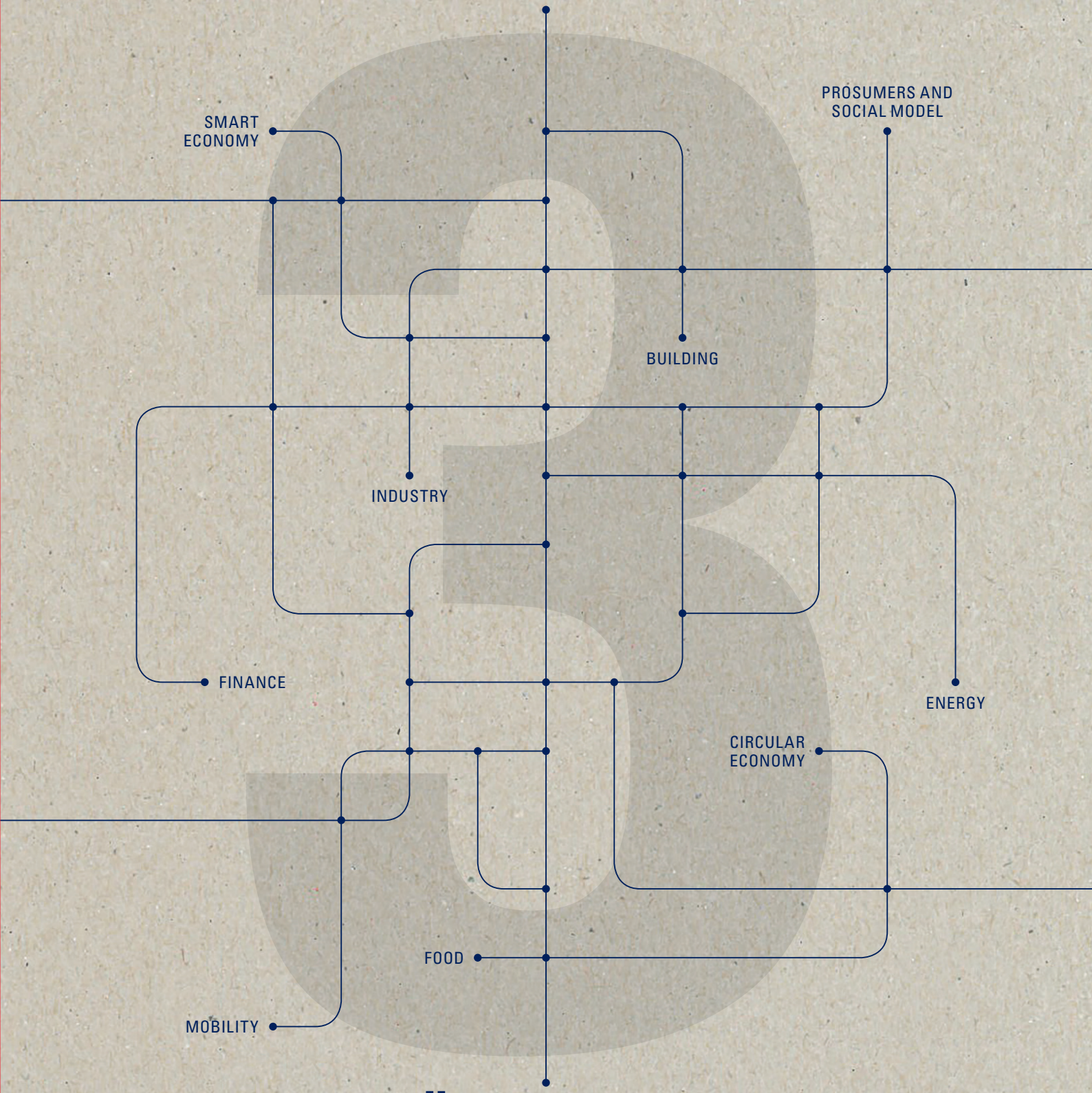
THE 3RD INDUSTRIAL REVOLUTION



LËTZEBUERG

THE 3RD INDUSTRIAL REVOLUTION STRATEGY STUDY FOR THE GRAND DUCHY OF LUXEMBOURG

THEMATIC SUMMARY

INTRODUCTION

The following thematic summary is a brief overview of some of the themes and proposals in the Third Industrial Revolution Strategy Study for the Grand Duchy of Luxembourg, prepared, in large part, by the Luxembourg Working Groups. The thematic summary highlights portions of the narrative as well as key ideas, insights, and initiatives in the larger Third Industrial Revolution Strategy Study.

It is not, however, meant to be an executive summary, but rather a series of snap shots to provide a sample of the results of the 10 month deep collaboration between the Working Groups of the Grand Duchy of Luxembourg and the consultants of the TIR Consulting Group LLC.

The longer report is a deeply structured, interdisciplinary, and systemic approach to transitioning Luxembourg into a Third Industrial Revolution economy and smart society between now and 2050. The Third Industrial Revolution Strategy Study includes historical analysis, scenario building, statistical projections, and economic modeling, with the aim of presenting a short-term, mid-term, and long-term framing document and workbook for launching the Grand Duchy of Luxembourg on the next stage of its journey.

While we welcome everyone reading the highlight papers, they should not be viewed as a substitute for undertaking a more rigorous read of the actual Third Industrial Revolution Strategy Study. The report has been prepared with the idea that it will be thoroughly read, debated, and acted upon.

To access the longer report of the 3rd Industrial Revolution Lëtzebuerg, please visit the website: www.tirlux.lu

IMPRESSUM

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PREFACE, JEREMY RIFKIN
PRESIDENT, TIR CONSULTING GROUP LLC

The Grand Duchy of Luxembourg and TIR Consulting Group LLC have engaged in a deep collaborative initiative over the past twelve months, designed to transform the country into the first nation-state of the smart green Third Industrial Revolution era. The year-long project has culminated in an extensive Third Industrial Revolution Strategy Study to help guide the Grand Duchy of Luxembourg into the next stage of its journey.

The process itself has established a new milestone in the governance of economic and social development. More than 300 socio-economic actors from government, the business community, academia, and civil society actively participated in the proceedings and in the preparation of the final Strategy Study and accompanying proposals. The government of the Grand Duchy of Luxembourg took on a new role as a facilitator of the process, replacing traditional top-down governance with a peer approach, engaging a broad representative swath of the national community in jointly planning the Third Industrial Revolution Strategy Study. The final Third Industrial Revolution Strategy Study for the Grand Duchy of Luxembourg encompasses the combined input of the 300 national stakeholders and TIR Consulting Group LLC's global team of experts.

The Third Industrial Revolution Strategy Study breaks additional ground by taking a cross-disciplinary approach to the future development of the Grand Duchy of Luxembourg, combining social, cultural, and environmental narratives and economic theory and business practices, with the goal of reconceiving economic development within a larger frame of "quality of life". While the early takeoff stage of the digital Third Industrial Revolution focused almost exclusively on new technologies, products, and services – the Silicon Valley model –, the Grand Duchy of Luxembourg has introduced the next level of engagement by concentrating equally on how the new Third Industrial Revolution infrastructure fosters an emerging global interconnectivity and accompanying planetary stewardship of the Earth's ecosystems – the

Biosphere Valley model. In the Biosphere Era, Luxembourg and every other political jurisdiction becomes responsible for its 19 kilometers of the biosphere stretching from the stratosphere to the sea, which makes up the life force of the planet and constitutes the indivisible community to which we are all beholden and whose well-being determines our own quality of life. Biosphere stewardship becomes the essential mission of each region and locality in reducing ecological footprint and addressing climate change in the coming era.

The Third Industrial Revolution narrative proposed in this Strategy Study introduces a sophisticated and nuanced new approach to economic development based on establishing digital ecosystems that mirror the dynamics of natural ecosystems, with the goal of establishing a seamless symbiotic relationship between the circular flows of nature and the economic activities of the Luxembourg society. With this in mind, the Strategy Study continually hones in on critical ecosystem features including self-organization, mutualism, co-evolution, diversity, emergence, resiliency, and adaptation in modelling Luxembourg's new digital ecosystems and accompanying business practices and regulatory regime.

Luxembourg has now developed the vision, the narrative, and the game plan to usher in a smart green digital society, paving the way for the nationwide deployment of a Third Industrial Revolution transition.

The publication and deployment of the Third Industrial Revolution Strategy Study positions the Grand Duchy of Luxembourg as a flagship nation in the European Union build out and scale up of a smart digital society. As a major financial center of Europe, Luxembourg can play an important role in marshalling the financial resources and preparing the EU regulatory framework for the scaling of a Third Industrial Revolution infrastructure across the 28 Member States and adjoining partnership regions to advance the European Dream of a borderless digital infrastructure and integrated single market.

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)

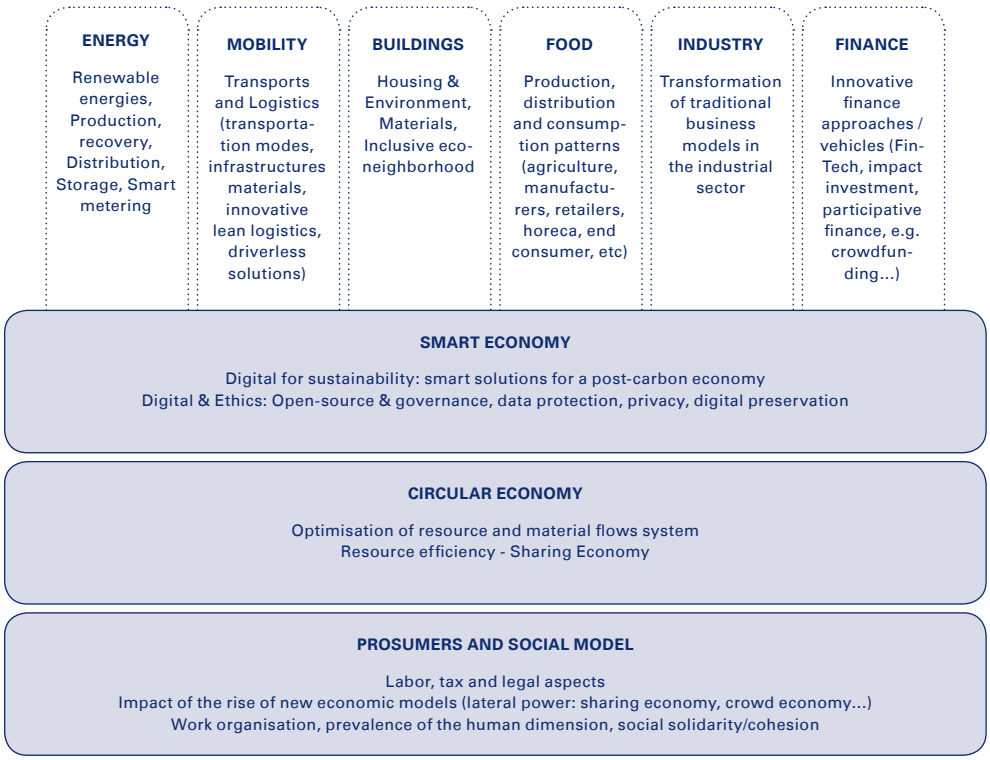
With the goal of establishing a more sustainable economic strategy for Luxembourg, the Ministry of the Economy, the Chamber of Commerce and IMS Luxembourg jointly launched the strategic study "The Third Industrial Revolution Strategy," carried out in close collaboration with Jeremy Rifkin and his team 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.

EXPLORING THE POTENTIAL ECONOMIC BENEFITS OF THE THIRD INDUSTRIAL REVOLUTION INNOVATION SCENARIO[1]

Exploring the potential macroeconomic benefits of the Third industrial revolution innovation scenarios for Luxembourg is an important element of the TIR master plan. Analyzing the current patterns of economic activity and energy consumption and exploring the scale of purposeful effort and investments that will enable Luxembourg to build up future opportunities is crucial. With this in mind, the TIR strategic study summarizes the major economic impacts of this specific inquiry and highlights the next critical steps that can ensure a more robust, resilient, and sustainable economy within Luxembourg. Nevertheless, it should be pointed out that such a long term modelling and forecasting exercise, until 2050, is of a very complex nature. Therefore, the mantra of such an exercise should always be the following: *"Modelling for insights, rather than precision."*

Depending on the mix and the productive uses of all the resources that are put to work, the Luxembourg economy is able to deliver an assortment of goods and services. This is typically measured as Gross domestic product (GDP). In most economic development assessments, labor and capital are thought to be the main elements that drive economic activity. Yet, it is energy - the third and often overlooked component of the economic process - that may prove to be the more critical driver. When optimally sourced and efficiently used, energy can amplify local economic development and spawn a more robust and resilient economy. But equally true, the wrong mix of those resources, and especially the inefficient use of those resources, can appreciably constrain the vitality of an economy.

For instance, in 2016 Luxembourg will spend about 2 billion euros to meet its combined energy needs. Although Luxembourg derives many benefits from this, there is also a significant opportunity to save money. While Luxembourg boasts a more energy efficient economy than the global economy on average, it still appears to waste more than 80 percent of its high quality energy resources. A working analysis based on data published by the International Energy Agency (IEA) suggests that Luxembourg may convert less than 20 percent of the available energy into useful work. This refers to the consumption of energy as it enables the transformation of materials and other resources into the desired mix of goods and services within the Luxembourg economy. With that magnitude of ongoing energy losses each day, and also with an over-reliance on fossil fuel resources, Luxembourg may face serious economic and competitive challenges should it continue with its current pattern of energy production and consumption. Systematic upgrades in the use of much more energy efficient technologies and productive investments in renewable energy systems can provide all of Luxembourg's energy needs by 2050. It is both technically and economically fea-

1 For a detailed narrative and further methodological and technical insights regarding the modeling, please consult the corresponding chapter in the full final report.

sible to encourage such a transition. A significant portion of the billions of euros already spent each year for energy consumption could be used in other ways to more productively strengthen the country's larger economy.

The TIR strategy study explores future economic development opportunities available to Luxembourg. More specifically, the analysis examines the prospective economic returns within the Luxembourg economy if households and businesses were to shift away from current investment patterns to pursue a more productive and cleaner energy future. The analysis investigates the benefits that energy efficiency and renewable energy resources can deliver to the economy as the basis for a revitalized economic development. It also examines the scale of investment that will be necessary to drive those improvements.

REGARDING THE FRAMEWORK OF THE ECONOMIC ASSESSMENT

Luxembourg sits at a moment in history in which inaction is not an option. Indeed, the country finds itself at the crossroads of both challenges and opportunities. On the one hand, compared to past historical experience, the economy shows a lagging growth in performance. Over the period 1985-2000, for example, the amount of Gross Domestic Product (GDP) supported by each job in the Luxembourg economy - a useful proxy of economy-wide productivity - grew at a very healthy rate of a +2.6 % annually. With a solid growth in both population and jobs, that meant the economy grew, on average, by nearly +6 percent per year over that 15-year period. Over the next 15-year period, however, the economy-wide gain in productivity was essentially flat and even a bit smaller in 2015 compared to 2000. Yet, a continuing increase in both population and jobs enabled the national economy to expand at a +2.8 percent rate per year. While significantly lower than earlier trends, this is still a healthy economic growth rate in an international comparison.

At the same time, the key driver of the Luxembourg expansion in the last 15 years appears more to be the influx of inhabitants and workers rather than the significant increase in overall productivity. And while standard economic projections suggest a continuing +3.0 percent annual growth through 2050, there are other forecasts and indications which suggest the possibility of a weaker and less robust level of economic activity and, especially, a lagging rate in the more productive use of capital, energy and other resources.

There are two key trends that have to be considered going forward. The first is the growth in economy-wide total factor productivity. Compared to the historical annual growth rate over 1985-2010, recent projections suggest a growth that is less than half the historical pace. In the 10-year period 2010-2020, reflecting

the economic volatility of the previous 10-year period, the rate of productivity is projected to fall but the trend increases slightly over the 30-year period 2020-2050. At the same time, there is a second trend that hints at a less resilient future economy, in this case because of a declining rate of investment. Recent projections indicate that the rate of Gross Fixed Capital Formation - the annual investments in Luxembourg's total fixed assets - is also decreasing compared to historical performance. This, in turn, may hamper a more vigorous future economic activity. And if we also fold in the many steps that need to be taken to address climate change and other environmental concerns, one can quickly imagine that failure to explore these possible outcomes may leave Luxembourg at risk. Given this backdrop, an important question to be explored is whether Luxembourg's economy can remain both vigorous and sustainable as productivity and the rate of Gross Capital Formation are shown to possibly decrease.

Preliminary inputs from STATEC, as well as key high-level reference case data, provide a useful starting point to make a number of economic performance projections through the year 2050. We can compare these reference case assumptions with expected results that might emerge from TIR Innovation Scenarios.

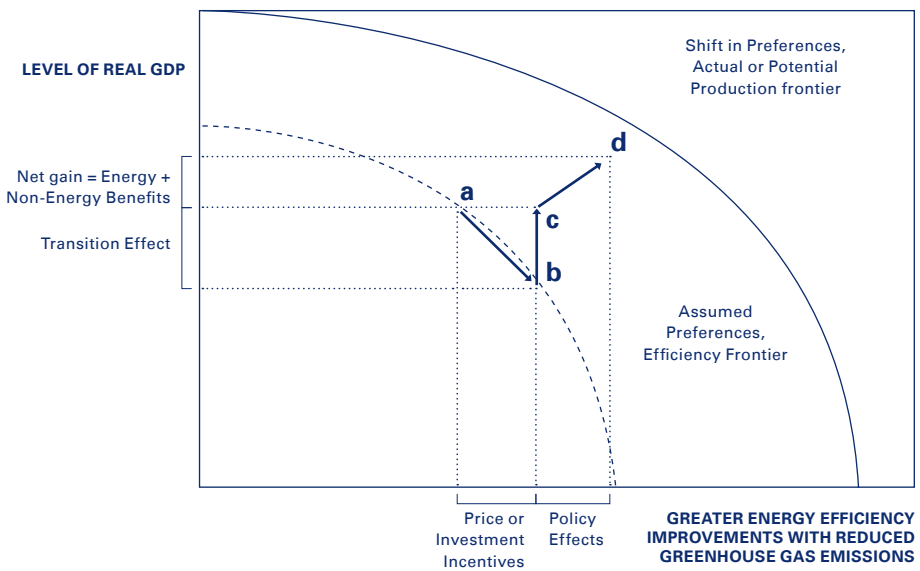
The question that might be helpful to raise is what mix of purposeful effort and more productive investments might ensure the development of a more robust economy. "TIR-like thinking" can become an insurance plan which can enable Luxembourg to maintain a healthy economy. The TIR Innovation Scenario, in turn, can provide insights into the kind of new economic platform which can ensure both a resilient and sustainable economy over a longer period of time.

Notwithstanding some early warning signs of a weaker economy, Luxembourg has a number of promising opportunities that can point the way to the more productive use of its many resources. Moreover, the hundreds of different opportunities identified in this TIR strategic study range from changes in transportation land-use patterns to large-scale improvements in Luxembourg's commercial and industrial enterprises. They also include the build-up of information and communication technologies that enable the many existing and new buildings, as well as other structures, to serve as interactive nodes that elevate and optimize overall economic performance of the Luxembourg economy. How might these options generate a net positive return compared to the standard business-as-usual assumptions (reference case)?

