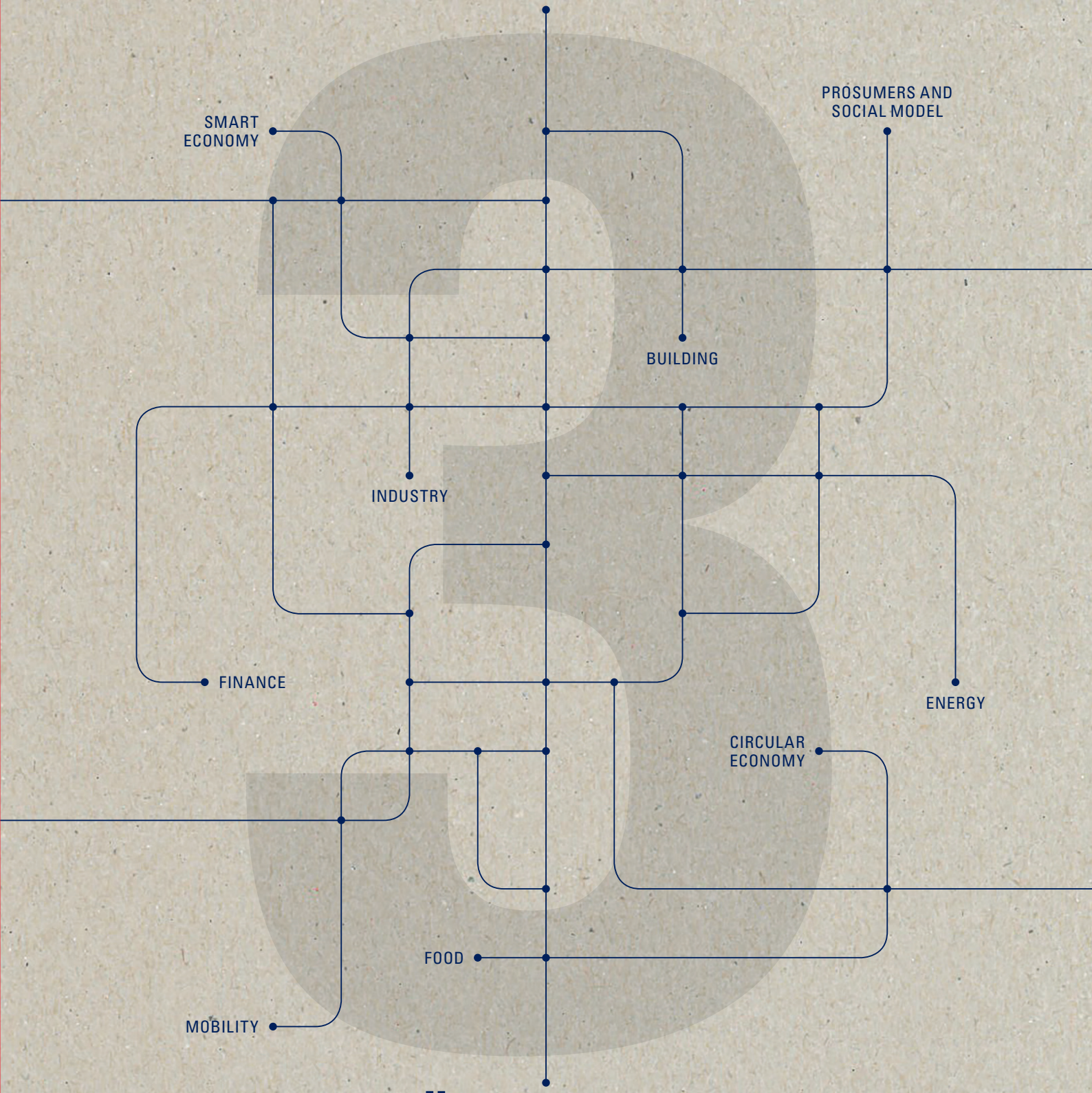
THE 3RD INDUSTRIAL REVOLUTION



LËTZEBUERG

CONTENTS

06 PREFACE

08 THE THIRD INDUSTRIAL REVOLUTION: THE PARADIGM SHIFT TO A SUSTAINABLE SMART LUXEMBOURG

12 LUXEMBOURG'S NATIONAL APPROACH TO THE THIRD INDUSTRIAL REVOLUTION (TIR)

15 EXPLORING THE POTENTIAL ECONOMIC BENEFITS OF THE THIRD INDUSTRIAL REVOLUTION INNOVATION SCENARIO

THEMATIC SUMMARY REPORTS

25 ENERGY
37 MOBILITY
51 BUILDING
63 FOOD
75 INDUSTRY
87 FINANCE
99 SMART ECONOMY
109 CIRCULAR ECONOMY
119 PROSUMERS AND SOCIAL MODEL

THE THIRD INDUSTRIAL REVOLUTION: THE PARADIGM SHIFT TO A SUSTAINABLE SMART LUXEMBOURG

The global economy is slowing, productivity is waning in many regions, and unemployment remains stubbornly high in most countries. Economists are predicting enduring low productivity and slow growth. And now, after two Industrial Revolutions in the 19th and 20th Centuries, the economic stagnation is compounded by the rapid acceleration of climate change brought on by the increasing emissions of greenhouse gases and accompanying rise in the Earth's temperature during the First and Second Industrial Revolutions. What makes the dramatic spikes in the Earth's temperature so worrying is that the increase in heat radically shifts the planet's hydrological cycle. The Earth's diverse ecosystems have evolved over geological time in direct relationship to precipitation patterns. Each rise in temperature of 1°C results in a 7% increase in the moisture-holding capacity of the atmosphere. This causes a radical change in the way water is distributed, with more intense precipitation but a reduction in duration and frequency. The consequences are already being felt in eco-systems around the world. We are experiencing more bitter winter snows, more dramatic spring storms and floods, more prolonged summer droughts, more wildfires, more intense hurricanes (category 3, 4, and 5), a melting of the ice caps on the great mountain ranges, and a rise in sea levels.

The Earth's ecosystems cannot readjust to a disruptive change in the planet's water cycle in such a brief moment in time and are under increasing stress, with some on the verge of collapse. The destabilization of ecosystem dynamics around the world has now pushed the biosphere into the sixth extinction event of the past 450 million years of life on Earth.

Now, however, a new economic paradigm is emerging that is going to radically change the way we organize economic life on the planet and dramatically reduce global warming emissions to address climate change. The European Union is embarking on a bold new course to create a high-tech 21st Century smart green digital economy, making Europe potentially the most productive commercial space in the world and the most ecologically sustainable society on Earth. The plan is called Smart Europe. The EU vision of a green digital economy is the cornerstone of the emerging Third Industrial Revolution.

