the bottles and the bottle caps would be reused multiples times as they are durable materials and any other material involved in manufacturing and distribution, like boxes or plastic wraps will be recycled into secondary raw material. In addition, the vehicles used to distribute the beverages could be leased or co-shared, hence maximising the value of said vehicles as they would be utilised by multiple users. Ultimately, the company is closing the loop in its supply chain by maintaining the value of most product, materials and resources, returning as many resources back into the cycle (supply chain) and minimising waste.

A growing number of companies have incorporated circularity into their operations, including major companies such as Unilever, Hewlett-Packard and Google (Ellen Macarthur Foundation, 2019). Most companies that have successfully adopted circular concepts have formulated a set of circular principles by which they operate. For example, Google's principles are maintain, refurbish, reuse and recycle (Google, 2016) and these principles guide Google's policies and operations. A closer look at the management of Google's data centres showed that Google replaces defective parts with new or refurbished parts, dismantles and de-kits decommissioned servers to be reused and added back to its inventory (Google, 2016). In addition, whatever excess components it has, it will first redistribute them internally and any excess will then be sold in the secondary market (Google, 2016). By adopting all these measures, Google not only experienced improvement in performance and reliability, but more importantly, saved approx.

USD 1 billion (Google, 2016). Undoubtedly, embracing circularity may potentially benefit companies operationally and financially.

Circular Economy in the Telecom Industry

As part of the secondary research for this case study, a benchmarking exercise was conducted focusing on circular economy in the telecommunications industry. Three major companies who operate in a circular economy were identified; Telefónica, S.A.[1] (Telefónica), Verizon Communications Inc.[2] (Verizon) and Telstra Corporation Limited[3] (Telstra). The exercise focused on selected activities of each company in four different categories - waste management, resource management, relationship with suppliers and customers respectively (Figure 14).

Figure 17: Key practices of the major telecommunications companies

In terms of waste management, Telefónica partnered up with a start up to develop its own waste management system called GReTel, the design and implementation of a web-based Waste Management System that links all Telefónica's offices, data centres, research and development centres and sites, and generates useful information such as measurements, ratios of reuse, valuation and other related information (Telefónica, 2017). The software enables the company to strategically increase the value of the waste managed by digitizing the process, as well as minimizing the associated risks (Telefónica, 2017).

With regards to resources management, Telstra has taken significant steps in its materials efficiency initiatives. In 2018, it reduced the thickness of the plastic used in its satchels used for retail products, saving an estimated 15 tonnes of plastic each year while halving packaging cost (Tesltra, 2018). The company also modified its SIM dispatch wallets which are now made from lighter, 99 per cent recycled cardboard, saving an estimated 8.5 tonnes of virgin cardboard each year (Telstra, 2018). Beyond its supply chain, Telstra made operational changes over the past five years; reduced its paper use for office, printing and billing activities (Tesltra, 2018).

As for relationship with suppliers, Verizon is committed to using responsible sourcing practices for its goods and services, which include handsets, accessories and network equipment, procured annually from around the world, (Verizon, 2018). To achieve its goal, Verizon

[1] Telefónica, S.A. is a Spanish multinational telecommunications company headquartered in Madrid, Spain. It is one of the largest telephone operators and mobile network providers in the world. It provides fixed and mobile telephony, broadband and subscription television, operating in Europe and America.

[2] Verizon Communications Inc. is an American multinational telecommunications conglomerate and a corporate component of the Dow Jones Industrial Average.

[3] Telstra Corporation Limited is Australia's largest telecommunications company which builds and operates telecommunications networks and markets voice, mobile, internet access, pay television and other products and services

formulated its own Supplier Code of Conduct and implemented processes to regularly monitor the performance of its largest suppliers in these areas - environment, labour and human rights, fair labour practices and sustainable procurement (Verizon, 2018). Also, in its effort to collaborate with suppliers to achieve its circular goals, Verizon uses EcoVadis and Avetta, third-party platforms, to assess its suppliers' corporate responsibility and where there are weaknesses, Verizon works with the supplier to create a corrective action plan (Verizon, 2018).

Lastly, for customer relationships, all companies actively include their customers in their circular approach by facilitating recycling of used materials and even raising awareness through educational, eco-rating and awareness initiatives. Both Telefónica and Verizon have introduced reward-based trade-in programs for used products (Telefónica, 2019) (Verizon, 2018). Telstra developed an app to strengthen its relationship with enterprise clients (Telstra, 2018).

Most importantly, based on this exercise, overall, it can be concluded that companies who have successfully adopted circularity in their operations incorporate the items specified in Figure 15 in their operations. Thus, companies seeking to make similar transition may take the necessary steps to adopt the same.

Figure 18: Key steps to becoming circular companies

Circular Economy in the EU and Cyprus

The European Commission (EC) is on a mission to transform the European Union into a sustainable, low carbon, resource efficient economic area which will make the EU a more competitive economy (European Commission, 2019). To achieve this, the EC launched its Circular Economy Action Plan in 2015, which adopted 54 actions, of which all have been delivered with some work still ongoing (European Commission, 2019). Throughout this period, the EU has seen positive financial benefits of such transformation and is now offering more funding opportunities to aid members states and corporations to embark on their own circular economy journey. In 2016, circular activities such as repair, reuse or recycling generated almost €147 billion in value added while accounting for around €17.5 billion worth of investments (European Commission, 2019). Moving forward, the EU is focusing a lot of effort on waste management, in particular with plastic, with the goal of ensuring that all plastic packaging should be recyclable by 2030.

Admittedly, Cyprus being an island nation faces some unique challenges like limited space, less access to shared markets and most importantly, finite resources; thus, making transition into circular economy more pertinent for the nation. Moreover, lack of co-ordination between the different administrative levels, absence of infrastructure and collection systems to divert biodegradable waste from disposal and lack of incentives to manage waste according to the waste hierarchy have made it more difficult for the country to meet EU's targets (European

Commission, n.d.). EU statistics showed that that the per capita municipal solid waste generation for Cyprus is one the highest among EU member states (Eurostat, 2019). Moreover, landfill rates in Cyprus remain very high (79%) and recycling rates are still too low (21%) to comply with the 50% set in the EU Waste Framework Directive which has to be met by 2020 (European Commission, n.d.).

Encouragingly, Cyprus has taken steps to embrace circularity. In line with the EU's plan, Cyprus is currently focusing on the recycling, reuse and repair sector (Marathovouniotis, S./In-Cyprus, 2019). To address this, the government has set a target to reduce municipal waste going to landfills to 10% of quantities produced by 2035 (Marathovouniotis, S./In-Cyprus, 2019). The country is also adopting strength in numbers and are pursuing collaborations with other Mediterranean islands. Besides waste minimization and management, Cyprus is currently focusing on achieving the following targets (Marathovouniotis, S./In-Cyprus, 2019):

- Reduce dependence on vehicles and fossil fuel consumption through the use of technology
- Improve public transportation to achieve sustainable mobility
- Stimulate economic growth based on sustainable tourism and smart cities

2.2.2 Cablenet Communications Systems Ltd

History of Cablenet Communications Systems Ltd

Cablenet was established in 2003 with the aim to provide cable TV in Cyprus. Following its acquisition by C.N. Shiacolas Group of Companies (CNS) in 2006, the company started its expansion of privately-owned network across the key areas of Nicosia, Larnaca and Limassol. In 2007, Cablenet launched a 'talk-surf-view' package which was the first package in Cyprus to offer its users high speed internet, TV and telephony. In the following years, the Company focused on increasing its connection speed and consistently offering superior speeds compared with local competitors reaching the speed of 100M in 2012. In 2014, a strategic share purchase agreement was completed with GO plc from Malta. In the recent years, the company focused on further geographical expansion across Cyprus and provision of TV content. In addition, strategic alliances have been built with the local football clubs which came with exclusive streaming rights for matches played by six of the key teams.

Performance and Market Share

Cablenet has completely disrupted the telecommunications market in Cyprus since entering it in 2003. It is the first company that truly posed the threat to the partially publicly-owned incumbent Cyta. Cablenet is the only independent telco provider in Cyprus that owns its network and does not need to rely on Cyta for its provision thus creating a unique opportunity in the market. Cablenet has gradually gained market share through expanding into a number of urban areas. The company's current overall market share is approximated at 21%, however, it is as high as 41% in the areas covered by Cablenet.

Values and Strategic Objectives

Cablenet's main objective is to provide all of its customers with highest connection speeds at lowest possible prices. The company seeks to ensure clients' satisfaction through optimising its operations in a rapidly evolving telco market in Cyprus. It engages in a number of operational excellence initiatives always aiming to pioneer in the local market and bring the latest technology and solutions to its subscribers. Cablenet's customer-oriented focus is reflected in

all areas of its business including organisational culture which is characterised by collaboration and mutual respect and trust. Employees are viewed as the key to company's success and a key element in achieving the highest levels of customer satisfaction. Cablenet's core defined five values are: efficiency, professionalism, consistency, ethos and one family.

2.2.3 Circular Economy at Cablenet

A Framework for Circular Economy

When we first met with the team at Cablenet in person and asked whether they applied circular economy in their businesses, we received blank stares and a muted response. However, through our research and interviews we realized that they already practiced several circular economy-related ideas. They'd arrived at these operational practices because they make sense to a leadership focused on long-term success and efficiency. Some of the practices reduce the lifetime costs of equipment through prolongment or resale. Others enabled lean and smart business practices. Some of the ideas fit into their medium-term strategy to leverage modern technology as a competitive advantage. The team at Cablenet is dedicated to growing the company efficiently and sustainably using their cash flow, but they're also thoughtful planners and operators. We decided that we needed a tool to help them realize that they're already practicing circular economy as smart business practices. We sought to help them realize that by acknowledging, measuring and integrating their circularity into the company culture, they could create purpose for their teams and unlock new avenues for growth.

To develop our framework, we considered the thought-leaders in the circular economy space and how their ideas applied to business practices. The Ellen MacArthur Foundation's case studies tag each one with a "Building Block" (*Building Blocks Of A Circular Economy - Circular Economy Design & Circular Economy Business Models*, 2019). These denote how the activities described in the case study enable a country, company or industry to become more circular. We brainstormed different ways that we could group the CE business practices. Ultimately, we decided that the 4 concepts described by the Ellen MacArthur Foundation – New Business Models, Reverse Logistics, Enablers, and Circular Design – could fit the current practices of Cablenet and help them develop new ideas for future growth. New Business Models include shifting from products to services or creating businesses that recapture and reuse valuable resources from supply chains. Reverse Logistics describes developing systems that return resources to nature or supply chains instead of disposing of them. Enablers are the technologies, knowledge, business models, and policies that promote sustainable shifts towards a circular economy. Circular Design considers reuse, repair, and waste minimization pre-production to minimize resource intensity and add value through modern data-driven design.

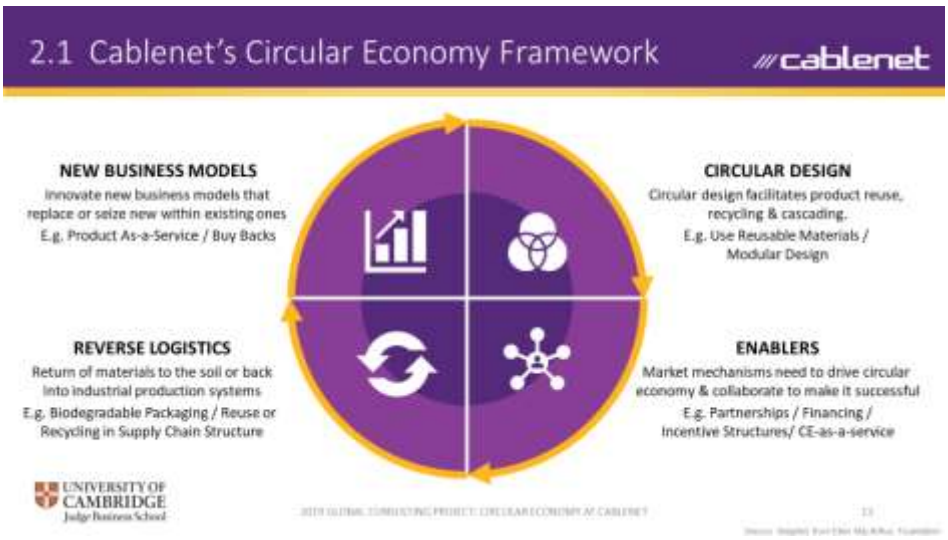

Figure 19: 4 Key Areas for Development of Circular Economy

At the Circle Conference hosted by the European Commission in Nicosia on 28-29 March, they heavily focused on the need to improve recycling and reuse practices and reduce plastic waste ('CIrClE 2019 + SMiLe 2019', 2019). There was also a short talk on smart cities which resonated with our goal of integrating IoT as an enabler of CE. The tenants of waste reduction and recycling are mainstream, but the idea of leveraging modern technology, engineering, and design to create new business models is still in its infancy. In our framework for Cablenet, we needed a way to recognize their circular practices that integrated forward-thinking innovation. We developed the ideas of a "Circular Economy 1.0" and "Circular Economy 2.0". CE 1.0 focuses on the necessary and well-recognized tenants of reduce, reuse, and recycle. We believe that these are necessary but not sufficient tenants for the transition to a circular economy. If CE 2.0 were to be summed up in three words, they'd be maintain, return, and minimize. CE 2.0 considers systems design, product development, and operational excellence for the whole lifetime of an asset or business plan. The goals go beyond waste reduction and reuse to include planning to repair assets and ultimately return all resources to a global supply chain while minimizing materials and leveraging technological advancements such as IoT to continuously improve and streamline processes.

Combining the building blocks from the Ellen MacArthur Foundation with our idea of CE 1.0 and 2.0, we developed a bespoke framework for Cablenet. We used this to both show how their current practices align with CE and to provide a structure for thinking about future opportunities. The coloration blends Cablenet purple with Cambridge Judge Business School gold:

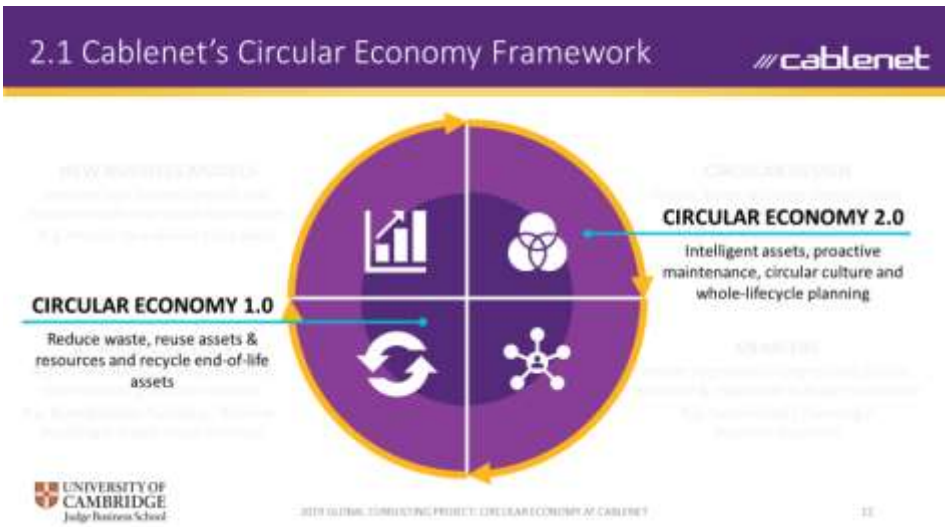

Figure 20: Maturity Levels, Circular Economy 1.0 and 2.0

Cablenet: Current State

Throughout the interview process, a common theme emerged in regard to how Cablenet employees viewed circular economy in their workplace: while it was not yet being used, everyone was interested in future integration of the concepts. Despite these claims, Cablenet has already instituted many circular initiatives under the premise of cost savings or efficiency. Circular economy aligns with business best practices when executed properly. Figure 3.3 shows Cablenet's current-state activities representing all four quadrants and both levels of the framework. The majority of activities fall in Circular Economy 1.0, which is understandable as Cablenet is still early on its circular journey. As employees become aware of the current practices, develop and measure them, and communicate their value the existing base can be built upon to support more Circular Economy 2.0 activities.

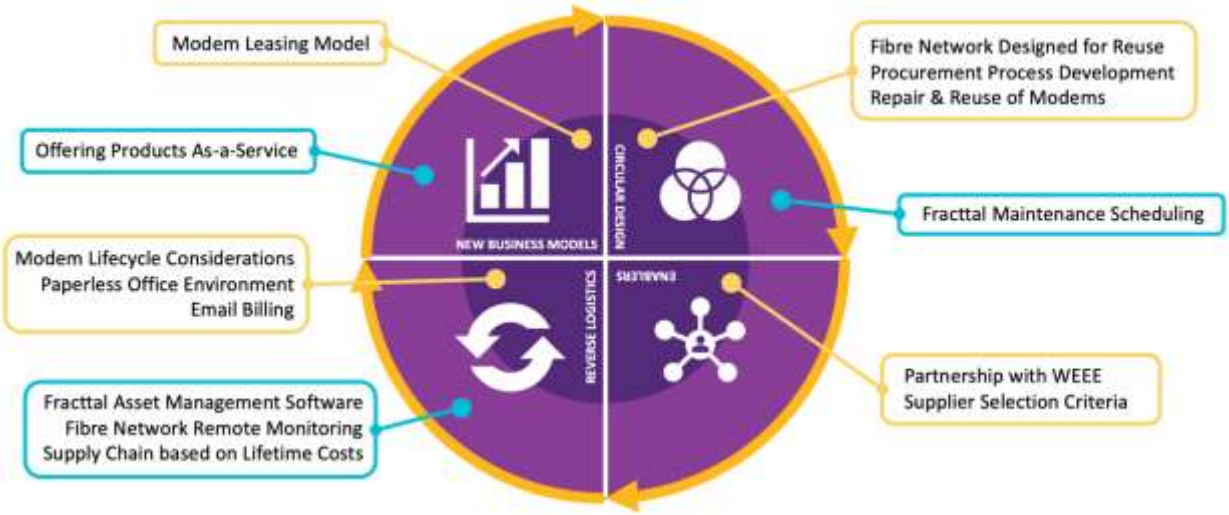

Figure 21: Classification of Current Circular Economy Activities being carried out by Cablenet

2.2.4 Use Case: Waste Reduction

Classification: CE 1.0: Reverse Logistics + Enablers

Europeans, on average, only recycle or compost 47% of generated waste. The EU is targeting an increase to >55% by 2025. In comparison, only 19% of Cypriot waste is recycled or composted, meaning 81% ends up in landfills (European Parliament, 2018). The island may have a long way to go to reach the European standard, however Cablenet is doing its part.

Cablenet is currently moving towards a paperless office environment. Day-to-day activities and business processes are being converted to digital at a rate that is sustainable while maintaining regular operation. A paperless business environment has reduced clutter yet provides consistent and easy accessibility to information. This increases knowledge sharing between employees across the business and can save time by streamline processes (using email delivery, electronic signatures, etc.). This is not a simple task, as processes need to be rewritten, templates need to be crafted, and digital systems need to be created. Cablenet is committed to the change and each step towards being fully paperless is a step away from waste generation and towards efficiency.

In addition, Cablenet are encouraging customers to opt-out of paper billing. Currently only 10% of subscribers receive invoices via email, and less than half of those have chosen email only billing. With a subscriber base of approximately 66,000, this means that over 64,000 (>96%) of users receiving invoices in the mail each month. This equates to approximately €25,000 per month for printing, envelopes, postage, etc., and a potential of €300,000 per year in savings if mail-out billing was eliminated completely. Cablenet believes this shift is possible (although perhaps not in such dramatic terms as discontinuation of paper invoicing) as the unreliable postal service puts customers at risk of not receiving their bill in time to pay. Additional incentivization might be required and should be considered.

On the flip-side, Cablenet is using more paper for delivering equipment to their customers: paper bags, that is. Rather than boxing up modems and wrapping decoders in plastic, equipment is placed in recyclable and reusable paper bags for delivery to the client. Look out for them in-use for bringing groceries home from the store in any of Cyprus' major cities.

Green Dot is a non-profit organization dedicated to Cyprus meeting its national recovery and recycling targets with a focus on packaging waste. As a member of Green Dot, Cablenet receives guidance on product packaging, as per the Packaging and Waste Packaging Law (Green Dot Cyprus, 2019c). Membership in Green Dot inspires goodwill within the Cypriot business community, in terms of commitment to green initiatives. Cablenet is much further along than this level of thinking in regard to sustainability, but there is a base commitment that must be demonstrated to match its competitors (all three of Cablenet's major competitors are members of Green Dot) (Green Dot Cyprus, 2019a). Cablenet has a contract with Green Dot subsidiary company Waste Electrical and Electronic Equipment in Cyprus (WEEE Cyprus) for disposal of modems, decoders and other equipment that cannot be repaired or returned to the manufacturer. WEEE Cyprus collects waste electrical and electronic equipment for recycling, rather than having it thrown away in the trash or improperly disposed of at scrap metal yards (Green Dot Cyprus, 2019b).

Additional Innovations:

CYTA has been named the first organization in Cyprus to be zero waste to landfill verified (by TUV Cyprus as of 2016) (CYTA, 2019). If Cablenet wants to be known as a circular leader and sustainability innovator within Cyprus, they should consider following suit and pursuing their

verification. The first step to achieving this would be to begin measurement of waste reduction activities. Once current initiatives have been quantified, realistic targets can be set and a roadmap to zero waste can be drawn.

2.2.5 Use Case: As a Service Model

Classification: CE 2.0: New Business Models

The New Business Models classification covers a broad range of approaches that create sustainable economic value while reducing the resource-intensity of legacy business models. Two well-known examples are As-a-Service (XaaS) and Sharing Economy. As-a-Service (XaaS) business models convert products into services which can be sold as subscriptions to customers ('Everything as a service', 2017). They also include businesses dematerialising physical products, reducing the resources needed for manufacturing, while providing the same benefit (i.e. DVDs vs. Netflix). Sharing economy models enable multiple customers to benefit from a single, shared asset or service ('Sharing economy', 2019). By enabling customers to gain benefit from underutilized assets, it reduces the overall resource-intensity of providing a product or service. For example, by enabling guests to rent vacation homes from their owners when they'd otherwise sit empty, Airbnb reduces the need for new lodging construction in tourist destinations.

Based on our interviews, Cablenet's first true as-a-Service product, Plume, will be launching in Q2 2019. Plume is a subscription service that Cablenet will resell which combines small wi-fi application hardware with security and home internet management software (*Plume*, 2019). The wi-fi amplification will extend the lifespan of routers, which primarily tend to need replacement due to degradation in wi-fi signal as they age. The smart internet management software will reduce the need for field tech visits by enabling remote diagnostics of issues and providing consumers greater visibility into their home wi-fi networks. About 80% of the customer support issues lodged with Cablenet relate to wi-fi so any service that improves customer wi-fi experience will also reduce the miles driven for tech visits and the demand on Cablenet's customer service teams.