We cannot know at this time either the scale of the stimulus, the productive impact of the many positive collaborations that will be necessary, or the precise outcomes that might result from such innovations. We can, however, offer a positive general explanation of how multiple benefits are likely to emerge through the TIR master planning process.

Regarding the figure below, the assumption might typically be made that Luxembourg is on a production frontier at point "a". Given the current market structures, technologies and social needs, any change to satisfy a demand for greater efficiencies, or for the reduction in greenhouse gas emissions, will likely result in a downward shift to the right. Basically, Luxembourg might achieve some mix of isolated productivity improvements, and there might be some reduction in greenhouse gas emissions, but it must surely come at the cost of a reduction in incomes and GDP. Yet, the TIR Innovation Scenario envisions a revitalized thinking, together with a set of programs, policies and incentives that may initially drive the economy down to point "b". Yet, such a shift may also create a productive transition that can lift the economy to point "c." The result might be an improvement in energy efficiencies (as well as the more productive use of resources more generally) even as the economy remains at a relatively stable level of GDP. At some point, however, the various energy and non-energy benefits that result from an array of incentives and policy initiatives can boost the performance of the economy to a higher than expected level of performance. The migration from point "a" to the eventual point "d" might represent a 30 percent reduction in energy requirements per unit of GDP.

FIGURE: CONCEPTUAL FRAMEWORK FOR EVALUATING TIR INNOVATION SCENARIOS



SOURCE: JOHN A. "SKIP" LAITNER (MAY 2016).

The net energy savings, together with a transition to a renewable energy system might, in turn, stimulate net gains in jobs and GDP. Equally critical, the TIR Innovation Scenario can become a framing tool to catalyze a continuous learning curve and encourage even more far-reaching innovations in ensuing decades, allowing Luxembourg to push ahead even more aggressively into the production frontier so that future technologies and markets are encouraged, developed, and implemented to the long-term benefit of the economy.

POTENTIAL RESULTS FROM THE TIR INNOVATION SCENARIO FOR LUXEMBOURG

The foundation for the overall economic assessment that has been completed as part of the Luxembourg TIR master planning process is the proprietary modelling system known as the Dynamic Energy Efficiency Policy Evaluation Routine (DEEPER). The model is a compact 15-sector dynamic input-output model of a given regional or national economy. The model is essentially a recipe that shows how different sectors of the economy are expected to buy and sell to each other, and how they might, in turn, be affected by changed investment and spending patterns. Setting up that recipe is a first step in exploring macroeconomic impacts as the Luxembourg economy shifts from the Second Industrial Revolution to the higher level of performance that is associated with the Third Industrial Revolution. The analysis for Luxembourg focused on the changes in larger resource productivity as well as improvements in infrastructure, information and communication technologies, and especially greater circularity, within the economy of Luxembourg. The economic assessment described here is a high level summary of these changes. The model built on an assumed reference case over the period 2015 through 2050 as reflected in a variety of data published by STATEC, the European Commission, the Organization of Economic Cooperation and Development, and the International Energy Agency, among other organizations and universities.

When comparing the Luxembourg reference case and the TIR innovation scenario, the question we want to ask is how TIR Innovation Scenario, based on the build out of a more robust and sustainable Third Industrial Revolution infrastructure and accompanying business models, might compare. The table below provides a more complete “scenario context” by underscoring the larger macroeconomic metrics associated with the difference between the business-as-usual (reference case) and the TIR Innovation Scenario.

TABLE: ILLUSTRATIVE OUTCOMES FOR LUXEMBOURG'S TIR INNOVATION SCENARIO

	Metric	2015	2017	2020
Population Growth	Inhabitants	576,192	596,303	627,794
GDP	Million $Euros_{2000}$	39,793	42,246	46,211
Total Energy Demand Reference Case	GWh	25,419	25,426	25,437
Reference Case Energy Expenditures	Million $Euros_{2015}$	1,997	2,008	2,024
TIR Innovation Energy Demand	GWh	25,419	25,122	24,243
Energy Efficiency Gain	GWh	0	304	1,194
Conventional Energy Demand	GWh	25,419	25,022	23,293
Clean Energy Demand	GWh	0	100	950
TIR Innovation Net Energy Bill Savings	Million $Euros_{2015}$	0	-14	52
Gross Energy Bill Savings	Million $Euros_{2015}$	0	0	96
Program, Policy, Transaction Costs	Million $Euros_{2015}$	0	8	16
Energy Efficiency Payments	Million $Euros_{2015}$	0	7	27
Energy Supply Expenditures	Million $Euros_{2015}$	1,997	2,008	1,928

In the row labelled TIR Innovation Energy Demand Scenario in the above table, the initial energy demand of 25.419 GWh[2] is listed in the year 2015. This is also referenced two rows down under the listing of Conventional Energy Demand. As both the energy efficiency investments kick in, beginning in 2017, and the "Clean Energy Demand" technologies begin to penetrate the market, conventional energy demand slowly drops to 0 GWh by 2050. The data also shows a significant reduction in Luxembourg's overall cost of energy services. Rather than a suggested annual cost of 2,190 million euros in the reference case, the TIR Innovation Scenario shows a much smaller energy bill of 1,369 million euros - an annual savings of 821 million euros by 2050.

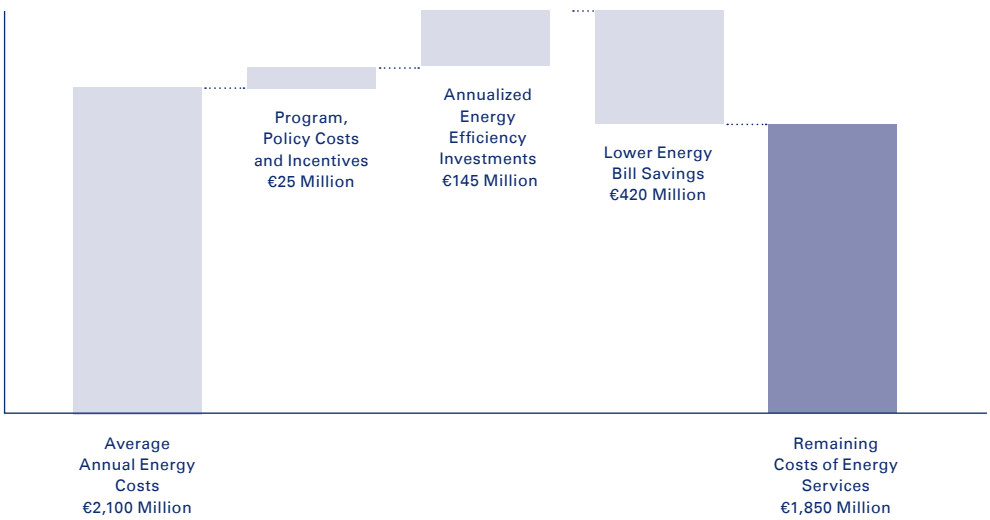
2 The 25.419 GWH of total energy demand in 2015 is a sum of total electricity demand in Luxembourg of 5.895 GWh, various demands for heat at 13.322 GWh, and local personal transportation energy requirements of 6.202 GWh equivalent. These totals do not consider the need for fuel tourism, transit, and aviation.

	2030	2040	2050	
Population Growth	745,278	884,746	1,050,315	
GDP	62,322	84,048	113,349	
Total Energy Demand Reference Case	25,473	25,509	25,545	**Average 2016-2050**
Reference Case Energy Expenditures	2,077	2,133	2,190	2,100
TIR Innovation Energy Demand	21,528	19,118	16,977	-
Energy Efficiency Gain	3,944	6,391	8,568	-
Conventional Energy Demand	15,329	7,529	0	-
Clean Energy Demand	6,200	11,588	16,977	-
TIR Innovation Net Energy Bill Savings	197	350	485	250
Gross Energy Bill Savings	334	575	821	420
Program, Policy, Transaction Costs	33	24	19	25
Energy Efficiency Payments	105	200	317	145
Energy Supply Expenditures	1,743	1,558	1,369	1,680

SOURCE: STATEC, OECD DATA/PROJECTIONS AND DEEPER MODEL SIMULATIONS

This 821 million cost reduction represents what might be termed gross energy savings. A more useful metric is the net energy bill savings in that same year. This mirrors the costs of related programs and policies, as well as the amortized payments made for the energy efficiency upgrades which will reduce gross savings in 2050 on the order of -336 million euros, down to 485 million euros. We can compare these same values as an annual average over the years 2016 through 2050 as shown in the Figure below. Instead of an average annual energy cost of 2,100 million euros, the TIR Innovation Scenario suggests a lower cost of only 1,680 million euros. So while the gross savings might be 420 million euros each year on average, paying for the additional energy efficiency investments, programs and policies reduces the gross savings to a net annual savings of 250 million euros. The remaining cost of energy services (including both the program costs, energy efficiency payments and the remaining cost of energy) is then 1,850 million euros.

FIGURE: THE AVERAGE ANNUAL PAYMENTS FOR ENERGY SERVICES, 2016 THROUGH 2050



SOURCE: JOHN A. "SKIP" LAITNER (SEPTEMBER 2016).

As beneficial as this outcome appears to be, it is merely the result of a lower total cost of energy-related resources.

At the same time, however, there are large reductions in the cost of externalities, which if included in the assessment here, would further extend the benefits of the TIR Innovation Scenario. We can also account for other social, economic, health, and environmental costs that will impact Luxembourg. For instance, following a recent study[3], if Luxembourg were to achieve a 100 percent renewable energy economy[4], the combined avoided air quality health effects and global climate-change impacts might approach 7 billion euros in further savings

3 Mark Z. Jacobson, Mark A. Delucchi, et al. (April 2016). 100% Clean and Renewable Wind, Water, and Sunlight (WWS) All-Sector Energy Roadmaps for 139 Countries of the World. Department of Civil and Environmental Engineering, Stanford University. https://web.stanford.edu/group/efmh/jacobson/Articles/I/CountriesWWS.pdf. Note that the original values reported here were originally expressed in 2013 US dollars. Those values were converted to Euros using a 2013 exchange rate of 1.328 USD per Euro.

4 At the same time, however, in the different energy scenarios characterized in the Energy section of the master plan, the most cost-effective future energy scenario is the one that increases the local production of energy to 70 percent within Luxembourg. The more cost-effective scenario is therefore the one in which 30 percent is imported from neighboring countries. This optimal TIR Innovation Scenario provides unit energy costs that are about 20 percent less expensive than if 100 percent of the renewables are generated within the region"

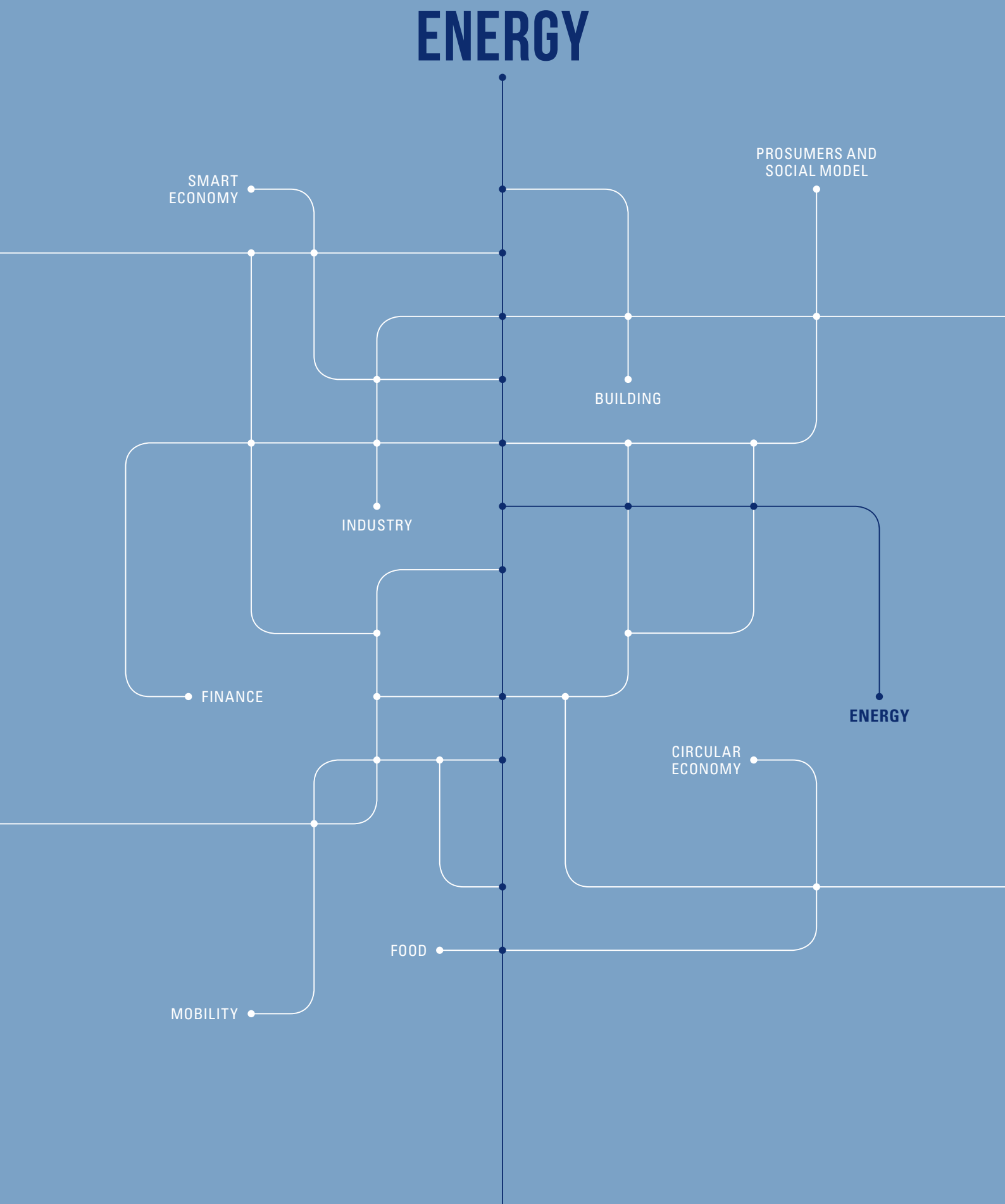
by 2050. This does not include further GDP and employment benefits that are likely to accrue from the more productive pattern of infrastructure investments, energy efficiency upgrades, as well as the deployment of large-scale renewable energy systems. Here we might imagine changes like the transportation land-use patterns, the build-up of information and communication technologies and a multitude of other infrastructure changes to optimize overall economic performance of the Luxembourg economy. Such an outcome then becomes an opportunity for a mix of more productive investments to reduce the total cost of energy services so that any remaining net costs are substantially smaller than a business-as-usual assumption. There have been several major international studies in the past few years all highlighting the potential in terms of increased efficiencies and productivity, new business models, and employment opportunities brought on by the shift to an Internet of Things smart economy. Nevertheless, the data that is now generally collected does not (yet) track either energy efficiency or productivity improvements driven specifically by the Internet of Things and by smart appliances and ICT-enabled networks.

Overall energy-related annual investments in the TIR Innovation scenario are made up of energy efficiency improvements, on the one hand, and renewable energy options, on the other hand. The volume of these investments is just under 100 million euros in 2017, growing slowly to an estimated 500 million by 2030. From there the investments decline somewhat to 377 million by 2050, with an average annual investment of 420 million in energy-related technologies. The reason for that very small reduction in annual investments in later years is because the less costly energy efficiency improvements begin to pick up more market share and penetration in 2030. This requires, in turn, a smaller contribution from the slightly more expensive investments in the renewable energy resources. Over the full period 2017-2050, the cumulative mix of annual energy efficiency and renewable energy investments will add up to just over 14 billion euros. Part of the reason is that the renewable energy costs are expected to decline over time. At the same time, however, there will be other information and infrastructure upgrades. The magnitude of these investments in ICT and connected infrastructures and platforms has still to be modelled and simulated into more detail. These upgrades might roughly triple the magnitude of investments suggested for the energy-related improvements alone. While at the moment the information does not exist in sufficient detail to provide a precise estimate of necessary investments for the non-energy infrastructure improvements, drawing from a variety of sources suggests a cumulative TIR related investment on the order of 46 billion euros. This is the equivalent of about one year's GDP invested to upgrade the infrastructure, equipment and appliances in Luxembourg over the next several decades.

Still, the lack of better data on these related costs, as they might be estimated for Luxembourg, is why the TIR strategic study emphasizes the need to establish new metrics applicable to the build out of the Third Industrial Revolution

digital infrastructure in order to facilitate future assessments. The means should be provided for collecting project data to underpin a new set of metrics. Both the data and the resulting metrics can guide next steps and aid in the assessment of how such projects might contribute to the larger social, economic, and environmental well-being of Luxembourg - beyond the initial energy-related investments and returns. It is critical, then, to develop a policy database and new analytical techniques that can inform the nation about the potential for more positive outcomes beyond an energy-led investment strategy. Among other factors, the share of costs and benefits between government, households and businesses has to be further explored.

While standard economic models and policy assessment tools have generally been able to track and evaluate many of the Second Industrial Revolution economic trends, they are not equipped to fully explore the potential outcomes of TIR-like innovation scenario. As Luxembourg tracks this data in real-time, it will be able to make critical projections on future social, economic and environmental well-being, based on the experience and insights gained at each step of the deployment. A particular focus might be documenting the costs and benefits of an interoperational digital infrastructure. This active tracking of Third Industrial Revolution metrics – again, including aggregate efficiency, productivity, reductions in material and carbon footprints, and marginal cost – will enable Luxembourg to make appropriate adjustments so that the goals are more likely achieved over the successive years.


ENERGY
SMART ECONOMY
PROSUMERS AND SOCIAL MODEL
BUILDING
INDUSTRY
FINANCE
ENERGY
CIRCULAR ECONOMY
FOOD
MOBILITY

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.

1 — STATE OF PLAY

Luxembourg is firmly embedded in Europe and its institutions. It depends for much of its economy on open access to and from other EU nations. Its population is expected to almost double by 2050, and thus the number of houses/apartments too. The need for new buildings presents an excellent opportunity to create a more sustainable building stock. Luxembourg is also a very small, open economy. About 45% of Luxembourg's total labor force is today made of cross-border workers from Belgium, France and Germany. A large part of the final energy consumption goes towards transport, specifically transit transport of goods by road, cross-border workers and ancillary fuel tourism. In order to become fully sustainable in the long run, a deep decarbonization of the transport sector will be needed.

Energy statistics of Luxembourg (2014)	
Final energy consumption (- 9.4% since 2005)	47 266 GWh
Electricity	
Electricity consumption	6 227 GWh
Electricity production	1 897 GWh
Generation from RES (+/- 20%)	369 GWh
Installed generating capacity	1.8 GW
Share of pumped-storage hydro	1.3 GW
Share of gas-fired generation	395 MW
(combined heat and power with NG, biomass and waste)	
Share of Solar PV	110 MW
Share of Wind	58 MW
Share of small hydro	34 MW
Share of steam	19.8 MW
Peak demand	1 014 MW
Oil	
Oil consumption	30 684 GWh
Natural gas	
NG consumption	7 016 GWh
Biogas injection	52 GWh
Heat generation from RES	842 GWh
Total energy import (%)	96,1%

The Grand Duchy and the TIR Consulting Group LLC have engaged in a deep collaborative initiative, designed to transform the country into the first nation-state of the smart green Third Industrial Revolution era.