To grasp the enormity of the economic change taking place, we need to understand the technological forces that have given rise to new economic systems throughout history. Every great economic paradigm requires three elements, each of which interacts with the other to enable the system to operate as a whole: new communication technologies to more efficiently manage economic activity; new sources of energy to more efficiently power economic activity; and new modes of transportation to more efficiently move economic activity.

In the 19th Century, steam-powered printing and the telegraph, abundant coal, and locomotives on national rail systems gave rise to the First Industrial Revolution. In the 20th Century, centralized electricity, the telephone, radio and

television, cheap oil, and internal combustion vehicles on national road systems converged to create an infrastructure for the Second Industrial Revolution.

Today, the European Union is laying the groundwork for the Third Industrial Revolution. The plan calls for a digitally connected smart Europe. The digital economy will revolutionize every commercial sector, disrupt the workings of virtually every industry, bring with it unprecedented new economic opportunities, put millions of people back to work, democratize economic life, and create a more sustainable low-carbon society to mitigate climate change. Equally important, the new economic narrative is being accompanied by a new biosphere consciousness, as the human race begins to perceive the Earth as its indivisible community. We are each beginning to take on our responsibilities as stewards of the planetary ecosystems which sustain all of life.

The digitalized Communication Internet is converging with a digitalized Renewable Energy Internet, and a digitalized automated Transportation and Logistics Internet, to create a super-Internet that rides atop an infrastructure called the Internet of Things. In the Internet of Things era, sensors and actuators will be embedded into every device and appliance, allowing them to communicate with each other and Internet users, connecting the human and natural environment in a global distributed intelligent network and providing up to the moment data on the managing, powering, and moving of economic activity in a smart Digital Europe. For the first time in history, the entire human race can collaborate directly with one another, dramatically expanding economic life.

The digitalization of communication, energy, and transportation also raises risks and challenges, not the least of which are guaranteeing network neutrality, preventing the creation of new corporate monopolies, protecting personal privacy, ensuring data security, and thwarting cyber-crime and cyber-terrorism. The European Commission has already begun to address these issues by establishing the broad principle that “privacy, data protection, and information security are complementary requirements for Internet of Things services.” These challenges will be addressed in the development and implementation of the TIR Strategy Study.

In this expanded digital economy, private enterprises connected to the Internet of Things will use Big Data and analytics to develop algorithms that speed aggregate efficiency, increase productivity, reduce ecological footprint, and lower the marginal cost of producing and distributing goods and services, making Luxembourg businesses more competitive in an emerging post-carbon global marketplace (marginal cost is the cost of producing an additional unit of a good or service, after fixed costs have been absorbed). The marginal cost of some goods and services in a Smart Europe will even approach zero, allowing millions of prosumers, connected to the Internet of Things, to produce and exchange things with one another, for nearly free, in the growing Sharing Economy.

AGGREGATE EFFICIENCIES AND PRODUCTIVITY

The transformation to an Internet of Things infrastructure and a Third Industrial Revolution paradigm is forcing a wholesale rethinking of economic theory and practice. The potential unleashing of extreme productivity brought by the digitalization of communication, energy, and transportation is leading to a reassessment of the very nature of productivity and a new understanding of ecological sustainability.

All economic activity comes from harnessing available energy in nature and converting it into goods and services. At every step in the extraction, production, storage, and distribution process, energy is used to transform nature's resources into finished goods and services. Whatever energy is embedded in the product or service is at the expense of energy used and lost – the entropic bill – in moving the economic activity along the value chain. Eventually, the goods we produce are consumed, discarded, and recycled back into nature, again, with an increase in entropy. The entropic bill for the First and Second Industrial Revolutions has arrived. The accumulation in carbon dioxide emissions in the atmosphere from burning massive amounts of carbon energy has given rise to climate change, the wholesale destruction of the Earth's biosphere, and the sixth extinction event in the history of our planet, throwing the existing economic model into question. The field of economics, by and large, has yet to confront the fact that economic activity is conditioned by the laws of thermodynamics.

Until very recently, economists were content to measure productivity by two factors: more capital invested in better performing machines and improved labor performance. But when Economics Nobel laureate Robert Solow – who won the Nobel Prize in economics in 1987 for his growth theory – tracked the Industrial Age, he found that machine capital and labor performance only accounted for approximately 12.5 percent of all of economic growth, raising the question of what was responsible for the other 87.5 percent. Over the past 25 years, a number of analysts have gone back and retraced the economic growth of the industrial period using a three-factor analysis of machine capital, labour performance, and thermodynamic efficiency of energy use. They found that it is "the increasing thermodynamic efficiency with which energy and raw materials are converted into useful work" that accounts for substantial gains in productivity and growth in industrial economies. In other words, "energy" is the missing factor.

A deeper look into the First and Second Industrial Revolutions reveals that the leaps in productivity and growth were made possible by the communication/energy/transportation matrix and accompanying infrastructure that comprised the general-purpose technology platform that firms connected to. For example, Henry Ford could not have enjoyed the dramatic advances in efficiency and productivity brought on by electrical power tools on the factory floor without an electricity grid. Nor could businesses reap the efficiencies and productivity gains of large, vertically integrated operations without the telegraph and, later,

the telephone providing them with instant communication, both upstream to suppliers and downstream to distributors, as well as instant access to chains of command in their internal and external operations. Nor could businesses significantly reduce their logistics costs without a fully built-out road system across national markets. Likewise, the electricity grid, telecommunications networks, and cars and trucks running on a national road system were all powered by fossil fuel energy, which required a vertically integrated energy infrastructure to move the resource from the wellhead to the end users.

The general-purpose technology infrastructure of the Second Industrial Revolution provided the productive potential for a dramatic increase in growth in the twentieth century. Between 1900 and 1929, the United States built out an incipient Second Industrial Revolution infrastructure – the electricity grid, telecommunications network, road system, oil and gas pipelines, water and sewer systems, and public school systems. The Depression and World War II slowed the effort, but after the war the laying down of the interstate highway system and the completion of a nationwide electricity grid and telecommunications network provided a mature, fully integrated infrastructure. The Second Industrial Revolution infrastructure advanced productivity across every industry.