Cablenet also offers shared data centre hosting and cloud computing-as-a-service, primarily to business customers. The data centre hosting enables other companies to share space and support services inside one of Cablenet's data centres. This reduces the need for additional data centres, which use significant amounts of resources, especially energy for cooling. For cloud computing-as-a-service, customers can rent processing power and storage on Cablenet's own servers. However, the customer adoption of these services is low. The Cablenet team attributes this to a relatively low overall adoption of cloud computing services in Cyprus combined with the presence of large cloud-computing incumbents such as Microsoft and Amazon. Both services reduce the need for customers to purchase and maintain their own hardware and increases the utilization of available computing capacity while reducing costs.

Additional Innovations:

Our discussion with Cablenet also considered additional services that Cablenet could provide that would reduce the need for hardware while providing comparable or superior benefits to customers. One area we looked at was television-as-a-service or bring-your-own-device television. In this model, Cablenet would provide their television services via an application that runs on a device that the customer already owns, eliminating the need for the set-top box hardware. The fiber optic network which provides home internet also carries the television

content and the application runs on a consumer's device such as a laptop or smart TV. According to our interviews, Cablenet is currently evaluating upgrading all of their customers to new set-top boxes which will enable the development and deployment of television streaming and on-demand applications. In the longer-term, they're developing their own streaming software that customers can operation on their own devices.

We also suggested additional partnerships that could benefit Cablenet by providing new revenue streams and opportunities to provide value to their customers. One example is partnering with a company like Nokia to provide "IoT Network Grid (WING) as a Service". IoT-network as a service enables internet service providers such as Cablenet to partner with Nokia to provide enterprises with the backbone of an internet-of-things network and services (*Nokia Worldwide IoT Network Grid (WING) as a Service*, 2017). We learned more about this service through our interview with Tim Fright at Nokia. IoT at its core is the ability of a network of connected devices to communicate remotely and generate data about their performance and environment ('Internet of things', 2019). This in turn enables a variety of new business opportunities capturing a wide-range of possible applications, from agricultural IoT that measures field conditions to manufacturing IoT where machines can predict their maintenance needs. Cablenet already leverages basic IoT capabilities internally through their new asset tracking & monitoring systems (discussed in 2.2.7). IoT-as-a-service could help Cablenet become an enabler of the adoption of IoT for other businesses in Cyprus.

2.2.6 Use Case: Procurement Process

Classification: CE 1.0: Circular Design + Enablers / CE 2.0: Reverse Logistics

Cablenet's previous business model involved each department ordering their own materials as required, however the company is now moving towards centralization. The newly-formed Procurement department is taking the time to understand each department's needs and habits prior to taking on its procurement activities. This is allowing for comprehensive processes to be created.

The formalization of procedures provides a holistic view of the procurement practices of the company, making benefits easier to identify and obtain. Circular Economy practices are easy to enact as there is significant overlap between cost and sustainability drivers. Reducing redundancies, consolidating shipments, ordering in bulk and finding late-life uses for assets with different departments all offer lower purchasing costs. They also eliminate excess products in the consumption cycle, reduce transportation impacts, and cascade assets through additional cycles.

Another best-practice that will surely be worked into supplier processes is renting or leasing products. Leasing/renting, rather than owning, is known as the "as-a-service" business model and is a Circular Economy 2.0 concept Cablenet participates in on both side of the equation (see Section 3.2.2 for Cablenet as a supplier). For large equipment, such as the fleet vehicles, Cablenet has chosen to lease rather than purchase. This allows the company to return assets at the end of their useful life – If Cablenet is done with the asset before its lifecycle has ended, the owners can refurbish or reuse it with another organization. Additionally, while building their own infrastructure for broadband is a competitive advantage, Cablenet operates as a mobile virtual network operator (MVNO) for its young mobile service. It essentially rents the mobile network by leasing wireless capacity from a third-party mobile network operator (MNO) (CYTA). Until the business is ready to create a sustainable network and the island of Cyprus is prepared to support multiple MNOs, acting as a MVNO is much more effective.

Additional Innovations:

When defining procurement processes, there is an opportunity to work in circular procedures surrounding supplier and product selection. Products could be evaluated on their circularity, using criteria such as durability, resource efficiency (electricity or fuel usage), likelihood of reuse, potential for refurbishment, or recyclability (Jones et al., 2017). Purchases should also be judged based on lifetime pricing rather than up-front price. When doing life-cycle costing, the following areas must be taken into account (Estevan & Schaefer, 2017):

- Acquisition costs (purchase or rental price)
- Transport costs (shipping)
- Installation costs
- Operating and maintenance costs (energy/fuel/water costs, existence of warranty, is maintenance included/cost of upkeep, cost of training)
- Disposal costs (including transport)
- Residual value (revenue from sale of asset at the end of useful life)

Supplier choice can be related to lifetime costing and location. A local supplier is more convenient for delivery, but the reduced transportation requirements are also greener. By targeting suppliers that focus on sustainable practices, Cablenet could work towards the ultimate goal of a fully circular supply chain, must as Verizon has achieved (see section: Circular Economy in the Telecoms Industry).

2.2.7 Use Case: Modem Lifecycle

Classification: CE 1.0: Reverse Logistics / CE 2.0: New Business Models

Modems are the primary consumer disposable at Cablenet and every customer must have one to receive their internet and power their wi-fi. Strategies that extend the modem's lifespan, reduce the needs for customer visits and responsibly dispose of obsolete or used modems reduce costs & resource intensity. Most of their current routers come from Arris, a global provider of all-in-one modems and wi-fi routers for businesses and consumers (*ARRIS | Redefining Connectivity*, 2019). They chose their modems based primarily on price-for-value as discussed in 2.2.5. Through our interviews, we identified three practices across the modem's lifecycle that apply circular economy concepts. These were a "lending" model for modems, sustainable packaging, and responsible end-of-life practices.

When a new customer signs up for services, Cablenet lends modems to customs for free in exchange for a minimal deposit. This reduces the cost and number of modems needed by enabling Cablenet to purchase in bulk and eliminate the need for consumers to buy their own hardware. If a customer cancels, the lending program enables Cablenet to retrieve and refurbish the modem for use in replacing modems that malfunction. By ensuring standard modems across all customers, Cablenet can also ensure a consistent and high-quality experience since they maintain control of the system's components. The modems are delivered to customers without unnecessary packaging or single-unit boxing. Typically, a technician will load a plastic tote with all of the necessary components for several installations and will use these for the day's installations. None of the components require their own individual packaging, reducing paper and plastic use and waste. When customers do need bags to carry goods from Cablenet stores, they receive reusable Cablenet bags instead of single-use plastic.

When modems reach their end of life, the company retrieves the modem and disposes of it responsibly via electronic waste recycling provided by Green Dot's WEEE program (Green Dot Cyprus, 2019b). If consumers purchased their own hardware, modems would likely end up in the garbage instead of recycling but Cablenet's economies of scale enable them to efficiently recycle the old electronics. Occasionally Cablenet will need to change many modems at once due to a crucial new hardware upgrade or a change in supplier. In this case, they identify hardware resellers or other internet service providers who could derive value from the older generation of hardware and sell them the used or legacy modems. This reduces the lifetime cost of the modems while prolonging their lifespan, which reduces the need for modems made from new materials.

Additional Innovations:

In our research, we realized that to truly enable a fully circular economy, companies have to focus on their entire supply chains and align customers, suppliers, partners, and policymakers around circular practices (*What Is The Circular Economy?*, 2019). Other European internet service providers have entered into pacts with their modem and hardware suppliers to develop fully circular practices. KPN, the major Dutch internet service provider, launched a pact with their suppliers – ARRIS, Ericsson, Hewlett Packard Enterprise, Huawei, and ZTE – and recycling and refurbishment firms Drake & Farrell and Teleplan (*KPN and major suppliers aim for circular operation by 2025*, 2017). As part of KPN's Circular Manifesto, all companies commit to enabling 100% recycling or reuse of components, to reducing the amount of virgin material in equipment, and to increasing the lifespans of assets by 2025. Given that Cablenet uses many of the same suppliers as KPN, signing on to a Circular Manifesto could enable them to gain the benefits of improved equipment with reduced lifetime costs and to increase Cablenet's brand awareness across the EU.

2.2.8 Use Case: Smart Asset Management

Classification: CE 2.0: Circular Design + Reverse Logistics

Cablenet has begun using the smart asset management software Fracttal. In their own words, "Fracttal bridges the gap between physical and digital assets, capturing information in real-time to predict and respond to possible failures in order to help companies world-wide work better" (Fracttal, 2019). Cablenet is in the process of recording all company assets in Fracttal. The unique code each item is assigned with allow traceability and care. Fracttal allows Cablenet to log physical assets, along with relevant data for planning and tracking the lifecycle of that asset. These can include purchase date, vendor, current location (varying from remote transmitter sites to the Nicosia-office board room), and maintenance procedures. Fracttal can tie in to IoT sensors on electrical equipment and is currently gathering readings from in-field infrastructure and data centre equipment. Readings are remotely monitored and used to adjust maintenance plans.

Maintenance can be planned and scheduled using manufacturer provided data, IoT data, and Fracttal's intelligence system. The software asks questions to determine life-expectancy of an asset and provides maintenance recommendations for lengthening it. The resulting maintenance plan is managed by Fracttal, which sends alerts when upkeep is required. Response records are kept, showing if scheduling is being followed and if it is effective - this is then used to prove ISO compliance.

The Ellen MacArthur Foundation states that, within asset management, value is in the knowledge of an asset's location, condition and availability. This is paired with the goals of extending asset lifecycle length, increasing utilization, and looping or cascading assets through additional lifecycles to identify value-add activities within asset management (see Table 1) (Ellen MacArthur Foundation, 2016).

Table 1: Interactions of Circular Economy and Asset Value Drivers and Examples of Value Creation Opportunities (Adopted from Ellen MacArthur Foundation, 2016)

Circular Economy Value Drivers	**Intelligent Asset Value Drivers**		
	Knowledge of the **Location** of an Asset	Knowledge of the **Condition** of an Asset	Knowledge of the **Availability** of an Asset
Extending the Use **Cycle Length** of an Asset	- Guided replacement service of broken component to extend asset use cycle - Optimised route planning to avoid vehicle wear	- Predictive maintenance & replacement of failing components prior to asset failure - Changes use patterns to minimise wear	- Improved product design for granular usage information - Optimized sizing, supply, and maintenance in energy systems from detailed use patterns
Increasing **Utilization** of an Asset	- Route planning to reduce driving time & improve utilisation rate - Swift localisation of shared assets	- Minimize downtime through predictive maintenance - Precise use of input factors in agriculture	- Automated connection of available, shared asset with next user - Transparency of available space to reduce waste
Looping/Cascading an Asset through **Additional Use Cycles**	- Enhanced reverse logistics planning - Automated localisation of durable goods & materials on secondary markets	- Predictive & effective remanufacturing - Accurate asset valuation by comparison with other assets - Accurate decision-making in future loops	- Improved recovery & reuse/repurposing of assets that are no longer in use - Digital marketplace for locally supplied secondary materials

Use of asset management software will allow Cablenet to extend the lifetime of assets and keep them operating effectively, thereby decreasing replacement and repair costs. Fracttal has quantified the average results of software users and the results are promising (Fracttal, 2019):

- Average of 55% Reduction in Overtime Costs
- Average of 25% Reduction in Equipment Downtime
- Average of 18% Reduction in Spare Parts and Consumables Costs

- Average of 8% Reduction in New Equipment Costs
- Average of 15% Increase in Availability of Assets

There exists a cascading effect of benefits within the maintenance space; the increased visibility allows proactive planning. Not only is equipment being utilized more effectively, but the maintenance crews can be dispatched in a more efficient manner. Maintenance can be planned based on geographical location, be executed based on expertise of the technologist on duty and addressed in order of priority. The tracking of maintenance encourages accountability within the maintenance team and helps maintain Cablenet's excellent record for low service-downtime.

Additional Innovations:

Moving forward, Cablenet should lean in to Fracttal and its capabilities. The ability to maximize value through remote monitoring can be extended further afield, as well as into the corporate office environment. A simple example would be using sensors in offices and conference rooms to control lighting and heating. By using less energy, Cablenet can reduce its carbon footprint and save money, as this is a leading business cost in both the island of Cyprus and the telecommunications industry as a whole. Analysis of the sensors data can detect patterns of use that would allow for better scheduling of cleaning/etc. and higher utilization of physical space.

2.2.9 Use Case: Network Infrastructure Components

Classification: CE 1.0: Circular Design / CE 2.0: Reverse Logistics

The fiber optic network and its components make up the largest proportion of Cablenet's physical assets. Cablenet's fiber optic network is either installed underground in trenches typically along roads that they have dug by contractors or strung along on the electrical poles through a leasing agreement with Cyprus's electricity company. Spread throughout the network are hundreds of nodes which connect the fiber optic backbone of the network to the cables that run into customers' homes. Signals traveling in fiber optic wires also degrade over distance travelled so several hundred amplifiers or repeaters boost the signal throughout the network (*A Complete Guide to Fiber Optic Internet*, 2019). Each amplifier also has its own diesel generator and each node has batteries to enable some continuity of service in an electrical outage, which are not uncommon in Cyprus. One of Cablenet's primary goals for 2019 is to expand their network to Pafos, one of the few major cities in Cyprus, so they'll be investing heavily in network components over the short term.

Currently, Cablenet has a dedicated team responsible for maintenance and repair of their network components. When technicians suspect a problem with the network, they travel into the field to identify the issue by hooking up sensors to nodes and other components. If there's a problem with nodes or amplifiers, they're brought back into the maintenance lab for diagnostics and repair. Since these are some of the most common and costly assets at Cablenet, their teams take care to try to repair and extend the lifespan as much as possible. As the network infrastructure becomes more sophisticated through the new smart asset management system, remotely-monitored modems, and more, Cablenet technicians should be able to diagnose issues more quickly with a reduced need to drive around manually checking sites for issues. This will in turn reduce costs and carbon emissions. At the end of life for network components, batteries are returned to their manufacturers for refurbishment or resource reclamation. Nodes, amplifiers, and fiber optic cables are recycled via Green Dot programs, for which there are bins in all the maintenance depots. Cablenet's current practices are thoughtful in that they focus on

prolonging the lifespan of and responsibly disposing of all components, but they don't take full advantage of new technologies.

Additional Innovations:

Currently, when there's an issue with the network, Cablenet technicians have to drive from node to node to plug in a sensor and identify potential issues. Through our research, we learned that other internet service providers are installing remote monitoring systems on their nodes and amplifiers. One such component, built-in OTDR monitoring enables technicians to pinpoint the location of a fiber optic cable break remotely (*How to Monitor Fiber Nodes*, no date). By pinpointing the location of a break, technicians can go directly to the site and begin repairs which reduces the costs and carbon emissions from driving around searching for the problem, while significantly improving response times for improved customer experience. These sensors and others could complement the value of the Fracttal system by increasing the data available for predictive maintenance and providing a real-time understanding of the network's status.

Cablenet's amplifiers also each have a diesel generator and batteries as backup in case of local power outages. Maintenance workers drive to these often-remote locations to top-up the gas tanks and test out components. Cyprus's climate is amenable to solar power generation and with the low cost for solar panels today, Cablenet could begin installing them on their amplifiers to generate power and store it in batteries. These in turn could be monitored remotely via a system of sensors. This would save on operating costs by reducing the frequency of maintenance visits while also reducing the company's electricity bills and carbon emissions.

2.2.10 Opportunities for the Future

Roadmap for Success

Whilst evidence exists that Cablenet is already engaging in circular projects, there are opportunities for the company to continue building on those initiatives and to introduce new ones in the future. Based on firm's current position in the market and its capabilities, a full complexity and feasibility assessment was undertaken to arrive at a three-phase roadmap for further CE practices implementation within the organisation. The figure below outlines the key aspirations behind each of the phases: short-term improvements, mid-term initiatives and long-term opportunities.

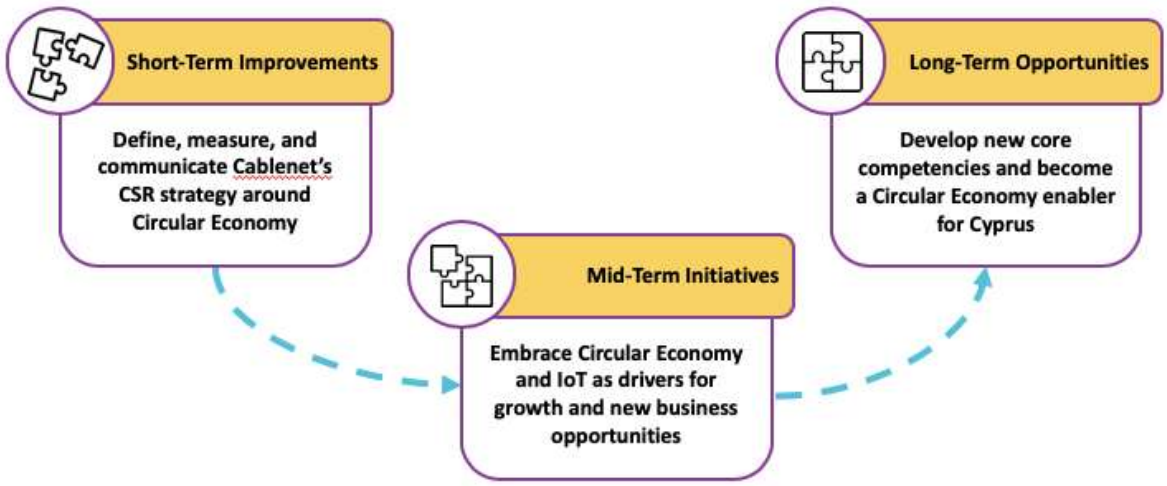

Figure 22: Circular Economy Roadmap at Cablenet

Short-term Improvements

A key recommendation to be implemented in the short-term is for Cablenet to build their CSR strategy around circular economy. As Marios Panayiotou mentioned during one of the interviews, the team would love to be able to say "Cablenet is not just purple, it's green". As proven by a number of case studies used in the analysis, organisations run their CE initiatives successfully through shaping them around a set of pre-defined principles that each project needs to address. Since Cablenet is already engaged in six different CE activities, the principles suggested are based on company's current efforts and use relevant business drivers proving they outside of CSR they are also aiming to deliver positive financial and operational impact. As they are built on the backs of the existing use cases, the strategy can be rolled out without significant additional investment. The three principles alongside the use cases they were inspired by and the associated business drivers are outlines in the figure below.

Figure 23: Outline of a corporate social responsibility framework around circular economy principles with associate business drivers

However, simply defining the principles will not be sufficient to ensure Cablenet is following through with the strategy in an attempt to become a fully circular business. Mechanisms need to be put in place in order to measure the success against each of them and to communicate progress across the organisation and outside it. Collecting the metrics will allow the company to quantify the impact each initiative has on the business and enhance reporting for ISO compliance. By communicating the principles and democratising the CE knowledge internally, Cablenet could count on newly trained employees to seek further initiatives to improve operational excellence and increase profitability. Through raising the awareness of its CE focus externally, the company would gain brand recognition and first-mover advantage not only in Cyprus but in Europe, thus creating opportunities for further international partnerships and funding from the European Commission.

Mid-term Initiatives

Cablenet's investment in Fiber to the Home (FTTH) technology and preparation for 5G opens door for additional opportunities for the multi trillion-dollar Circular Economy and IoT sector. With long term vision, Cablenet should be prepared to embrace those new business opportunities. Particularly, Cablenet has a potential to become an enabler of Circular Economy in Cyprus through interplay between CE and IoT. As a high-speed internet service provider,

Cablenet has a potential to become a backbone of an intelligent IoT platform that monitors, connects and senses systems to enable preventive maintenance and extend use cycle of assets, thus, creating value in CE 2.0.

Realising the CE's benefit to environment and boost to competitiveness and resilience, the EU is investing heavily to stimulate member countries for transition to CE through programmes and policies (EC, 2015). As the policies become more formalised, it is inevitable that the EU would require compliance from its member countries going forward. For example, the EU has already defined an action plan around waste reduction, recycling targets and extended producer responsibility schemes. In Europe, compliance with those goals and policies as well as adoption of principles of CE by businesses would create further business growth opportunities estimated at €1.3 trillion by 2030 (McKinsey, 2015).

In the medium term, we suggest Cablenet to:

- Building upon network expansion, realise its potential of becoming IoT as-a-service provider
- Build capacity in understanding and implementing circular business models and develop culture and values around circular economy, systems driven thinking within the company
- Build partnerships with IoT providers, tech start-ups that require IoT platform
- Become an enabler for CE 2.0 by providing B2B IoT-as-service

Long-term Opportunities

Through our SME interviews, we identified that major telecom players such as AT&T, Vodafone, Verizon etc. have already created new revenue stream in B2B IoT platform space. In the context of Cyprus, the country has potential, for instance, to develop circular economy in areas such as smart cities, smart offices and homes, prevention and reduction of food waste and smart asset management in logistics sector using IoT platforms.

Circular Economy and IoT potential opportunities in Cyprus.

Smart Cities

Paphos is on its path of becoming a smart city in Cyprus through EU-Interreg programme. In addition to simplifying access to information on public transport, the city is aiming to reduce carbon dioxide emissions from urban transport by introducing electric buses (Cyplive, 2017).

Smart Energy Grid IoT

Cyprus has a small and isolated energy system and there are no interconnections of electricity, oil or gas pipeline with other countries. Cyprus is almost entirely dependent on imports for its supply in conventional energy, where 30% of the country import is petroleum products. However, Cyprus also has an enormous potential for renewable energies such as solar and wind power. Investment in Smart Grid IoT for renewable energy storage will not only help balance out fluctuation in solar and wind energy releasing excess energy stored, but also ensure energy security in an energy isolated country.

Thinking Outside the Box

It is impossible to predict exactly what the future of Cablenet will be but having the correct mindset can help ensure it is successful. This means being prepared for different eventualities and keeping an open mind. Out-of-the-box thinking is where real impact can be had.

The Football Pitch

Cablenet is not just purple, it is green – it is time that everyone knows this. What better place to make it known than on the football pitch? Cablenet and Primetel have exclusive rights to televise live football games for 7 of the 12 top teams in Cyprus, through an agreement with the competitor (Hadjioannou, 2018). This partnership with the sports franchises provides a big opportunity. The passion the Cypriot people have for football is obvious. Why not leverage their loyalty to their team and worship of their favourite players? Cablenet could work with the football clubs and facilities to spread the word of sustainability and circular economy, improving the image of Cablenet and the teams/stadiums in the process.

One way of showing a commitment to the environment is through the stadium itself. Many top facilities around the world boast solar panels, including the New Lawn Stadium in Gloucestershire, England. On top of the 100 solar panels, the stadium also has the grass cut by a solar-powered robotic mower, rain water recycling, and a sustainable match day menu. An incredibly innovative street stadium (Morro da Mineira) in Rio de Janeiro, Brazil features 200 underground kinetic tiles that convert players' movements into electricity that power the lights (Turner, 2016). However, most teams already have facilities, so Cablenet would need to find a way to help improve the existing stadiums. Arsenal FC has an environmental management system that sets targets, collects data, and implements actions to ensure resource efficiency across day-to-day operations. One of the ways this is carried out is through a building maintenance system, also adopted by Chelsea FC. These systems use IoT and sensors to ensure unoccupied rooms are not being heated, cooled, lit, etc. (Webb, 2019). This would be a great use of Cablenet's network.