2 — VISION

There is a global drive to drastically reduce CO_2 emissions to reduce the effects of climate change. The necessary decarbonisation, the depletion of fossil fuels in the mid and long term, as well as geopolitical uncertainties, require us to reduce the consumption of and our dependence on fossil fuels and replace them with renewable energy resources. Luxembourg's future energy system should therefore be based mostly on renewables, organized in predominantly autonomous regional energy clusters and supported at all levels by smart ICT infrastructure. The energy mix should be free of nuclear and coal in the perspective of 2050. In particular, wind, solar, biomass and geothermal energy will play an important role. A small share of fossil energy sources (like crude oil and natural gas) might still be part of the energy system in 2050 for back-up and transition reasons.

Initial modelling by TIR Consulting LLC and subsequent discussions with the national working group show that Luxembourg has the technical potential to generate all of its energy nationally with solar, wind, and other renewable energies. Advancing toward this goal will depend, to a great extent, on the continued technological advances that have been dramatically reducing the fixed cost and distribution cost of generating solar, wind, and other renewable energies, the impact of the EU integrated Energy Union, and the increase in energy efficiencies in Luxembourg – adjusted to demographic projections – as well as other variables.

Today's most mature, affordable, and scalable renewable energy technologies are solar PV and wind. They constitute the main components of the future energy system. The diffusion path laid down in the modelling for solar PV and wind is about 200 MW and 150 MW per year respectively from 2030 on. To illustrate the unparalleled magnitude of this challenge, this implies more new installations in both fields per year than have been installed over the last 10 to 15 years.

Since conversion of electricity to other energy carriers is currently not very efficient and therefore economically and energetically undesirable, we are facing an electrification of the energy system at a large scale. This electrification, discussed briefly below, touches on all aspects of the energy system.

SOURCES AND USE OF ENERGY

- Important **reduction of energy consumption** through increased energy efficiency in all sectors.
- Using electricity for **space heating**. Using heat pumps requires the heat demand of buildings to go down dramatically, mandating new buildings to be near zero-energy as well as massive renovation of the existing building stock.
- The potential for electrification of industrial **process heat** strongly depends on the nature of the process and will have to be assessed on a case by case basis.

- The **domestic mobility** sector will essentially rely on **electricity**, whereas CNG **will** play a very limited role as a transition fuel in the short term. LNG, hydrogen, and potentially biodiesel will only play a role for the long distance freight transport. Biofuels also have some potential to play a role, especially in aviation.
- Where building renovation fails to sufficiently reduce space heating needs or when process specifics defy electrification, natural **gas** will continue to fulfill a transitional role but can be replaced, where feasible, by central or distributed renewable energy production based on biomass or, to a lesser extent, on biogas.

ASSETS & GRIDS

- **Local and/or regional energy clusters** will become more important to reduce grid loss, increase the system's resiliency and create virtual power plants.
- Electrification of the energy system will mean an increased need for **transport and distribution capacity**.
- Due to the intermittent nature of wind and solar PV, **smart grids** are needed to continuously match supply and demand.
- To mitigate the intermittencies and prepare for seasonal effects in energy production and consumption, **storage** as well as other flexibility options, notably on the demand side level, will need to be embedded at multiple levels in the energy system.
- Where local generation is not the optimal solution, **centralized (sustainable) production plants** will provide energy (in particular electricity) and contribute to security of supply by acting as a back-up system.

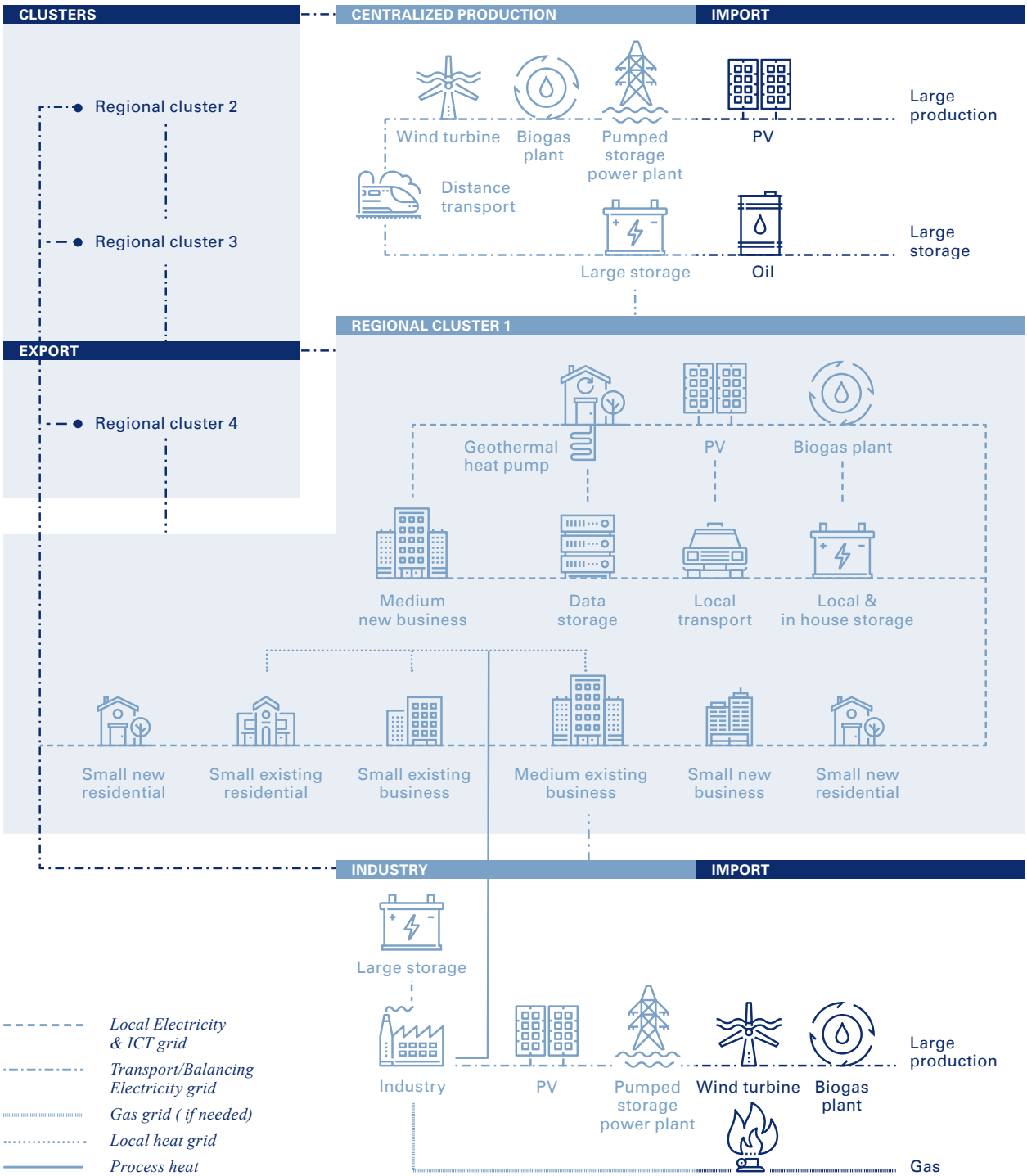
MARKETS & SERVICES

- Increasingly **integrated EU energy markets** will play a pivotal role in managing Luxembourg's **security of supply**.
- Innovative ICT solutions will be the basis of a flexible demand side management and contribute to an increased flexibility of the energy market(s).

ROLES & RESPONSIBILITIES

- As a **prosumer**, the client will play a crucial role in the future energy system.
- **Aggregators** will emerge that **accumulate flexibility** from prosumers, ensuring the available flexibility is used to the system's benefit while simultaneously mitigating the prosumer's exposure to the risks involved in participating in the energy market.

SCHEMATIC REPRESENTATION OF THE ENERGY SYSTEM 2050



To quantify the transformation path towards the envisioned energy system 2050, the following objectives for 2025, 2040 and 2050 have been identified:

Energy statistics of Luxembourg (2014)	**2025**	**2040**	**2050**
Renovation rate per year Boundary conditions: certain amount of trained resources and reaching a certain level of industrialization of the renovation process	3%	3%	3%
Energy demand reduction per capita (without petrol exports) (in reference to 2015)	-20%	-35%	-50%
% of nationally produced renewable energy in relation to the total national consumption	15%	30%	50-100%*
Imports of renewable energy	The remaining share of the national consumption that cannot be covered by nationally produced renewable energy.		

*100%: A) IF ECONOMICALLY SOUND, B) SOME NATIONAL EXPERTS INVOLVED IN THE PROCESS OF THIS STUDY THINK THAT 100% SHOULD BE TARGETED IN ORDER TO BE IN LINE WITH THE OBJECTIVES OF THE COP21 AGREEMENT

The following agreed-upon objectives informed this target setting:

- 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.

3 — STRATEGIC MEASURES

Luxembourg should aim to have a fully sustainable energy supply by 2050. It should try to achieve this by smartly and quickly adopting and extending innovations and learning experiences from current front runners. The ambition should be not just to transition to a fully sustainable energy system, but to use this transition to also drive a robust economy with less energy by smartly combining technical and market innovations and creating a SusTech sector analogous to its current FinTech sector – thus becoming a leader in the integration and application of sustainable energy technology.

Luxembourg is a relatively small country and, as a result, its influence on international developments in energy is limited. Investments, particularly in assets, are capital intensive and done for long periods of time. Europe's transition to a zero-carbon enegy system still carries a large number of unknowns. The optimal solution for Luxembourg will depend on international policy choices and technological developments that are not yet fully known. Therefore, a no-regrets strategy should be followed. An extensive and intense program of field trials should be initiated to identify and implement no-regrets as quickly as possible, thereby enabling Luxembourg to lead the pack of early-adaptors.

The table below contains five key transformational no-regret projects that will help Luxembourg in its transition to become Europe's leading carbon-free economy.

A. CROSS CATEGORY MEASURE: CREATION OF A NATIONAL ENERGY INTERNET

The Energy Internet consists of a network made of different users with a generation and storage capacity which offers a distributed and coordinated demand management as well as energy services and is the basis for the development of smart markets and new services and products. The energy grids of Luxembourg will have to be transformed into a smart digital Energy Internet to accommodate the flow of energy produced by thousands of green micro power plants. The reconfiguration of the Luxembourg electricity grid into an Energy Internet will generate new job opportunities and give birth to cleantech app start-up companies.

- Creation of a national governance structure "Smart Energy Platform" that will play a key role in defining an action plan to implement the Energy Internet in Luxembourg, as well as determining standards and the roles of the different stakeholders. The stakeholders of the smart energy platform will also need to prioritize the appropriate investments and initiate demonstration projects to facilitate a smooth transition into the Third Industrial Revolution paradigm.

- Creation of a National Energy Information system: In order for Luxembourg to be able to make the best possible decisions at any given time and be able to identify the no-regret and high-risk options at any point, an energy data monitoring, modelling and visualization platform should be created that serves as a decision support system for design choices regarding Luxembourg's future energy system and ensures that these decisions and their effects can be effectively communicated to all stakeholders.

B. REGULATORY MEASURES: INCREASE ENERGY EFFICIENCY THROUGH NEW BUILDING, RENOVATION, AND MOBILITY STANDARDS

Based on the energy performance certificate, Luxembourg has set a clear schedule for shoring up requirements in the area of energy performance for new and existing residential buildings to reach the nearly zero energy building standard. The national evaluation tool "Luxemburger Nachhaltigkeits-Zertifizierung für Wohngebäude" (LENOZ) facilitates the assesment of key performance indicators with regard to the sustainabily of buildings. Based on these experiences as well as international developments, Luxembourg should aim for an innovative set of additional standards covering the reusability of materials (circular economy), home automation, as well as "smart neighborhoods" and "smart districts".

- In line with the conclusions of the buildings pillar, the energy pillar recommends establishing a national strategy for defining the criterea of an energy efficient, smart, sustainable and circular building as well as crafting a comprehensive certificate including the different indicators. This role and responsibility could be given to the "Conseil National de la Construction Durable (CNCD)", whose vision is to help shape a more sustainable future and ensure the competitiveness of the Luxembourg construction sector through the development of its competences in the area of sustainable construction.

C. REGULATORY MEASURES: CREATION OF A NATIONAL LEGAL FRAMEWORK FOR THE PROMOTION OF RENEWABLE ENERGY SELF-CONSUMPTION

Creation of a national regulatory framework to enable the development of self-consumption. Luxembourg requires a renewable energy system strategy in which the idea of removing legal barriers for self-consumption plays an important role. Permit and grid integration procedures need to be simplified, land resource management procedures will have to be adapted, and investment in medium/large-scale renewable energy systems will need to be made. In the future, energy production and consumption will increasingly be distributed/decentralized and self production and consumption will make consumers active players in the energy transition. Passive consumers of energy will become

active prosumers of their own green energy, which they can then use off-grid to manage facilities, store, or sell back to the Energy Internet.

D. TECHNICAL MEASURE: ELECTRIFICATION OF MOBILITY

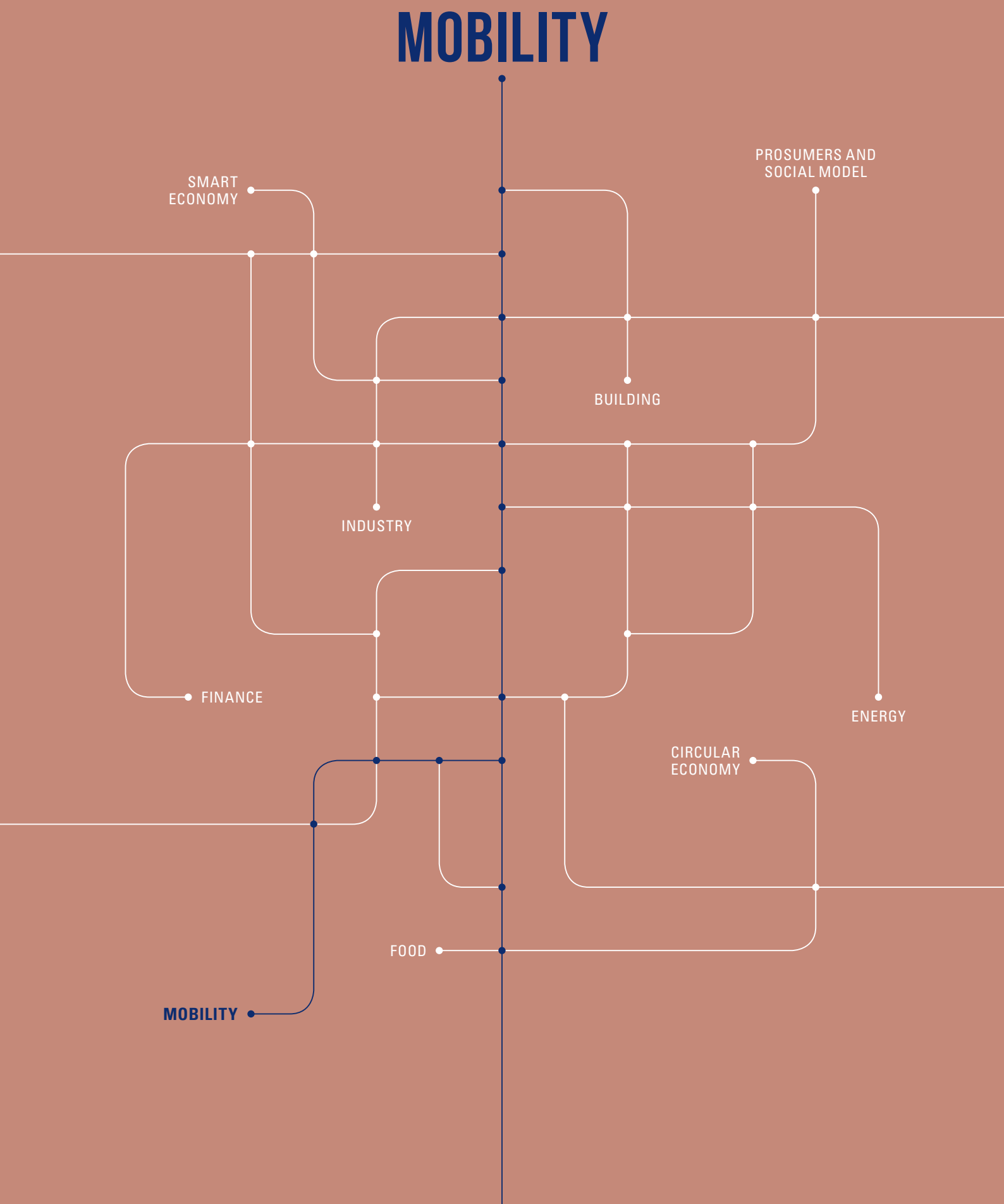
The fast development of clean mobility based on e-mobility is a key priority to meet a dramatic reduction in emissions. The mobility pillar formulated a vision to have a 100% electric fleet for passenger cars and public transport in 2050. It should be noted that Luxembourg recently outlined a plan to install 800 charging stations by 2020, which accounts for a 1 plug to 20 cars ratio. These public charging stations should be accompanied by the installation of charging stations in residential and commercial buildings. However, while switching the fleet to electric cars addresses emission issues, it does not solve the problem of accessibility and traffic congestion. Therefore, e-mobility needs to be paired with policies of car-sharing and car-pooling and with automation technologies that will help respond, in a much more flexible way, to the travel demand.

- Support two-way charging infrastructure for electric vehicles. Given the current and projected maturity, availability, and uptake of full electric vehicles, supporting the creation of a two-way charging infrastructure should be characterized as a no-regret option.

E. BUSINESS MODEL INNOVATION MEASURES: IMPLEMENT "SMART DISTRICT" LIGHTHOUSE PROJECTS

Develop and implement first experimental distribution grid clusters integrating smart meters, and smart homes as well as the smart grid in general. These experimental smart local microgrids allow the exchange of data and energy among the different prosumers aiming at an efficient intra-cluster demand side management. Lighthouse projects require the technical aspects as well the legal framework, investment solutions and governance structures. These projects create learning and testing opportunities that are specific for the context of Luxembourg and, as such, contribute to a successful transformation towards an intelligent, user-driven and demand-oriented infrastructure and accompanying services.

- Luxembourg, together with two other major cities, aims at participating in the European project Horizon 2020 – "Smart Cities and Communities lighthouse projects".


MOBILITY
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MOBILITY

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.

1 — STATE OF PLAY

The Grand Duchy of Luxembourg is located at the heart of an integrated cross-border region. This strategic position allows the country to have good connections with European road, rail, air and inland waterway networks and to stand as an important point of intersection and interaction between passengers and logistics flows. With a population potentially reaching 1 million and 320 000 cross-border commuters by 2046, the country's strong economic and demographic growth contributes to a staggering rise in transportation and mobility pressures on the economy and society.