During the period from 1900 to 1980 in the United States, aggregate energy efficiency – the ratio of potential to useful physical work that can be extracted from materials – steadily rose along with the development of the nation's infrastructure, from 2.48 percent to 12.3 percent. The aggregate energy efficiency leveled off in the 1990s at around 14 percent with the completion of the Second Industrial Revolution infrastructure. Despite a significant increase in efficiency, which gave the United States extraordinary productivity and growth, nearly 86 percent of the energy we used in the Second Industrial Revolution was wasted during transmission. Every other industrialized nation experienced a similar productivity curve and peak. For example, despite the significant increase in aggregate energy efficiency in Luxembourg during the 20th Century, the country still wastes more than 80% of its energy resources.

Even if we were to upgrade the Second Industrial Revolution infrastructure, there will be only a limited effect on aggregate efficiency, productivity, and growth. Fossil fuel energies have matured. And the technologies designed and engineered to run on these energies, like the internal-combustion engine and the centralized electricity grid, have largely exhausted their productivity, with little potential left to exploit.

The build out and scale up of the Third Industrial Revolution Internet of Things platform will enable businesses in Luxembourg to dramatically increase aggregate efficiencies across their value chains, increase productivity, and reduce marginal costs and ecological footprint in managing, powering, and moving economic activity, making the nation a leader in the shift to the new economic paradigm and an ecological society.

LUXEMBOURG'S NATIONAL APPROACH TO THE THIRD INDUSTRIAL REVOLUTION (TIR)

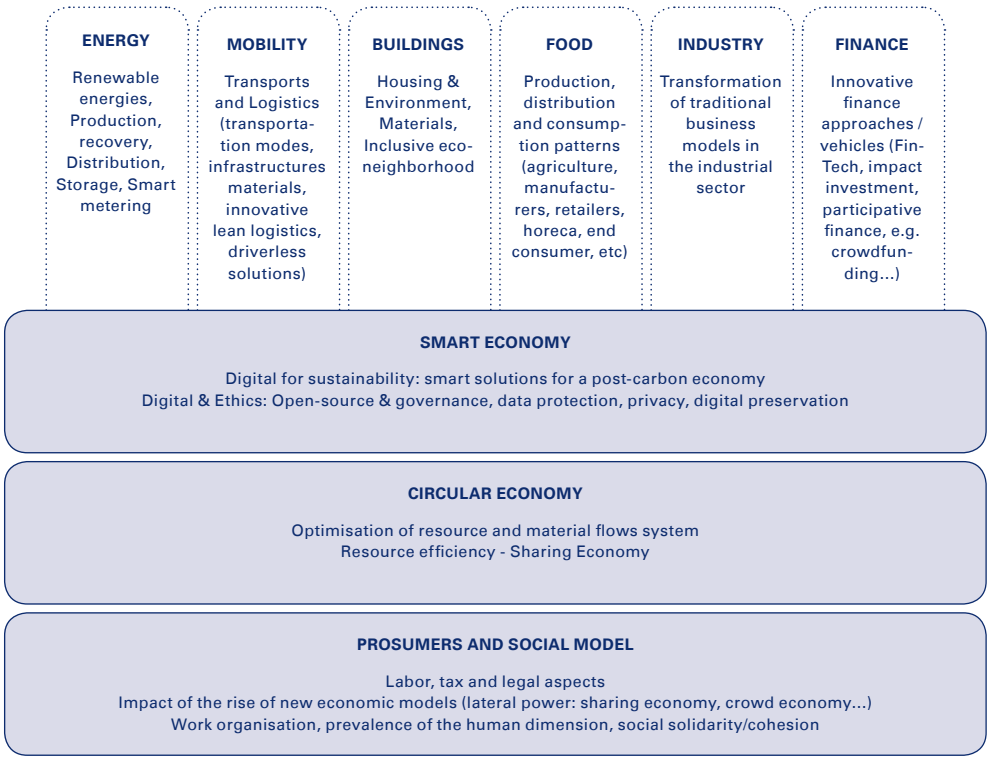
With the goal of establishing a more sustainable economic strategy for Luxembourg, the Ministry of the Economy, the Chamber of Commerce and IMS Luxembourg jointly launched the strategic study "The Third Industrial Revolution Strategy," carried out in close collaboration with Jeremy Rifkin and his team of international experts. Through its economic diversification policies and different relevant action plans, Luxembourg has made important inroads in key sectors of TIR for more than a decade. The purpose of the study is to accelerate these dynamics and foster a more resilient socio-economic model for the benefit of present and future generations. The outcome of the study is a coherent and holistic strategy allowing Luxembourg to break new ground towards the ushering in of the Third Industrial Revolution. As a cosmopolitan crossroads at the heart of Europe, the country's openness and ability to reinvent itself while continuously adapting to a changing environment are essential components in its successful development. Moreover, its membership in the European Union is crucial in expediting the transition into the TIR.

Today, Luxembourg's socio-economic model is driven by extensive growth, primarily driven by labour-force growth and less conditioned by productivity gains. The economic pattern and lifestyle are mainly oriented towards resource intensive linear consumption causing negative economic, social and environmental externalities. The implementation of the TIR facilitates Luxembourg's shift to qualitative growth, based on technological progress, aggregate efficiencies, productivity gains and an intelligent management of resources, with the goal of rendering our socio-economic model more sustainable. This qualitative growth enables responsible wealth creation which is indispensable in tackling major societal and environmental issues such as poverty, unemployment, inequalities, loss of biodiversity and climate change.

A major aim of the study is to raise awareness and prepare Luxembourg's economy and society for the upcoming megatrends and inherent disruptive forces – notably digitalisation, automation, decarbonisation, and efficient resource use – as well as for the new economic models, including the circular economy and the sharing economy. By means of the study, perceived threats ought to be transformed into opportunities to be seized by all the key stakeholders across the Luxembourg society. While Luxembourg is not the driver of these worldwide megatrends, it is essential that the country anticipates the changes and takes preventive action to ensure the nation's future competitiveness. In this spirit, Luxembourg's strategic TIR study is a toolbox containing various instruments to prepare for the future.

The study has been conducted using a lateral bottom-up approach, actively involving national stakeholders who contributed their know-how, ideas, views, experiences and visions in order to bring multiple perspectives into the process. In tandem with country-specific macroeconomic data, this unprecedented collaboration resulted in a tailor-made study adapted to local realities. The partici-

pation of many national actors in this common effort was a key factor in ensuring its success and comported with the "collaborative commons" approach and open innovation paradigm inherent to TIR. The cross-functional participation was organized in nine working groups comprised of six vertical pillars that dealt with the sectorial topics of energy, mobility, buildings, food, industry, and finance and three horizontal axes that covered the transversal areas of the smart economy, circular economy, and the prosumers and social model.