Some teams focus more on social impact. For example, the Forest Green Rovers (often considered the 'Greenest Football Club'), on top of other things, encourages team, staff, and fans to keep to a completely sustainable vegan diet. While helping the environment it also helps the team: " Our vegan diet has definitely had an impact on the pitch, we had no soft tissue injuries in the whole squad last year at the end of the season at Wembley, pretty much unheard of in football" (UN Climate Change News, 2017). Easier to duplicate and more applicable to Cablenet's message, the Manchester United 'Reds Go Green' Initiative delivers lessons on sustainability to local schools, covering best practices in waste management & recycling (Sustainability in Sport, 2019).

The key is, with any initiative, that Cablenet ensure that not only the message of circular economy gets promoted, but also how Cablenet is a leading innovator in this new world of sustainable businesses.

2.2.11 Closing the Loop

The three major actions that we propose for Cablenet's development of a Circular Economy culture are to define, measure, and communicate. These steps are roughly sequential, and we provided direction on how to begin through our interviews, presentation, and case study.

Define

In the define stage, Cablenet's leadership team needs to make the connection between their circular economy practices and their key commercial goals. By explicitly tying goals such as growth, lean cost structures, brand-building, and risk reduction to parts of circular economy which the company already practices, employees and leadership will gain a holistic view on their business and its interaction with suppliers, consumers, policymakers, and the environment. Supporting their focus on growth, circular economy opportunities such as as-a-Service business models can open new revenue streams. As a lean company, Cablenet already repairs and reuses

many of their assets to extend their lifespan. Acknowledging this and expanding on it through whole-lifecycle planning and lifetime cost assessments for assets can raise the awareness of employees to CE issues while driving down costs. We provided Cablenet a new bespoke Circular Economy framework (detailed in 2.2.3) for the leadership to use to communicate the connections between their operations and circular economy concepts. We also showed them how thinking about circular economy practices can form the core of their corporate social responsibility (CSR) strategy. Developing CSR around their existing application of CE will reduce the labour-intensity of the initiative. Combined, these can help build a culture that thinks in terms of systems and long-term outcomes, which in turn will provide a competitive advantage as they grow.

Measure

As identified through our interviews and analysis, Cablenet already applies circular economy concepts in their business. However, rapid growth and a lack of top-down emphasis means that many of their practices remain minimally documented. We showed how their circular economy use cases are tied to business drivers and financial metrics (detailed in 2.2.4). Documenting their processes will enable the teams to measure and improve the outcomes of their operations. Measuring outcomes tied to business processes has the benefits of helping Cablenet market their waste reduction and circular practices externally while continuously improving operations internally. They could also begin tracking waste, repair, and reuse to better understand the lifetime costs of assets and extending products lifespans. New tools such as the Fracttal system unlock the possibility of improved measurements, remote sensing, and circular logistics. While challenging at a fast growth company, the value from being able to manage the levers of business outweighs the costs of measuring them.

Communicate

Once Cablenet's leaders define the opportunity for circular economy to drive operational excellence and managers begin measuring their business processes, the final step is to consistently communicate the value. This includes emphasizing a cultural shift towards process-driven thinking and measurement of nonfinancial business drivers (in addition to the financial ones). Cablenet can also build capabilities to support future business models such as IoT-as-a-Service by expanding their internal remote asset sensing and management. Both IoT and circular economy encourage thinking in terms of systems instead of actions, which can help managers be more aware of opportunities to develop partnerships or work with suppliers to drive future growth. By recognizing and praising the fact that Cablenet already applies circular economy concepts, leadership can build a foundation for sustainable business growth, raise their awareness across the European Union, and improve their relationships with their suppliers and customers.

2.2.12 Bibliography

A Complete Guide to Fiber Optic Internet (2019) *OTELCO*. Available at: https://www.otelco.com/resources/a-guide-to-fiber-optic-internet/ (Accessed: 22 April 2019).

ARRIS | Redefining Connectivity (2019). Available at: https://www.arris.com/ (Accessed: 22 April 2019).

Building Blocks Of A Circular Economy - Circular Economy Design & Circular Economy Business Models (2019). Available at: https://www.ellenmacarthurfoundation.org/circular-economy/concept/building-blocks.

Cablenet (n.d.) *About us*. Available at: https://cablenet.com.cy/en/about-us/ (Accessed 15th April 2019).

Cablenet (n.d.) *Philosophy.* Available at: https://cablenet.com.cy/en/about-us/philosophy/ (Accessed 15th April 2019).

'CIrClE 2019 + SMiLe 2019' (2019). Nicosia, Cyprus, 28 March. Available at: https://circle2019.eu/ (Accessed: 11 April 2019).

CYTA. (2019). '*Zero Waste to Landfill*'. Available at: https://www.cyta.com.cy/zero-waste-to-landfill/en (Accessed: 04-Apr-19).

Ellen MacArthur Foundation. (2016). '*Intelligent Assets: Unlocking the Circular Economy Potential*'. Available at: https://www.ellenmacarthurfoundation.org/publications/intelligent-assets (Accessed: 02-Apr-19).

Ellen Macarthur Foundation (2011) *Re-thinking Progress: The Circular Economy*. Available at: https://www.youtube.com/watch?v=zCRKvDyyHmI&feature=youtu.be (Accessed: 4 April 2019).

Estevan, H. and Schaefer, B. (2017). '*Life Cycle Costing State of the Art Report*'. SPP Regions (Sustainable Public Procurement Regions) Project Consortium. ICLEI – Local Governments for Sustainability, European Secretariat.

European Commission (n.d.) *Cyprus - Municipal waste generation and management: current situation and distance to target.* Available at: http://ec.europa.eu/environment/waste/framework/pdf/Waste%20Summary_CY.pdf (Accessed: 4 April 2019).

European Commission (2019) *Commission delivers on Circular Economy Action Plan.* Available at: https://ec.europa.eu/commission/news/commission-delivers-circular-economy-action-plan-2019-mar-04_en (Accessed: 4 April 2019).

European Commission (2019) *Report from the Commission to The European Parliament, The Council, The European Economic and Social Committee and The Committee of The Regions on the implementation of the Circular Economy Action Plan.* Available at: http://ec.europa.eu/environment/circular-economy/pdf/report_implementation_circular_economy_action_plan.pdf (Accessed: 4 April 2019).

European Parliament. (2018). '*Waste Management in the EU: Infographic with Facts and Figures*'. Available at: http://www.europarl.europa.eu/news/en/headlines/priorities/circular-economy/20180328STO00751/eu-waste-management-infographic-with-facts-and-figures (Accessed: 03-Apr-19).

Eurostat (2019) *Introduction: Circular Economy*. Available at: https://ec.europa.eu/eurostat/cache/infographs/circulareconomy/ (Accessed: 4 April 2019).

Eurostat (2019) *Municipal waste statistics*. Available at: https://ec.europa.eu/eurostat/statistics-explained/index.php/Municipal_waste_statistics (Accessed: 4 April 2019).

'Everything as a service' (2017) *Simple English Wikipedia, the free encyclopedia*. Available at: https://simple.wikipedia.org/w/index.php?title=Everything_as_a_service&oldid=5799801 (Accessed: 22 April 2019).

Fracttal. (2019) '*Maintenance Software for Technology Companies*'. Available at: https://www.fracttal.com/en/ (Accessed: 02-Apr-19).

Green Dot Cyprus. (2019). '*Business: Why Cooperate with us? / Members List*'. Available at: http://greendot.com.cy/en/epicheireseis/synergasia-me-organismoys (Accessed: 02-Apr-19).

Green Dot Cyprus. (2019). '*Partners: AFIS & WEEE Cyprus*'. Available at: http://greendot.com.cy/en/partners/afis-weee-cyprus (Accessed: 02-Apr-19).

Green Dot Cyprus. (2019). '*Our Organization*'. Available at: http://greendot.com.cy/en/epicheireseis/synergasia-me-organismoys (Accessed: 02-Apr-19).

Hadjioannou, B. (2018). '*Cablenet-Primetel in agreement over football broadcasts*'. In-cyprus. Available at: https://in-cyprus.com/cablenet-primetel-in-agreement-over-football-broadcasts/ (Accessed: 11-Apr-19).

How to Monitor Fiber Nodes (no date). Available at: https://www.dpstele.com/rtu/fiber-node-monitoring.php (Accessed: 22 April 2019).

'Internet of things' (2019) *Wikipedia*. Available at: https://en.wikipedia.org/w/index.php?title=Internet_of_things&oldid=893456072 (Accessed: 22 April 2019).

Jones, M., Kinch Sohn, I., and Lysemose Bendsen, A.M. (2017). '*Circular Procurement Best Practices Report*'. SPP Regions (Sustainable Public Procurement Regions) Project Consortium. ICLEI – Local Governments for Sustainability, European Secretariat.

KPN and major suppliers aim for circular operation by 2025 (2017) *KPN Corporate EN*. Available at: https://overons.kpn/en/news/2017/kpn-and-major-suppliers-aim-for-circular-operation-by-2025 (Accessed: 22 April 2019).

Marathovouniotis, S./In-Cyprus (2019) *Circular economy and sustainable mobility models discussed at Nicosia conference* [Press release]. 28/March. Available at: https://in-cyprus.com/circular-economy-and-sustainable-mobility-models-discussed-at-nicosia-conference/ (Accessed: 4 April 2019).

Nokia Worldwide IoT Network Grid (WING) as a Service (2017) *Nokia Networks*. Available at: https://networks.nokia.com/services/wing (Accessed: 22 April 2019).

Plume (2019). Available at: https://www.plume.com/ (Accessed: 22 April 2019).

Rana, S. and Brandt, K. (2016) *Circular Economy At Work In Google Data Centers.* Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/data-center-case-study-14-9-16.pdf (Accessed: 4 April 2019).

'Sharing economy' (2019) *Wikipedia*. Available at: https://en.wikipedia.org/w/index.php?title=Sharing_economy&oldid=891056373 (Accessed: 22 April 2019).

Sustainability in Sport. (2019). '*Manchester United Case Study*'. Available at: http://www.sustainabilityinsport.com/case-studies/manchester-united (Accessed: 04-Apr-19).

Telefónica (2017) *Telefónica digitizes the management of its waste to boost the circular economy*. Available at: https://www.telefonica.com/en/web/responsible-business/article/-/blogs/telefonica-digitizes-the-management-of-its-waste-to-boost-the-circular-economy (Accessed: 4 April 2019).

Telefónica (2019) *Circular Economy*. Available at: https://www.telefonica.com/en/web/responsible-business/environment/circular-economy (Accessed: 4 April 2019).

Telefónica (2019) *About Telefónica*. Available at: https://www.telefonica.com/en/web/about_telefonica (Accessed: 4 April 2019).

Telstra (2018) *Bigger Picture 2018 Sustainability Report*. Available at: https://exchange.telstra.com.au/sustainability/ (Accessed: 4 April 2019).

Telstra (2019) *Our Company*. Available at: https://www.telstra.com.au/aboutus/our-company (Accessed: 4 April 2019).

Turner, J. (2016). '*8 football stadiums designed to save the world'*. Redbull. Available at: https://www.redbull.com/int-en/8-football-stadiums-designed-to-save-the-world (Accessed: 04-Apr-19).

UN Climate Change News. (2017). '*World's Greenest Soccer Club Kicks Off in Professional League'*. Available at: https://unfccc.int/news/world-s-greenest-soccer-club-kicks-off-in-professional-league (Accessed: 04-Apr-19).

Verizon (2018) Positive Change Through Innovation -2018 Corporate Responsibility Report. Available at: https://www.verizon.com/about/sites/default/files/corporate-responsibility-report/2018/2018-Corporate-Responsibility-Report.pdf (Accessed: 4 April 2019).

Verizon (2019) *Our Company*. Available at: https://www.verizon.com/about/our-company (Accessed: 4 April 2019).

Webb, E. (2019). '*Is football top of the sustainability league?*'. Specifier Review. Available at: https://specifierreview.com/2017/08/19/football-sustainability-league/ (Accessed: 04-Apr-19).

What Is The Circular Economy? (2019). Available at: https://www.ellenmacarthurfoundation.org/circular-economy/what-is-the-circular-economy (Accessed: 22 April 2019).

2.3 Case Study – Cyber Security for CE-IoT and CE-IoT Consortium Collaboration Framework: A case study on cyber security as an enabler of CE-IoT based on findings at Deloitte and framework for collaboration within CE-IoT value chain

2.3.1 Introduction

Circular economy is a new wave of thinking that disrupts the traditional 'make-use-dispose' approach of doing business to transition into reducing waste and making the most out of materials and processes. This case study was prepared in conjunction with the EU H2020 CE-IoT project on "Business models for interplay of circular economy with Internet of Things (IoT)", undertaken by University of Cambridge Master of Business Administration candidates (Team), under the Circular Economy Centre (CEC) of Judge Business School together with Deloitte Belgium (Deloitte).

The main objective of the CE-IoT project is to stimulate knowledge sharing between CEC and the other consortium members with an overarching goal of exploring novel circular economy business models and circular-by-design IoT architecture. The Team has had the opportunity to work closely with all three corporate consortium members, Cablenet, Bluesoft and Deloitte and this case study summarises the Team's findings and proposals, focusing on potential collaboration framework between the three parties, with the support of CEC.

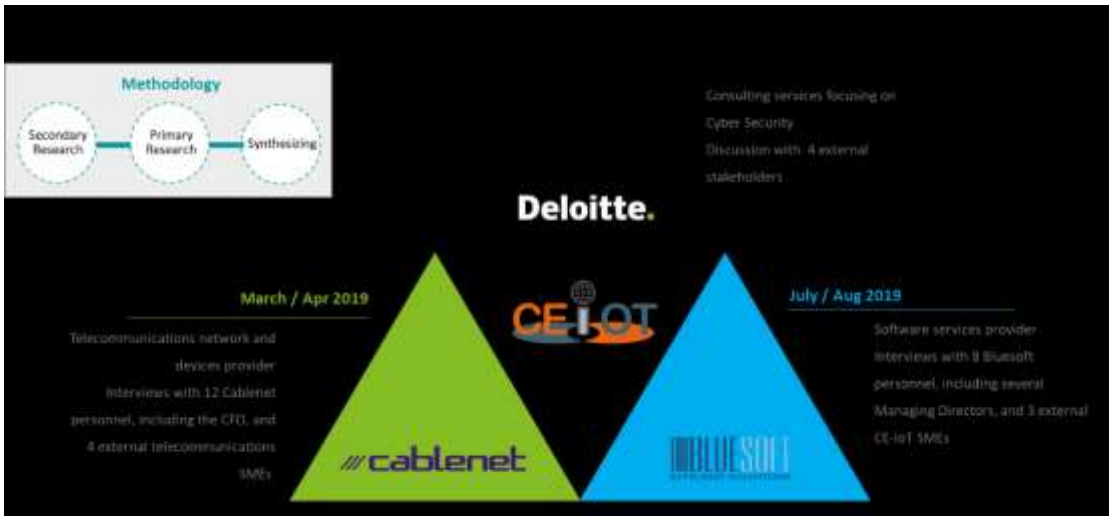

Figure 24: Triangulation approach to CE-IoT collaboration

Over the period of March 2019 to September 2019, the Team has interviewed over 20 key personnel of the respective parties, sought advice from over 10 subject-matter experts and developed 3 bespoke strategy frameworks around CE-IoT. These frameworks were designed to enable the respective parties to further capture and develop circular business models and opportunities within its operations. However, given that the Team was in a unique position whereby it has had the chance to gain exposure and understanding to the respective businesses, the Team also formulated an over-arching narrative to demonstrate the synergies and full potential of collaboration between consortium members. Whilst this case study presents a high-

level framework and use case, it should form the foundation for future discussions and work for CE-IoT.

In addition, the Team's research focused on cyber security as an enabler of CE-IoT. For CE-IoT to achieve its goals, security should not be an afterthought, it should be at the forefront of any discussions and implementation. The Team examined the key components of IoT that enable circular economy business models and explored potential risks, threats and vulnerabilities that ensue with the presence of IoT. Based on its finding, the Team then created a framework to help mitigate such risks, threats and vulnerabilities through increased and effective security, vigilance and resilience.

2.3.2 CE-IoT Business Models

Circular Economy value chain

Closed loop value chain is at the core of Circular Economy principles. The main principles are manufacture/remanufacture, sell/resell, use/share, repair/repurpose, collect/recover and restore/reduce (WBCSD (1), 2017). Compared to traditional linear value chain, circular value chain aims to decouple raw materials consumption and minimise waste in the loop. When each actor in the supply chain adopt circular approaches, circular economy would become a reality. Hence, it is vital for actors to work together and create joint value in circular economy.

Circular economy strives in innovative ecosystems, partnerships and collaboration of both stakeholders and competitors. Based on the research by R2PI (2018), it was identified that organisations that collaborate with others to change an industry have a stronger impact on the value chain and facilitate the shift towards a circular economy. In addition, collaboration in circular value chain encouraged suppliers to innovate and enabled circular design solutions.

Business case for Circular Economy

One of the main reasons why circular economy is becoming a reality is that digitization is changing the industry landscape providing new sets of competitors (Hirt, M. and Willmot, P., 2014) but also further economic opportunities. Technological advancements enable circular economy by making organisational shifts affordable and strategic. In addition to environmental and societal benefits, there are strong business cases for circular economy.

Firstly, circular economy provides cost optimization strategy for organisations through reduced raw materials consumption, energy efficiency and optimised use of goods and products (WBCSD (2), 2017). Second, consumer values are changing in recent years whereby renting goods rather than owning is more preferred, more attention is paid to sustainability and environmental footprint of products and ease of access to goods and services is valued. Furthermore, the multi-channel environment involving digital and social media provide new perspectives in engagement and connectivity with consumers and partners looking for relationships that go beyond transactions (Philips, 2019). Finally, the concept of circularity is powered by Industry 4 and disruptive tech developments ranging from IoT, AI to machine learning and 3D printing.

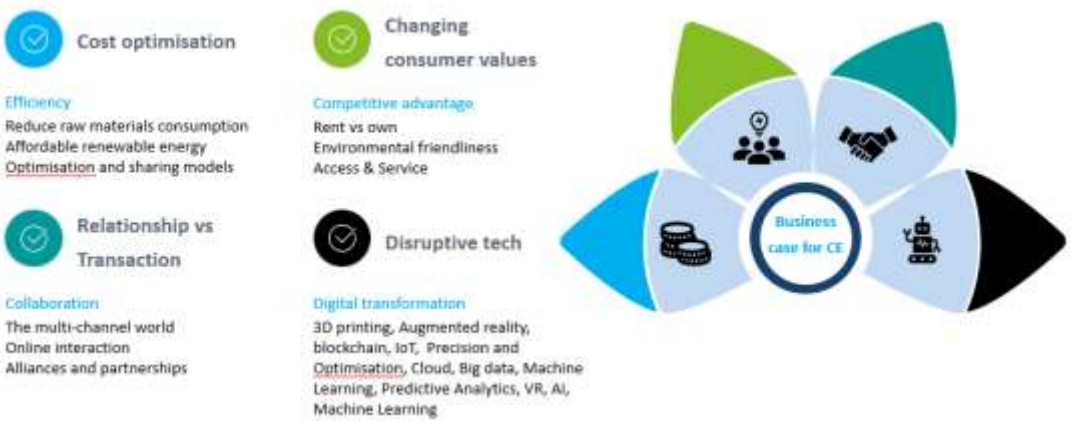

Figure 25: Business case for Circular Economy

Circular Economy business models

Building on the CE-IoT framework constructed for Bluesoft, we identified six categories of business models in CE (Figure 26): circular supplies, product life extension, resource recovery, sharing platform, product-as-as-service and optimisation[4].

1. Circular design and supplies: Using renewable energy and bio-based or fully recyclable inputs, keeping materials in a closed loop;
2. Resource recovery: recover useful resources out of materials, by-products or waste and return recovered biological resources to the nature;
3. Product life extension: Extend product lifecycles by repairing, upgrading and reselling, as well as through innovation and product design;
4. Sharing platform: Connect product users to one another and encourage shared use, access or ownership to increase product use and maximize utilization of products;
5. Products as a service: Move away from product ownership and offer customers paid access to products e.g. deliver utility virtually, allowing companies to retain the benefits of circular resource productivity or ownership to increase product use;
6. Optimise: improve efficiency (e.g. energy) and reduce waste (e.g. resource efficiency) in processes, products and business models.

[4] Based on Accenture model on CE (Accenture, 2015) and complemented by the McKinsey model on CE "ReSOLVE" (McKinsey, 2016).

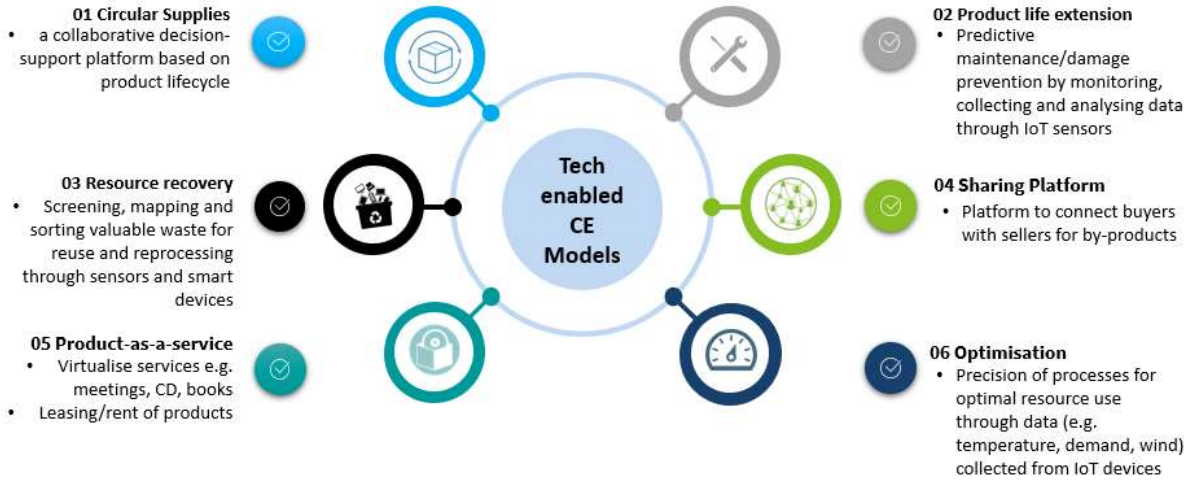

Figure 26: Technology enables CE business models

Cyber Security Can Make or Break CE-IoT

As defined by the Ellen MacArthur Foundation (2017), the building blocks for successful CE projects involve circular design, new business models, reverse cycles involving connected devices and enablers and favourable system conditions including collaboration between multiple stakeholders. Building products designed-to-last, with easy end-of-life sorting, separation or reuse of products and materials and capabilities to return materials to the nature require creating new business models that are profitable and innovative. Technological advancements such as IoT and connected devices make it possible to build such new business models and a breakthrough approach would be made possible through collaboration between various partners and stakeholders.

In order for a technology enabled CE project to be truly circular and robust in the long term, it needs to ensure that a project has additionality (i.e. providing net circularity economy benefit), is scalable and has a reliable and secure infrastructure.