As regards the logistics infrastructure, Luxembourg demonstrates strong competitive assets, currently ranking number 2 worldwide according to the World Bank's Logistics Performance Index. With the support of the Cluster for Logistics, Luxembourg's highly advanced infrastructure and operations will enable the country to speed its transition into a highly efficient automated digitalized transportation and logistics hub.

However, despite encouraging governmental initiatives and a proactive Sustainable Mobility (MoDu) plan, Luxembourg faces a severe mobility challenge. According to Eurostat, with 672 passenger cars per 1000 inhabitants, the country has the highest number of vehicles per capita in Europe, while the average across the EU is 486 passenger cars per 1000 inhabitants in 2013. A significant part of traffic comes from the 175.000 commuters per day, 86% of them travelling by car and representing, in absolute terms, the second highest number of cross-border commutes in the EU. This results in Luxembourg being the 4th most congested country in the EU. A major flaw lies in the lack of attractive alternative transportation. Indeed, as stated in the 2012 MoDu, public transport usage (14.5%) and active mobility (13%) are low compared to the usage of individual cars (72.5%). Car dependency is mainly driven by the following factors: urban sprawl, lack of mixed-used urban developments, centralization of economic life, and scarcity of national regulations fostering the use of clean transportation means. Adding to the critical situation of mobility, Luxembourg offers one of the most lightly taxed fuels in Europe, resulting in approximately 75% of the oil products sold consumed outside of the country.

The mobility issue is fundamental to the definition of a new sustainable economic model as transport represents the major source of energy consumption (61%) and global warming emissions in the Grand-Duchy (64%). The mobility system, as it is organized today, shows a certain number of inefficiencies. One of its greatest inefficiencies is its massive reliance on fossil fuels with negative effects on energy waste, pollution and GHG emissions. Inefficiency also comes from relying heavily on privately owned individual cars, which have an occupancy ratio of only 1,1 passengers and spend the bulk of their time standing still, typically occupying valuable space in crowded city centers. A further inefficiency which, however, is typical of our times, comes from the full reliance on a single human for driving and wayfinding. Finally, unnecessary travels, consequences

of the car-centered Second Industrial Revolution social organization, represent another major source of inefficiency. Importantly, half the trips made by car are shorter than 5 kilometers. Considering total travel time, active mobility – walking and biking – would actually be faster on those distances, let alone free up greater public space and reduce energy consumption. Unfortunately, it is a testament to the limited attractive walking and cycling infrastructure created over the past century.

In view of this, the country has put a high priority on developing new, more sustainable, and less-polluting transports. The government, during the totality of its parliamentary term, will have invested 2.4 billion euros in infrastructure and launched the implementation of several MoDu elements. Main initiatives led by government or municipalities, include LuxTram – a tramway connecting all the major areas of the city – as well as creating multimodal hubs, new train stations in the outskirts of the capital, a reorganization of the regional bus network, plug-in hybrid electric buses, a new tax legislation favoring zero emission cars for private use and low emission vehicles for company cars, installment of 1.600 public charging points for electric vehicles until 2020, the creation of national telematics project “mLive” for public transport, additional 13.100 Park&Ride (P+R) parking slots, car sharing initiatives such as CARLOH in Luxembourg City, as well as the creation of 700 km of additional cycling paths. These initiatives will significantly improve multimodality in the near future and encourage residents as well as commuters to opt for more sustainable modes of transportation. The implementation of the MoDu aims for a substantial increase of the modal split for public transport (19%) and active mobility (25%) by 2020. The existing governmental approach lays the foundational stones and sets the appropriate context for the Third Industrial Revolution transportation and mobility strategy. The challenge here resides in a shift towards a new transport paradigm, leveraging both green technologies and digitalization.

2 — VISION

An intelligent, sustainable, cohesive, and resilient mobility and transport ecosystem for the benefit of the Luxembourg society and economy.

With the fast-paced rise of its population and working force between now and 2050, Luxembourg will have to provide solutions for the increased mobility and transport needs that are foreseen. Incremental measures alone will not be sufficient to tackle this issue, the symptoms of which we can already witness today: traffic congestion, pollution, loss in productivity, impact on quality of life, etc. A change in paradigm is necessary, implying some fundamental disruptive transformations. Emerging technologies, combined with greener energies and the build-out of a favorable mobility ecosystem will be decisive to revolutionize the Luxembourg mobility and transportation system. This approach implies the conjunction of several initiatives.

A fast development of **emission-free mobility** based on e-vehicles and active mobility is a key priority to meet dramatic reduction of emissions. The vision for Luxembourg is to have a 100% electric fleet for passenger cars and public transport before 2050. Whilst closely monitoring international developments and pending the availability from car manufacturers, this means new measures favoring a shift of all new passenger cars and public transports to electric from 2025 onwards.

However, while switching the fleet to electric cars does address emission issues, it does not solve the problem of accessibility and traffic congestion. E-mobility needs to be paired with sharing and pooling systems as well as **automation technologies** that will help respond in a much more flexible and multimodal way to travel demands. Such a system, based on a performant and comprehensive transportation data structure, will enable the deployment of on-demand automated rapid personal and group transit vehicles. This flexible transport mode is expected to gain a substantial part of traffic in the next 10-20 years, thus redefining transport and freeing attractive urban space for active mobility in urban centers. Automated transport constitutes, along with the Communication Internet and the Energy Internet, the kernel of the IoT platform. Automation technologies and development of a transport data system will be a strong source of efficiency for logistics through optimized travels of standardized goods, reverse logistics and last-mile delivery. At the same time, the transport system must be resilient to extraordinary disruption of services for short and long periods brought on by cybercrime, cyberterrorism, and climate-related natural disasters.

A key component of a shift towards sustainable mobility is the development of a **rich multimodal offer** that will include car sharing, carpooling, bicycles and public transports as well as innovative transport systems, where mobility is seen as a service. All the transport solutions have to be integrated via a comprehensive data system to produce and deliver a service to support the individuals' daily plan of activities as well as logistics needs. As a result, the

ecological footprint and marginal cost of every trip will be dramatically reduced. This new concept of a so called **"mobility-as-a-service"** requires specific supporting interventions, a balanced combination of push and pull measures in order to discourage unsustainable mobility behaviors and promote sustainable ones, reducing what is called the "cost of cognitive effort" in changing behavior. This is particularly important knowing the "high powered car" ownership culture that is very present in the country.

Thus, considering the travel increase due to population and commuter growth resulting from an extrapolation of current trends until 2050, a significant shift in the modal split should be targeted (in share of daily travels): 30% of active mobility, 40% of public transports – as well as all shared transports – and 30% of individual cars.

Although a strong increase in travel is clearly foreseen, transportation needs should not be considered as an intangible given. A change in the mobility paradigm redefines the transportation system but also transforms the very way we live in society. In this holistic approach to mobility, a set of solutions is required which contributes to the build-out of a **favorable mobility ecosystem** in Luxembourg, notably through flexible working schemes and intelligent urban planning in order to avoid developments that create private cars dependency, urban sprawl, single use neighborhoods, and monopolization of public spaces. This approach underlines the importance of a shift from a constraint to a "chosen" mobility.

Last, but not least, the creation of a sustainable mobility fund will help accelerate the transition by fostering innovation and developing a "mobility of the future" Luxembourg economy. Going forward, the Grand Duchy will be increasing its attractiveness thanks to an intelligent and seamless transports ecosystem and will stand as an important testbed for smart mobility by building on its central location, its excellent ICT infrastructure and know-how, as well as the innovation driven automotive supplier sector. In the future, Luxembourg will offer companies favorable conditions through a nationwide network of intelligent infrastructures and services.

3 — STRATEGIC MEASURES

A. PROMOTING A TOTAL SHIFT TOWARDS EMISSION-FREE VEHICLES

Alongside with active mobility, the shift to electric vehicles is key to the successful transition into clean mobility and transport at near zero marginal cost. Luxembourg should employ its size and flexibility, as well as its strength, to reset the regulatory framework quickly, and promote the new e-mobility technology. This includes electric passenger cars – both owned and shared-, e-bikes, micro mobility, public transport as well as last-mile logistics. With a vision to reach the goal of 100% of this fleet being electric by 2050, it is recommended that Luxembourg enact measures requiring that all new registrations in the country be electric from 2025 onwards, whilst closely monitoring international developments. Overcoming the two main barriers to e-vehicles (EV) adoption, namely the strong purchase price gap versus conventional vehicles and the range anxiety will require proactive initiatives in Luxembourg.

- It is expected that EV will reach the same purchase price as conventional cars from mid-2020 onwards. To address the cost barrier in this early stage of EV development, strong incentives are necessary to cover the transition period. Studies show that governments in various countries have often put in place incremental incentives that have not produced the expected results. Therefore, **a game-changer incentive scheme** is recommended whereby EV purchase price does not exceed the price of traditional cars. In the short run, new fiscal instruments taxing polluting vehicles and incentivizing emission-free vehicles have to be put in place following the bonus-malus approach (fiscally neutral and polluter-pay principle). This system can be complemented by a per-usage tax, providing extra funding, which stands as an efficient tool to take into consideration the actual vehicle usage.

Development of a private charging infrastructure should also be incentivized to stimulate smart grid readiness. Photovoltaic systems installed close to the charging point that meets at least the electricity demand of the EV should similarly be incentivized.

- **A fast and smart charging infrastructure program** is recommended. To address the range question, it is essential to install a **dense network of smart bidirectional charging points** and **pre-equip**, where feasible, **any new building** with charging facilities or infrastructure facilitating them. The public charging infrastructure of 1.600 charging points (3,7 - 22 kW) until 2020 is a good starting point to promote electric mobility and reduce range anxiety. However, in order to enable long distance travels with electric vehicles, fast charging infrastructure (> 50 kW) should also be installed on highways and Luxembourg should prepare for new dynamic and inductive charging technologies.

EV charging must be smart. This means, among other things, that measures must be taken to avoid all EVs being charged at the same time. The charging, communication and billing infrastructure, must be further developed and established to enable and force smart charging. Moreover, the need for compensation and storage of fluctuating electricity produced by photovoltaic and wind is growing and can partly be satisfied by EVs. With bidirectional charging, electricity stored in EV batteries will support the electricity grid during peak periods. Lastly, it is important to promote an increase in the number of reserved parking slots with charging facilities as it will reduce range anxiety and represent an additional advantage for EV users.

- **An interdisciplinary task** force on policy (MEC, MDDI, DSO, ILR) should be assisted by the private sector and the research sector to identify the need for regulatory developments and prepare proposals. Covered subjects are numerous, such as standardized accessibility of charging points, new buildings pre-equipment obligations, energy sent back to the grid, new types of revenues and business models, sustainability of batteries, etc. The priority should be to work on infrastructure needs and **accompanying regulations** that allow only new vehicle registrations for emission-free vehicles from 2025 onwards.

- An **informative campaign** should be conducted on new measures that eliminate misconceptions – especially as regards to high range need – and educate people on intelligent recharging.

A different approach is taken for very-long-distance freight (above 1000km). Here, rail presents a sustainable economic advantage. Long-distance logistics, below 1000km, the needs of which are not all satisfactorily met by rail solutions, could benefit from a strong cooperation with neighboring countries on alternative fuel based solutions (“Future transport fuel” platform, see energy section), as the key transit questions cannot be solved only in the context of Luxembourg.

B. INVESTING IN MOBILITY-AS-A-SERVICE: A MULTIMODAL-CENTERED SOLUTION

Mobility-as-a-service is a new approach where each particular travel is offered as a service on a usage basis, as opposed to a one-off selling of a vehicle that is owned. This is strongly linked to the rise of the Sharing Economy, where usage prevails over ownership. An **enhanced multimodality**, where car sharing and carpooling are highly promoted, is central to this new seamless mobility equation.

Mobility-as-a-Service is made possible by combining and managing all transport services and trips on the same digitalized platform. Based on the current mobiliteit.lu platform, this **unique gateway to mobility** must be supported by

a robust multimodal real-time and predictive data management system able to provide users tailor-made transport solutions based on individual needs, with the objective of enabling users to enjoy a seamless on-demand travel experience. The system, represented by mobiliteit.lu, will stand as a centerpiece of the Mobility Internet. Information provided will show all public transports solutions but also P+R availability for private car transport, bikes and e-bikes availability, walking times, ride sharing options, provide booking services and road user charging, and dynamic pricing for parking depending on peak/off-peak hours. In the long run, this could also serve as a platform where people can share their autonomous car and thereby generate revenues. This single-entry system is a response to the multiplication of sharing platforms that are part and parcel of the new mobility solutions. It should be set up in cooperation with all private and public transportation stakeholders and with neighboring countries for a "Grande Region" approach that will eventually unify standardization, regulations, ticketing schemes, booking and services across the European Union.

A similar concept is emerging in the logistics field where private vehicles and private management of logistics chains will tend to be abandoned for a multimodal flexible travel capacity and collaborative networks. Multimodality should be extensively promoted, as initiated with the creation of the multimodal logistics platform in Bettembourg. A gain in efficiency will also be achieved through optimized use of passenger transportation means. Such a flexible solution, hosted on a **transports-as-a-service** single-entry platform will be managed through collaborative networks with the prerequisite to unify regulations, standards and services.

With the increased dependency on data, Luxembourg should also provide a **robust resiliency monitoring program**. This program will track traffic conditions, both for passengers and goods flows, the capacity of the infrastructure, and energy demands, which can be used as a database to model prediction scenarios for massive disruptions to the system brought on by catastrophic climate change events or cyber-crime and cyberterrorism.

C. ACCELERATING THE TRANSITION TO DRIVERLESS VEHICLES

The **automation of public transport** is an essential component of the build out of an automated transportation and logistics Internet for the Grand Duchy of Luxembourg. Driverless public transport will reduce both the fixed cost and marginal cost of providing public transportation and help expand services to low-demand areas and during off-peak times. This innovation marks the conjunction of electric, automated, connected and shared mobility. Automated public transport is already technically viable and being piloted in several cities. Luxembourg should be a first-adopter in introducing automated public transport in the EU. The **launch of an autonomous public transport system** (a.k.a. rapid

Personal and Group Transit System), offering flexible on-demand and ultimately door-to-door mobility solutions is therefore highly recommended with pilots in selected areas.

The creation of a **cluster for autonomous transports** will prepare the Grand-Duchy for the advent of autonomous driverless vehicles. Personal cars, taxis, or even trucks that can relocate themselves are a breakthrough innovation. However, they require a level-5 automation and will take longer to appear than autonomous public transport. The dedicated taskforce "smart mobility", gathering public and private stakeholders (MEC, MDDI, R&D, LuxInnovation, Cluster for Logistics), will address various aspects of automation: economic (e.g. Sharing Economy), legal (e.g. data protection issues of autonomous driving), technological (each vehicle is interconnected to each other, to the infrastructure, and Internet-connected to the cloud), and automotive cybersecurity. (see smart economy section) The update of regulation for driverless vehicles, is essential. Laws and regulations must be adjusted to make it possible in the next ten years to extend the driverless technology from small shuttles in selected areas to bigger, faster free-ranging vehicles. The scope should also include the promising role of automation in logistics, such as examining regional truck platooning opportunities. Finally, the potential of drones should be fully explored. Luxembourg could be a testbed for drone technologies.

D. LIMITING THE NEED FOR MOBILITY

Luxembourg City comprises 40% of the country's employment even though it only represents 18% of the population. Slow commutes become a key concern and companies are already finding it difficult to attract talent from neighboring countries because of increasing traffic congestion during home-work travels. Intelligent urban and transport planning that promotes dense and mixed use settlements is a critical priority to reduce traveled distances. This supposes a closer cooperation between municipal and national authorities in order to integrate urban planning with transportation and mobility planning at the national level. The shift to a Third Industrial Revolution mobility infrastructure will need to be accompanied by a **regulatory regime** that enables all the facets of mobility to operate together and seamlessly. A special focus is placed on the promotion of active mobility through **car-free and shared-space zones developments** as well as the **introduction of a network of fast-cycling lanes**.

The digital revolution and augmented and virtual reality environments will increasingly decouple work activity and the traditional working space. Telework and remote working spaces will progressively limit mobility demands in the future, and should be factored into long-term transport planning to ensure against an underutilized transport system. According to STATEC figures (2010), 7% of employees in Luxembourg work from home while ¾ of employees have no

flexibility. A dedicated taskforce should be created with the aim of adopting **new legislation on telework**. Its members should discuss various aspects such as social benefits issues, data privacy, safety, flexibility with adjustable working hours or days, and regional fiscal harmonization. The first step is to reach the target of one day of telework per week for all Luxembourg residents with compatible functions in the short-term. In parallel, **co-working spaces** should be developed in outskirt areas located near multimodal hubs for increased flexibility.