The different working groups enriched Luxembourg's TIR study by identifying and discussing related opportunities, challenges and trends, and proposing strategic measures and concrete actions in different arenas including infrastructure, technology, regulatory framework, policies, new business models, finance and education. Although each topic has been treated separately, the different issues interconnect, requiring that the study is considered systemically and in its entirety. Manifold links and interactions exist, not only via the horizontal axes but also between the vertical pillars. The three horizontal axes influence all economic life and society as a whole. Smart technologies constitute the backbone of Internet of Things applications. The concept of circular economy penetrates

every economic sector and closes the loop in the consumption of resources. The Sharing Economy, a new economic system and business model, impacts all of the vertical pillars and horizontal axes. The "finance" pillar also contains a transversal aspect in its function as enabler of TIR projects and investments. In addition, various issues not explicitly named in the designation of the working groups are integrated into the study and discussed in detail in different chapters. These topics include the role of public authorities as actor and facilitator, the effects on employment and working conditions, the importance of literacy, the challenges in education and training, as well as the socio-cultural shift and changes in mind-set that accompany and condition the transition. The study also includes an assessment of innovation scenarios that explore the potential macroeconomic benefits for Luxembourg.

Luxembourg's changeover towards the TIR is an ongoing and long-term process that will stretch over the next several decades. The strategic study will serve as catalyst and centrepiece of a broad public debate on the nation's social and economic future. The study is not set in stone and must be continually adapted to technological progress and societal developments. It is a flexible instrument to pave the way for transition and to guide socio-economic actors on their path forward.

ENERGY OVERVIEW

2016
TODAY

STATE OF PLAY

- Embedded in Europe and its institutions
- Very small
- Open economy
- 45% of workforce made of cross borders
- Transport is the key sector of energy saving

x 2 POPULATION COULD POTENTIALLY DOUBLE BY 2050

OPPORTUNITIES

WIND | SOLAR | BIOMASS | GEOTHERMAL ENERGIES

VISION

- Luxembourg should exploit the total energy efficiency potential that can be achieved through the renovation of the building stock
- Luxembourg should find cleaner alternatives to oil exports according to COP21 agreements
- Luxembourg should exploit the totality of its economically feasible renewable energy production potential. This should cover up to 70% of its total consumption
- Energy imports will continue to be necessary, but will decrease depending on the share of nationally produced renewable energy

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

The bulk of the energy we use to heat and cool our homes and run our appliances, power our businesses, drive our vehicles, and operate every part of the global economy will soon be generated at near zero marginal cost and be nearly free in the coming decades. That is already the case for several million early adopters in the EU who have transformed their homes and businesses into micro-power plants to harvest renewable energy on-site.

Currently, 33% of the electricity powering Germany comes from solar, wind and other renewable energies, accounting for approximately 15% of the total final energy consumption. By 2030, a minimum of 50% of the electricity powering Germany will be generated by renewable energies.

The quickening pace of renewable energy deployment is due, in large part, to the plunging cost of solar and wind energy harvesting technologies. The reduction in fixed costs of solar and wind technologies have been on exponential curves for more than 20 years. In 1977, the cost of generating a single watt of solar electricity was 76 dollars, and by 2017 the cost will have fallen to 55 cents/ Watt. After the fixed costs for the installation of solar and wind are paid back—often as little as 5 to 8 years—the marginal cost of the harvested energy is nearly free.

Unlike fossil fuels and uranium for nuclear power, in which the commodity itself always costs something, the sun and the wind are free. In some regions of Europe and America, solar and wind energy is already as cheap, or cheaper, than fossil fuel or nuclear generated energy.

The phase-in and integration of the Renewable Energy Internet and the generation of near zero marginal cost renewable energy in Luxembourg will enable every business, neighborhood, and homeowner to become a producer of electricity, sharing their surplus with others both domestically and across Europe.

Luxembourg enterprises plugging into the Renewable Energy Internet will be able to access electricity at near zero marginal cost in the managing, powering, and moving of economic activity across their value chains, affording them a vast increase in aggregate efficiency and productivity, and an equally dramatic reduction in ecological footprint and the marginal cost of doing business.

MOBILITY OVERVIEW

2016
TODAY

STATE OF PLAY

- Transport is the major source of energy consumption (61%) and global warming emissions (64%), making Luxembourg the 4th most congested country in the EU
- Current modal split: public transport (14,5%), active mobility (13%), individual cars (72,5%)
- Highest number of vehicles / capita in Europe; 175 000 commuters / day (86% travelling by car)
- 75% of oil products sold in Luxembourg is consumed outside the country
- Excellent ICT infrastructure and know-how
- Logistics infrastructure with strong competitive assets and support of the Cluster for Logistics
- A proactive Sustainable Mobility (MoDu) plan, initiatives led by government and municipalities

OPPORTUNITIES

- Green technologies
- Digitalization
- Sharing economy
- Active mobility
- New working schemes

MOBILITY-AS-A-SERVICE AND MULTIMODAL APPROACH

VISION

AN INTELLIGENT, SUSTAINABLE, COHESIVE, AND RESILIENT MOBILITY AND TRANSPORT ECOSYSTEM FOR THE BENEFIT OF THE LUXEMBOURG SOCIETY AND ECONOMY.

- Shift in modal split: 30% of active mobility, 40% of public transports and 30% of individual cars
- 100% emission-free mobility for passenger cars, public transports and last-mile logistics

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

The meshing of the Communication Internet and the Energy Internet makes the build-out and scale-up of the automated Transportation and Logistics Internet possible. The convergence of these three Internets comprise the kernel of the Internet of Things platform for managing, powering, and transporting passengers and goods in a Third Industrial Revolution economy.

First, charging stations will need to be installed ubiquitously across land masses, allowing not only cars, but also buses and trucks, to power up or send back electricity to the grid.

Second, sensors embedded in devices across road networks as well as vehicles will provide real-time data to help manage traffic flows, identify the best itineraries for automated vehicles, and provide information to the users (i.e. collective public transport information, car sharing and car pooling, etc.), and across logistics networks to allow factories, warehouses, wholesalers, retailers, and end users to have up-to-the-moment data on logistical flows that affect their value chain.

Third, the storage and transit of all physical goods will need to be standardized so that they can be efficiently passed off to any node and sent along any passageway operating across the Mobility Internet in the same way that information flows effortlessly and efficiently across the World Wide Web.