Cyber Security angle plays a fundamental role in ensuring the reliability of the technology infrastructure upon which the tech enabled CE projects are based. Since the CE projects involve multiple stakeholders across value chains, a vigorous security strategy and systems need to be embedded from the beginning. As more and more actors work together within the supply chain through connected devices, it would become inevitable to build complex database and information sharing infrastructure to collect, process and share data. When such system becomes vulnerable to external threats and malfunctioning, there is a risk of an entire value chain disruption causing a domino effect. Therefore, cyber security is an enabling factor of a tech based circular economy solution without which it would not function otherwise.

2.3.3 Cyber security as an enabler of CE-IoT

Key Components of IoT for Circular Economy

Internet of Things (IoT) is the concept of connecting any device to other devices through the internet thus creating a giant network of connected things and people – all of which collect and share data about the way they are used and about the environment around them (Clark, 2016). Without a doubt IoT is at the forefront of circular economy; enabling devices and objects with built in sensors to be connected to a platform, which integrates data from the different devices

and applies analytics to share the most valuable information with applications built to address specific needs (Clark,2016). There are numerous examples of CE-IoT presently and this movement will continue to grow as IoT becomes more accessible, affordable and efficient.

Numerous companies have or are now undergoing internal transformation to integrate IoT to their business to optimise their operations and improve services to customers. Cablenet for example has taken the right steps towards smart asset management. The Ellen MacArthur Foundation states that within asset management, value is in the knowledge of an asset's location, condition and availability. This is paired with the goals of extending asset lifecycle length, increasing utilization, and looping or cascading assets through additional lifecycles to identify value-add activities within asset management (Ellen MacArthur Foundation, 2016). Cablenet has begun using the smart asset management software Fracttal to record all company assets along with relevant data for planning and tracking the lifecycle of that asset. This enables Cablenet to plan and schedule maintenance, which in turns extends the life cycle of the asset. Others have instead moved towards offering IoT as a service, by providing the infrastructure and software required to create an IoT platform. Bluesoft for an example has provided software and integration support for local smart asset management projects. Given that Bluesoft has a wide array for applicable proprietary software and the capability to integrate its own- and third-party software, it is seen as a core player in the market for this function.

But what features of IoT that makes it an important enabler of circular economy? There are three keys features – sense, communicate and locate. Sense is the ability for devices to connect with each other using sensors. Communicate is the ability for devices to communicate i.e. transfer vast amount of data or even to initiate action remotely. Locate enables devices to identify the location of one another through transmission of data or GPS capabilities. These key features are not mutually exclusive; they complement each other to create a cohesive IoT platform. In addition, an IoT platform requires strong data management and analytics capabilities to process large amount of data transmitted and to execute or determine the next course of action with limited human intervention; the system must be smart of it to operate at an optimal level. The platform also needs to be built on a secured infrastructure, capable of withstanding the increased risks, threats and vulnerabilities of operating in a more interconnected ecosystem.

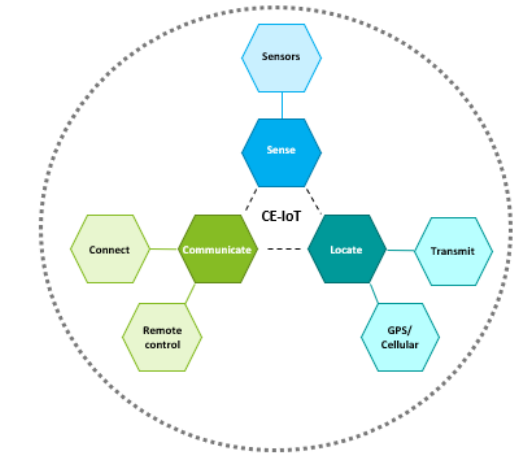

Figure 27: Key features of IoT

There are numerous examples of how these key features of IoT has enabled circular economy business models. Exhibit 5 below provides examples of activities that have been implemented by either Cablenet or Bluesoft for internal operations or as an “IoT as a Service” offering. For example, both companies are offering “IoT as a Service” offerings that extends a product’s life cycle through remote diagnostics and predictive maintenance. Cablenet launched Plume, a subscription service that combines small wi-fi amplification hardware with security and home internet management software that can extend the lifespan of routers. This smart internet management software will reduce the need for field tech visits by enabling remote diagnostics of issues and providing consumers greater visibility into their home wi-fi networks. Bluesoft also has partnered with local players in the district of Wroclaw to implement a predictive maintenance system for the sewer system, thus extending the life cycle of pipes and other

equipment.

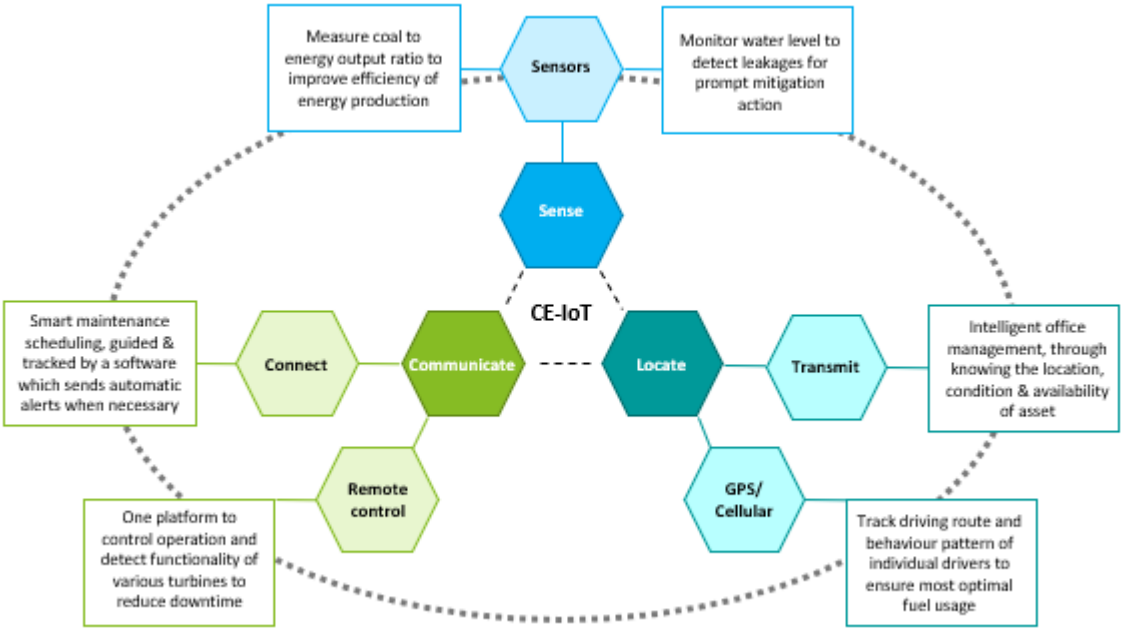

Figure 28: Examples of CE-IoT

CE-IoT Enablers and Inhibitors

Undeniably, IoT technology is evolving rapidly and becoming more accessible, affordable and efficient. Many industries too will evolve as IoT become easily deployable. In this regard, increased efforts should be placed strenthening enabling factors and addressing inhibiting ones, especially security and privary risks which will be elaborated in the next section.

ENABLERS	INHIBITORS
• **Miniaturisation of high-performing computers** • **Consumerisation of IT** • **Intelligence and analytics** • **Reduction in IT costs**	• **Security and privacy risks** • **Lack of business awareness** • **No clear or unified standards** • **Lack of technical skills**

Understanding the Vulnerabilities, Threats and Assets

Cyber security risks are most commonly defined as a sum of vulnerabilities of the system, external and internal threats and value of the assets the system protects. Once IoT is introduced to a given system the number of vulnerabilities and threats increases significantly whilst the assets protected grow in value.

Vulnerabilities

Introduction of connectivity creates countless points where the system can be potentially breached. Data sharing means that it is transferred across a multitude of devices and can be accessed by numerous people. The whole system is only as strong as it is weakest link as the hackers only need to access one device to gain visibility or take control of the entire system. Retrofitting and extending functionality of existing sensors is particularly difficult as those

devices have not been designed with connectivity in mind and may be missing a number of native security protocols that are needed for data sharing. Furthermore, there currently is no common set of IoT standards meaning that data is transferred in different formats and using different communication protocols. It creates additional gaps in the system and therefore, additional vulnerabilities. Lastly, IoT systems do not benefit from as much human supervision as the traditional ones and discrepancies may not be picked up if the system is not sufficiently trained.

Threats

Introduction of IoT also created a number of additional threats that the connected systems are faces with. Data exfiltration through hacking is one of the most common one as it has been enabled through increased data sharing. Furthermore, sensor counterfeiting, and identity spoofing pose another threat to connected systems. Sensor counterfeiting assumes introducing fake sensors to gain access to other connected devices whilst identity spoofing focuses on obtaining unauthorised access through using legitimate credentials. Malicious modification of components is another problem that the cyber security professionals need to take into consideration when protecting IoT connected systems. This method allows hackers to manipulate the data that is shared by the sensors and as such they can replace the actual metrics with false information.

Assets

Whilst introduction of connectivity to the system means that it is exposed to increased vulnerabilities and threats, it also means that the assets it protects are much greater in value. IoT sensors are producing new data that was previously unfeasible or impossible to collect. That data can replace inaccurate estimates or costly manual methods of taking the measurements. In addition, it is collected in real time and straight from the source which can enhance operational processes, day-to-day decision making and future predictions. In addition, some IoT systems allow for automated processes to be based on the real time data provided which increases business' dependence on that data and as such it becomes more valuable.

IoT Cybersecurity measures

Whilst the inherent risks of the system increase with the introduction of connectivity, there is a number of security measures that can and should be used to decrease them. Deloitte recommends a holistic approach to cybersecurity which is referred to as SVR framework in addition to a number of IoT-specific solutions.

SVR Framework

SVR framework is a holistic cybersecurity approach that does not solely focus on security but also vigilance and resilience. The figure below illustrates how the three components relate to each other. Security protocols ensure that protection measures are included in the system. Vigilance controls allow the system administrators to effectively and timely detect any breaches. Resilience procedures dictate how the organisation should respond should any incidents occur.

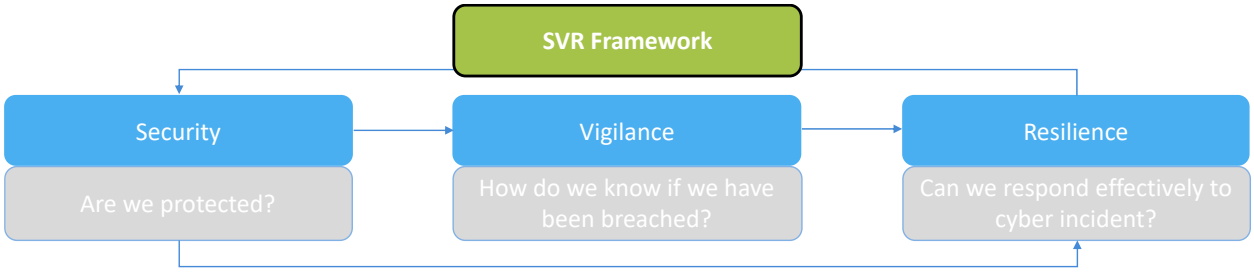

Figure 29: SVR Framework

CE and Value chain-specific measures

In addition to the SVR framework, there is a number of security measures that are specific to IoT systems and can be particularly important for organisations utilising technology to enable circular business models. Such organisation may, for instance, consider engaging in development and promotion of a single set of IoT standards across their supply chain. Many of the circular business models assume connectivity across the vale chain and as such using different data formats and communication protocols exposes the entire system to attacks. Furthermore, if more than one organisation is responsible for the administration of the IoT system there is potential for gaps in accountability and miscommunication. As such, it is vitally important that the data governance is managed at the system level rather than organisational level. Another security measure would be to design new and bespoke elements and add-ons for the connected systems. As described in the previous section, retrofitting and extending functionality of existing sensors can be a source of additional vulnerabilities if proper security measures are not in place. Last but not least, it is important to maintain loosely coupled, fail-safe systems in case of a breach to avoid a domino effect and limit the impact of an attack to a minimum.

2.3.4 Consortium Collaboration Framework

The Consortium Members

The three consortium members, Deloitte, Bluesoft, and Cablenet, has distinct but complementing areas of expertise. Cablenet is active in telecommunications and entertainment services sectors. It is present both in corporate and retail markets, expanding beyond Cyprus. Cablenet has its' own network in Cyprus and has a membership with EU Internet Exchange Association. Cablenet is also a partner of 500 network service providers. It has expertise on data centre hosting capabilities, telecommunications devices, and related network solutions. These capabilities place Cablenet as the hardware expert within the consortium.

Bluesoft is the software services provider which is active in corporate markets and industries. It is active in a wide range of industries ranging from banking to pharmaceuticals or from insurance to energy. Bluesoft praises on the customised and flexible solutions developed for its' clients. The company is not only very active within Poland and neighbouring countries but also has a growing presence in international markets. Systems integration and automation capabilities of Bluesoft place the company in a unique and strategic place within the consortium. Bluesoft is very experienced in designing enterprise IT architectures, cloud services, workforce management solutions, live data point management and predictive management, which is very important for predictive CE-IoT solutions. The company is currently working on machine learning solutions for data management and soon will be launching new software solutions for CE-IoT purposes.

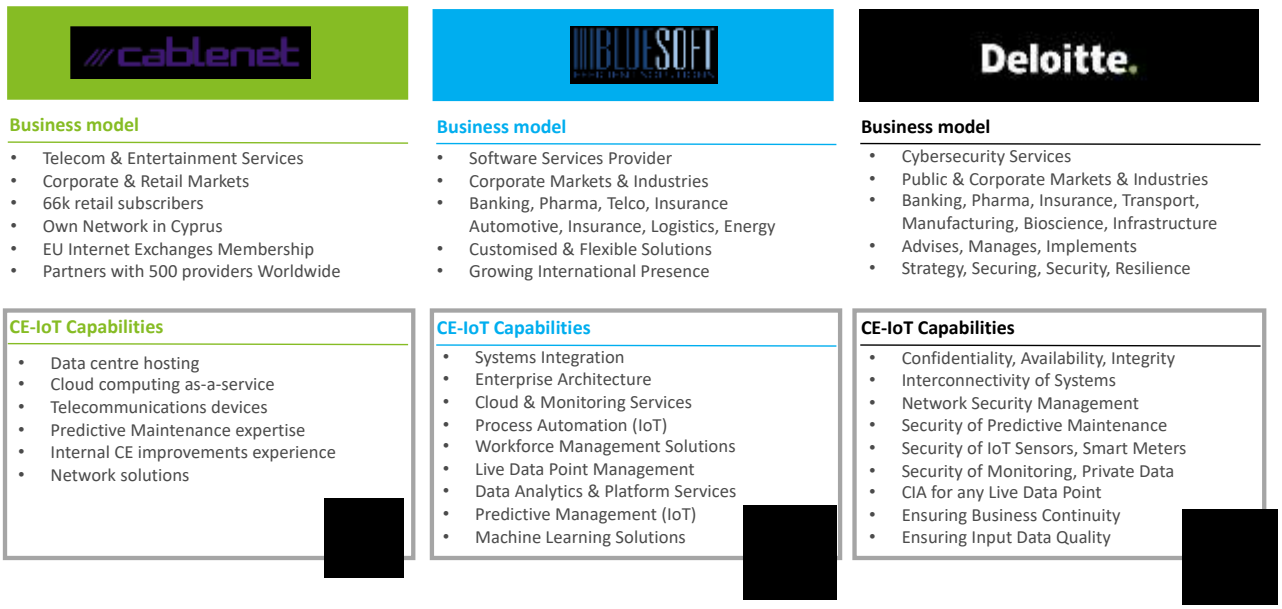

Figure 30: Collaboration Framework

The third member of consortium, Deloitte, is active on cybersecurity services. As an advocate of "security is not afterthought but an enabler" approach, Deloitte provides both security solutions and strategy for its clients. Similar to Bluesoft, Deloitte is active in a wide range of industries. There are numerous clients from manufacturing, banking, pharmaceuticals, insurance, bioscience and infrastructure sectors. The coinciding sectors with Bluesoft is another factor pointing out the possibility of synergies. Different from Bluesoft, Deloitte's approach to cybersecurity can be summarised as advice strategies, manage existing cybersecurity systems, and implement possible solutions. Deloitte's emphasis on strategy, security, and resilience of network systems has huge importance for the durability and security of CE-IoT systems. The company has plenty of capabilities for network security management, interconnectivity of different systems, CIA for live data points and ensuring input data quality of any system.

The Framework and Potential Synergies

The potential synergies among consortium members can be divided into 3 main functional areas including infrastructure, data analytics, and strategy. Regarding the infrastructure domain, Cablenet has capabilities on sensors, network, and connectivity. Bluesoft can complement Cablenet for infrastructure management, computing, and data storage. The data management services offered by Bluesoft are particularly useful for CE-IoT domains. In addition, Bluesoft is also the dominant player for data analytics functional area by way of its' offered solutions on performance management, business intelligence, and advanced analytics which incorporates machine learning. These capabilities are especially important when it comes to ensuring circular value supplies, product life extension, resource optimisation and resource recovery within different industry applications.

Deloitte, by way of its' consulting and cyber security experiences, is the dominant player when it comes to providing and overall strategy to clients. Deloitte's capabilities complement all functional areas, including infrastructure and analytics which Cablenet or Bluesoft are active in. Deloitte's capabilities include ensuring security by design, data encryption, privacy, access control, regulatory compliances and device safety. All the functional areas and different expertise of consortium members are needed when it comes to implementing the Circular Business Models introduced in the earlier chapters.

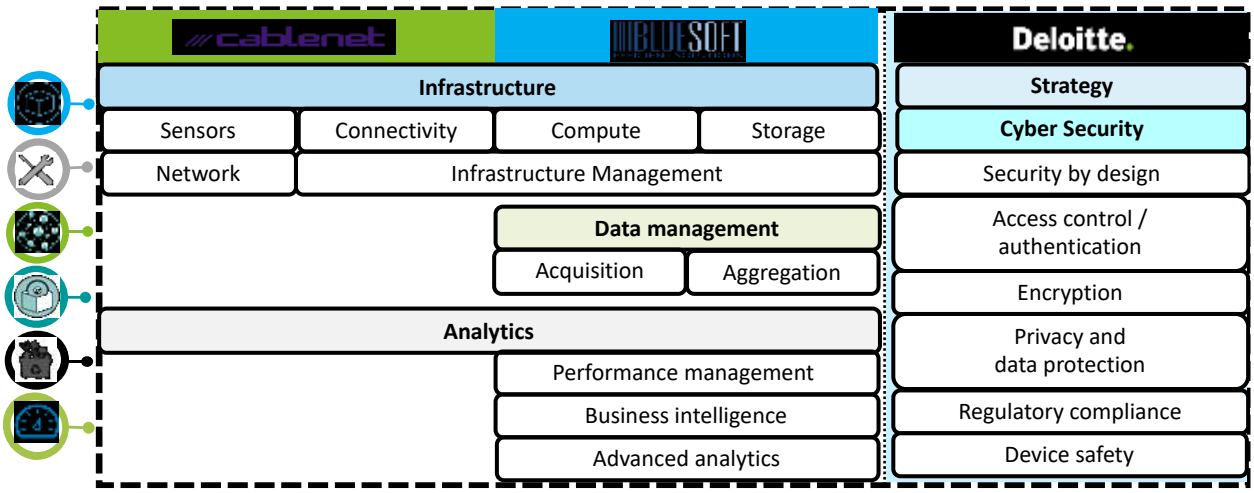

Figure 31: Collaboration synergies

Potential Use Case

The proposed CE-IoT consortium could generate a number of use cases. The client case studies prepared by the project team in Bluesoft's and Cablenet's projects are all suitable for the CE-IoT consortium, with far reaching effects on the overall value chains of clients. The capabilities of Deloitte for strategy and security, Cablenet for network and devices, and Bluesoft for software and integration can be pondered within the following potential use case. This example is devised from a previous project of Bluesoft with a local municipality.

Let's assume that the consortium collaborated to build a smart water system network for managing resources and the sewer systems. The IoT enabled sensors coupled with Bluesoft's data management system can detect the current leaks and water pressure gradients within the pipe network. The proposed system can notify the surveillance center and prompt the initiation of repairment works by technicians. Bluesoft's HAB Workforce Management software would also be scheduling the deployment of field teams, thus reducing the damage to the assets. Deloitte can lead this project within all phases by ensuring cybersecurity and data flow quality for the overall system. Sample schematic used for Deloitte client presentation can be seen below.

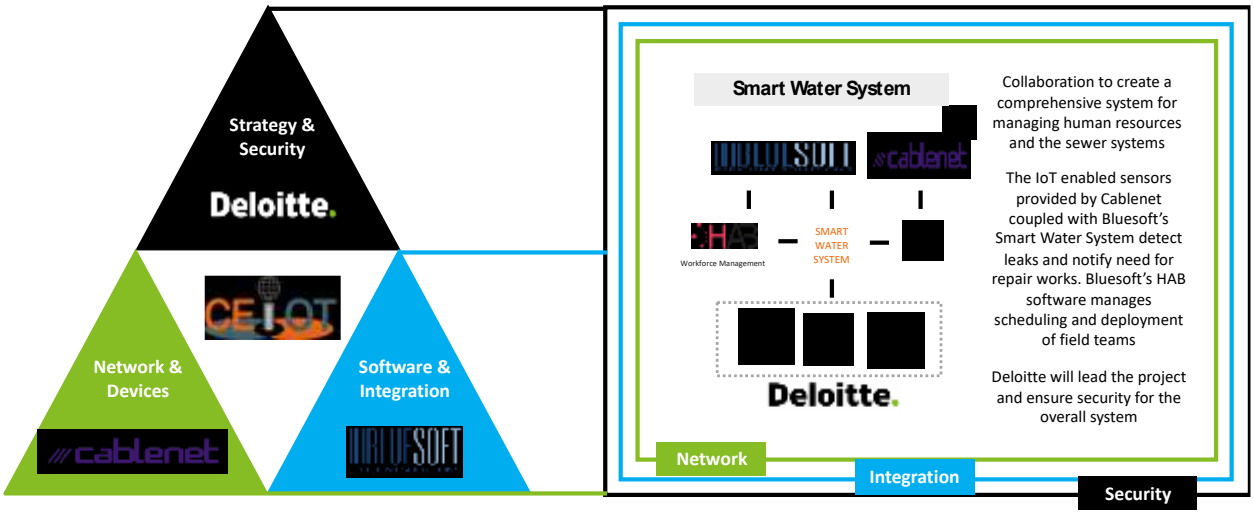

Figure 32: Theoretical case

This case study can be implemented in any dispersed complex system, either tangible or intangible, where there is plenty of uncontrolled information flow, requiring external action with limited resources.

Enabling Circular Economy through Collaboration

The CE transition requires collaboration between different partners and competitors (R2PI, 2018). As identified in Bluesoft case study, a stakeholder mapping tool (Exhibit 9) would be useful for Deloitte and the consortium members to develop stakeholder engagement strategies when pursuing CE opportunities. The various players in the CE space are defined as follows:

Potential enablers (lower left quadrant) are those organisations that primarily provide services, however, within their service offerings currently do not have CE solutions and/or have not adopted CE practices within their internal operations (e.g. waste disposal, business travel, purchased goods and services etc). Those organisations have a potential to become CE enablers by supporting resource intensive organisations to adopt more circular approach. Consortium members (Cablenet, Bluesoft and Deloitte) for example, have a potential to become CE enablers.