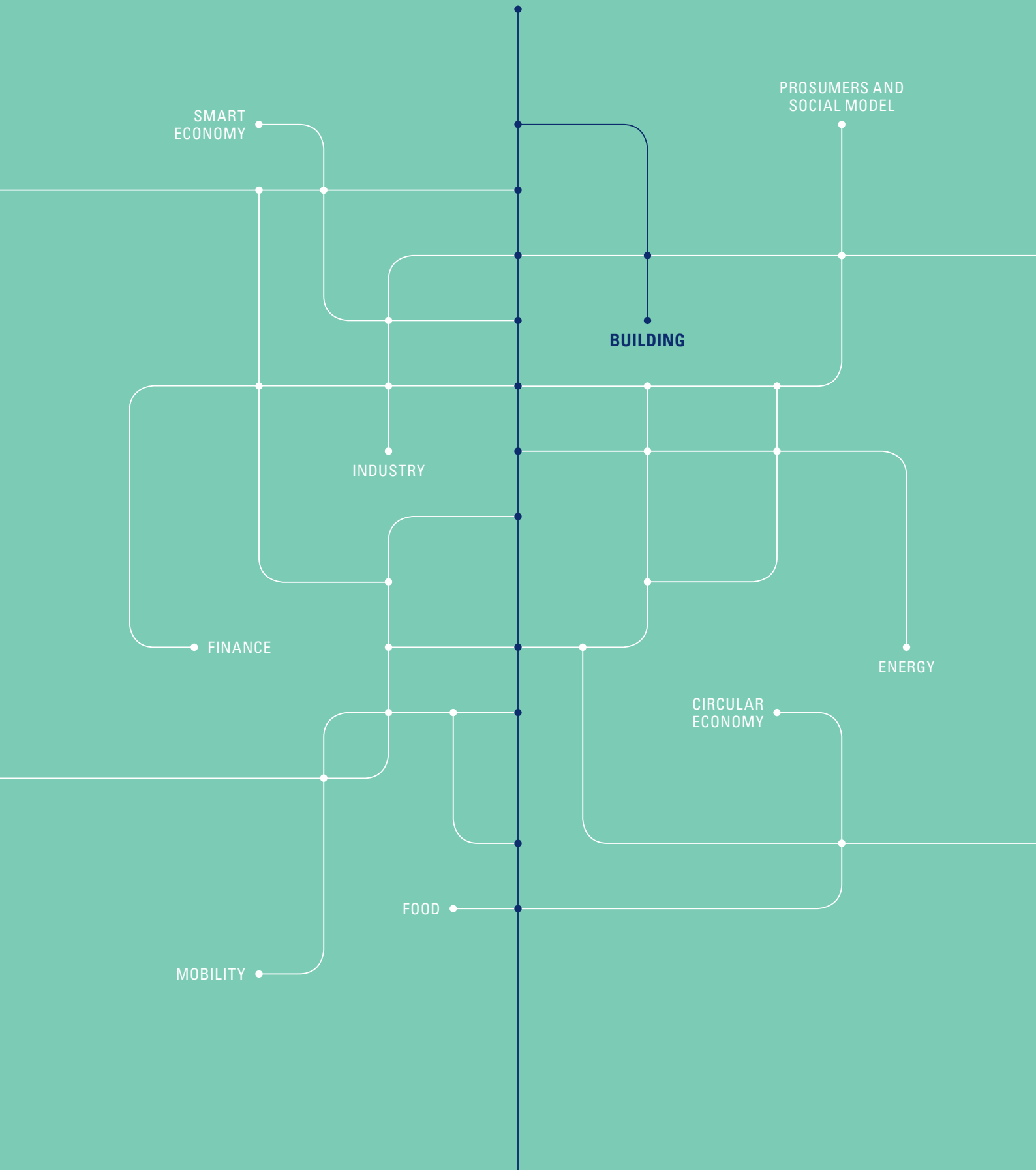
E. FUNDING SUSTAINABLE TRANSPORTS INITIATIVES

A key recommendation is to **create a Sustainable Mobility Fund** that will facilitate the development of all the above measures. It would follow the internalization of externalities principle and act as a three-fold financing tool:

- Finance additional specific incentives targeted at users (managed by the Ministry of Finance)
- Subsidize innovative municipalities on mobility developments (managed by the MDDI)
- Contribute to financing start-ups and innovative projects including on-field pilot tests and experimentations as well as research and development works (managed by the MEC)

In the phasing out period, where fuel exportation will still be important -but ultimately won't be an ingredient of the sustainable mobility future-, it is recommended that a substantial part of fuel tax revenue could be dedicated, on top of the Climate fund, to the specific financing of sustainable mobility projects. A percentage of the 2,7B liters sold revenue in Luxembourg could be directed to this Sustainable Mobility Fund. The sum allocated to this fund has to be considered keeping in mind the cost of negative externalities which are estimated to be at least 1 to 3% of the country's GDP. Potential synergies will be sought with the Luxembourg Sustainable Development Finance Platform. (see Finance section) The Luxembourg Sustainable Mobility Fund could be created in the very short term.

BUILDING


SMART ECONOMY
PROSUMERS AND SOCIAL MODEL
BUILDING
INDUSTRY
FINANCE
ENERGY
CIRCULAR ECONOMY
FOOD
MOBILITY

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.

1 — STATE OF PLAY

The building sector is a core element of the "Third Industrial Revolution" (TIR) roadmap. The built environment is responsible for 40% of the total energy consumption and 36% of the CO_2 emissions in the EU. Buildings are long lasting and play an important role in our economy as investment opportunities and properties. Noting that Luxembourg's population is expected to almost double by 2050, there is a significant opportunity to create a more sustainable national building stock.

Building statistics of Luxembourg	
Residential and semi-residential buildings	**140.172**
Single-family houses	82,9%
Apartment blocks	10,9%
Semi-residential houses	6,1%
Non-residential buildings	**4.336**
Mixed-use buildings	37,3%
Commercial buildings	21,5%
Industrial and commercial	12,5%
Agricultural buildings	10,9%
Administrative buildings	6,1%
Other buildings	11,7%

SOURCE: HTTP://WWW.STATISTIQUES.PUBLIC.LU/CATALOGUE-PUBLICATIONS/REGARDS/2015/PDF-06-2015.PDF

Almost half of the building stock was built prior to the 1970s while 17.8 % was built after the 2000s. For single-family houses, 50.5 % were built before 1970 and 12.9 % during the last 15 years. Apartment blocks are gaining in importance, and in terms of residential buildings built after 1995 the proportion of apartment blocks is greater than that of single-family houses.

Restoration or renovation of old buildings is more costly than demolition. Some 200 demolitions of residential and semi-residential buildings have been registered between 2011 and 2013, the majority of which were single-family houses. Buildings built before 1945 are the most commonly demolished (69,1%) and buildings built after 1981 only represent 2,2 % of demolitions.

Luxembourg is aiming to actively prepare and stimulate the transformation process of the building sector with the TIR. The convergence of the Communication Internet, renewable Energy Internet, and automated transportation and logistics Internet, atop an Internet of Things (IoT) infrastructure, enables to build out and scale up a new generation of buildings and accompanying infrastructure. In the future, buildings will provide perfect comfort by intelligent and efficient design and infrastructure as well as information and communication technology (ICT) systems, which can read the needs of the occupants and provide a comfortable environment.

2 — VISION

"Smart, green and circular buildings in an optimal shared and attractive district" is the vision and aim outlined by the Building Working Group (BWG). Within a district the buildings of the TIR will be energy self-sufficient by an efficient use of energy, mainly by photovoltaic generation. Buildings will be zero energy or plus energy buildings, optimizing the balance of efficiency, by insulation of the building envelope, by the passive use of solar energy in south oriented windows, and by the generation of electricity and heat using solar energy and heat pumps. The BWG's approach focuses on building and urban development that takes into consideration not only Luxembourg's economic and population growth but, equally important, the human dimension that accompanies the shift in population. The group foresaw a more people-oriented place for the buildings in a mixed and attractive urban setting. Quality of life becomes the essential frame of reference for the future build out of the Luxembourg building stock.

Buildings will be intelligent by using **Building Information and Modelling** (BIM) technologies along the entire chain from design, construction and operation to disassembly and re-use of elements and materials. This contributes to the aim of **total circularity**, where no waste is generated in the construction sector, since only **circular materials and re-usable structural elements** are used. While buildings will remain residential, they should also become **more flexible and serve multiple functions** that include data handling and storage, micropower generation, and electric vehicle charging.

Luxembourg is also emphasizing the need to ensure a **high quality of life** in the future by ensuring that buildings assist in providing a **healthy and sound environment** for the occupants. The BWG emphasizes that quality of life depends, at least in part, on the construction material. The overall aim of buildings is also to protect the occupants from the weather, from noise and bad air, and provide a healthy environment which is well tempered, provides daylight and fresh air, and enough space for people and goods. In addition, buildings will provide a favorable connection to the outside world by ICT for entertainment, information, communication and education.

Retrofitting is an **essential pre-requisite** for transforming the economy into an Internet of Things Third Industrial Revolution. With regard to the existing building stock, the group supports retrofitting when it is worthwhile compared to demolition. BWG emphasizes that old and new, historic and futuristic, should be combined by taking into account the "human" aspect and maintaining the "beauty" of a building.

An important step towards the BWG's vision is the development of **education and training**. The education programs should include courses on energy strategy and smart city or district objectives.

The TIR urban concept prioritizes an **attractive urban design** with **lively public spaces, art and culture**, integrated with state of the art ICT solutions and digital interconnectivity. The goal is to create a sense of community that promotes a cooperative spirit and advances the quality of life of all the residents.

The different fields of action in the building sector for implementing the TIR roadmap are listed below.

FIELDS OF ACTION IN THE BUILDING SECTOR IN IMPLEMENTING THE TIR ROADMAP

Buildings as physical structures and infrastructure providers

- Static structure, facades and roofs: thermal and noise insulation, weather protection, daylight use, passive solar energy use, energy generation, “eco-positive” elements, façade to public space, place for food growing
- Provider of technical infrastructure: electricity, gas, heat, cold, water / energy generation / thermal and electric storage / air conditioning
- Provider of ICT infrastructure: Cable and Wireless LAN, data storage
- Building ICT system, smart home solutions

Buildings as property items

- Property
- Rented apartments: investor – tenant dilemma
- Living space as human right = social question
- Affordability of owning and renting
- Profitability / investment attractiveness for investors
- Heritage for the new generation

Construction and deconstruction of buildings

- Design
- Planning
- Construction
- Operation
- Disassembly
- Re-use of elements and materials

Buildings as comfortable places to live

- Sufficient space for people and goods
- Protection against uncomfortable temperatures, noise, polluted air, heavy daylight
- Providing security and private space, separating private from public space
- Provide light, water, communication and information
- Supports disposal of sewage water, waste, used materials and goods

(Urban) Environment of the buildings

District as ecosystems providing key services:

- Mobility (individual, public,...)
- Social life, attractive public spaces for leisure, culture, recreation...
- Food, goods,...
- Nature, sun, water, clean air,...
- Jobs
- Health and care (children, elderly,...)
- Education (kindergarten, schools, university, professional training,...)

TIR Transformation process

- Participation of stakeholders
- Financing of investments, refurbishment
- Subsidies, regulation, legislation
- Public responsibilities
- How to introduce innovations
- Governance of transformation
- Education

3 — STRATEGIC MEASURES

The projects stated below only represent a high profile sample of the measures identified by the TIR team and the BWG. The measures featured are those that will help Luxembourg in its transition to create a more sustainable building stock.

A. BUSINESS MODEL INNOVATION (1): BUILD UP LIGHTHOUSE PROJECTS TO DEMONSTRATE SMART, GREEN, AND CIRCULAR ZERO-ENERGY DISTRICTS

The implementation of all the TIR technologies in a designated district or city with all cross-linkages between the components of each of the three internets – communication, energy, and mobility – and the IoT platform will provide a real time laboratory site for the build out and scale up of a new generation of buildings and accompanying infrastructure.

As a first step, we propose the setting-up of a **lighthouse project** that demonstrates solutions at the district level, integrating smart buildings, smart grids (electricity, district heating, etc.), energy storage, electric vehicles, smart charging infrastructure, sustainable elements and circular elements, using the latest ICT platforms. Through the lighthouse project, integrated innovative solutions can be tested and developed at a larger scale. A large number of interconnected smart buildings will create a smart district by increasing synergies and decreasing costs. We recommend that the lighthouse project be set-up in an attractive district. This would give us a successful transformation model.

- Luxembourg, together with two other major cities, aims at participating in the European project Horizon 2020 – "Smart Cities and Communities lighthouse projects".

B. BUSINESS MODEL INNOVATION (2): INTRODUCE INTEGRAL AND SUSTAINABLE CONCEPTS TO THE CONSTRUCTION SECTOR

To unblock the efficiency potential of the digitalization of the construction sector, it is recommended that Luxembourg establish a Building Information Management (BIM) where all participants in the supply chain access the same dataset of a building and add their results to this dataset, which then can be directly used by other actors.

- Effort should be focused on the development of the **national BIM strategy**, together with all the stakeholder groups of the construction sector, to assure a high acceptance of the concept. We recommend that the BIM system would become mandatory for all non-residential buildings and that the process would be extended to all residential and private buildings.

Luxembourg should develop and implement minimum legal standards for healthy design, construction, and disassembly. The already existing Energy Performance Certificate (EPC) and the sustainability guideline "Luxemburger Nachhaltigkeits-Zertifizierung für Wohngebäude" (LENOZ), assess the energy efficiency and the sustainability of buildings. In addition, it is also essential to develop a set of key performance indicators to assess the smartness of a building, and the feasibility of reuse and recycling. Based on all the indicators, a comprehensive **TIR certificate** should be developed that includes energy efficiency, sustainability, circularity, and smartness.

Additionally, the efficiency improvements can only be achieved if construction elements and materials are reduced, reused and recycled after the end of life of the building. It is necessary to develop a **"material databank for buildings"**, which gathers all information on materials (origin, volume, environmental data, etc.) used in a building from construction to disassembly. This will allow automated lifecycle assessments of buildings during the planning phase and the optimization of design based on the assessment of materials used.

- Set-up a national strategy for defining smart, sustainable and circular buildings as well as a comprehensive certification process for recognizing smart, energy efficient, green, and circular building standards implementation. This responsibility could be given to the Conseil National de la Construction Durable (CNCD)", whose mission is to help shape a more sustainable future and ensure the competitiveness of Luxembourg's construction sector through the development of its competences in the area of sustainable construction.

C. REGULATORY ISSUES

A first important step to stimulate the TIR transition is working on the regulatory and supervisory framework by abolishing outdated laws and focusing on continuous improvement of the legal framework to accelerate smart innovations in the building stock.

The existing legislation should be adapted to reflect the considerations stated below:

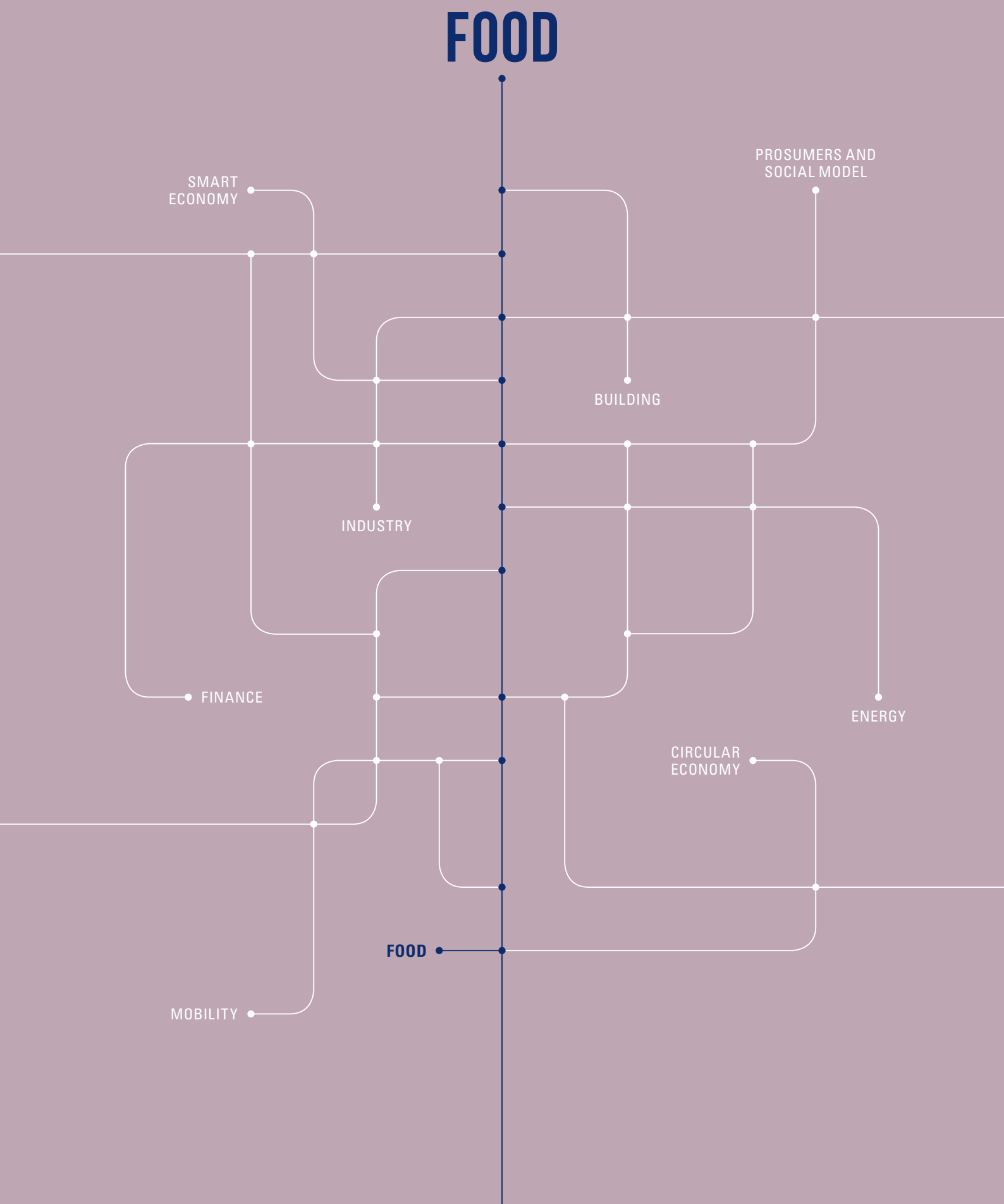
- Establish legislation to stimulate refurbishment of buildings: the creation of a national long-term strategy for mobilizing investment in the renovation of the national stock of residential and non-residential buildings is a pre-requiste for transforming the building sector. The national long-term strategy will include the critical elements of the TIR roadmap. Once finalized, Luxembourg can begin to implement an action plan for refurbishmet of residential buildings. (first by start-up projects and in a second phase by developing a massive scale-up of houses/buildings).

- Legislate urban context-adapted density and high-rise construction: spatial planning should be reviewed with the emphasis on increasing density in appropriate urban settings. These aspects are considered in the new sectorial plan for housing and specified in the annex of the program "directeur d'Aménagement du territoire". With the expected population growth, the design of cities and villages will need to follow a different path in order to reduce the consumption of space.
- A mobility concept which frees up more public living and meeting spaces and is in line with the TIR mobility roadmap.
- Requirements for key performance indicators for eco-design and the use of eco-materials in a circular economy.
- Measures to provide high resilience against natural disasters.

D. EDUCATION

Another important step towards the TIR transformation process is the development of **education and lifelong training**. It is recommended that specific units on energy efficiency, smartness, sustainablitiy, and circularity are promoted in new educational programs in all the education layers. The changes of the future as well as the new living concepts need to be continuously communicated to a smart citizens of all age levels.

Digitalization will also enhance the design process in transforming buildings and require the coming together of skills across academic disciplines. Luxembourg should also support **research programs** on sustainable materials, construction elements, integration of functionalities, reusability of elements etc. Consideration should be given to transforming the University of Luxembourg into a "Living Lab" where various academic disciplines can collaborate in the research, development, and deployement of TIR concepts.


FOOD
SMART ECONOMY
PROSUMERS AND SOCIAL MODEL
BUILDING
INDUSTRY
FINANCE
ENERGY
CIRCULAR ECONOMY
FOOD
MOBILITY

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.

1 — STATE OF PLAY

The food sector is a major consumer of energy in Luxembourg and across the European Union. The cultivation, harvesting, storing, processing, packaging, and shipping of food to wholesalers and retailers, use massive amounts of energy. Petrochemical fertilizers and pesticides account for a significant portion of the energy bill. Operating farm machinery is also a major energy expenditure. In the EU, the cultivation of crops and animal rearing use the most energy in the food value chain, making up one third of the energy bill. Industrial processing makes up another 26% of total energy use, while food packaging and logistics uses 22% of the total energy expended. Final disposal of food waste makes up about 5% of total energy use; food waste is also growing, from 89 million tonnes in 2006 to 100 million tonnes in 2014 and is projected to grow to 126 million tonnes by 2020 at the EU level. Animal-based food production and refined food products require more energy than fruits and vegetables.

When all the energy cost of food production, distribution, and recycling are added up, EU agricultural food production is a whopping 26% of the EU's total energy consumption annually, making it a major contributor to greenhouse gas emissions. The food sector has lagged woefully behind other commercial sectors in increasing renewable energies, with only 7% of total energy used coming from renewable sources, in sharp contrast to 15% in the overall energy mix. Weaning Luxembourg's food sector off of petrochemical based farming is a formidable task.