Fourth, all of the actors in public transport systems and logistic corridors have to continue their efforts to operate synergistically and in coordination. By the end of 2017, all the public transport operators will provide a seamless public transport system based on interchange between different transports modes, with a single tariff system and travel document and coordination between the services. Operators along the transport corridors, in turn, need to continue to aggregate into collaborative networks to bring all of their assets into a shared mobility space to optimize passenger traffic and the shipment of goods, taking advantage of lateral economies of scale. For example, warehouses and distribution centers might establish cooperatives to share unused spaces, allowing carriers to drop off and pick up shipments using the most efficient path en route to their destination.

The Internet of Things platform will provide real-time logistical data on pick-up and delivery schedules, weather conditions, traffic flows, and up-to-the-moment information on warehouse storage capacities en route in Luxembourg. Automated dispatching will use Big Data and analytics to create algorithms and applications to ensure the optimization of aggregate efficiencies along the passenger corridors and shipping routes and, by so doing, dramatically increase productivity while dramatically reducing the ecological footprint and the marginal cost of every trip and shipment.

Globally, by 2020-2025, at least some of the passenger traffic and shipments on roads, railways, water, and air corridors, will likely be carried out by automated electric and fuel cell transport, powered by near zero marginal cost renewable energies, and operated by increasingly sophisticated analytics and algorithms. Driverless transport will accelerate productivity and reduce the marginal labor cost of moving people and shipping goods toward near zero on a smart automated Transportation and Logistics Internet.

BUILDING OVERVIEW

2016
TODAY

STATE OF PLAY

- Stock of 140 000 residential buildings and 5 000 commercial and industrial buildings
- Built environment is responsible for 40% of the total energy consumption and 36% of the CO_2 emissions in the EU

In Luxembourg

82,9 %

of residential and semi-residential buildings are single family houses

OPPORTUNITIES

- GREEN POWER PRODUCTION
- ENERGY STORAGE
- SOLAR, WIND, GEOTHERMAL AND BIOMASS ENERGY
- CIRCULAR ECONOMY

VISION

- "Smart, green and circular buildings in an optimal shared and attractive district"
- Zero energy or plus energy buildings
- Aim to total circularity, where no waste is generated in the construction sector
- Buildings should become more flexible and serve multiple functions
- Ensure high quality of life providing healthy and sound environment
- Development of education and training
- Prioritize an attractive urban design with lively public spaces, art and culture
- Retrofitting is an essential pre-requisite

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

Luxembourg will need to transform its stock of 140,000 residential buildings and 5,000 commercial and industrial buildings and its existing infrastructure into smart, digital buildings and networks across an Internet of Things platform to usher in a Third Industrial Revolution. The country could face a population growth rate from roughly 560,000 people in 2015 up to about 1 million inhabitants in 2050. In effect, Luxembourg is potentially the fastest growing population in the EU-28 through the year 2050. By comparison, the EU population growth will increase by only 0.1% annually over the years 2013 to 2050, while Luxembourg could grow 1.8% per year over that same time horizon. The potential increase in population could provide an opportunity to build out and scale up a new generation of neighborhoods and buildings and accompanying infrastructure.

Buildings connected to the Internet of Things infrastructure will play an increasing role in data handling, green power production, energy storage, and act as transport and logistics hubs to manage, power, and move economic activity in a smart Luxembourg. The build out and scale up of a new generation of neighborhoods and buildings can advance aggregate efficiency, increasing productivity and reducing marginal costs and ecological footprint, making Luxembourg one of the most competitive and ecologically sustainable commercial spaces in the world.

First, buildings will have to undergo deep retrofitting operations, to seal their interiors, minimize energy loss, and optimize efficiency. Second, smart Internet of Things technology will need to be installed throughout the interior and exterior space surrounding buildings. Potentially within a district/eco-neighborhood, buildings will become nodes connected to every other building across the infrastructure to allow families, businesses, and communities to monitor Big Data flowing along the value chains and use analytics to create algorithms and apps that can increase their aggregate efficiency. Third, renewable energy harvesting technologies – solar, wind, geothermal, and biomass – will need to be installed in and around residential, commercial, and industrial sites to generate green electricity, heat and cold for immediate use within the buildings or sale back to the electricity, heating and cooling grid. Energy storage technologies, including notably batteries,hydrogen fuel cells and thermal storage tanks, will need to be installed alongside the renewable energy harvesting technologies to store intermittent green energy for use or sale back to the energy grids to ensure a reliable supply of energy. Fourth, electric charging stations will need to be installed in or alongside buildings to power electric vehicles for use on the automated, GPS-guided and driverless passenger and freight vehicles of the Transport and Logistics Internet.

The return on investment in energy efficiency and energy savings takes place over relatively few years, after which the owner or renter enjoys a reliable stream of savings on its energy cost for decades. Studies show that retrofitted energy efficient buildings that serve as digital nodes enjoy a higher market value, higher rents, and higher occupancy rates. A typical study of residential buildings across France shows a 40% increase in market value for buildings receiving the top energy performance certificates.

FOOD OVERVIEW

2016
TODAY

STATE OF PLAY

- 0.3% of GDP / Gross Value Added: 164 millions in 2002 / 80 millions in 2009
- 2 586 km² of higly diverse landscape
- 50% agricultural, 1/2 are permanent grassland
- Less than half of agricultural land is owned by farmers, high rents, mainly family businesses in dairy and beef production
- Open to common markets (EU / Worldwide)
- Agriculture have to comply to the EU's Common Agricultural Policy
- Challenge of increasing worlwide population and climate change

OPPORTUNITIES

- Develop and settle its agriculture in a niche
- Become a business model for other regions

- SUSTAINABLE FOOD SECTOR (FARMERS, TRANSFORMATION INDUSTRY, DISTRIBUTORS, CONSUMERS AND CITIZENS)
- RENEWABLE ENERGY

VISION

A safe, high quality, transparent and sustainable food sector

- How can we feed sustainably ? By farming in nature's image !

Make
100 %
of Luxembourg agriculture organic

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

The phase in of the Internet of Things (IoT) infrastructure for a Third Industrial Revolution (TIR) portends vast gains in aggregate efficiency and productivity for Luxembourg farmers, food processors, wholesalers, and distributors. Farmers are already utilizing the emerging Internet of Things with sensors to monitor weather conditions, changes in soil moisture, the spread of pollen, and other factors that affect yields, and automated response mechanisms are being installed to ensure proper growing conditions.

The agricultural Internet extends beyond the harvest to include the distribution of food to wholesalers and retailers. Sensors are being attached to vegetables and fruit cartons in transit to both track their whereabouts and sniff produce to warn of spoilage so shipments can be rerouted to vendors.