CE-enablers (lower right quadrant) are service organisations that have adopted CE practices within their operations and provide CE solutions to resource intensive industries. This is where partnerships are formed to provide end–to-end CE-IoT solutions. CE-enablers are key drivers for CE transition supporting organisations with CE solutions. Within the category of CE-enablers, examples of organisations include service-oriented businesses and research institutes that provide CE solutions.

Potential embracers (higher left quadrant) are organisations that are highly dependent on resources and do not have CE principles in its operations. These are high CE impact organisations whereby CE practices would greatly benefit both the organisation and the environment. However, initial discussions with potential embracers would require time investment to educate and demonstrate value proposition of CE solutions. CE-enablers have opportunities to transform them into Embracers of CE through its services and CE solutions.

Embracers of CE (higher right quadrant) have adopted CE practices and incorporate CE principles in its operations benefitting from competitive edge through CE innovation. Those organisations are open to innovation and value proposition in CE solutions. For Enablers of CE, those organisations would be target clients. Ellen MacArthur Foundation has a network of CE100 consisting of business, innovators, cities, governments, universities, and thought leaders and would be examples of embracers of CE[5].

[5] https://www.ellenmacarthurfoundation.org/our-work/activities/ce100/members

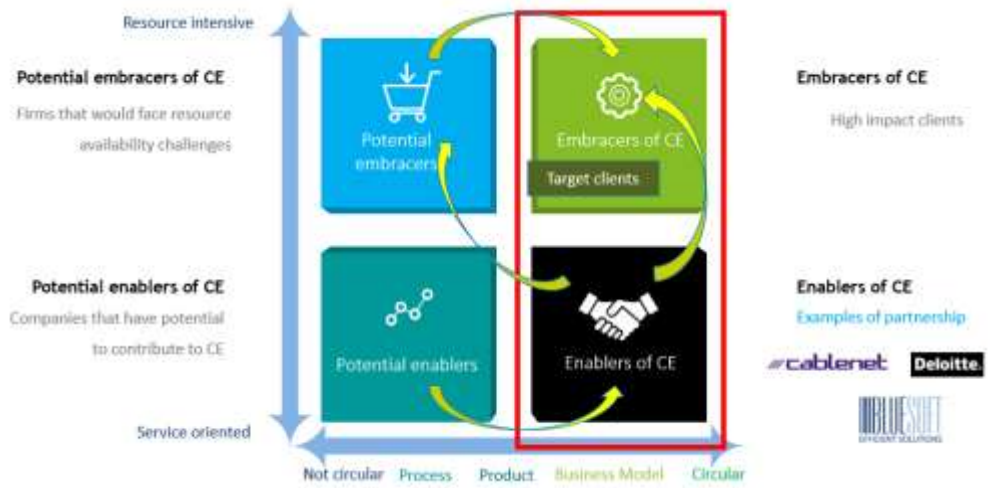

Figure 33: Mapping stakeholders in CE

The main idea behind the CE stakeholder mapping tool is for all organisations to transition to Circular Economy model by either becoming embracers of the CE or enablers of CE.

2.3.5 Closing the Loop

As technology becomes more and more widespread into our lives and many industries, we have the privilege of having more with less. The advent of technology made IoT much more accessible to SMEs, retail, and corporate consumers. The IoT devices are very useful for increasing the number of data points and having increased control over any given system, serving for the Circular Economy business models. However, increased connectivity means increased risk for cyber-attacks, which may target the overall functionality or the input data quality for any system. So, cyber security plays a key role as a major enabler of CE-IoT since IoT increases the inherent risks of the system.

By analysing each company's core capabilities, previous experiences, and functional areas, our team found out that all consortium members have distinct CE-IoT capabilities and that a shared framework will not only maximise their value to their clients but also to CE-IoT consortium efforts.

2.3.6 References

Accenture, 2015, *Circular Advantage: Innovative Business Models and Technologies to Create Value in a World without Limits to Growth.* Available at: https://www.accenture.com/t20150523t053139__w__/usen/_acnmedia/accenture/conversion-assets/dotcom/documents/global/pdf/strategy_6/accenture-circularadvantage-innovative-business-models-technologies-value-growth.pdf (Accessed: 8 August 2019)

Clark, J., 2016. *What is the Internet of Things?*. Available at: https://www.ibm.com/blogs/internet-of-things/what-is-the-iot/ (Accessed 13 Nov 2019).

Ellen MacArthur Foundation, 2016. *Intelligent Assets: Unlocking the Circular Economy Potential*. Available at: https://www.ellenmacarthurfoundation.org/publications/intelligent-assets (Accessed: 3 Sep 19)

Ellen MacArthur Foundation, 2017, *Building Blocks of a Circular Economy, Available at:* https://www.ellenmacarthurfoundation.org/circular-economy/concept/building-blocks (Accessed: 3 Sep 19)

Hirt, M. and Willmot, P., 2014, *Strategic Principles for Competing in the Digital Age.* McKinsey Quarterly, May 2014. Available at https://www.mckinsey.com/business-functions/strategy-and-corporate-finance/our-insights/strategic-principles-for-competing-in-the-digital-age (Accessed: 10 Sep 2019)

McKinsey & Company 2016, *Circular Economy: Moving from Theory to Practice,* Available at: https://www.mckinsey.com/~/media/McKinsey/Business%20Functions/Sustainability/Our%20Insights/The%20circular%20economy%20Moving%20from%20theory%20to%20practice/The%20circular%20economy%20Moving%20from%20theory%20to%20practice.ashx. (Accessed: 8 August 2019).

Phillips, 2019, Rethinking the Future: Our Transition towards a Circular Economy, Available at: https://www.philips.com/a-w/about/sustainability/sustainable-planet/circular-economy.html (Accessed: 10 Sep 2019)

R2PI, 2018. *Stakeholder views report: Enablers and Barriers to a Circular Economy.* Available at: http://www.r2piproject.eu/wp-content/uploads/2018/08/R2pi-stakeholders-report-sept-2018.pdf (Accessed: 10 Sep 2019)

WBCSD (1), 2017, *CEO guide to Circular Economy*, Available at: https://docs.wbcsd.org/2017/06/CEO_Guide_to_CE.pdf (Accessed: 1 August 2019).

WBCSD (2). (2017). *'8 Business Cases for the Circular Economy'*. Available at: https://www.wbcsd.org/Programs/Circular-Economy/Factor-10/Resources/8-Business-Cases-to-the-Circular-Economy/ (Accessed: 11 August 2019)

2.4 Case Study – Bluesoft as a Loyalty Platform Provider.

2.4.1 Executive Summary

Research Achievements:

The development of product-service roadmaps is explored by analysing organisational potentials in incorporating the concept of circular economy with IoT.

The benefits that circular economy can provide to organisation are explored by simulating financial statements scenarios and investment-return output.

Company Request:

1. The circular economy is a new concept for the company. Despite all the benefits attributed to circularity, Bluesoft finds it difficult to educate the sales team to sell this concept to the clients. Even within the company, the management could not see the benefits in going circular, hence the management is not motivated to promote it within Bluesoft. Therefore, Bluesoft would like to know how to introduce circularity to their clients and their own teams, as well as how and IT consultancy can fit in the context.
2. Bluesoft has a broad arrange of customers but as an IT consultancy, they don't have a lot of experience in manufacturing. They would like to know how if there is a chance to move towards this sector.

Solutions

To start with, a case scenario of an EU fridge manufacturer is set up for further studies. The client requests a loyalty platform, which is one of the most common cases that Bluesoft has been working on daily. In this case, a three-step framework is suggested to Bluesoft.

2.4.2 Case study

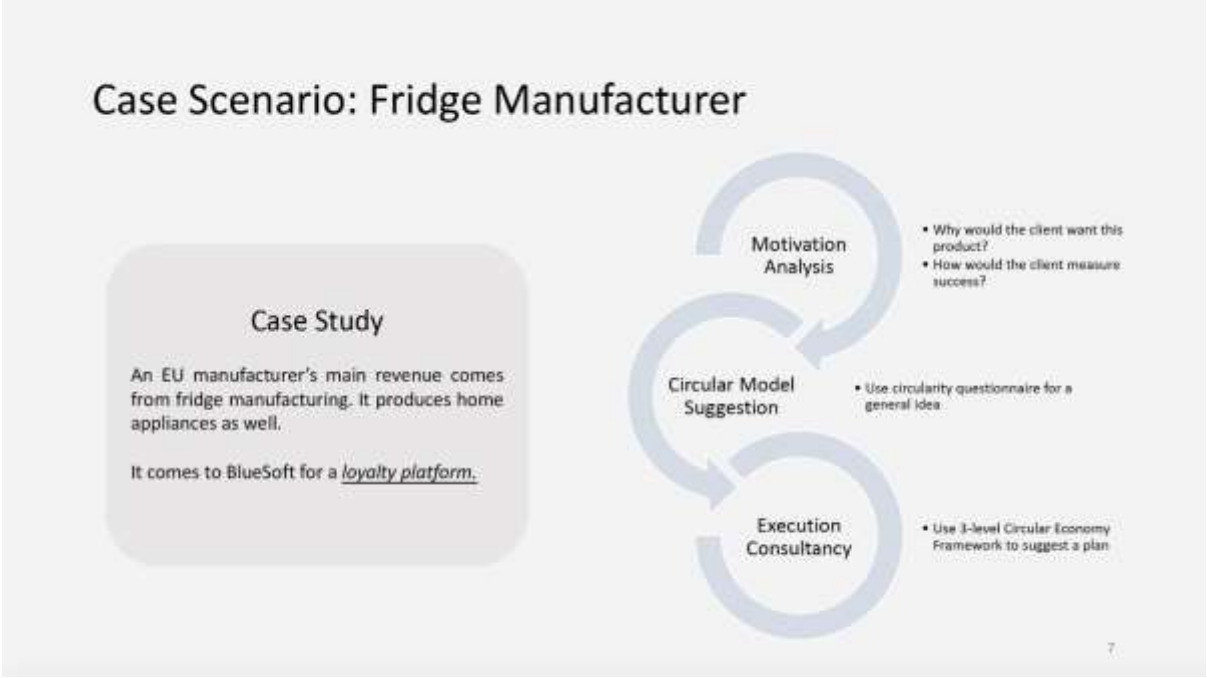

Figure 34: Case Scenario: Fridge Manufacturer

Step 1: Motivation Analysis

This case aims to identify the client's motivation for this particular service. This gives us some ideas for follow-up solutions, for example, some solutions can reduce the workforce while some can benefit the cost reduction. By identifying the motivations and measurements of success, we will be able to offer the most attractive solutions to the clients.

In the fridge manufacturer case scenario, if we identified the client's motivation for developing the loyalty platform is to attract more customers, which will be measured by the year-on-year new member registration growth rate, we can therefore offer solutions focusing more on gaining new members.

Step 2: Circular Model Suggestion

At this stage, the general idea and direction of the circular economic model will be suggested. By using a 'Circularity Questionnaire' tool, we are able to measure each RESOLVE model with a confidence score. The higher the score is, the more confidence we have in helping the client with that particular model.

Step3: Execution Consultancy

At this stage, detailed step-by-step guide of building circular economy models will be introduced. By referencing '3-level Circular Economic Framework', we are able to offer solutions according to client's cost allowance, return expectations and growth horizon preferences.

Circularity Questionnaire

This questionnaire is based on 10 questions. Each question carries 1 point and is classified into either Operating or Financial indicators. The overall score measures how confident we are to offer successful solutions to the client with respect to each element of the RESOLVE

calculations. Any score above 6 (high confidence) is believed to be a beneficial situation for that model. A score between 4 and 6 (medium confidence) is considered to have a chance in the model but may not be very suitable. If a score is under 4 (low confidence), the client is not advised to take on that model. Operating and financial indicators each carry a maximum of 5 points. The higher the score is, the more operating/financial benefits can be generated by that RESOLVE model. (Detailed classification and algorisms can be found in the 'RESOLVE calculator')

From the result, clients will be able to see whether a model is worth of taking on. The heat map gives a visual idea of the confidence score. If the score falls within high confidence zone, the client will be advised with detailed solutions suggested by the 3-Level Framework at a later stage. If the score is low, the client will also know whether the obstacles come from the operating side or the financial side.

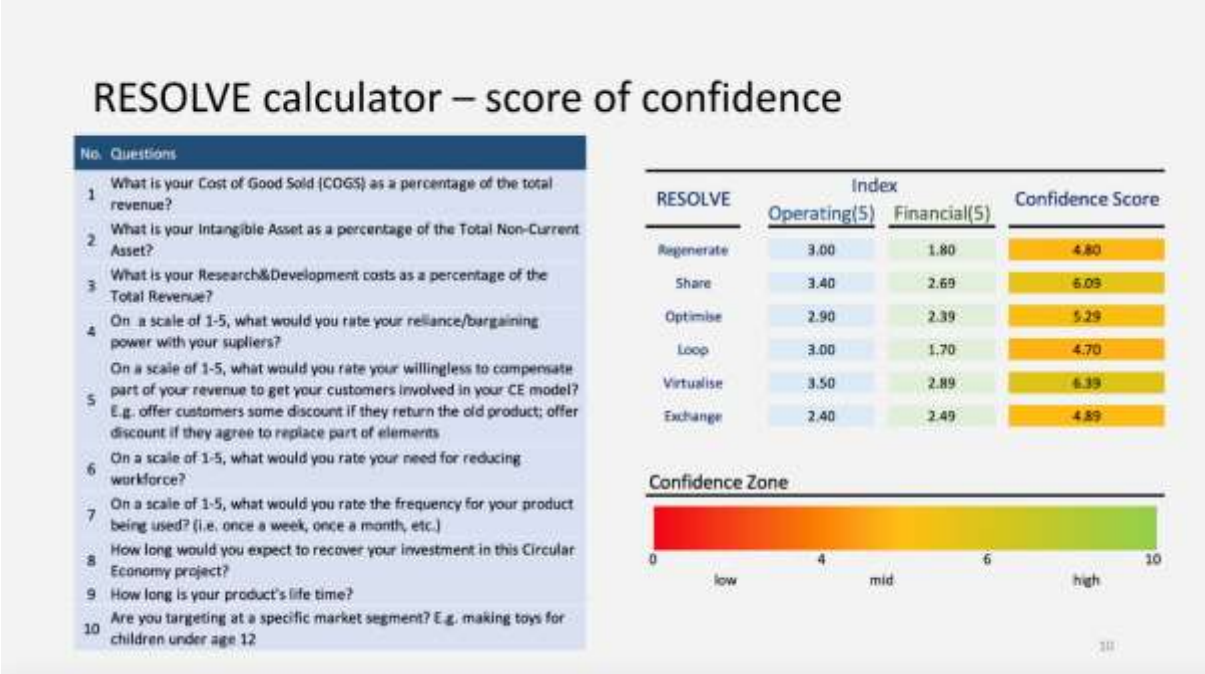

Figure 35: RESOLVE calculator

For example, in the simulated case above, this client is particularly suitable for Sharing and Virtualisation models for higher operating scores. They can benefit the most from the operating side. Although this client seems to have opportunities in all RESOLVE models, the Loop might be less interesting since it may not generate attractive financial benefits with a 1.7/5.0 financial score.

3-level Circular Economy Framework

This framework allows us to help clients to build their circular economy model step by step. Clients can choose their preferred level of execution given costs, time preferences and other considerations.

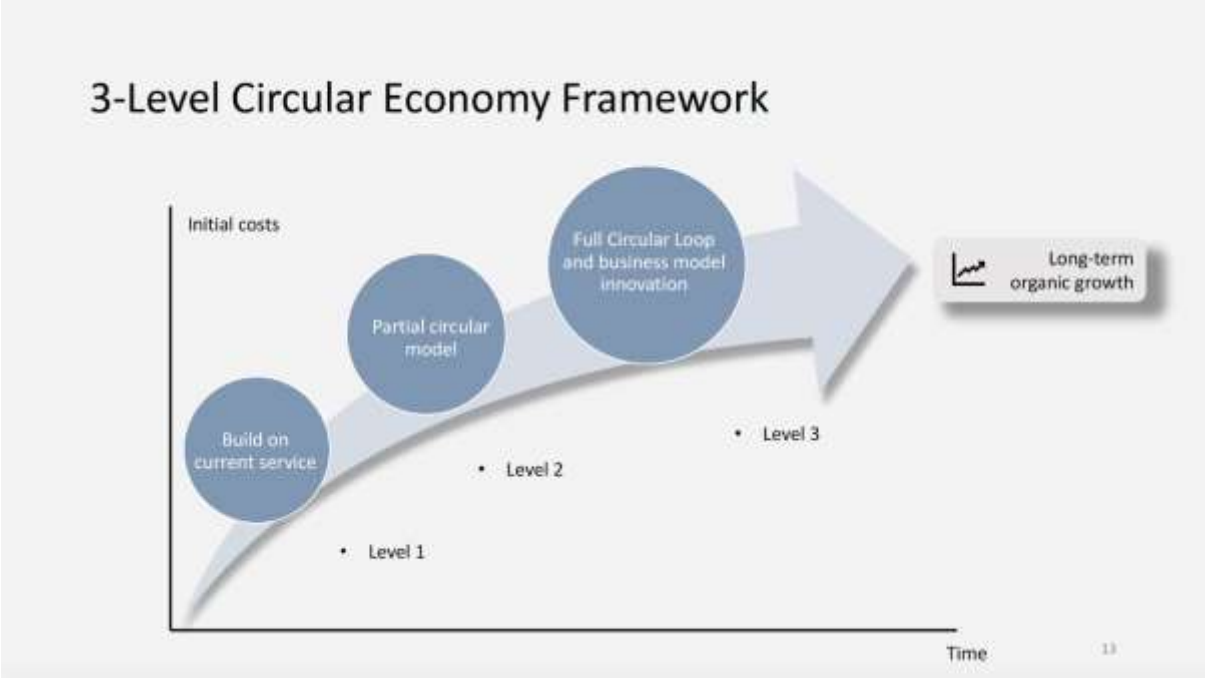

Figure 36: 3-level Circular Economy Framework

Level 1: build on current service

At this level, we will only make a small change on top of the client's original request. For example, on top of the loyalty platform, we can suggest building a simple virtualisation plug-in that can generate a lot of benefits. The client does not need to spend a lot of money and time on this. By referencing with industrial use cases, the cost and benefits can be reliably measured.

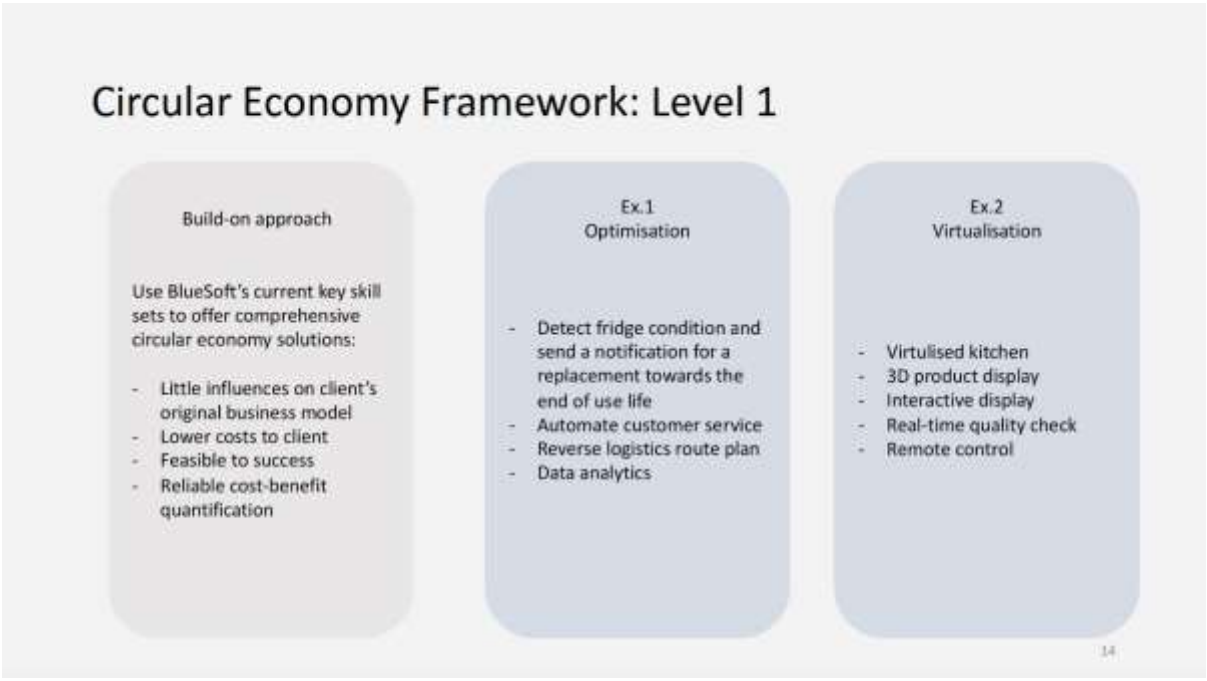

Figure 37: CE Framework – level 1

Level 2: Partial Circular Model

At this level, instead of closing the loop within the company, clients can outsource part of the work to a third party or use existing products to build a cycle. In this way, the client can avoid the hassle of investing in non-core business.

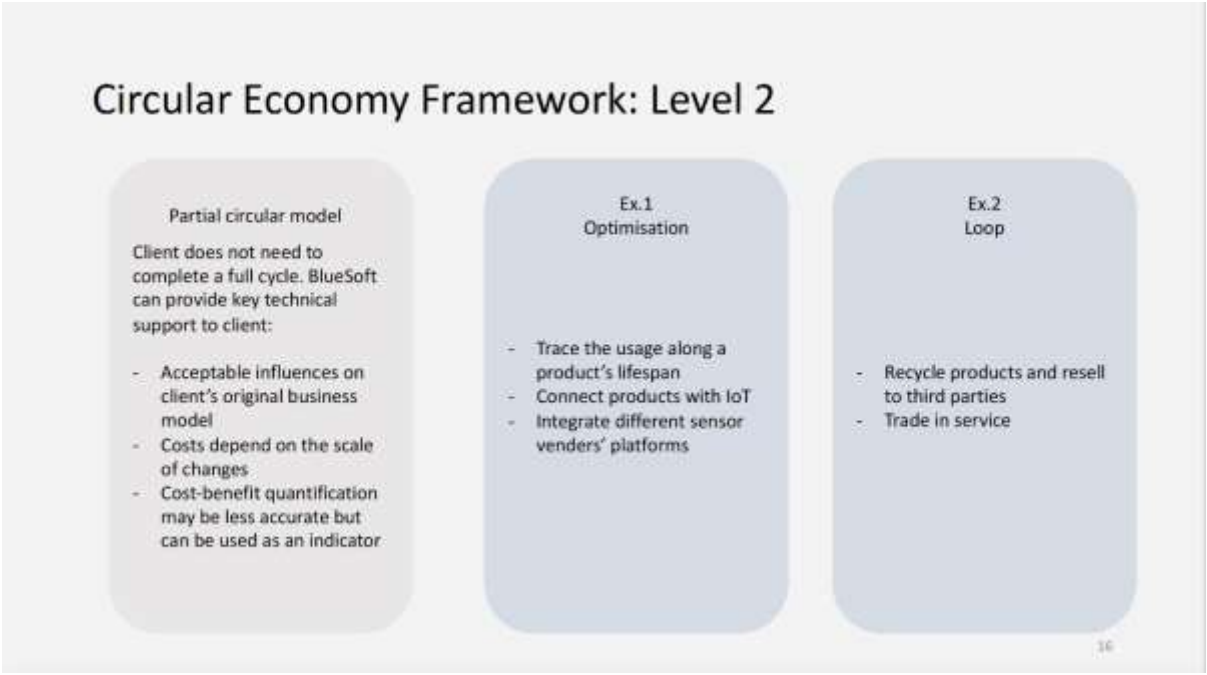

Figure 38: CE Framework – level 2

Level 3: Full Circular Loop

This level requires a business model innovation inside the client's company.