The Grand Duchy of Luxembourg represents 2.586 km2 of highly diverse landscape – in the North, Ardennes Eifel (volcanic geology: 300 – 550 m NN) and in the South Bassin parisien (sediment geology: 120 – 300 m NN). 1/3 is covered by forests. 50% are agricultural of which ½ are permanent grassland, i.e. 1/4 of the total area. Luxembourg has three natural parks: *Uewersauer, Our, Müllerthal and 66 Natura 2.000 zones.* These areas cover a big part of the territory, and have high bio- and agro-diversity potentials. Less than half of the agricultural land is owned by the farmers themselves. This renders the change in the use of land difficult. Furthermore, premiums per ha flow indirectly to the landlords via higher rents.

Luxembourg's food and agricultural contribution to GDP is approximately 0,3 percent. The gross value added from the agriculture sector has fluctuated over the past two decades from a high of 164 million Euros in 2002 to a low of 80 million Euros in 2009. Milk (26.5%) and forage plants (28.4%) represent more than half of Luxembourg's agriculture sector total value.

Luxembourg's agricultural activity is completely open to the common market of the EU, which is again increasingly open to the world market, due to the liberalization of the common agricultural policy. The dependency on international markets will, with no doubt, continue to increase in the future.

At a worldwide level, the current state of agricultural product prices are very low and frequently below the break-even point price for basic agricultural commodities for the medium size farms in Luxembourg, (mainly meat, milk products, and cereals). It is expected that by 2050 global agriculture yields will decline by 25% due to climate change, even as the global population increases, leading to a 70% increase in demand for food products. The "no crisis" scenario implies a growth of +95% in food production by 2050. Thus, the international market prices of all agricultural products will increase due to the pressure in food demand.

Regarding climate change, Luxembourg's agriculture sector was responsible for 5.65% of the nation's total GHG emissions per year – or approximately 614,000 metric tons (mt) in 2012. Emissions from agricultural soils constituted the largest fraction (45.3%, 278,000 mt), followed by enteric fermentation (35.8%, 220,000 mt) and manure management (18.9%, 116,000 mt). Land-based CO_2-equivalent emissions were reduced through LULUCF (forestry) activities by 515,000 mt between 1990 and 2012, along with a 46,000 mt reduction from grasslands during the same time period. Overall, agriculture emissions declined by 10.2 percent, despite the increased emissions of 37,000 mt due to the expansion of cropland.

Added Value faces complications due to the terms and conditions set out by the EU's Common Agricultural Policy (CAP), which provides EU farmers' annual Direct Payments under the diverse support schemes. According to the most recent EU Regulation No 1307/2013, Luxembourg's net ceiling is set at 33.6 million euros in 2015, slightly declining to 33.4 million euros by 2020. In addition to the first pillar, the second pillar of the CAP, implemented by the national Development Program and by the new "agricultural law" (Loi du 27 juin 2016 concernant le soutien au développement durable des zones rurales) provides for almost 70 million euros per year of financing, mostly for agri-environment and climate measures, for investment aid, and for innovation partnerships.

Luxembourg is classified as a less favored area (therefore all farmers get annual compensatory payments). This regime is in a reform process as new CAP standards regarding geology, climate, and soil will have to be assessed and applied. It is not sure if this status will be retained for the whole territory.

As of today, approximately 10% of the groundwater is distributed as drinking water, i.e. approximately 7.000 m^3, have to be further treated to eliminate the water pollution from agricultural sources in particular due to the presence of metabolites of phytosanitary products in the water (métolachlore ESA, métazachlore ESA). The additional cost of water treatment paid by consumers is estimated at 0,3 - 0,5euros / m^3 or about 1.000.000 euro / year (purchase price, construction of new infrastructures of drinking water).

Luxembourg's farmers get EUR >50.000,-/farm as yearly premiums. This could be converted into a basic income, once the farm complies with sustainability standards. This is linked to the high average size of 64 ha/farm, and the fact that the farms are mainly fulltime family businesses in dairy and beef production on grassland.

Nevertheless, Luxembourg's agriculture will continue on while trying to compete in international markets: the net income of farmers is lower than the compensatory payments. This is true for conventional farms and for organic farms, except for fruit, vegetable and wine production.

Importing alimentary goods will stay a necessity in the future and initiatives like *Urban Gardening*, *Permaculture* and *Aquaponic* systems are highly welcomed.

A SAFE, HIGH QUALITY, TRANSPARENT AND SUSTAINABLE FOOD SECTOR.

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

Luxembourg should **develop and settle its agriculture in a niche**. If the whole country goes sustainable (organic), every drop of honey, every mushroom, every apple and pear as well as milk and bread, will be free of contaminants. The quality of the surface waters and our drinking water supply will improve in the long run.

The transition into sustainable, organic, biologic, and ecological agriculture will need to occur quickly and smoothly. To make this happen, we will need foolproof and practical indicators assessing the short, mid and long term evolution towards sustainability on each farm and industry.

Sustainable agriculture can be defined and assessed by the underlying production processes and the collateral deeds. Therefore, we need a full, transparent and regular (= annual) accounting of food production to weigh the beneficial influences and potential damage of all the inherent material flows driven by photosynthesis and human-made actions. A sustainable agriculture should minimize nutrient losses, maximize net/solar energy output, maintain or enhance soil fertility, minimize GHG emissions, maximize carbon sequestration, and optimize profitability. To achieve those objectives, farmers and gardeners need to maximize biological efficiency by intensifying the underlying natural processes. This fundamental approach of analysis and assessment has been evolving in Luxembourg for more than 20 years.

By gaining domestic market experience and accruing performance gains from learning curves throughout the renewable energy supply chain and value net, Luxembourg can create additional business opportunities to export this model to other regions.

Besides the enhanced use of the natural life cycles in the production of food, farmers will continue to invest in the renewable energy sector. Today, they already produce a significant percentage of the total renewable energy in Luxembourg through photovoltaic panels on the roofs of their barns and stables as well as their dense net of biogas plants fermenting mainly slurry, food waste, and corn.

3 — STRATEGIC MEASURES

A. LUXEMBOURG SHOULD ACCELERATE THE LOW CARBON ECONOMY AND ENERGY TRANSITION BY IMPLEMENTING RENEWABLE ENERGY ON FARMLAND

Shifting Luxembourg to renewable energy resources is a promising option. The nation is dependent on imported oil and natural gas, and a large percentage of imported electricity. For Luxembourg's farming community, introducing wind and solar harvesting technology may offer a diversification of their source of revenue. These revenues could alleviate the economic conditions that many in the farming community have faced for years.

Luxembourg should continue to support the creation of **farmers' energy cooperatives** to facilitate the expansion of farm-based energy production (solar, wind, and biogas). The financial security from onsite energy production systems also enables greater flexibility in eliminating petrochemical inputs through ecological methods and organic practices.

A key recommendation is establishing a public-private partnership between key government agencies, industries, and research institutions at the national and local levels to develop the action map for accelerating the transition to more renewable energy projects in the food sector.

Luxembourg's food sector can be a laboratory in research on the food sector. Luxembourg's agriculture sector has the great advantages of outstanding research institutes in composite plastics, as well as world leading corporations on composite materials. One of the areas worthy of additional research and analysis is to determine the added-value for farmers in cultivating feedstock and/or gathering a percentage of residues for use in the bioplastic materials industry.

Farmers should also be at the forefront of significantly **reducing the high level of CO_2 emissions and other pollutants towards zero**. Luxembourg's per capita CO_2 emission levels are more than twice as high as the EU average.

Electric pick-up trucks are becoming available, ready to help farmers' frequent mobility needs, like 20 to 30 kilometer round-trips to feed and part stores, chores in the fields, going to and from grain elevators, moving loads, etc. The excellent torque of electric motors would be a benefit for hauling animals or towing trailers. In addition to displacing fuels and emissions, there are other benefits. For example, sensors are embedded into each electric motor that monitors torque loading. There are other sensor and controller feedback communication features capable of performing a number of other real-time fine-tuning and optimizing adjustments. Fuel costs can be reduced by one-fourth by using electric motors to replace hydraulics.

B. LUXEMBOURG SHOULD ESTABLISH A ROADMAP TOWARDS SUSTAINABLE FOOD PRODUCTION

The transition to a post-carbon economy pushes agriculture in establishing a new era of best sustainable practices by optimizing the overall material and energy flows on each farm while dramatically reducing the ecological costs and marginal costs of operations. **This may position Luxembourg agricultural products as a premier global brand, noteworthy for the care, stewardship, and regenerative approach to farming, which results in healthy, nourishing, safe products that citizens can trust and prefer**. The ecological brand goes hand-in-hand with obtaining a premium price for Luxembourg agricultural products.

Moreover, Luxembourg's government strongly promotes ICT innovations through collaborations between advanced research centers and business firms - innovations including High Performance Computing (HPC), Big Data Analytics (BDA), high-speed Internet connectivity, computational visualization, geo-informatics, smart wireless sensor networks, blockchain distributed ledger technology, and more. All have great relevance in the designing, siting, engineering, constructing, operating, and blockchaining of the electricity and monetary transactions between farmers, transmission companies, and consumers.

Blockchain technology has emerged as a valuable transaction and activity tracking tool that can be applied all along the agricultural value chain to build consumer trust and confidence in the health and safety of food products. Organic food and farming methods are critical to sustainability and the long-term health of a population. The biggest challenge that these inherently decentralized farming methods face is that they must compete with the economies-of-scale of large agribusinesses. The solution has been for farmers to cooperatize their marketing and sales efforts to try to boost their bargaining power. However, there is a fundamental difficulty because large-scale buyers can't be assured that the production coming from multiple producers is of uniform quality. The blockchain offers a potential solution as it can be used to keep track of authenticated credentials of producers in employing sustainable farming practices that significantly reduce the ecological footprint. In a blockchain, a farmer is unable to alter the record inserted by whatever body is employed to periodically verify that he or she is meeting required standards. As bio-sensory technology advances, this authentication process can be increasingly automated and increasingly trustworthy.

C. LUXEMBOURG SHOULD ENCOURAGE NEW RELATIONS BETWEEN CONSUMERS AND PRODUCERS IN COMMUNITY SUPPORTED AGRICULTURE'S (CSA) AND PROMOTE NEW HABITS OF CONSUMPTION IN THE FOOD SECTOR

The nation's growth in organic products has been expanding by 5 to 10 percent per annum in recent years, accounting for roughly 3 percent of agriculture production. Luxembourg reportedly has one of the highest per capita consumption rates for organic products in the world, although more than 80 % of the organic products are imported. While there is a National Action Plan and policy supported by the Ministry of Agriculture promoting organic food research, consumer awareness, educational programs, training, and marketing support, the nation's farmers are not responding or converting to organic.

One possibility deserving to be explored is to work with farmers to phase in smart farming methods, which help them transition into sustainable crop and animal production while reducing the need for as much petrochemical inputs (fuel, fertilizers, and pesticides). **Implementation of ICT-based knowledge tracking and decision support systems is integral to achieving low-input agriculture systems**. ICT-based apps and healthy food platforms can also be employed to engage more citizens in participating in Community-Supported Agriculture. **This process would help persuade farmers of the market demand for healthy, safe, and nourishing food products**. **Luxembourg should set up a quadruple helix innovation network platform focused on creating an open source GPS-based inventory map of all intra urban land sites capable of growing food** as well as an inventory of land sites that may need detoxification prior to being used for food production. An inventory of available land is a first step in an ongoing process of informing citizens of the opportunities in engaging in local gardening and food production.

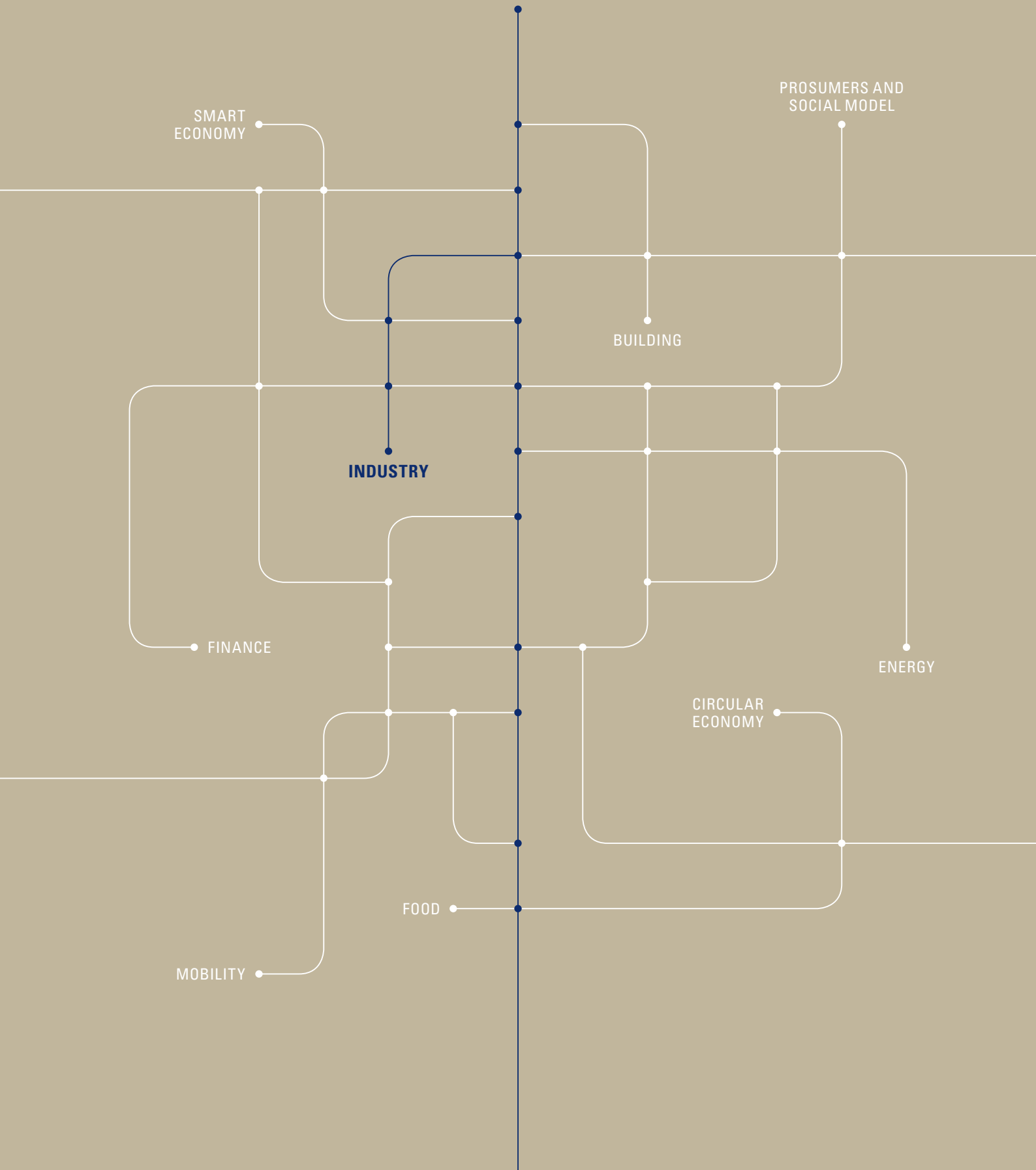
Food is lost and wasted after the farm gate and in particular at the retail and consumption stages. Waste streams are created at every level of the agro-food value chain and it is important that these be managed appropriately, in order to reduce the waste stream impact on the economy, society and the environment. The strategy of the 3 Rs (reduction, reuse and recycle) should be adopted.

Urban and suburban community gardens, occurring in both public spaces and on the grounds of private institutions and companies, are a well-established phenomenon worldwide. An estimated 15% to 20% of total global food production is currently grown in cities and communities. Luxembourg might take on the task of Internet mapping the nation's available community lands for expanding gardens, and making this open source platform available to citizens

wanting to engage in gardening. Given that there is wide variation in the productivity of urban farming and garden growing techniques, as well the range of practices, including or excluding the use of pesticides, the Internet platform can provide apps that effectively engage and educate citizens on how to significantly increase produce yields entirely through organic production methods.

The education system at all age levels offers a valuable focal point for engaging youth about the food system. It is a well-observed social phenomenon that young start-up enterprises are mainly comprised of youthful entrepreneurs. Gaining experience in the art and practice of gardening ranks as one of the finest applied learning opportunities, opening a potentially life-long interest in healthy food cultivation, whether pursued as a career or a recreational past time.

INDUSTRY


SMART ECONOMY
PROSUMERS AND SOCIAL MODEL
BUILDING
INDUSTRY
FINANCE
ENERGY
CIRCULAR ECONOMY
FOOD
MOBILITY

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.

1 — STATE OF PLAY

The Grand Duchy of Luxembourg has a long-standing industrial tradition. In the late 19th century and throughout the 20th century, iron and steel production overshadowed all other forms of economic activity and accounted for about 80 per cent, by value, of all forms of production. However, in the 1970s, the iron and steel industries fell on hard times. Despite the challenges, the Luxembourg industrial sector managed, in succeeding decades, to establish a healthy mix of large and medium-sized industrial enterprises in an environment that is constantly changing. Industrial diversification was and is still a permanent objective for the country and the only realistic course to maintaining a vigorous industrial base able to keep pace with changes in technology and society. This would not have been feasible without a wide ranging set of advantages which helped to make Luxembourg an attractive territory for industrial production processes. The central location of the country in Europe, its social-political stability, and its rich pool of qualified and multilingual workers, represent a set of appealing attributes that have helped Luxembourg attract foreign direct investment and establish the activities of several world class enterprises.

Nowadays, the country hosts a large and diverse number of industrial enterprises. The iron and steel industry is still a key player in Luxembourg's economy. In addition to the long standing steel industry, the country boasts several other industrial actors in domains such as the processing and manufacturing of metals and the chemical industry with its main activities evolving around processing chemical products. Luxembourg also hosts companies involved in the production of non-metallic mineral products, glass products, woodworking, and other raw material used in the construction sector. The food industry and the manufacture of beverages and tobacco are also important historic players in Luxembourg.

The very notion of what constitutes an industry is metamorphosing with the introduction of the digitalized Third Industrial Revolution paradigm. The shift to a digital infrastructure brings with it new business models and business practices that converge products and services in an economy that is moving from conventional ownership in markets to non-traditional access to services in networks. The shift to a digital infrastructure will bring with it not only new business practices, but also significant challenges.

The convergence of the Communication Internet, the digitalized Renewable Energy Internet, and the digitalized automated Transportation and Logistics Internet atop the Internet of Things platform will create a paradigm shift for Luxembourg's industries. Huge opportunities lie ahead that may allow the various players to dramatically increase their productivity and reduce their ecological footprint and the marginal cost of managing, powering, and moving economic activity across their value chains. Industry 4.0, 3D printing, virtual design, robots that learn on the job, and augmented reality work environments will benefit all of the key industrial sectors of Luxembourg. Additive manufacturing and con-

sumer-scale 3D printing reveals the significant potential value to be gained in a wide number of manufacturing venues. Ultra-light materials are being fabricated in the aerospace industry for achieving dramatic fuel savings from light-weighting everything from passenger seats to the skins of aircraft bodies and wings. Freeform curves, lattice structures and intricate shapes that do not follow predictable geometries, are being 3D printed in ways unavailable in traditional manufacturing processes.