As the IoT infrastructure is phased in, farmers, processors, wholesalers, and distributors in Luxembourg will be able to mine the Big Data flowing across their value chains. They will be able to use increasingly sophisticated analytics to create algorithms and apps, allowing them to dramatically increase their aggregate efficiency and productivity, and reduce their marginal cost and ecological footprint in the managing, powering, and transporting of food, taking the food industry out of the chemical era and into an ecological era mediated by smart, new digital interconnectivity.

INDUSTRY OVERVIEW

2016
TODAY

STATE OF PLAY

- Central location in Europe
- Economic, social and political stability
- Rich pool of qualified and multilingual workers
- Luxembourg industrial sector managed to establish a healthy mix of large and medium size industrial enterprises
- In a digitalized Third Industrial Revolution the very notion of what constitutes an industry is metamorphosing

DEMATERIALISATION

OPPORTUNITIES

4.0

Industry 4.0:
Smart solutions
for the future
of Industry

- 3D PRINTING
- ROBOTICS
- VIRTUAL DESIGN
- ULTRA LIGHT MATERIALS
- AUGMENTED REALITY
- INTERNET OF THINGS

VISION

**LUXEMBOURG:
AN INTERNATIONALLY RECOGNIZED PLATFORM
FOR SUSTAINABLE INDUSTRIAL EXCELLENCE
THROUGH INNOVATIVE SOLUTIONS.**

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

Luxembourg hosts diverse industrial sectors including finance, logistics, chemicals, biotechnology, agriculture, steel, glass, audiovisual, crafts, and tourism. Luxembourg ranks only second to Germany among the 28 EU member states in business innovation, making its business culture primed for leading the EU into the digital economy.

Cross-industry collaborations, the development of open-source platforms, the lateralization of value chains, collaboration between conventional market-based companies and startups in the Sharing Economy, and new distributed business models, will draw Luxembourg's industrial sectors into the emerging digital business culture. Every industry will be tasked with exploring new ways to utilize the Internet of Things to increase its aggregate efficiencies, raise productivity, reduce marginal costs, and lower its ecological footprint in a smart green Luxembourg.

The erection of the Third Industrial Revolution Internet of Things infrastructure in Luxembourg will necessitate the active engagement of virtually every industrial sector, spur commercial innovations, promote Small and Medium Sized Enterprises, and employ thousands of workers over the next thirty five years.

The business at hand for Luxembourg will be to provide retraining for the existing workforce and the appropriate skill development for students coming into the labor market to ease the transition into the new business opportunities and job categories that come with a massive build-out of the Third Industrial Revolution infrastructure.

FINANCE OVERVIEW

2016
TODAY

STATE OF PLAY

- Luxembourg is an important financial center at the heart of Europe
- The state of the art infrastructure encompassing a high quality regulatory and supervisory framework places the financial center at the forefront of innovation
- Luxembourg is also an emerging FinTech hub
- Worldwide leading center for domiciling microfinance investment funds

2015
143
banks

OPPORTUNITIES

2014
1ST
In cross border fund distribution in Europe

2016
3666
Investments Funds

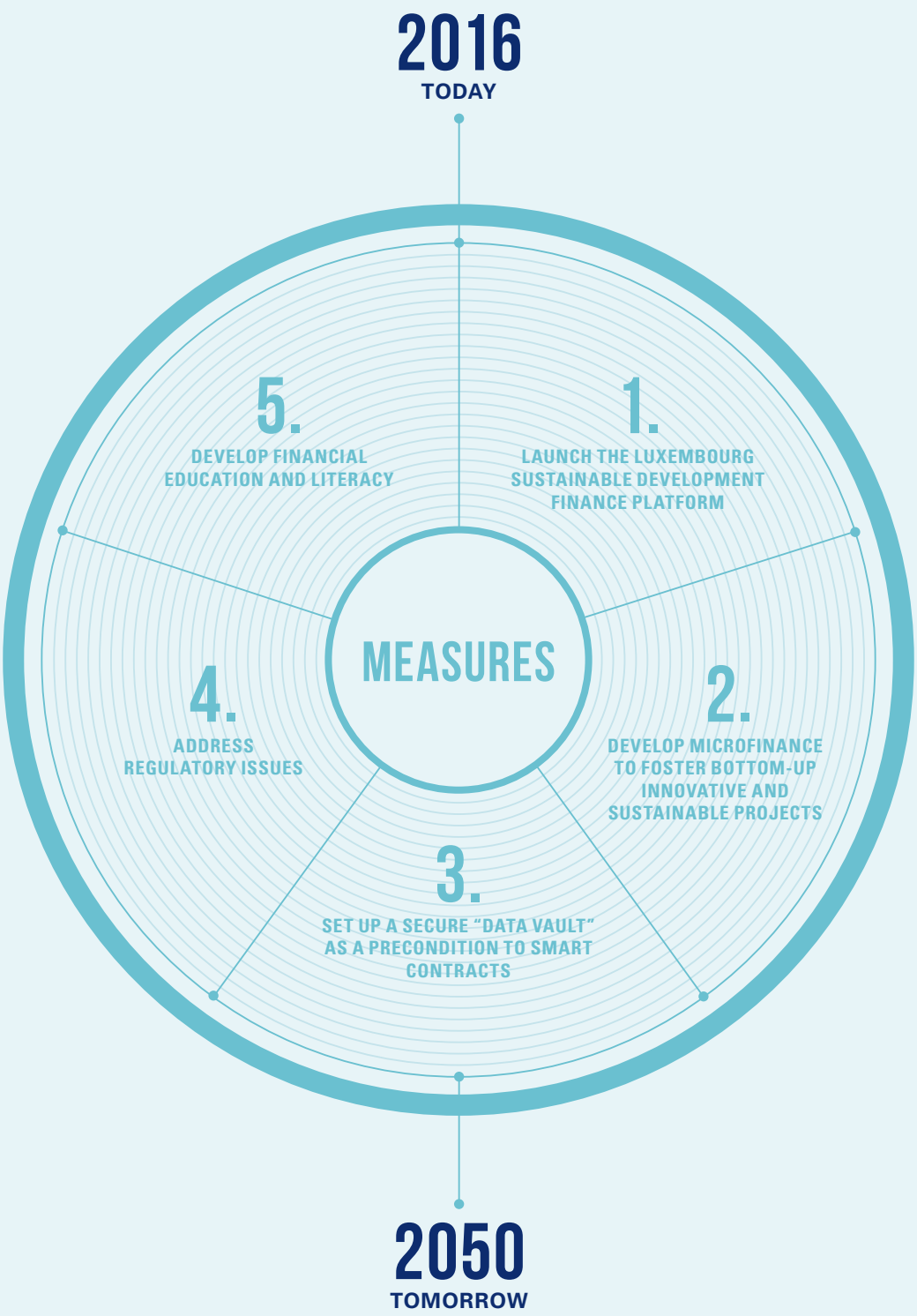
- Internet of things
- Smart digital economy
- FinTech

VISION

LUXEMBOURG: A SUSTAINABLE WORLD-CLASS FINANCIAL HUB AT THE VANGUARD OF THE DIGITAL REVOLUTION MAKING TRANSFORMATION HAPPEN.