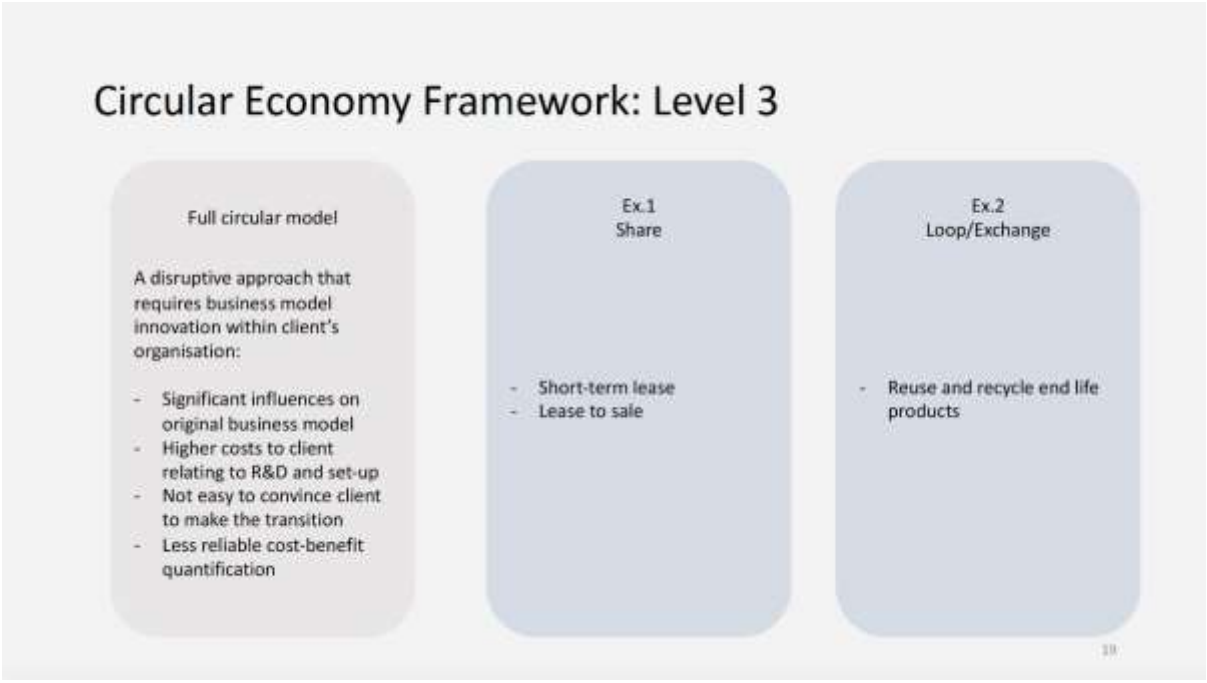

Figure 39: CE Framework – level 3

In order to help clients to measure their potential benefits, a financial simulation model is introduced here. Below is a base case scenario assumption created for a recycling model. From the return simulation outcome, a clear increase in the return rate (IRR) can be observed.

Assumptions	2017	2018	2019
Revenue changes	-5%	0%	5%
Percentage of recycling	50%	50%	50%
Cost of second hand materials comparing to virgin materials	40%	40%	40%
COGS reduction	20.00%	20.00%	20.00%
Increased operating expenses relating to sales and admin	5%	5%	5%
Inventory reduction - raw materials	50%	50%	50%
PPE increase - machinery	25%	25%	25%
Accumulated depreciated related to machinery	5%	5%	5%
Increased R&D	5%	1%	1%

For the Fiscal Period Ending	2017	2018	2019
Gross Profit	**53,058.4**	**63,026.8**	**72,459.7**
Selling General & Admin Exp.	14,676.9	15,098.0	15,009.8
Research & Development Cost	4,776.6	1,134.4	1,266.6
Depreciation & Amort.	4,562.0	4,662.0	4,045.0
Operating Income	**29,042.9**	**42,132.5**	**52,138.3**
Interest and Invest. Income	2,842.0	2,791.0	2,843.0
EBT	**31,884.9**	**44,923.5**	**54,981.3**
Income Tax Expense	7,174.1	10,107.8	12,370.8
Net Income	**19,026.8**	**29,233.7**	**36,924.5**
Net Income before transition	18937.75	20902.85	23284.275
Gain from transition	**89.05**	**8,330.84**	**13,640.23**
Gain from transition NPV	89.0	8,398.3	13,862.1
R&D Allowance	**36,661.50**	**46,057.85**	**56,247.90**
Total Investment	5,475.50	1,853.33	1,981.35
Net gain from transition	(5,386.45)	6,477.51	11,658.87
IRR	-	**20.26%**	**119.06%**
Net gain from transition NPV	(5,386.45)	6529.98	11848.51
IRR NPV	-	**21.23%**	**120.84%**

Figure 40: Financial Simulation Model 1

Clients can play with the assumptions and replace the financial statements to find their own cases. For example, if the client believes they need more investment, say, 10%, in the first year, the return simulation will be automatically changed to reflect the situation. This time, a negative return in the second year is observed, however, the client can still get their money back in the third year.

Increased R&D	10%	1%	1%

For the Fiscal Period Ending	2017	2018	2019
Gross Profit	**53,058.4**	**63,026.8**	**72,459.7**
Selling General & Admin Exp.	14,676.9	15,098.0	15,009.8
Research & Development Cost	9,553.2	1,134.4	1,266.6
Depreciation & Amort.	4,562.0	4,662.0	4,045.0
Operating Income	**24,266.3**	**42,132.5**	**52,138.3**
Interest and Invest. Income	2,842.0	2,791.0	2,843.0
EBT	**27,108.3**	**44,923.5**	**54,981.3**
Income Tax Expense	6,099.4	10,107.8	12,370.8
Net Income	**15,324.9**	**29,233.7**	**36,924.5**
Net Income before transition	18937.75	20902.85	23284.275
Gain from transition	**(3,612.82)**	**8,330.84**	**13,640.23**
Gain from transition NPV	(3,612.8)	8,398.3	13,862.1
R&D Allowance	**36,661.50**	**46,057.85**	**56,247.90**
Total Investment	10,252.10	1,853.33	1,981.35
Net gain from transition	(13,864.92)	6,477.51	11,658.87
IRR	-	**-53.28%**	**17.99%**
Net gain from transition NPV	(13,864.92)	6529.98	11848.51
IRR NPV	-	**-52.90%**	**18.94%**

Figure 41: Financial Simulation Model 2

Next steps

From Bluesoft's perspective, they wish the algorism behind the RESOLVE calculator to be improved to rescale the score. They wish to see a score higher than 9 to impress the clients rather than 6. They also wish to test the process on existing clients to improve the accuracy of this calculator and financial simulation tool. Further adjustments will be required according to the outcome.

2.5 Case Study – Bluesoft: Focus on Smart Insurance Contracts

2.5.1 Introduction and Project Scope

The purpose of this research is to explore IoT-enabled circular business models. IoT is an abbreviation for "Internet of Things" and is used to describe the inter-connectivity of various devices through the Cloud. In other words, IoT is the ecosystem where a person's Smart Phone can be connected to his Smart Home and so on. Important to note is the use of sensors in the IoT ecosystem. Sensors are important because they can be used for extensive data analytics and predictive analytics. This in turn has financial benefits such as cost reductions, processing time decreases, increased efficiency and improved safety.

"Circularity" and "circular economics" is an environmentally sustainable and cost-friendly way of doing business compared to traditional linear economics. "Looking beyond the current take-make-waste extractive industrial model, a circular economy aims to redefine growth, focusing on positive society-wide benefits. It entails gradually decoupling economic activity from the consumption of finite resources and designing waste out of the system" (Ellen MacArthur Foundation, 2019).

There are numerous industries who would observe financial benefits from implementing circularity in their business. For example, some industries which would be arguably the most improved through circularity are the fashion, agriculture, and manufacturing industries. As it is impossible to perform an in-depth analysis on all industries within this paper**, the focus of this research report will be on how IoT-enabled circularity empowers risk management. This concept will be examined through the use case of smart insurance contracts.** (Smart contracts refer to legal insurance documents which are put on the Cloud or blockchain). Smart insurance contracts can in turn be applied to various industries such as manufacturing, real estate management and logistics.

2.5.2 Overview of Insurance Use Case in Circularity

To begin this discussion, it would be helpful to learn how insurance companies work. In brief, underwriters charge an insurance premium for taking on a risk. This premium is calculated through various qualitative and quantitative analyses to predict future claims pay-out. As an example, if an individual buys auto insurance, his premium is calculated by the expected costs he will incur over the time span of the insurance contract. Because it is difficult to specify each individual risk, sometimes the risks are pooled into groups. For example, auto insurance customers may be sub-divided based on:

1. Gender,
2. Age, and
3. Historical data.

One of the greatest advantages of IoT-enabled Smart Contracts is the new ability to create niche market segments. This will be elaborated on further in the report.

The collected premiums are then used by the insurance company to manage assets. Short-term insurance contracts (e.g. – auto) may be managed by buying and selling short-term assets like equities. Long-term insurance contracts (e.g. – life insurance) would normally be invested in longer term assets such as real estate and bonds. This is known as asset-liability matching (AML). Legislation such as Basel III and Solvency II have become stricter in the application of AML, so it is therefore of utmost importance that financial institutions keep in mind their risk-weighted asset portfolio composition in order to avoid penalties.

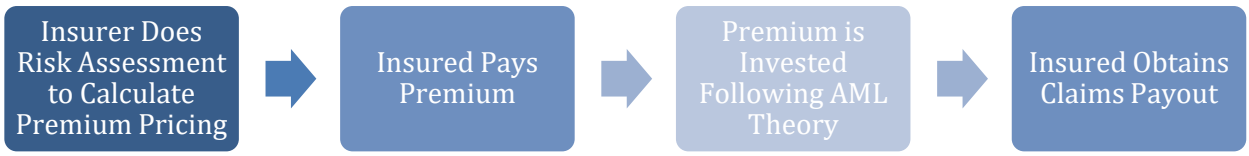

Figure 42: Insurance Model Flow Chart

Once the insurance money is collected, the premium is invested and later paid back when the insured files a claim. The primary ratios used to calculate the success of these investments is the loss ratio and the combined ratio.

EQUATION 1 – LOSS RATIO

$$Loss\ Ratio = \frac{\text{Incurred Losses}}{\text{Earned Premium}}$$

EQUATION 2 – COMBINED RATIO

$$Combined\ Ratio = \frac{\text{Incurred Losses} + \text{Expenses}}{\text{Earned Premium}}$$

The main difference between the two ratios is that the combined ratio takes the loss ratio then adds on expenses such as overhead expense and payroll. A ratio below 100% is considered good / profitable whereas a ratio above 100% is undesirable. Keep in mind that a discrepancy between losses and premiums could be offset by investments. This is one reason why insurance companies are some of the largest institutional investors in the world. However, due to stricter asset management regulation and the current macroeconomic environment which includes elements such as low-interest rates, gaining a profit through asset management has become increasingly difficult for insurers.

Moreover, the insurance and reinsurance industries are experiencing major disruptions. The disruptions come from a myriad of sources including, but not limited to changes in legislature, emergence of insurtech start-ups, stricter data protection laws and an abundance of M&A transactions in the market. (Re)insurers need innovation. Circularity offers many benefits to this traditional industry. Like all industries, circular business models are beneficial in lowering costs, increasing profits and improving goodwill / customer satisfaction. In particular, for insurance companies, circularity offers a new business model by enabling the issuance of IoT-based contracts. These contracts can be distributed amongst various lines of business such as property insurance, liability insurance and health insurance. Furthermore, new opportunities such as sub-segmentation of customer groups will be possible.

2.5.3 Smart Insurance Contracts Applied to Manufacturing

IoT applied to the manufacturing industry is often referred to as Industry 4.0 (I4.0). The term derives from the fact that many economists see the introduction of sensors as the 4th Industrial Revolution. In other words, IoT has the game-changing potential on par with major human innovations such as the division of labour and the widespread use of electricity. There are numerous benefits from installing sensors in the manufacturing industry. There are also challenges such as updating the technology and maintaining the assets. Of course, cyber security will always be a concern.

Pain Point	Improved with IoT	Description
Increased Safety	✓	Sensors would be able to track the health conditions of workers through wearable technology. Moreover, traditional risk exposures such as asbestos exposure or sources of fires could be traced. Workers would be warned and evacuated from unsafe conditions.
Improved Quality Control	✓	Sensors measure performance and durability of products. This ensures proper quality control and increases customer satisfaction.
Streamlined Inventory	✓	Inventory can be updated in real-time. Sensors could be further programmed to order resources. For example, retailers could equip sensors in their shops which correspond to factories directing levels of productions and establishing new purchases. This technology avoids over-stocking and spoilage. Under-stocking of goods would also be avoided. This corresponds to the circularity principle where resources are used in the most efficient manner.
Decreased Machine Downtime	✓	Machine downtime is one of the greatest costs to manufacturers. By equipping sensors in a Smart Factory, predictive maintenance and early identification of threats will prevent malfunctions and downtime.
Data Driven Supply Chain	✓	Optimization in the supply chain will be possible not only within the Smart Factory but across the entire chain. Information which is collected within the Smart Factory can be coordinated with fleet management, retail and resource management. In the future, other components along the supply chain such as logistics will be automated leading to a holistic data driven supply chain.
Informed Decision Making	✓	IoT unlocks critical data about performance and allows those insights to flow freely. Managers are then able to make the most appropriate decisions on safety, resource management and financials in real-time.

Source: Fathym, 2017

Figure 43: Benefits Enabled From IoT For Smart Factories

The main uncertainty revolving around I4.0 is the disruption in the business model. Let's take an example. Assume there is a manufacturing plant in Texas, USA. The plant manufactures

textiles. For the last 100 years, the manufacturing plant purchased property insurance from Rizzo Insurance Company. Over these 100 years, the manufacturer experienced four fires resulting in a 100% total loss. After reviewing the historical data, it is concluded that all four fires were caused by an overheating of Machine X.

To avoid future property claims, sensors are installed on Machine X. These sensors measure the temperature of the machine and collect data on other variables such as efficiency, use of raw materials and safety standards. Moreover, metadata tags are coded in the sensors. These act as triggers. In other words, the sensor is coded to tell the machine that if Machine X's temperature rises to 104ºF, then initiate cooling system and reduce capacity by 20%.

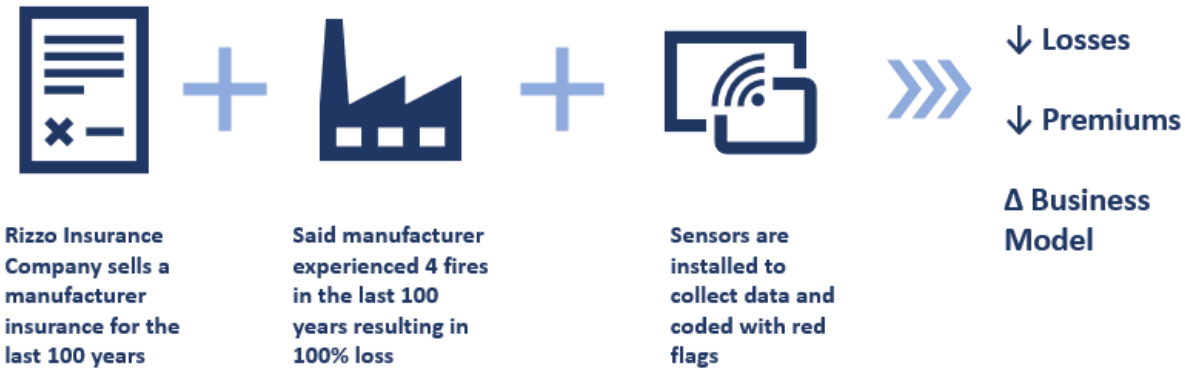

Figure 44: I4.0 Use Case Example

The application of sensors to the manufacturing has clear risk management benefits. Benefits for circularity include:

- Streamlined energy usage,
- Collection of discarded materials to recycle and
- Improved inventory maintenance.

Many of these benefits are reflected in the financial statement. Streamlined energy usage would be described in a reduction in overhead costs. As an example, by installing sensors throughout a manufacturing plant, the owner would be able to observe where human activity takes place and when. Lighting, air conditioning and so forth could be optimized. Moreover, efficiency ratios would be improved (WorkerBase, 2019).

Data collected would also be beneficial in tracing and reusing discarded materials. There is a plethora of waste generated when resources fall off the conveyer belt. Waste is also produced when a malfunction occurs leading to an anaesthetic product. Once data on the waste is collected, managers become aware of how much resources they are "throwing away" and can invent new ways of reusing or reducing waste. Pez, a popular candy manufacturer, would discard any candy items which had a visible defect (Pez, 2019). Once the company became aware of how much candy was actively discarded, leadership looked for outside parties who may be interested in their candy. Local farms raised their hands as these farmers could use the candy as livestock feed. This matching created an entirely new revenue stream for Pez. The benefit presented from IoT is that data may be collected in order to raise awareness. Moreover, IoT-enabled business models encourage circularity by quantifying benefits to leadership and investors.

Another example is Ikea (Pedestrian, 2019). In Summer 2019, the Australian IKEA offices organized a linen collection to recycle old linens into pet beds for dog and cat rescue organisations. Models like this can be done with or without IoT and may be organized for profit or not-for-profit. Regardless, the positive impact on the environment is omnipresent. And in respect to investor relations, the positive news coverage is always advantageous for goodwill.

One of the top costs for manufacturers is inventory maintenance. There are numerous factors which contribute to this variable including, but not limited to:

- Depreciation expense,
- Human resources needed to maintain and monitor equipment,
- Leasing costs of equipment and
- Audit costs for equipment.

Installing sensors could lead to real-time feedback on the condition of equipment (Deloitte, 2015). This information would significantly reduce maintenance costs which were traditionally done by repairmen and auditors. Companies like Bluesoft could aid in solving this pain point by offering asset financing and leasing software. This software would track the depreciation, ownership rights and maintenance schedule for the equipment.

IoT-Enabled Circularity	Impact on Financial Statement
Streamlined Energy Consumption	↓ COGS ✓ Improved Efficiency Ratios
Reduced Quantity of Discarded Materials	↓ Raw Materials **$** New Revenue Streams ✓ Improved Efficiency Ratios
Enhanced Inventory Maintenance	↓ Human Resources ↓ Overhead Costs ↓ Depreciation Expense ↑ Equipment Longevity

Figure 45: Summary of Benefits & Impact on Financial Statements

On December 4th, 2015, the Financial Stability Board (FSB) established the Task Force on Climate-Related Financial Disclosure (TFCD). The goal of the TFCD is to develop risk standards and accounting guidelines where companies can voluntary begin taking accountability for their environmental impact. The research of the TFCD is ground-breaking in that companies will begin to be incentivized to think-through their environmental risks and openly disclose this information. Building upon this, socially responsible companies would have the opportunity to quantify and showcase their green efforts leading to what many would hope for as a ripple in the pond.

According to Richard Cantor, the Chief Risk Officer of TCFD, “by firms revealing their preparedness and the impact of these changes on their business, that kind of alleviates some of that uncertainty and can actually raise the value of their stocks and bonds” (TCFD, 2019). A major challenge for the TCFD to meet its goal is in the collection of data. In order to properly

quantify risks and reward good behavior, there needs to be an active source of data collection measuring change over time. IoT-enabled circularity could assist in this gap by providing real-time "audits."

Triple bottom line accounting considers social, environmental and financial performance. Environmental metrics which could be evaluated with the aid of IoT-enabled circularity include the concentration of sulphur monoxide, nitrogen oxides, pollutants, electricity, fuel, solid waste and hazard waste (Slaper, 2011). Other metrics which could be measured include land usage and genetically modified ingredients (GMOs). Because of these changes to accounting spearheaded by the TCFD and thought leaders of triple bottom line accounting, it is becoming easier to underscore circularity on financial statements. This is fantastic news for company leaders who want to gain goodwill and new customers / investors.

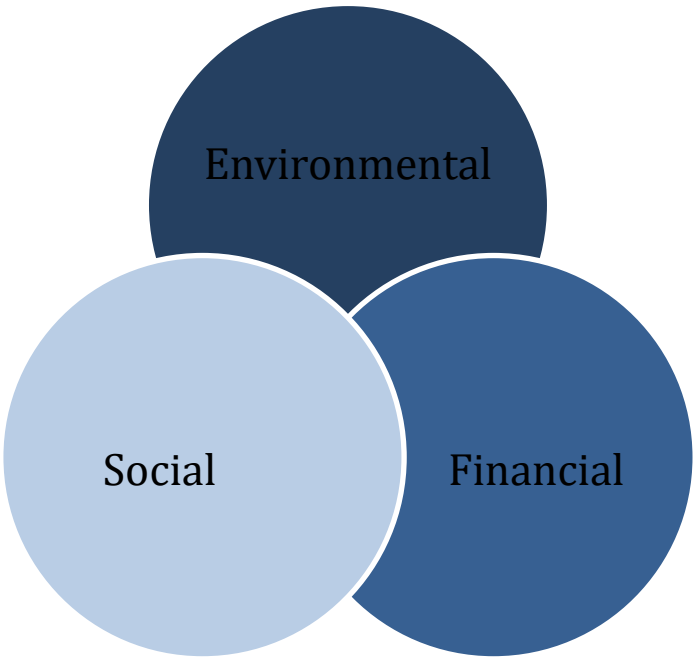

Figure 46: Triple Bottom Line Accounting Framework

So far, the application of IoT to the manufacturing industry sounds idyllic. Cost are reduced, machine downtime is decreased, energy usage has become more efficient and safety has improved. But what about the business model? Insurance companies obtain profit by understanding the risk. Insurers calculate premium from proprietary historical data, loss triangles and statistical models. This information asymmetry is one reason why an insured would cede their risk to an insurer. With the use of sensors (especially if the insured owns the data from these sensors), the information asymmetry is diminished.