2 — VISION

Waves of disruption have regularly challenged companies in Luxembourg. Some companies disappear while new ones emerge. Hence it is important to detect the opportunities of tomorrow and help existing companies to reinvent themselves and to support promising new startups that might become the leading actors of tomorrow's Third Industrial Revolution.

As such, a bold vision statement sums up what the Luxembourg industry intends to be:

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

The vision should provide guidance and inspiration throughout this transformational process. It is a brief, but powerful statement. It is aimed at helping all stakeholders in their efforts to address the opportunities and challenges of the Third Industrial Revolution. The first part of the sentence "An internationally recognized platform for sustainable industrial excellence" represents the goal that the Luxembourg industry would like to reach, while the second part of the sentence "innovative solutions" stands for the means required in order to reach this goal. It is important to stress here that the vision is a unique statement only applicable in the context of the Luxembourg environment.

GLOSSARY:

Internationally recognized Platform: a vibrant cluster of stakeholders who have a strong vested interest in the development of Industries. These stakeholders come from both the public and private sector. The concept of the Public Private Partnership is the cornerstone of the entire initiative.

Sustainable: mindful use of resources (energy and raw materials), growing people (safe and skill-enhancing working conditions) and profitable. The principles of the circular economy are fully acknowledged and recognized.

Industrial Excellence: production of world-renowned and high quality industrial products. The Business Model for these products may be a standard purchase model of a product, or the delivery of this product as a service.

Innovative: research fueled, symbiotic link between research and industries. The focus is on applied research.

Solutions: offering solutions (products, services, hybrid models) to end-customers.

While the vision statement describes what the Luxembourg Industry wants to be in the future, the working group proposes, as well, a mission statement in the form of a promise of what it wants to do in the future. The mission statement should guide the actions and strategies, provide a path forward, and inform the decision making process.

"DEVELOP AN ECOSYSTEM THAT WILL BE A FERTILE GROUND FOR THE DEVELOPMENT OF INDUSTRIAL PRODUCTS AND SERVICES WHICH WILL BE INNOVATIVE, MINDFUL OF ENVIRONMENTAL IMPACTS, THRIFTY IN THE USE OF THE EARTH'S LIMITED RESOURCES AND ENABLE THE TRANSFORMATION OF THE ECONOMY FROM A CARBON FOSSIL MODEL TO RENEWABLE ENERGY."

A. BUSINESS MODEL INNOVATION

1. Leverage and empower the "Haut Comité pour l'Industrie" [High Committee for Industry] to develop an industrial eco-system.

The High Committee for Industry is an established national board with high representatives from government, industry and research. The mission of the High Committee for Industry is to assure regular exchanges between members of the government and experts from the industrial sector, with the objective of safeguarding and supporting existing industries and creating an environment conducive to helping establish new industrial activities, support industrial actors active on the international market, and identify new activity niches.

The High Committee for Industry is also charged with the task of providing an in-depth and holistic overview of the current economy, and giving guidance as to the opportunities and challenges faced by Luxembourg industries and would be an ideal platform for the main actors to meet regularly and set priorities for the development of an industrial eco-system according to the Third Industrial Revolution principles. Stakeholders include: companies, actors in research and development, government agencies, and the Business Federation of Luxembourg (Fedil).

B. TECHNICAL

2. Develop technology platforms for co-located industry and university researchers working on common transversal issues.

Luxembourg will need to develop an ecosystem strategy that encourages, stimulates, and increases the innovative capacity of industrial companies. There are several high potential domains of common technology platforms, such as the IPCEI on High Performance Computing and Big Data Enabled Applications, which comprise wide-ranging and transversal benefits for FinTech, Smart Space, Smart Agriculture, Smart City, Smart Energy, Smart Water, Smart Building, Smart Mobility, Personalized Medicine, Smart Manufacturing, Smart Materials and Civil Protection. Robotics is also a promising field covering a broad scope of areas such as small flexible robots, ergonomics, automated guided vehicles (AGVs), lifting and "Pick&Place". The National Additive Manufacturing Centre, National Composite Centre and the Automotive Campus are recent initiatives on the national level pointing in this direction. It is essential to align national research (university & public research centers) with the needs of industry and other beneficiaries, to foster serendipity innovation, risk sharing of research and

innovation, and mutual learning. It will be crucial to promote complementary multi-industry public-private-partnerships, with stakeholders collaborating on common topics with governmental and financial (public and private) support. Transversal issues can be addressed (e.g. energy efficiency improvements) by including cross-sectorial, cross-application products and services, creating critical mass in product and service lines and through the valorisation (duplication) of innovation in different industrial applications, market segments and sectors that may benefit several stakeholders. Setting up enabling technology platforms will help facilitate cost reduction of RDI through the sharing of resources (researchers, equipment, facilities, etc.), developing new applications, and providing foundations for innovation (proof of concept, scale up, industrial transfer, mass production) through equipment, pilot lines, enabling platforms, technology and infrastructure. Several challenges have to be faced and certain sub-measures taken into account such as: overcoming the difficulties of up-front investment from private industry when no direct return on investment is involved, and garnering public support to put the initial technology platform in place and have the private sector subsequently contribute in the second phase. Moreover multi-partner PPPs are quasi non-existent; there is a lack of critical mass in multiple markets, sectors, and domains and the European state-aid rules are becoming more stringent.

3. Set up a data driven, visually mapped, inventory of exergy opportunities.

This kind of exergy platform would take the form of compiling all of the energy, water and resource consuming processes and equipment in the industry sector. This is the first step in developing a living roadmap and action plan for implementing exergetic efficiency and productivity by tracking down, for instance, sources of waste heat, residual materials and energy consumption. The exergy data visualization platform may also be used to make aggregated purchases and procurement of high efficiency equipment upgrades.

C. FINANCIAL

4. Build an acceleration program for start-ups whose vision is to create products and services aimed at reducing carbon footprint and advancing other environmental benefits.

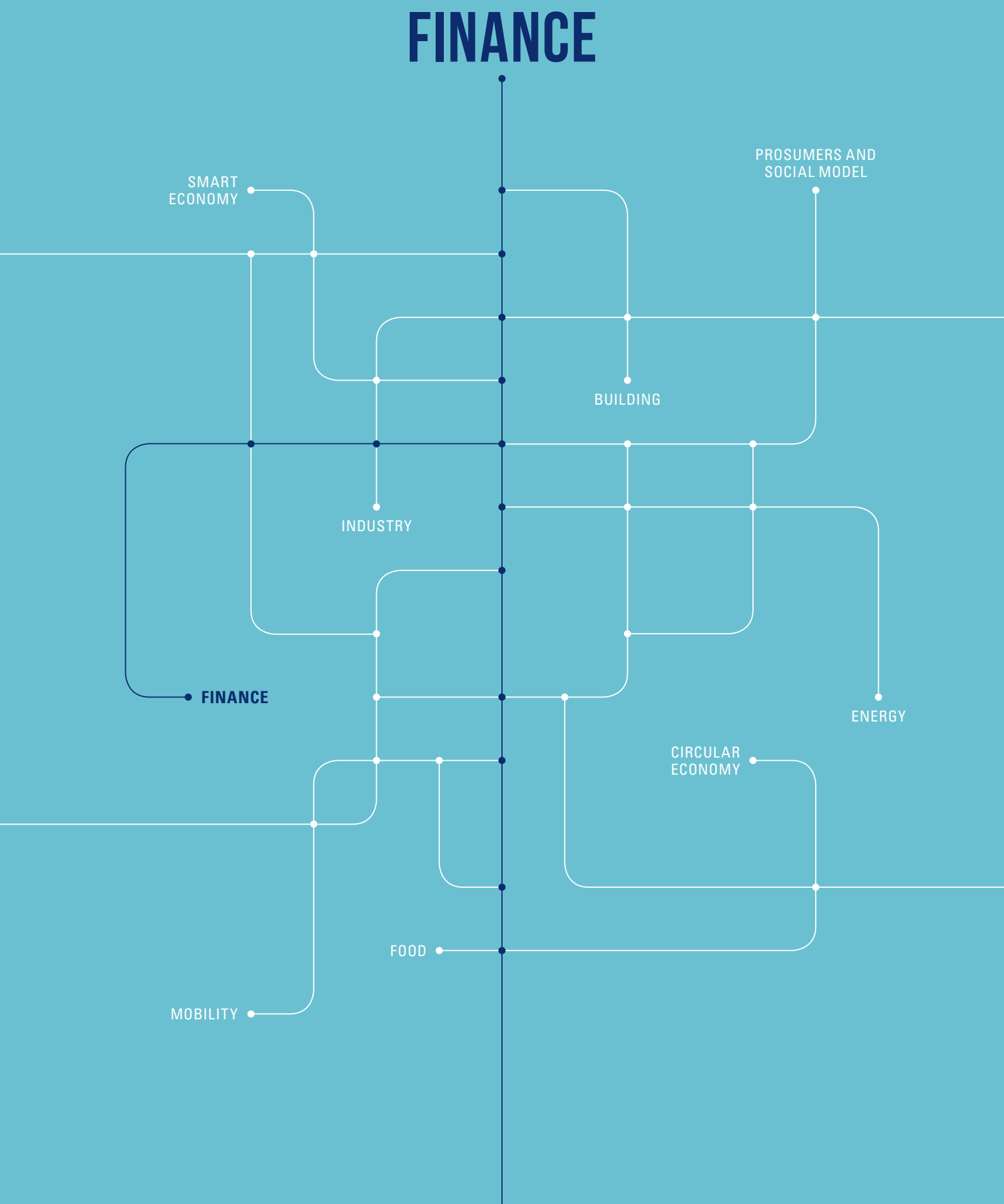
Innovation is the battleground of the future. Luxembourg is focusing on building an entrepreneurship ecosystem in which both the public and private sector work hand in hand to facilitate and support the emergence of sustainable products and services through the creation and development of start-up com-

panies. One of the most significant areas of economic opportunity lies in the field of eco-innovation which can be described as the development of products and services that contribute to sustainable development, by fostering direct or indirect ecological improvements. This includes a range of related ideas, from environmentally friendly technological advances to socially acceptable innovative paths towards sustainability. Thus, it is of great importance that we build an acceleration program that can identify and support the most innovative ideas in the field of eco-innovation in the field of start-ups. The objective is to run the program for 3 years, with 10 companies selected each year. The focus of the companies should be outward-looking and global, and should offer high growth potential. Moreover, impact on the environment should be measurable - products and services should reduce energy consumption in the processes they will be enhancing. Stakeholders should include: The Ministry of the Economy (Owner) – Fit for Start Program; Ministry of the Environment; Nyuko/Technoport; International Experts and Mentors; Lux Innovation – Fit 4 Start Program; University researchers. (See as well the measure "Develop a private equity investment fund for industry oriented projects and companies in Luxembourg" in the TIR Strategy Study).

5. **Expand educational re-skilling and up-skilling workers in a digitalized and automated work environment and design curricula that incorporate the kinds of new aptitudes, skills, and competences vital for the Third Industrial Revolution process.**

Investment in initial education to provide future workers with the high skills needed to take advantage of technology advances. Curricula should include increasing intellectual capital through STEM subjects (science, technology, engineering, maths), as well as enhancing human and social capital skills through team learning, brain storming, communication, and designing and carrying out diverse projects. The curricula should not be limited to classroom instruction, but also include onsite apprentice programs, real-world field experience, and online collective intelligence networks (COINs). It will also be essential to reform the vocational training policy to ensure ready access to retraining services so that every employee has a fair opportunity to react to evolutions induced by the Third Industrial Revolution. Stakeholders should include: Government that needs to invest in and initiate reforms in initial education and vocational training to make the system of education and life-long learning fast enough to race ahead with machines and digitalisation instead of racing against them; Social partners who need to actively participate in the anticipation of future needs and in the reforms of initial and vocational training policies; Enterprises that need to anticipate the re-skilling of their workers; and Universities (Science, Technology & Engineers) who need to offer related education programs (Bachelor, Master,

PhD, life-long learning). Qualified employees will obtain a diploma and a professional qualification or certification which will require continuous life-long learning to remain current and valid. Workers will also receive commendations based on the Validation of the Acquisition of Experience (VAE). Protocols will need to be put in place to assure that all workers deserving training will be able to do so. Efforts will need to be undertaken to reduce registration fees for training institutes and ensure upskilling training for every worker.


FINANCE
SMART ECONOMY
PROSUMERS AND SOCIAL MODEL
BUILDING
INDUSTRY
FINANCE
ENERGY
CIRCULAR ECONOMY
FOOD
MOBILITY

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

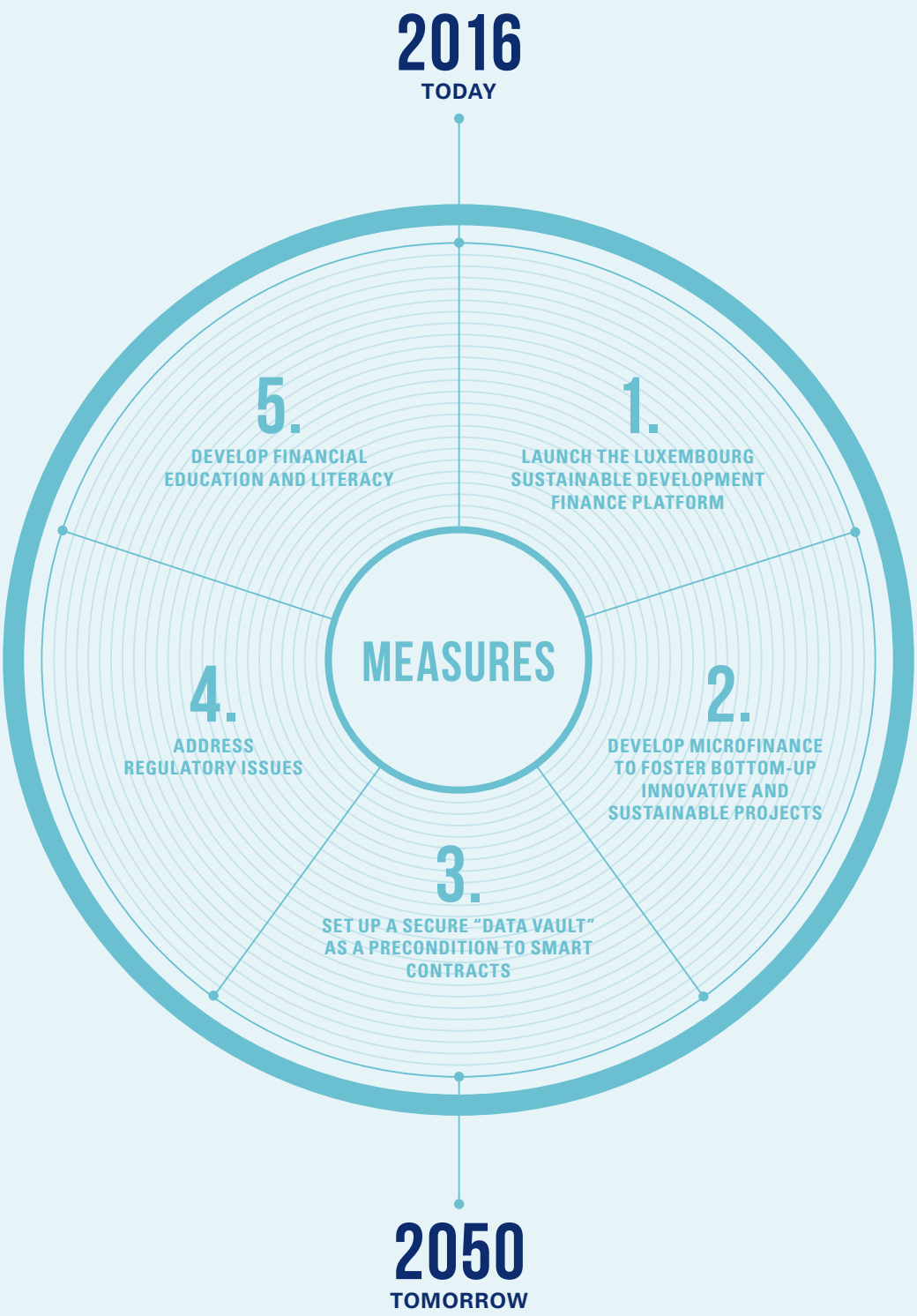
- Internet of things
- Smart digital economy
- FinTech

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.

1 — STATE OF PLAY

Luxembourg is an important financial center at the heart of Europe. Banks, investment funds, insurance and reinsurance companies and a multitude of specialized service providers leverage Luxembourg as a hub to provide cross-border banking services, asset management, corporate lending, fund administration and international distribution to a wide range of private and institutional customers. The state-of-the-art infrastructure encompassing a high quality regulatory and supervisory framework places the financial center at the forefront of innovation. Next to the traditional business lines, Luxembourg is also an emerging FinTech hub as well as a worldwide leading center for domiciling microfinance investment funds and for managing green bonds. Luxembourg has also become a center for Islamic finance and the renminbi business.

The convergence of the Communication Internet, renewable Energy Internet, and automated transportation and logistics Internet, atop an Internet of Things (IoT) infrastructure, enables the financial sector to reinvent financial services in the context of a smart digital economy. Luxembourg's financial ecosystem will need to successfully manage its digital transformation in order to leverage the opportunities brought about by digitalization. New business models will be enabled by IoT-related technologies. However, only a strong and robust financial center, leveraging the best people and technologies and embedded within a coherent and proactive legal, regulatory, and supervisory environment can continue to thrive and become a key enabler in the susccessful transition towards the "Third Industrial Revolution" (TIR).

2 — VISION

"Luxembourg: a sustainable, world-class financial hub at the vanguard of the digital revolution making transformation happen": This is the overarching vision sketched by the Finance Working Group (FWG). To achieve its vision, the Luxembourg FWG has prioritized key elements in the transition to a TIR economy.

- A resilient and diversified international financial sector servicing customers in Luxembourg, Europe and the world.
- A financial center that successfully incorporates the digital revolution into every aspect of its operations and activities.
- A financial center with a high capacity to adapt its offer in order to facilitate the TIR.
- A world-class framework for data protection and infrastructure for e-service.
- A worldwide leading hub for financial innovation, SRI, trust and transparency where impact and socio-economic sustainability go hand-in-hand.

And every word of the vision matters in its own right and as a part of the overall statement:

- "Sustainable": the financial hub as an engine for Luxembourg's socio-economic development.
- "World class": the financial hub addresses the needs of domestic, European and international customers.
- "At the vanguard of the digital revolution": disruptive technologies, new business models, disintermediation, the "FinTech" wave, blockchain… need to be anticipated, mastered, and implemented for Luxembourg to keep a leading edge and to drive transformation.
- "Making transformation happen": the financial ecosystem as a key enabler in ushering in the TIR.

3 — STRATEGIC MEASURES

Opening comment: the measures and projects stated below are a subset of the overall game plan jointly developed by the TIR-team and the FWG. The measures featured are those where we believe the country is in the driver's seat to shape the related developments in an ambitious PPP-type approach.