2050
TOMORROW

STRATEGIC MEASURES



The third industrial revolution narrative

The emerging "Finternet of Things" (the Financial Internet of Things) in the evolving Third Industrial Revolution will transform many aspects of financial services, foster new business models, and reshape the industry over the course of the coming decade. Financial services, more than any other industry, rely on the collection, analysis, and transfer of data. No wonder industry analysts view the Internet of Things (IoT) as a game changer for the financial services sector. Sensors connecting every device across the value chain will generate Big Data in every sector of the economy, giving banks, other financial institutions, and insurance companies a steady flow of vital economic data in real time. The data can be mined with analytics to create algorithms and apps that will allow the financial services industry to increase aggregate efficiencies and productivity and reduce transactional and marginal cost in back office functions, the delivery of services to customers, retail payments, investment advice, investment decisions, and trading by algorithms. The IoT will also enable banks to issue virtual currencies.

As a financial powerhouse, Luxembourg also has the unique opportunity to strategically leverage financial investment and services that could facilitate and accelerate the transition to a digitally interconnected Third Industrial Revolution economy. Future data management and digital technology infrastructure are positioned as key components in the transition to a TIR economy. Intelligent linking of the various technologies (e.g., digitalization of infrastructure, crowdfunding, microfinancing, blockchain) can accrue knock-on benefits that accelerate the TIR transition.

SMART ECONOMY OVERVIEW

2016
TODAY

STATE OF PLAY

- Luxembourg boasts a highly advanced ICT sector
- Connectivity, human capital and use of internet are the 2016 dimensions where Luxembourg performs best according to Digital Scoreboard of the European Commission
- Luxembourg is lacking the expertise to deploy the digital revolution and the educational system is not adapted to overcome that digital skill gap

100 %
broadband coverage

OPPORTUNITIES

- New technologies for managing communications and big Data
- Smart antennas
- Dynamic spectrum access
- Cognitive radio-technologies
- Mesh networks

EVOLVED WIFI
AND 5G NETWORKS

VISION

A SMART ECONOMY SHOULD RECONCILE THE ECONOMY WITH THE PRINCIPLES OF SUSTAINABILITY THROUGH THE USE OF ICT FOR INCLUSIVE GROWTH, ECONOMIC DIVERSIFICATION AND SOCIAL EMPOWERMENT

- Competitiveness and efficient use of resources
- Digital inclusion, "buy in" by society at large
- Sustainable growth and social welfare model

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

Three and a half billion people, nearly half the human population on Earth, are currently connected to the Internet. Recently, China began manufacturing $25 smart phones with more computing power than what was used to send our astronauts to the moon, increasing the prospect that soon the entire human race will be connected and communicating with one another, sharing knowledge, work, and entertainment, making new friendships and finding mates at near zero marginal cost in the largest extended fictional family in history. The Communication Internet is erasing border after border and connecting the human race in a single, global, virtual public square – and the marginal cost of participating is nearly zero and virtually free.

And now, even the airwaves are becoming potentially free. New technologies for managing communications and Big Data over the radio frequencies are changing the very nature of broadband communications. Smart antennas, dynamic spectrum access, cognitive radio technologies, and mesh networks are among the new technologies that are expanding the spectrum to a cheap and abundant resource by using it more efficiently and with greater agility. This will result in both licensed and unlicensed use of spectrum, addressing the needs for ultrabroadband access, mission critical services, and the Internet of Things with trillions of interconnected devices. Evolved WiFi and 5G networks hold the promise to fulfil these dreams.

CIRCULAR ECONOMY OVERVIEW

2016
TODAY

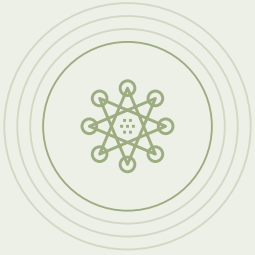
STATE OF PLAY

- Consumption is at the center of economic growth
- Existing supply chains are very often highly complex and long and make it almost impossible to identify all the materials, components and ingredients
- Product design does often not allow proper disassembly
- Infrastructure is poorly designed for reverse logistics
- General awareness of Circular Economy is still in the starting blocks

Every euro of economic activity generates about

2,5 KG

of waste



OPPORTUNITIES

- Eco-design
- Blockchain technology for safe data transfer
- New business models: Pay for Performance or Product as a Service
- IoT platform to allow these new business models
- Development of reverse logistics infrastructure

UPCYCLING OF USED MATERIALS INTO THE INDUSTRIAL CHAIN OF PRODUCTION CREATES ADDITIONAL VALUE

VISION

LUXEMBOURG WILL BE THE FIRST CIRCULAR NATION, WHERE NEW BUSINESS MODELS BASED ON THE PRODUCT AS A SERVICE PRINCIPLE BECOME STANDARD.

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

The Circular Economy (also called circularity) is both indispensable to the goal of increasing aggregate efficiencies and reducing ecological footprint, as well as a source of new innovations with multiple ancillary benefits. The circular economy is designed to mimic the material and energy flows in mature ecosystems where resources are continuously appropriated, used, redistributed, and recycled for future use. Circularity spans three areas: the production of goods and services, consumption and behavior, and waste valorisation.

These fields are expressed in seven pillars: sustainable supply, eco-design, industrial ecology, functional economy (or functionality), responsible consumption, increase of the life duration, and recycling. Sustainable supply concerns the way resources are extracted with the goal of minimizing the environmental impact and optimizing the extraction process. It is valid for energy and minerals, but also for agriculture and forestry. Eco-design addresses all the ways to improve the environmental impacts of goods, optimizing the aggregate efficiency of matter used, including life-cycle analyses. Industrial and territorial ecology mediates the relationship between the biosphere and human societies through the knowledge of material and energy flows across economies. The functional economy emphasizes the use of a product rather than its ownership. Responsible consumption focuses on making economic choices based on evaluating the sustainable life cycle of a product or service. Recycling is a well-known process by which used products are re-introduced into the industrial chain of production. For example, currently, small companies are manufacturing 3D printed products from recycled plastic, paper, and metal objects.