Risks will be more accurately priced to reflect the exposure. From an insured's perspective, this is good news. Assume you are a 16-year old American male who inherited a red sportscar from your father. Normally you would be placed in the risk category with all other young, male drivers. However, you believe your driving is better than average and volunteer to install a driving app on your phone. The data collected shows that you are indeed a safe driver and your insurance premium is lowered to reflect this decreased risk. Similarly, the manufacturer mentioned in the example above, could use sensor data to pinpoint the source of its property exposure and implement tailored solutions (such as a parametric trigger policy and proper

machine maintenance) to decrease the frequency and severity of the risk. In short, IoT-enabled insurance would allow better customer segmentation as well as tailoring of the insurance products.

From an insurer's perspective, IoT-enabled risk management has the potential to kill its traditional business models. This is because once the information asymmetry is diminished, the loss ratio nears 100%. There will be an increasing pressure for insurers to then make money from asset management which in this regulatory environment with strict AML guidelines and low bond rates is near impossible. Adding to this, many insureds may decide to retain their risk.

2.5.4 Smart Insurance Contracts – Black Box

The application of sensor data to the insurance industry has been especially zealous from the transportation business. In particular, auto underwriters have piloted "black boxes" which can be installed in cars to collect driver data. These sensors may be developed to both collect data and offer predictive analytics. Taking the black box a step further, premiums may be autocorrected daily (or even simultaneously) to reflect the risk exposure.

An interesting reaction to the black box pilots has been adverse selection. When insurers began prototyping their black boxes, it was voluntary for drivers to sign up for their data to be collected. Logically, it became common for good drivers to volunteer. This led to adverse selection as bad drivers would purposely opt out. This consumer behavior brings a further question in ethics: is it fair for customers who do not want their data to be collected to automatically be segmented into higher risk categories? In other words, with the growing concerns on data collection by Big Brother, what are the financial and social implications for customers who simply want to protect their privacy?

The black box has led to sub-segmentation and opened new opportunities for financial inclusion. "New" lines of business-like pet insurance are now offered. Moreover, traditional excess and surplus lines of business (ESL) are opened to the public.

The important characteristics of the black box use case include voluntary involvement in insurance pricing, customer sub-segmentation and the identification of adverse selection. IoT-enabled risk management has disrupted the insurance industry and resulted in the rise of peer-to-peer (P2P) platforms. P2P is a circular business model in that it supports shared economics in the financial services. Thought leaders in the insurance P2P arena include companies like Lemonade and Trōv.

It is important to note as well that IoT-enabled circularity is not only present for the automobile industry but for the wider logistics industry as well (Digitalist, 2016). Airline companies would see benefits from IoT-enabled circularity both in their manufacturing and services. For example, the shared economy principle could be applied for airplanes then tracked with IoT. Another industry which is exploring IoT-enabled circularity is fleet management. In the United States, it is estimated that 69% of goods are moved with trucks (Bureau of Transportation Statistics, 2018). There are many experiments in automating transportation fleets as this would decrease traffic, increase roadside safety and make delivery more efficient. Automated fleets would have huge circular economic benefits as delivery routes could be prepared in advance in a manner which causes the least pollution. Big catastrophes such as oil spills could also be avoided. Supporting industries would benefit too. For instance, road safety would be improved, and maintenance costs would decrease. In turn, this would save the government millions of dollars. Furthermore, in countries like the United States, attacks on the highway system and infrastructure maintenance are major concerns. By installing sensors, predictive analytics could be programmed to streamline maintenance and shutdown unsafe highways.

2.5.5 Smart Insurance Contracts – Smart Homes

Building upon the examples above, IoT-enabled circularity may also be applied to real estate insurance. In general, it would be easiest to apply IoT and circularity to property insurance at the beginning. This is because property risks can be coded with parametric triggers allowing a better collaboration with IoT. Similarly, for circular economics, property risks are easier to measure than other risks like liability or health. In other words, once researchers are able to gather data on elements such as improved efficiency ratios in a power plant or decreased energy costs in homes, the use case is proven and can be built upon for more subjective use cases like reduction in healthcare costs. This is why this research paper will focus on property risks first for beta tests.

In respect to Smart Homes, one of the easy gains is in optimized energy consumption. Temperature, lighting and home appliances can be organized for optimal energy consumption. Another advantage is that traditional loss exposures like fire could be prevented. Other exposures like flooding could be maintained if the risk is related to the breakdown of physical goods. For instance, many flooding claims derive from malfunctions in water pipes. Oftentimes, homeowners do not detect a leakage or are not well-educated about home maintenance. This results in small exposures like a leaking water pipe to go undetected until the issue becomes visible. At this point, often there is mould, permanent damage to floorboards, etc. Similar to the example in the Industry 4.0 section above, triggers could be coded for water pipes resulting in predictive maintenance.

Another major advantage of upgrading to Smart Homes is using sensors to improve safety. Besides the traditional benefits of video cameras, alarm systems, etc., sensor manufacturers are now promoting the use of IoT devices to help the elderly and children. For instance, Amazon's Echo can be used to call emergency operators should someone fall down. Sensors can also be equipped with video cameras. These cameras could be used as baby monitors with safety-alarms pre-programmed into the device.

2.5.6 Opportunities for Bluesoft

When considering IoT-enabled circularity, there are an abundance of opportunities, but execution is still low. Companies like Bluesoft in Warsaw, Poland could become a pioneer in this field. Bluesoft is a software development / consulting firm with clients across the United States and Europe. Their primary market is Poland and Eastern Europe. Bluesoft offers solutions to clients in various industries such as pharmaceutical, banking, insurance, logistics, transportation, telecommunications and energy. In 2019, Orange announced its acquisition of Bluesoft. In developing a circular strategy for Bluesoft, it is recommended that leadership selects 2-3 confident use cases which build on the company's existing strengths in software development, workforce management and consulting.

The example above on smart insurance contracts has several gaps which a company like Bluesoft could come in and solve. For example, as IoT becomes more common in society, the problem of aligning various IoT sensors together is apparent. In other words, the sensors which connect a person's Smart Home to his Smart car may be coded in different languages. Bluesoft could add value to customers by developing a platform which brings these various languages / data sets together. Another gap is in automation of insurance underwriting. The underwriting process is becoming increasingly automated; however, this automation is fragmented along the value chain. In short, claims handling is becoming automated. Risk assessments are becoming automated. Premium collection is going digital. The gap is in bringing together all these segmented improvements onto a common platform. Moreover, the market demands holistic

insurance policies. Rather than a homeowner buying separate auto insurance, homeowner insurance, and cyber insurance; the future will be to bundle these packages together with automated insurance premium calculations and an overhead umbrella policy.

Bluesoft already established various software which could aid in these circular business models. The company's HAB software manages workflow. "HAB improves the task planning process for employees, monitors work in progress in real time, coordinates external processes and tasks underway, and enables efficient communication with field teams... As a result, the solution shortens even processing time, improves efficiency of the work in progress, enhances customer satisfaction and due to process optimization, boosts revenue" (Bluesoft, 2019). This sophisticated workflow tool could be applied for I4.0 and fleet management. Already the tool is applied to construction, energy and manufacturing projects in Poland. Efficiency gains have been observed. For example, upon installing HAB as a workflow management tool, productivity increases by 10%. Looking ahead, HAB could also be applied to other industries such as banking, insurance, healthcare, hospice and marine.

A topic of interest in circularity would be the maintenance plans for sensors. The battery in a sensor will normally last for 3-5 years. Currently, it is easier to install new sensors than replace a battery in a sensor. Although IoT-enabled circularity creates numerous benefits for society, it is important to consider the maintenance plan and disposal of these devices. Batteries take c.100 years to decompose (Ecology Services, 2019). Yet replacing a battery is 2-4 times more expensive than simply buying and installing a new sensor. So far, there is little regulation nor ownership regarding the maintenance of these sensors. A potential solution would be for sensor manufacturers to open a recycling center like TerraCycle in North America (TerraCycle, 2019). Nonetheless, the ultimate goal would be to discover a 2nd life use case for these burnout batteries.

2.5.7 Opportunities for Circularity in Poland & European Union

Coming to Poland and working with colleagues at Bluesoft was an amazing opportunity. Having learned about circularity at Cambridge and coming from the United States, there are many opportunities for cross-cultural learnings. For examples, the United States which opted out of the 2015 Paris Agreement, has become one of the largest contributors to green financing in the world. China, which is arguably one of the top polluters is now spearheading initiatives in green auditing and utilizing available green equity to finance infrastructure projects.

Poland faces her own challenges in growing its green footprint. The country experienced many obstacles from World War II and the years of Soviet occupation. In fact, after the Warsaw Uprising of 1944, approximately 80% of the capital was destroyed and c.20% of its citizens passed away (Wikipedia, 2019). Poland, like many other countries in Europe, has fought its way to a becoming a developed, modernized country.

In respect to environment initiatives, Poland, which is the largest market for Bluesoft, now has the infrastructure but not necessarily the leadership to drive circularity. There is huge potential for companies like Bluesoft to build circular business models in the Polish market which may be spread to other clients globally. After conducting a gap analysis, a few opportunities for circularity in Poland would include:

- *Constructing a recycling program* – Until 2017, recycling in Poland was not offered. Many citizens are still unaware of the most efficient means to recycle. It is estimated that only c.28% of materials which could be recycled are actually recycled (JustAsk, 2017). In short, recycling programs in Poland and other countries around the world (i.e.

– Tuluva, Romania, Italy, etc.) are relatively greenfield and provide excellent opportunities for partnerships.

- *Introducing new packaging options* – At grocery stores, many goods are still packaged in single use plastic. It would be relatively easy to copycat global ideas in packaging and leapfrog years of research in Poland. For instance, several countries in Europe and various states in America offer incentives for shoppers who bring in their own shopping bags. Once at the store, there is room for improvement in respect to product packaging. Perhaps the best example of this is at the grocery store. In response to this wasteland of single-use packaging, companies like the English grocer, Thornton Budgens, pioneered "plastic free zones" (The Telegraph, 2018). Alternative packaging like cloth bags for produce or wrapping fish in banana leaves has been prototyped. Taking this concept, a step further, North America has experimented in opening up container free bulk stores (CNBC, 2018). These initiatives are not only eco-friendly but also save the retailers tons of money. In America, grocery packaging is estimated to cost $18.2B per annum. This packaging results in 1.84M tons of food waste per year.
- *Encouraging green financing* – Specifically, infrastructure projects would be eligible for various green financing initiatives. Over the years, green hedge funds and investment options have become increasingly available. Granted, green projects normally take a higher initial capital outlay but the gain over time in terms of depreciation cost reduction and increase in efficiency is significant. The main challenge is making project owners aware of their options then connecting them to green investors.

The ideas mentioned above underscore the greenfield opportunity for circular economics in Poland. In order for circular principles to become a success, there will need to be workforce planning, transition phases and management training. A company like Bluesoft could step in to provide management consulting as well as workflow software to help transition the country to a greener state.

2.5.8 Conclusion

In summary, circular economics has direct impact on financial statements which could benefit not only the environment but also investors, entrepreneurs and project owners. IoT can be utilized as an enabler in growing circularity. Because these concepts are still relatively new, it is important to begin by building out use cases. This paper focused on the application of IoT-enabled circularity for risk management. Specifically, the three use cases of applied circularity to I4.0, transportation and real estate was examined. It is recommended to begin with property risk because a) the cost savings from circularity are easier to quantify and b) property insurance is easier to link to IoT due to the binary nature of claims handling.

For IoT-enabled circularity to grow, there must be champions pushing the cause. Companies like Bluesoft in Poland could benefit greatly by promoting circularity as there are ample pain points in their communities and clients. Overall, circularity is a complex topic but has significant benefits in respect to Cost of Goods Sold (COGS) reduction, 2nd life potential, resource management, energy cost saving and the creation of new revenue streams.

2.5.9 Bibliography

BlueSoft (2019) *BlueSoft Efficient Solutions* Available at: https://bluesoft.com/en/ (Accessed: 1 August 2019).

Bureau of Transportation Statistics (2018) 2017 *North American Freight Numbers* Available at: https://www.bts.gov/newsroom/2017-north-american-freight-numbers (Accessed: 7 July 2019).

CNBC (2018) *Zero Waste Stores Pop Up in the US Targeting Shoppers Tired of all the Waste* Available at: https://www.cnbc.com/2018/10/19/zero-waste-markets-want-to-shake-up-grocery-shelves-and-your-shopping.html (Accessed: 27 July 2019).

Deloitte (2015) *The Derivative Effect: How Financial Services Can Make IoT Technology Pay Off* Available at: https://www2.deloitte.com/insights/us/en/focus/internet-of-things/iot-in-financial-services-industry.html?id=us:2el:3dc:dup1166:eng:fsi:iot:dcpromo (Accessed: 1 July 2019).

Digitalist (2016) *IoT and Smart Cars: Changing the World for the Better* Available at: https://www.digitalistmag.com/iot/2016/08/30/iot-smart-connected-cars-will-change-world-04422640 (Accessed: 1 September 2019).

Ecology Services (2019) *Ten Types of Trash that Take the Longest to Decompose* Available at: http://ecoparts.com/10-types-of-trash-that-take-the-longest-to-decompose/ (Accessed: 6 July 2019).

Ellen MacArthur Foundation (2019) *What is Circular Economy? A Framework for an Economy that is Restorative and Regenerative by Design* Available at: https://www.ellenmacarthurfoundation.org/circular-economy/concept (Accessed: 10 July 2019).

Fathym (2017*) Five Powerful Benefits of IoT in the Manufacturing Industry* Available at: https://fathym.com/2017/05/5-powerful-benefits-iot-manufacturing-industry/ (Accessed: 1 July 2019).

JustAsk (2017) *New Rules of Waste Management in Poland* Available at: https://www.justaskpoland.com/new-rules-of-waste-management-in-poland/ (Accessed: 1 September 2019).

Pedestrian (2019) *Ikea Wants Your Old Bed Linen to Make New Beds for Wee RSPCA Adoptees* Available at: https://www.pedestrian.tv/pets/ikea-linen-take-back-rspca-bedding-drive/ (Accessed: 5 July 2019).

Pez (2019) *Pez Candy* Available at: https://us.pez.com/ (Accessed: 4 September 2019).

Slaper, T. (2011) *The Triple Bottom Line: What it is and How does it Work?* Available at: https://stuff.mit.edu/afs/athena/course/2/2.813/www/readings/TripleBottomLine.pdf (Accessed: 20 July 2019).

TCFD (2019) *Task Force on Climate-Related Financial Disclosers* Available at: https://www.fsb-tcfd.org/about/ (Accessed: 5 July 2019).

TerraCycle (2019) *Recycle Everything with TerraCycle* Available at: https://www.terracycle.com/en-US/ (Accessed 2 September 2019).

The Telegraphy (2018) *Britain's First Plastic Free Zones Open* Available at: https://www.telegraph.co.uk/news/2018/11/07/britains-first-plastic-free-supermarket-zones-open/ (Accessed: 8 July 2019).

Wikipedia (2019) *Warsaw Uprising* Available at: https://en.wikipedia.org/wiki/Warsaw_Uprising (Accessed: 3 September 2019).

WorkerBase (2019) *Five Benefits of IoT in Manufacturing* Available at: https://workerbase.com/blog/5-benefits-of-iot-in-manufacturing/ (Accessed: 8 July 2019).

2.6 Case Study – Circular economy in Industrial Construction: How IoT can Reduce Industrial Construction Waste

2.6.1 Executive Summary

This white paper proposes a circular economy model to transform industrial construction by levering the potential of Internet of Things (IoT). Industrial construction refers to construction activities undertaken across various industries such as steel, oil and gas, cement etc. Firstly, the current landscape in industrial construction is reviewed in conjunction with the European Commission's waste management ambitions to identify opportunities. A conceptual circular economy model is proposed to prevent landfilling of excess materials generated during industrial construction. The proposed model uses IoT to address barriers to circularity. However, using IoT exposes industrial construction to cyber-security risks that need to be acknowledged.

Following are the key insights from the white paper.

- Circular economy in industrial construction is attainable. European Union and government policy and legislation can facilitate and where necessary, expedite implementation. Appropriate incentives as well as creation of relevant platforms can produce an environment conducive to circularity.
- The industrial IoT maturity model in the Industrial Construction Sector allows us to evaluate the current position of the industry and set clear objectives as to how to enact change. It serves as a path to reduce waste, giving competitive gains and efficiency.
- The adoption of an emergent maturity model that enables the industry to secure the social license to operate and thrive. Building on existing relationships within the supply chain, competitors, government and legislators as well as communities and customers. Transitioning the industry in phases from exploration to adoption and thence adaptation delivering real economic, environmental and social benefits.
- Training and Awareness across all levels of organizations adopting IoT dependent strategies are critical to reducing cyber-risk.

2.6.2 Introduction

The European Commission's Waste Framework Directive 2008/98/EC aimed to achieve a 70% recycling rate for construction and demolition waste by 2020. However, according to the EU Construction and Demolition Waste Protocol and Guidelines (European Commission, 2018), with the exception of a select few EU countries, this recycling rate for the rest of the European Union is as low as c.50%. The protocol identifies the lack of confidence in the quality of recycled materials as a key barrier to increase recycling rates. Consequently, a large proportion of the waste generated during industrial construction is regularly sent to landfill. For example, 9 million tons (estimated) of refractories are available for recycling or land filling annually from construction and demolition activities in the steel industry (Madias, 2017).

This paper examines the use of IoT as an enabler for circular economy in industrial construction. A new model is proposed that enables the reuse of excess materials by other industry partners. The materials are redeployed to where the need is, enabling circularity. The model is based on providing traceability and transparency across multiple supply chains by leveraging IoT and distributed ledger technology. This vision is further supported by Ellen MacArthur foundation's white paper, *Completing the picture – how the circular economy tackles climate change* (Ellen MacArthur Foundation, 2019). The paper advocates recirculating of materials as a measure to reduce greenhouse gas emissions.

Although IoT is a powerful enabling technology, when adopting connected technologies, we introduce cyber-security risk that can impact confidentiality, availability and integrity of the connected parties and materials. This paper explores industry specific ICT risks, especially those that can have a lasting physical impact.

Like most traditional industries, the industrial construction sector prioritises physical security over cyber-security. There is generally a low level of awareness of the consequences of cyber-security risk. However, with the advent of Industry 4.0, regulatory authorities have increased focus on cyber-security. Driven by regulation, the industrial construction sector will have to acknowledge the physical consequences of cyber risk and take action or risk obsolescence.

2.6.3 Current practice in Industrial Construction

Industrial construction projects adopt the traditional design, bid and build approach, where an Engineering Consultancy is responsible for producing design specifications, drawings and bill of materials for an Industrial customer. The customer then selects a manufacturer(s) and constructor(s) following a tendering process for a fixed price contract(s). For example, a Steel company has the need to rebuild a Blast Furnace. The steel company would engage an Engineering Consultancy to undertake the design of the blast furnace and specify the required materials. The steel company would then use the information to procure the materials such as refractories from various manufacturers. The steel company would also appoint one or more construction companies to undertake the build.

Figure 34 shows this linear operating model practiced by the industrial construction sector. The bill of materials generated has excess materials included as contingency. In addition, due to the severe financial consequences of an overrun, the customer orders further materials as project risk mitigation. On completion of construction, the majority of the excess materials are disposed of via landfill. The key reasons for excess materials reaching landfills include lack of traceability, shelf life constraints and inadequate storage facilities.

Figure 47: Typical operating model in the industrial construction sector

2.6.4 Bringing circularity to Industrial Construction

Circularity can be achieved in the industrial construction sector primarily by addressing material traceability and facilitating integration of multiple supply chains. In industrial construction, the focus of material transaction is on verifying that the delivered materials meet quality requirements and are consumed within a specified timeframe. For example, monolithic refractories (bagged cement like substance) delivered to any customer are required to have the specified chemical composition and physical properties. They should be packaged appropriately to protect against rain damage and moisture ingress and typically need to be consumed within 12-24 months of manufacture.

In the prevalent linear economic model, the supply chain is short and well-defined. Trust between parties is direct, time limited and contractual. Figure 35a shows the lifecycle of industrial construction materials in a linear model. In most circumstances it is not practical to sell or pass-on the unused materials to other consumers due to lack of traceability and quality assurance following the initial sale. The use of inferior materials could have a detrimental impact on the design life of the asset, pose a health and safety risk or result in a catastrophic failure halting production, thus the linear approach.

In the proposed circular economy model, the supply chain remains open ended until all material is consumed. Quality assurance, traceability and tracking of goods is made possible by IoT. The manufacturer would provide the specification and test certificates which would be stored using technology such as RFID. Continuous monitoring using IoT would commence as soon as goods leave the manufacturing facility, recording attributes such as temperature, humidity, location etc. If any of the requisite conditions are breached, the system would trigger a request for retesting and re-certification of materials. Figure 35b shows the proposed circular economy model for industrial construction.

Figure 48a: Linear economic model

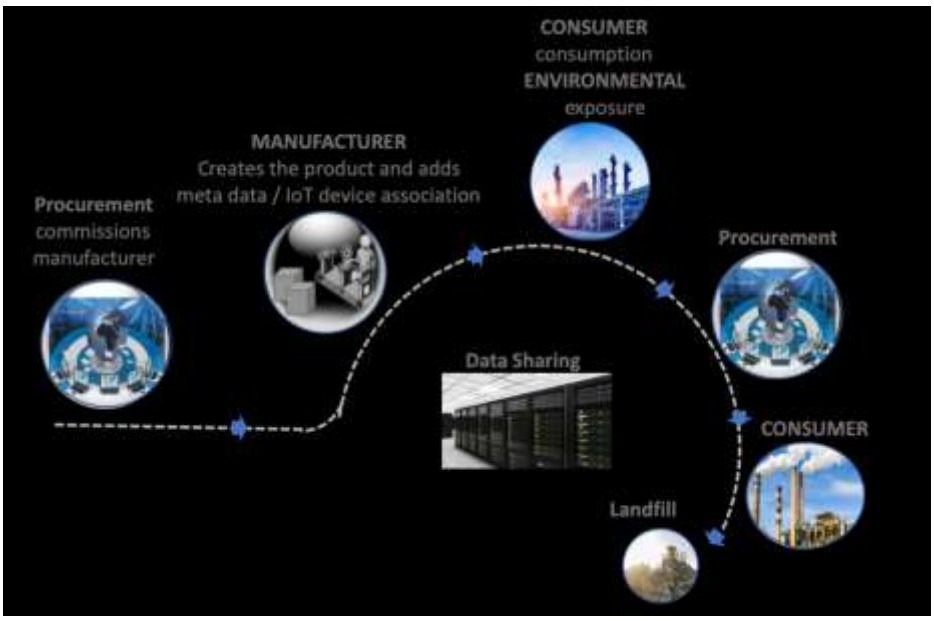

Figure 48b: Proposed circular economy model

2.6.5 IoT as an Enabler for Circularity in Industrial Construction

IoT will enable monitoring of materials in real time to provide the traceability that is essential for consumer confidence. It will provide multiple consumers from different industries access to excess materials, thus reducing waste. Key to successful adoption will be enabling trust between unrelated parties which can be brought about by technology advances such as blockchain. The conceptual stages of this circular economy model are described as follows.