It should be emphasized that the circular economy is much more than recycling and restoration of materials used. Keeping resources in circulation for as long as possible is also a critical aspect of the circular economy. In the Sharing Economy, the redistribution of product usage means extracting higher value from fewer resources. This leads to an increase in aggregate efficiency and productivity. An Accenture assessment projects that savings in materials, recycling, and restoration, will likely exceed $4.5 trillion by 2030 in the global economy while increasing productivity, reducing fixed and marginal costs, creating net new jobs, and lowering ecological footprint.

For every euro of economic activity, the Luxembourg economy generates about 2.5 kilograms of waste. Yet, there are promising developments in the steel and chemical industries, the food and agricultural sector, as well as in financial services and the development of information technologies (among others) to suggest that such wastes can be profitably reduced over time while simultaneously increasing overall aggregate efficiency and economic productivity.

Recall, aggregate efficiency measures the ratio of potential to useful work in every economic conversion. The higher the aggregate efficiency, the less material and energy are wasted in every stage of conversion across the value chain. The build-out of an IoT infrastructure across Luxembourg provides a technological platform for increasing aggregate efficiency and tightening circularity at every conversion point in the managing, powering, and moving of economic activity. The IoT platform also assists circularity in another way. By reducing the marginal cost of producing and distributing virtual goods and an increasing array of physical goods to near zero, the IoT fosters the growth of the Sharing Economy. The Sharing Economy is by its very nature a circular economy. Goods and services are redistributed over and over, enabling a much higher efficiency per used resource.

PROSUMERS AND SOCIAL MODEL OVERVIEW

2016
TODAY

STATE OF PLAY

- Cosmopolitan crossroads in the heart of Europe and driving force to the Greater Region
- Economic pattern and lifestyle are marked by a throwaway culture and mainly oriented towards resource intensive linear consumption
- General social security and healthcare systems require steady GDP growth to be viable
- Expected increase of national and foreign resident population, and forecasted rise of cross-border commuters
- Mobility problems, environmental issues, rising housing prices, socio-cultural challenges
- 16,4% of population were at risk of poverty after social transfers in 2014

CHALLENGES AND OPPORTUNITIES

- Impacts on businesses, employment opportunities, working environment, education, healthcare and more
- Citizens' participation to induce a socio-cultural shift and changes in mind-set
- Collaborative economy characterized by lateral power, open commons and social capital

INCLUDE SOCIO-ECONOMIC ACTORS AND CITIZENRY TO STIMULATE A BROAD PUBLIC DEBATE ON LUXEMBOURG'S FUTURE CONFIGURATION

VISION

PEOPLE LIE AT THE HEART OF THE THIRD INDUSTRIAL REVOLUTION

RAISE AWARENESS AND FAMILIARIZE THE POPULATION WITH THE HOLISTIC CONCEPT OF TIR, INCLUDING UNDERLYING PRINCIPLES LIKE THE COLLABORATIVE COMMONS, SUSTAINABILITY AND CIRCULARITY

IMPLEMENT NEW "QUALITIY OF LIFE" INDICATORS TO BETTER ASSESS SOCIAL, ECONOMIC AND ENVIRONMENTAL PERFORMANCE

2050
TOMORROW

STRATEGIC MEASURES

The third industrial revolution narrative

Capitalism is giving birth to a progeny. It is called the Sharing Economy on the Collaborative Commons. This is the first new economic system to enter onto the world stage since the advent of capitalism and socialism in the early nineteenth century, making it a remarkable historical event. The Sharing Economy is changing the way we organize economic life, offering the possibility of dramatically narrowing the income divide, democratizing the global economy, and creating a more ecologically sustainable society. To the extent that capitalism can create new business models and practices that will support the development of the sharing economy, it will prosper along with its offspring.

The triggering agent that's precipitating this great economic transformation is zero marginal cost brought on by the digitalization of communication, energy, and transport, and now the introduction of the Internet of Things platform (zero marginal cost is the cost of producing an additional unit of a good or service after the fixed costs have been absorbed). Businesses have always sought new technologies that could increase productivity and reduce the marginal cost of producing and distributing goods and services, in order to lower their prices, win over consumers and market share, and return profits to their investors. They never anticipated, however, a digital technology revolution that might unleash "extreme productivity" bringing marginal costs to near zero, making information, energy, and many physical goods and services nearly free, abundant, and no longer subject to market exchanges. That's now beginning to happen.

The near zero marginal cost phenomenon wreaked havoc across the "information goods" industries over the past decade as millions of consumers turned prosumers and began to produce and share their own music via file sharing services, their own videos on YouTube, their own knowledge on Wikipedia, their own

news on social media, and even their own free e-books on the World Wide Web. The Zero Marginal Cost phenomenon brought the music industry to its knees, shook the film industry, forced newspapers and magazines out of business, and crippled the book publishing market.

Meanwhile, six million students are currently enrolled in free Massive Open Online Courses (MOOCs) that operate at near zero marginal cost and are taught by some of the most distinguished professors in the world, and receiving college credit, forcing universities to rethink their costly business model.

While many traditional industries suffered, the zero marginal cost phenomenon also gave rise to a spate of new entrepreneurial enterprises including Google, Facebook, Twitter, and YouTube, and thousands of other Internet companies, who reaped profits by creating new applications and establishing the networks that allow the Sharing Economy to flourish.

Economists acknowledge the powerful impact Zero Marginal Cost has had on the information goods industries, but until recently, have argued that it would not pass across the firewall of the virtual world into the brick-and-mortar economy of energy, and physical goods and services. That firewall has now been breached.

The Internet of Things platform is emerging, allowing millions — and soon hundreds of millions — of prosumers to make and share their own energy, share vehicles, share homes, and share an increasing array of 3D printed products at low to near zero marginal cost.

In the digitalized Sharing Economy, social capital is as vital as market capital, access is as important as ownership, sustainability supersedes consumerism, collaboration is as crucial as competition, virtual integration of value chains gives way to lateral economies of scale, intellectual property makes room for open sourcing and creative commons licensing, GDP becomes less relevant, and social indicators become more valuable in measuring the quality of life of society, and an economy based on scarcity and profit vies with a Zero Marginal Cost Society where an increasing array of goods and services are produced and shared for free in an economy of abundance.

The exponential growth of the Sharing Economy raises a number of critical policy and regulatory questions that will need to be addressed by Luxembourg. New regulations will have to be enacted to ensure the social security benefits and general welfare of a growing freelance workforce. Additional regulatory policies will need to be adopted to promote a level playing field between the market economy and the Sharing Economy.