IoT devices such as sensors and RFID tags are installed on material packaging by the manufacturer before despatch. They contain material specification and allowable limits of environmental and physical variables to be measured. The variables being measured include parameters such as temperature and humidity. These variables are measured by sensors and converted to digital data. This data is stored temporarily within the IoT devices. Data leaves these devices through gateways and is transmitted to the cloud. Connectivity of IoT devices and cloud is made possible via Bluetooth, Wi-Fi or 5g.

The transmitted data is analysed to ensure it is within the allowable limits defined by the manufacturer. Thus, the variables measured conform to the quality requirements set by the manufacturer and the material remains useable for initial construction purposes or circularity. This information is made available for stakeholders to view by displaying it on the relevant platform. If the required conditions are breached, an alert is generated for the material owner to take action. In such circumstances, the material can only be used if it is tested for quality and recertified. Once the material becomes waste for the first consumer, it shows up as available on the relevant platform for other consumers to take ownership.

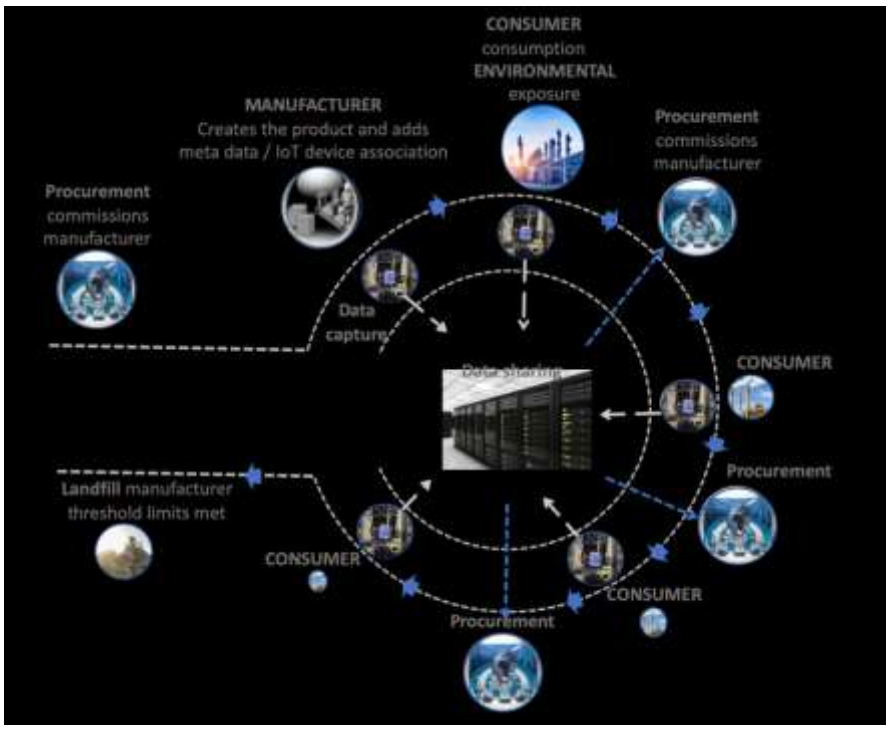

Figure 49: proposed platform for supporting CE

In figure 36, data created at source (manufacturer) is saved to a central data repository. This data is then updated via IoT devices during its use by a customer. When 'complete' is flagged, this data is updated and available for either procurement teams or flagged for landfill.

It should be noted that such technology is not new to industrial construction. However, the primary driver in the industrial construction for technological innovation is physical safety. For example, Guardhat are using RFID to delivery proximity warnings as an initiative for improving safety. They have created connected hard-hats that can detect falls and nearby moving objects, monitor locations and provide live assistance to industrial workers. The willingness to utilise technology beyond physical safety needs to be realised to achieve financial and environmental benefits.

However, we need to be mindful that while the IoT may be an enabler it also poses real security questions for organisations. The threat landscape across IoT devices and associated networks is pervasive in the Industrial construction sector. In this context confidentiality, integrity and availability are key areas that should be looked at when analysing cyber-security Risk. One such risk is that of hackers, who are causing havoc by infiltrating connected devices. This is often due to the poor security structure of IoT devices implemented by design vendors who are focussed on speed to market rather than cyber security.

2.6.6 Cyber-security Risk

We know the industrial construction sector is by degrees becoming more and more connected through IoT and remotely accessible systems. When these technological leaps are overlaid onto this industry, the infrastructure is often older computer hardware with a large variety of legacy systems. This means when companies connect these legacy systems to the internet, they can struggle to maintain end to end security, making it easy for hacker infiltration.

To exemplify the potential cyber-security risk scenarios that could develop and rapidly escalate, we will explore some hypothetical and real-world examples.

Consider a hypothetical scenario involving an integrated steel plant, SteelCo. The company adopts the circular economy model proposed in this white paper. It intends to undertake a major overhaul of a production unit spanning a period of 3 months. During those 3 months, SteelCo's output would be reduced by 30%. The overhaul needs to be executed as planned to ensure SteelCo retains its customer base. Any delays would result in depletion of stock levels, putting order fulfilment at risk.

SteelCo orders materials for the overhaul with active RFID tags that store specification and certification. The material is also equipped with sensors for continuous monitoring of storage conditions such as temperature, humidity and dust particulates together with GPS for tracking. This will enable SteelCo to make excess material available on the secondary market for re-sale following completion of the overhaul. However, a cyber-security breach exploiting a system vulnerability occurs. Information is purloined by hackers from RFID tags attached to some specialist construction materials. Based on the material specification, quantities ordered and delivery dates, the hackers are able to predict the production outage and its timing. They sell this information to one of Steelco's competitors who increases production to take advantage of SteelCo's reduced output, gaining market share.

A second cyber-security breach occurs, this time exploiting network vulnerability. Hackers track the location of some long lead time specialist materials, re-direct the shipment and take physical ownership of the same. They release the materials to SteelCo after receipt of a ransom. Even though Steelco pays the ransom, the incident extends the duration of the overhaul by 3 weeks, exacerbating Steelco's losses.

The scenario's described might be hypothetical but similar events have materialised making them highly plausible. In 2012, Saudi Aramco was exposed to the Shamoon malware which wiped data from over 30,000 computers and caused servers to be taken off-line. Although the oil drilling operation continued unhindered, the ability of Aramco to manage supplies, logistics, contracts and communications was severely affected. The financial cost of the attack has not been disclosed, but as the company provides 10% of the world's oil supply and the effects lasted over 3 weeks, the lost revenue alone, gives an indication of the financial impact. Aramco reportedly went to extreme lengths to recover from the attack, which included buying the global supply of hard-drives currently in production at a premium. Following such an experience it would seem reasonable to assume cyber-security would be at the forefront of the organisation's concerns. However, in 2016 Aramco and in 2018, one of Aramco's main contractors, Saipem, were again infected with variants of the same malware.

In a 2014 example, a cyber-attack on a German steel manufacturer resulted in serious physical infrastructure damage to a blast furnace following malicious de-activation of safety systems. The attack was initiated in an office network but was able to penetrate through the organisation's connected IT systems to take over the plant control systems (BSI, 2014). This precedent demonstrates the convergence of digital security with physical security, an area of historical intense focus for the construction industry. Hence it is imperative that digital security now receives the same scrutiny in the industry as physical safety.

The common element to these attacks is that, to the best of the publicly available knowledge, the infections were introduced by malicious emails opened by unsuspecting employees. In a connected world, unless systems implementation and training are given the necessary priority, the consequences can be significant. It has been demonstrated that education and training of employees significantly reduces the number of phishing attacks (KnowBe4, 2019). By way of a benchmark for the severity of this risk, even with the current level if ICT adoption, the

construction sector is ranked 3rd in the number of malicious emails per user at 26.6%, behind Mining and Wholesale Trade in the U.S. (Symantec, 2019).

The industrial construction sector like other industries needs to ensure it has appropriate risk management strategies in place to curb cyber-crime. Investors look to weigh up the risk and return for any investment. Just like industry and practitioners are pushing for ESG (Environmental, Social and Governance) principles to be embedded in corporate decision making as part of creating long term value (as opposed to short term profits). So too can Industrial Construction companies benefit from putting cyber-security at the heart of their risk operations in the company's risk register.

In a similar fashion, Industrial Construction companies could increase their ESG ratings and be more attractive investment opportunities by being circular, and even more attractive by being seen to take cyber-risk seriously through the implementation of robust cyber-security policies. Industrial Construction companies need to realise they are digital. Companies need to display this in their annual report and in the composition of the board. Many boards now have an IT professional at Director Level or sitting on the board.

The proposed changes would be a fundamental shift in thinking for an Industrial construction company that traditionally favours physical security over cyber-security, requiring this mindset to permeate to the top of the organisation. However, a forthright leader will recognise that this is crucial for the Industry and companies within it to survive. Cyber-security is a risky business that should be taken seriously. Just like going circular for Industrial Construction companies is new territory, so too is cyber risk, but an opportunity exists to create real long-term value, not just the resulting profit, but for the environment and society as a whole.

Another consideration for the industry will be niche raw materials and if they need a specific sensor to monitor conditions and any special conditions required for transport. Are mainstream designers in the ecosystem willing to create tailored solutions for customers and how incentivised will they be if this drives up their cost of design? Does this expose further cyber risk scenarios in relation to specialist materials? Rather than being seen as blocks to CE, these should be seen as entrepreneurial opportunities and a source of economic growth.

As IoT adoption increases, this creates more opportunities for cyber criminals to hack. In the construction sector, it is likely to take place is one of three areas (AON Risk Solutions, 2018):

- Building Information Modelling (BIM)
- Telematics
- Project management software

To date, the industrial construction sector has not been heavily regulated and limited guidance is available. The general cyber landscape however is changing, and cyber security is gaining more attention in the EU with a view of creating a safe digital economy. The Network and Information Security (NIS) directive was adopted in 2016 with the goal of enhancing cyber-security across the EU. The objective being to prepare EU countries to be ready to prevent and respond to cyberattacks. On a global scale, the ISO standard BS ISO/IEC 27001 for IT and cyber-security is used internationally to indicate effective information security management. To date this is the only generally recognised certification standard for information and cyber security. It is to this landscape that the sector employs IoT.

The E.U. Cyber-security Act was launched in June 2019, furthering efforts of European Union Agency for Cyber-security, ENISA, an agency of the European Union tasked with making Europe cyber secure by preparing European cyber-security certification schemes. In a 2018 independent review of IoT security standards gaps, ENISA stated that there are no significant standard gaps relating to security and privacy. However, the existing standards focus on

discrete elements of the ecosystem that constitutes the IoT. Consequently, a device can be brought to market which provides user authentication, encrypts and decrypts data that is transmitted or received and can verify proof of integrity but remains insecure, despite the manufacturer adhering to design and development processes outlined in management guidelines such as ISO-27000 information security standards.

Furthermore, if we look internally to an organisation implementing IoT it is often those employees who are most knowledgeable about IoT implementation and possess the best knowledge about securing devices further down the chain who are least confident in expressing this to senior management (SANS Institute, 2018). This can be tied to an industry that is patriarchal and hierarchical where people do not want to deliver bad news. Especially in an industry that is struggling to achieve ROI and meet profit expectations amid sensitivity to economic down-turn and environmental issues.

Institutional change of this magnitude will require the engagement of all employees, not just the IoT savvy, guided by a clear vision and ability to affect change which begins with education and awareness.

2.6.7 Conclusion

There are many factors that need to align in order for circularity to be adopted at a large scale in the industrial construction sector. IoT availability will increase at lower cost, driven by rapid development in the technology sector. In parallel, connectivity will improve as new communications networks e.g. 5G, are rolled out. The general adoption of a digital culture, e-commerce and cash-less society means even small construction companies will implement digital solutions. However, the availability of technology is outstripping the knowledge of correct implementation, and a connected network is only as strong as the weakest node. Therefore, adoption brings new risks and awareness of those risks will be critical to avoid events that de-rail progress.

As the number of IoT devices entering the market increases, combined with the general lack of cyber awareness, it is likely that cyber-attacks such as those discussed previously will increase. Standardised security requirements for IoT devices together with methodology for correct implementation and network design are essential.

The rapidly evolving IoT ecosystem provides a unique challenge to regulators who must develop a flexible regulatory framework that enables the adoption of IoT. Hence, a holistic approach is advocated allowing for adaptive, context-based and risk-based solutions which do not hamper competitiveness or innovation (ENISA, 2018). In the meantime, the onus for security falls to adopters of IoT who must be aware of both component-driven and system-driven risks, that is to say, the threats and vulnerabilities to technical components as well as the system as a whole (NCSC, 2018). Designing organisational security policies based on the principles of Confidentiality, Integrity and Availability (CIA) which focus on providing reliable access to trustworthy, accurate information only to those who need access and are authorized, is a good basis from which to reduce cyber-risk when implementing IoT until overarching, industry-wide standardized directives can be agreed and implemented.

The industrial construction sector is highly regulated with respect to physical safety, and therefore the mechanisms and culture of implementing and adhering to regulations are in place. Up until now however, limited cyber-safety regulation and guidance for construction companies has resulted in less focus on cyber-security relative to other industries. This is despite the fact that the industrial construction sector faces the same threats as other industries, and indeed, could be considered prime targets. In common with many highly competitive

industries, Industrial construction companies tend to be more focused on commercial drivers, albeit with a strong health and safety focus. Consequently, safety polices should be expanded to include cyber safety and security. This translates to more proactive cyber policies with value added risk management support providing a key enabler for those domain companies that do not have adequate skills in information security (Allied World, 2018).

However, at a societal and governmental level, a holistic approach is required to successfully implement circular economy. Which stays true to the circular economy core values of creating a change in mindset focused on strategic thinking for a sustainable future, enabling real long-term value. The European Commission and governments have the potential to create suitable conditions through policy and legislation to promote circularity in industrial construction. Appropriate platforms for integration of supply chains can be expedited through appropriate policies.

Within the framework of this white paper, the sustainable future can have a macro-economic and micro-economic impact. Organisations and within the sector, employees can have a positive impact and become more motivated being part of a paradigm shift in the industry, driven by:

- Legislation supported with appropriate incentives
- Corporate adoption
- Collaboration across the entire supply chain

Circularity in the Industrial Construction Sector reinforces our need to be more environmentally aware, proactive and innovative in our dealings with our peers and surroundings.

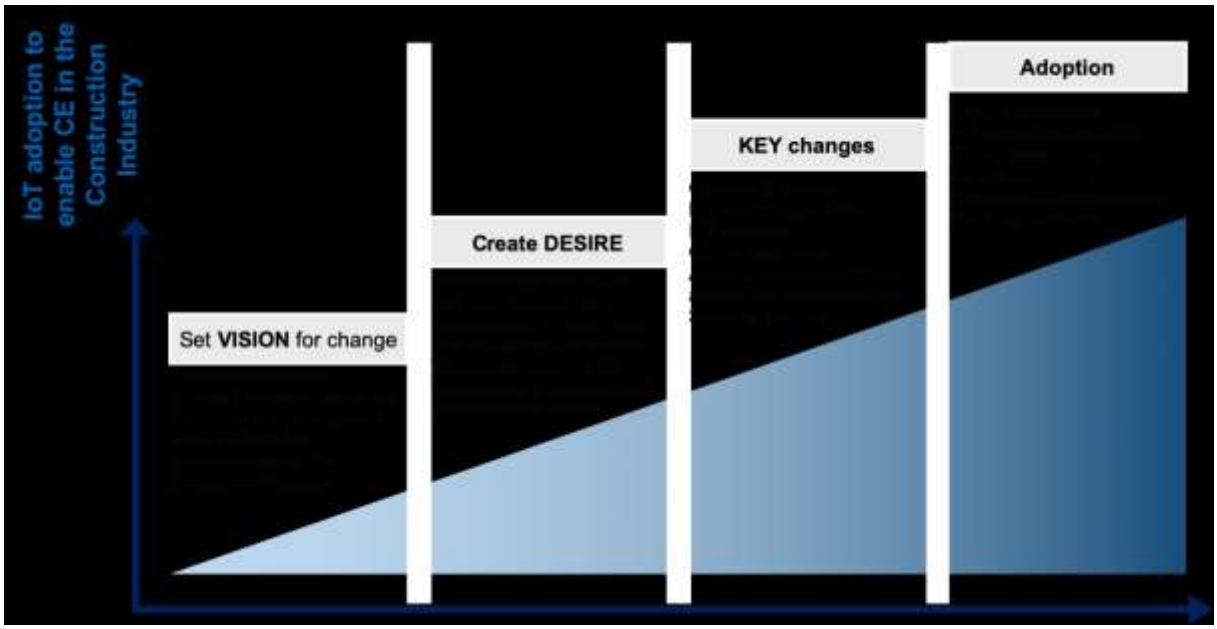

Figure 50: IoT adoption to enable CE in the Construction Industry

2.6.8 References

Allied World (2018) *The Case for Cyber Coverage in the Construction Industry*, *Risk & Insurance*. Available at: https://riskandinsurance.com/case-cyber-coverage-construction-industry/ (Accessed: 6 October 2019).

AON Risk Solutions (2018) 'Cyber Risk for the Construction Industry', 20 September. Available at: https://higherlogicdownload.s3.amazonaws.com/CFMA/4c0399f9-60b2-45ae-b6f0-899f2dd0fcef/UploadedImages/Cyber_Risk_for_Construction_Industry_.pdf (Accessed: 6 October 2019).

BSI (2014) *Die Lage der IT-Sicherheit in Deutschland 2014*, p. 44.

Ellen MacArthur Foundation (2019) *Completing The Picture - How The Circular Economy Tackles Climate Change*. Ellen Macarthur Foundation. Available at: https://www.ellenmacarthurfoundation.org/assets/downloads/Completing_The_Picture_How_The_Circular_Economy-_Tackles_Climate_Change_V3_26_September.pdf (Accessed: 6 October 2019).

ENISA (2018) *IoT Security Standards Gap Analysis*.

European Commission (2018) *EU Construction and Demolition Waste Protocol and Guidelines*, *Internal Market, Industry, Entrepreneurship and SMEs - European Commission*. Available at: https://ec.europa.eu/growth/content/eu-construction-and-demolition-waste-protocol-0_en (Accessed: 4 September 2019).

KnowBe4 (2019) 'Phishing By Industry Benchmarking Report', p. 13.

Madias, J. (2017) 'A Review on recycling of refractories for the iron and steel industry', *UNITECR 2017 – 15th Biennial Worldwide Congress*.

NCSC (2018) *Risk management guidance*. Available at: https://www.ncsc.gov.uk/collection/risk-management-collection/essential-topics/introduction-risk-management-cyber-security-guidance (Accessed: 29 September 2019).

SANS Institute (2018) *Shaping IIoT Security Concerns*. Available at: https://www.sans.org/reading-room/whitepapers/ICS/paper/38505 (Accessed: 6 October 2019).

Symantec (2019) *Internet Security Threat Report*. Available at: https://www.symantec.com/content/dam/symantec/docs/reports/istr-24-2019-en.pdf (Accessed: 3 October 2019).

3 Conclusion

One of the key enablers to implementing an effective and efficient working circular economy business model in our economic and business system is the Internet of Things (IoT). This is a system and an infrastructure of interdependent, interrelated and correlated machines and devices that have the ability and capacity to communicate information and data over the internet without the need for direct intervention by people. The system depends on embedded sensors in all devices and equipment; this can be mobile, electrical devices, vehicles, barcodes, scanners, and anything that is used on a daily basis. These sensors emit data about the current functioning and working state of devices that are being used at all levels. The data is shared over a common platform or infrastructure that use a common language for these devices to communicate with each other. Once the data is sent to a cloud platform the data is analysed and then the important information is extracted to help making decisions on all possible levels input, operational, output, distribution, consumption and utilisation. In general, our economic system has moved and is moving towards adopting smart devices, phones, cars, and cities; all of these will have an impact on our lives.

The adoption of IoT technology to facilitating the working of a circular economy is crucial to the success of adopting this form of economic and business model, hence the current project that we are conducting will have an invaluable impact on the introduction, implementation and impact of a circular economy model. Therefore, exploring and adopting "A framework for pairing Circular Economy and IoT: as an enabler of the Circular Economy & circularity-by-design as an enabler for IoT" is critical to building the business models in this area. This part of CE-IoT D2.2 relating to Business models for interplay of circular economy with IoT focused on building case studies that involved the different members of the consortium.

The studies conducted and the cases developed in this part of the research provide us with a detailed insight of how the adoption of intelligent assets through the linkage of the IoT infrastructure and the application of a circular economy system can facilitate the development of an efficient and effective business model. Applicable in different areas of industries and sectors in our economic system, this model will have the impact of reducing waste, enhancing efficiency, and extracting value from and ongoing model for as long as possible.

4 References – Introduction and Conclusion

Accenture-Circular-Advantage-Innovative-Business-Models-Technologies-ValueGrowth.pdf' (no date). Available at: https://www.accenture.com/t20150523T053139Zw/usen/_acnmedia/Accenture/ConversionAssets/DotCom/Documents/Global/PDF/Strategy_6/Accenture-Circular-AdvantageInnovative-Business-Models-Technologies-Value-Growth.pdf%20-%20zoom=50 (Accessed: 31 January 2019).

Berg, H. and Wilts, H. (2018) '*Digital platforms as market places for the circular economy—requirements and challenges*', NachhaltigkeitsManagementForum | Sustainability Management Forum. doi: 10.1007/s00550-018-0468-9.

Biddle, D. (1993) '*Recycling for Profit: The New Green Business Frontier*', Harvard Business Review, 1 November. Available at: https://hbr.org/1993/11/recycling-for-profitthe-new-green-business-frontier (Accessed: 5 February 2019)

Bressanelli, G. et al. (2018) '*The role of digital technologies to overcome Circular Economy challenges in PSS Business Models: an exploratory case study*', Procedia CIRP. (10th CIRP Conference on Industrial Product-Service Systems, IPS2 2018, 2931 May 2018, Linköping, Sweden), 73, pp. 216–221. doi: 10.1016/j.procir.2018.03.322.

Dam, R. and Siang, T. (2019) *5 Stages in the Design Thinking Process, The Interaction Design Foundation.* Available at: https://www.interaction-design.org/literature/article/5stages-in-the-design-thinking-process (Accessed: 25 February 2019).

Ellen-MacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf' (no date). Available at:https://www.ellenmacarthurfoundation.org/assets/downloads/publications/EllenMacArthur-Foundation-Towards-the-Circular-Economy-vol.1.pdf (Accessed: 20 January 2019).

Marcus, G. (2018) '*Deep Learning: A Critical Appraisal*', arXiv:1801.00631 [cs, stat]. Available at: http://arxiv.org/abs/1801.00631 (Accessed: 16 February 2019).

Ofcom research shows 4G significantly outperforms 3G networks (2016) Ofcom. Available at: https://www.ofcom.org.uk/about-ofcom/latest/media/mediareleases/2015/4g-outperforms-3g (Accessed: 18 February 2019).

Sustainable Prosperity for Europe (2017). Available at: http://www.epc.eu/prog_forum.php?forum_id=77&prog_id=2 (Accessed: 28 February 2019).

Vodafone IoT Barometer 2019 (2019). Available at: https://www.vodafone.com/business/news-and-insights/white-paper/vodafone-iotbarometer-2019 (Accessed: 26 February 2019).