A. BUSINESS MODEL INNOVATION (1): THE LUXEMBOURG SUSTAINABLE DEVELOPMENT FINANCE PLATFORM

The financial Working Group and TIR Consulting Group LLC recommend the creation of a central interface platform - a "marketplace" - that would support the financing of investable projects in all the pillar sectors of sustainable development (economic, social, environmental), including TIR projects (but not limited to), as well as their promotion among potential investors and project promoters.

This platform could be called the **"Luxembourg Sustainable Development Finance Platform"** (LSDFP). The main idea is to have the LSDFP as a body to interface between potential financial contributors (public and private) and project promoters (public and private) and to assess each of the projects submitted in order to ensure compliance with a given set of eligibility criteria (such as the Sustainable Development Goals and respectively their relevance to the TIR) as well as quality checks on the feasibility of the project, the value creation, and its output to potential investors. Most TIR projects, if not all of them, will require some sort of financing. It is therefore vital to connect projects (of all sizes) to all types of potential investors via different investment channels. This platform can provide investors and promoters with various advantages:

- Provide access to privileged information and opportunities.
- Allow financial contributors to invest according to their individual risk appetite and expectations in terms of financial return and impact.
- Allow project promoters to submit project proposals in line with their policies, missions, mandates and business plans.
- Allow structured and blended financing (public/private) for better risk management (i.a. through guaranties) and increased leverage.
- Provide quality and compliance certification.

The platform should be set up under the form of a PPP (private-public-partnership). A proper analysis on the optimal legal structure for the platform needs to be carried out.

Project promoters will need guidance to choose the right financing instruments. The eligibility of project proposals to the platform should be based on a preliminary assessment. The implementation of LSDFP will help to bridge a gap that still exists between mutually reinforcing types of (public and private)

financial contributors and investors in search of investment opportunities in the field of sustainable development and TIR, on the one side, and project promoters in search of adapted financing for the implementation of their projects, on the other side. In this respect, the LSDFP serves a public mission, i.e. providing sustainable financing for sustainable development. The objective of this public mission justifies public seed funding for financial risk mitigation and technical assistance. On the other hand, the implementation of the public mission requires financial and non-financial input from actors in the private sector as well as the non-profit sector. An economic perspective motivates long term engagement of private sector actors.

In concrete terms, LSDFP launches calls for project proposals in the sectors of sustainable development, including TIR-related proposals. It provides project promoters access to financial contributors and adapted financial instruments. LSDFP proactively reaches out to potential financial contributors and compiles investment proposals and adapted investment instruments and makes them available to project promoters.

The establishment of LSDFP should not be perceived or interpreted as an attempt by the public sector to bail out of their existing (i.a. financial) obligations and commitments, regardless of the activities that, in the future, may receive financing through the matchmaking efforts of the LSDFP. On the contrary, the activities of the LSDFP should allow for leveraging like-minded private investment in addition to existing funding through public funds. The governance of the platform (multistakeholder representation), its IT infrastructure (adapted to the needs in terms of volume and reliability) and necessary skill sets (pluri-disciplinary) of its staff have to be carefully assessed. As to the options to cover the operational cost of the LSDFP, the idea of a membership fee for investors and a handling fee per project could be addressed.

The LSDFP would be ideally placed to aggregate demand for sustainable energy services in both the public and the private sector, but instead of issuing financial instruments itself, the LSDFP should rather concentrate on making the best adapted financing solution (bonds or other financial instruments) available to the public and private sector participating organizations and the ESCOs (Energy service companies) they would be working with. Incidentally this way of proceeding would keep the set-up of the LSDFP lean and its operating cost low, while the financing of energy producing and distributing activities could still be designed with no up-front costs. Guarantee schemes with public funding could still be envisaged for riskier ventures.

Hence, the LSDFP is not meant to manage financial flows or raise capital itself. Issues regarding liability, regulation, and supervision would be difficult to address and risk hampering the mission of the LSDFP as a matchmaking interface. If the LSDFP were to issue instruments such as “sustainable energy bonds”

or raise other funding, it would probably duplicate capacities and expertise readily available among existing public and private sector actors (government, banks, companies, etc.) with higher professional skills and means. Hence it is strongly suggested that the LSDFP focus on bridging the communication gap between project promoters and investors and engage in opportunity data mining. Therein lies its genuine value added.

The LSDFP set-up integrates with the "Sustainable Energy Finance" (SEF) model, a critical financial mechanism that would underpin the interaction between supply and demand for sustainable energy resources at infrastructure-scale. LuxSEF could operate in parallel to the LSDFP, in particular receiving participants who have been informed and motivated by LSDFP to design projects. It enables infrastructure-scale change through structured and standardized arrangements between capital providers, energy service companies, and program participants (public and private).

B. BUSINESS MODEL INNOVATION (2): MICROFINANCE TO FOSTER BOTTOM-UP INNOVATIVE AND SUSTAINABLE PROJECTS

Luxembourg is the leading financial center for domiciling microfinance investment funds. Nevertheless microfinance for Luxembourg is a novelty and offers concrete opportunities for financing projects in the framework of the TIR. Social start-ups, in particular, offer innovative solutions within the Sharing Economy and are based on business models that have positive social and environmental impacts. In the context of tighter lending policies and regulation, micro- and social entrepreneurs can be excluded from the regular credit system. Microfinance as smart money, combining financial support with training, coaching and mentoring contributes to the financing of the TIR.

As far as green bonds are concerned, distributed-ledger technology will mediate the flow of information and money, which in turn will foster new, negotiable energy and finance instruments. These include contracts backed by low-scale "prosumer" generation capacity and new equity-like carbon-trading assets whose dividends are based on the environmental benefit and cost savings delivered by the underlying investment. Such investments can, in turn, be bundled into smart contract-managed securitizations that depend on a blockchain to manage a distributed securities exchange, creating opportunities for asset management firms, as well as for individuals, to participate in microfinance and crowdfunded investments. Given Europe's commitment to a continent-wide conversion to renewable energy, these new asset classes may quickly evolve into very large, liquid markets. If Luxembourg leads the way, and embraces the blockchain infrastructure that will secure them, it can become a global hub for the origination, collateralization and trading of these products.

C. TECHNICAL: A SECURE "DATA VAULT" AS A PRECONDITION TO SMART CONTRACTS

Blockchains are an essential technology for ensuring a more efficient, transparent, and secure transaction-based economy. Identity, data security and protection, anchoring and auditability, tokenization and smart contracts; all these key issues have been identified as challenges but also opportunities, linked to blockchain. Likewise, is has been stressed that blockchain technologies are a key enabler for other recommendations, such as the launch of B2C and B2B complementary currencies and green finance.

As a starting point and in order to kick-start all the related developments, we advocate the setting-up of a national secure data vault to drive efficiency and become the leader in the design and implementation of smart contracts. Luxembourg should thus strive to set up a central, national platform where citizens and companies may upload any of their personal data (name, address, property data, electronic medical data etc.); a sort of "e-safe" hosting the data and giving the citizen or the company the possibility to grant access to specific parts of this vault to selected stakeholders (e.g. government, banks, insurance companies, etc.).

Data would only have to be uploaded once and changes could be made centrally, automatically updating contractual relations for these specific areas in the vault for which stakeholder access is granted. The deployment of such a centralized secure vault seems to be a precondition for a nationwide roll-out of "smart contracts", in the financial sector realm and beyond. A roll-out of such an ambitious project would imply:

- Identifying and defining a first viable proof of concept.
- Providing the technical, secured environment.
- Considering a secured interaction between smart contracts and big data related concepts.

D. REGULATORY ISSUES

A holistic and consistent deployment of regulation and supervision is of key importance. Digital transformation should be understood as a whole, seeking the right balance between the drivers of change and the impact on the existing business models. European legislative frameworks and initiatives, such as the single digital market, must be leveraged. Among the main priorities are: the set-up of the regulatory and supervisory framework to ensure that the right conditions for innovation are able to thrive (e.g. regulate activities not actors) and regulatory sandboxes to address the growing threats from cybercrime. Data protection rules must strike the right balance between safeguarding confidential data while allowing for new innovative, customer-centered financial products.

E. FINANCIAL EDUCATION

At a time when financial decisions are becoming increasingly significant in the lives of citizens, financial education and literacy are key. Against this backdrop, a growing number of countries have developed national strategies for financial literacy; a subject matter which forms an integral part of the broader topic of economic education, which aims to give citizens and professionals the keys to understand and apprehend the economic and financial world we live in. Compared to other regions, Luxembourg appears to lag behind in terms of financial education, although some players – often private – already offer educational modules to schools and/or the broader public. Luxembourg, however, has not yet adopted a national strategy for financial literacy, nor has it designated a competent authority in this field. Also, research carried-out in this area seems to be insufficient.

We recommand a comprehensive strategy that can benefit many different stakeholders:

- For students: existing educational programs should include more focus on financial literacy.
- For teachers: exchange and information programs may need to be developed.
- For consumers: exchange and information programs may need to be developed.
- For professionals: specific programs should be put in place as offers on the topic are insufficient at this stage. Specific tools are needed at the start-up level.

Action at the level of financial education should commence as soon as possible. As far as secondary schooling is concerned, Luxembourg is currently preparing a comprehensive reform bill. Ideally, financial and economic education should be ambitiously integrated within the realm of this reform. The overall aim should be the creation of a well-functioning ecosystem where all the actors can easily interact. Main priorities should include:

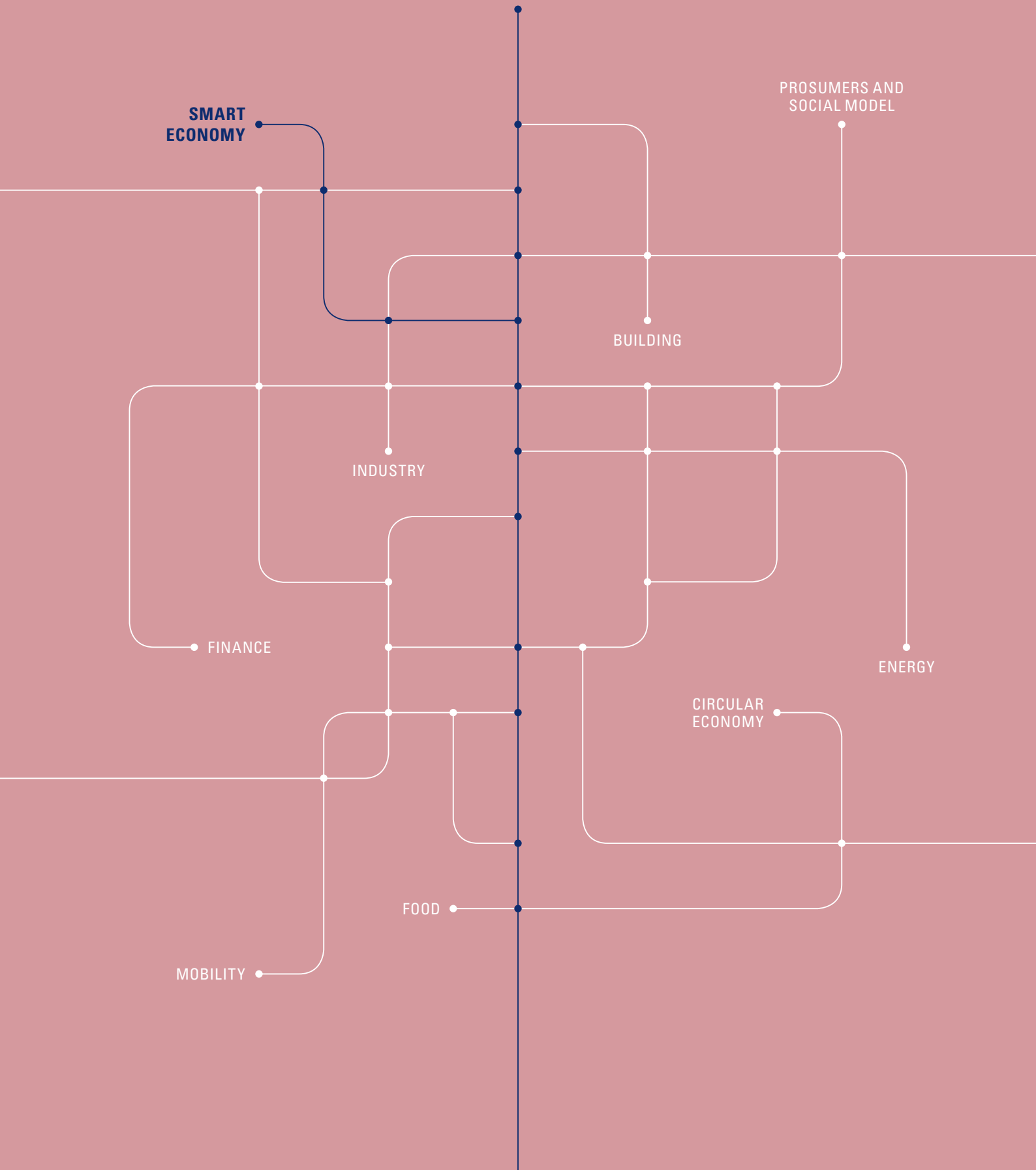
- The strengths and weaknesses of population in the field of financial education should be identified via an assessment study (e.g. there is a specific module on financial education within the OECD PISA program that could be used as a baseline),
- a long-term national strategy in the field of financial education should be defined and implemented,
- financial education should be incorporated into the general school curricula (e.g. within mathematics and language classes).

Dedicated actions plans should also be rolled out for consumers and professionals. Relevant working groups should be created, engaging all the comptent public and private stakeholders. Luxembourg should strive for a smooth interac-

tion between the development of its financial center, on the one hand, and training and education of local resources, on the other hand. The main objectives in this field are twofold:

- To encourage and motivate youngsters to experience entrepreneurship and look for learning opportunities in the domain of current and future financial instruments (e.g. FinTech).
- In the short term, the holding of meetings between professional decision-makers of the financial sector and teachers to exchange views on current and future topics, instruments and issues in the field of FinTech and their impact on the Luxembourg Financial Sector.

SMART ECONOMY



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.

1 — STATE OF PLAY

The dot-com bubble of the late 1990s was a misestimate of the timing, but not the magnitude of the digital revolution. Today, digital technologies are the driver of the transformation processes in the economy and society at large and often disrupt entire economic value chains. Luxembourg has to position itself in this global digital transition towards a world in which the most powerful global flows will be ideas, e-services and digital capital.

Luxembourg boasts a highly advanced ICT sector which makes up 6.6% of the total gross added value of the country. The ICT sector accounts for 4% of employment in Luxembourg. Moreover, Luxembourg hosts some of the leading ICT companies including Amazon, Ebay, Vodafone, and Rakuten.

As regards the general framework conditions, the latest Digital Scoreboard of the European Commission (DESI) outlines the state of play in Luxembourg in this transition process towards a "Digital Economy". Connectivity, along with Human Capital and Use of Internet, are the DESI 2016 dimensions where Luxembourg performs best. With an overall Connectivity score of 0.73 the country ranks 4th among EU countries. Luxembourg has completed broadband coverage (100%) and a fast broadband connection (at least 30 Mbps) is available to 94% of households. Take up is also strong for the faster connections in line with the "ultra-fast networks strategy "of the government.

The adoption of e-Business practices by companies in Luxembourg shows a contrasting picture. In the dimension "Integration of Digital Technology" by businesses, Luxembourg scores only 0.28, its worst score among the five DESI 2016 dimensions, and ranks 21st among EU countries. Both the percentage of SMEs selling online and the share of eCommerce in SME's turnover are low.

Another key weakness is that Luxembourg is lacking the expertise to deploy the digital revolution and the educational system is not adapted to overcome that digital skills gap. While the proportion of ICT specialists in total employment is relatively high, at 5.1%, Luxembourg is lacking skilled ICT professionals. In 2015, 59.1% of companies which recruited or tried to recruit staff for jobs requiring ICT specialist skills reported problems in filling these positions, up from 58.5% in 2014. This is the second-highest figure in the EU. This problem is also related to Luxembourg's low number of STEM (Science, Technology, Engineering and Mathematics) graduates. Luxembourg is the worst performer in the EU in STEM graduates with a mere 3.6 graduates in STEM per 1000 individuals.

In terms of nation branding, Luxembourg has traditionally been perceived as a business friendly place with its main strength being a stable political and regulatory environment conducive to growth and easy access to public decision makers. However, when looking at the latest WEF network readiness index ranking, Luxembourg is only placed 27th within the pillar "Business and innovation environment".

2 — VISION

The "Smart Economy" working group should achieve the following overarching objectives:

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

In other words, 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. ICT is used to enhance quality, performance, and interactivity of services, while reducing costs and resource consumption and improving contact between users.

The transition into a seamless emerging Digital Era will favor regions that build the infrastructure, institutions, skills and business environments that their innovators, companies, and citizens need to participate fully.

Adapting to this digital transition will require shifts in mindsets, policies, investments (especially in human capital and innovation), and increasingly also models of employment and distribution. For an agile, wealthy and advanced economy such as Luxembourg, this creates new opportunities to carve out profitable roles in the new digital global economy. Already a world leader in digital adoption, Luxembourg has a competitive advantage when it comes to the build out and scale up of a Third Industrial Revolution digital infrastructure.

To quickly advance the new economic paradigm, Luxembourg will need to draw upon its prior success in the ICT sector and begin a rapid build out of a digitalized renewable Energy Internet and digitalized Mobility Internet alongside its already developed Communication Internet, connected by an Internet of Things platform.

Based on lessons learned from comparable second mover (in comparison to Silicon Valley) smart economy hubs such as Tel Aviv, Singapore, London, Barcelona and Zurich, we believe that strength in only one aspect of a digital/smart economy (namely Luxembourg's outstanding digital infrastructure) is not sufficient to boost overall economic performance, tax revenue, and employment. What is needed is an interactive mix of institutions, skills, business ecosystems, regulation and infrastructure.

It is therefore of utmost importance to formulate one core strategic vision that builds upon Luxembourg's existing assets as described above, positioning Luxembourg both as a producer and as a recipient of digital flows, and develop these strands further into an overarching theme that can position Luxembourg as an innovation leader in the journey to a smart Digital Europe.

A. BUSINESS MODEL INNOVATION

1) By fostering and focusing applied research in the key areas of smart city, smart energy, autonomous driving, High Performance Computing and Big Data enabled applications

I) Development of an Automotive Campus:

The future Luxembourg Automotive Campus will house research and innovation activities of several companies within the automotive sector. Common infrastructure will be provided, such as test laboratories and research facilities, meeting rooms, dining areas and exhibition areas. The test track site offers opportunities for testing and validating prototypes in the field of logistics and addressing realistic traffic scenarios. This project will pave the way for economic (for instance the Sharing Economy), technological (each car is interconnected to each other) and cybersecurity R&D to successfully set up autonomous driving and car-to-car and car-to-infrastructure networking.

Beyond this, the campus will also foster entrepreneurship by hosting innovative automotive start-up companies.

II) High Performance Computing (HPC)

Luxembourg, together with France, Italy, and Spain, have launched an Important Project of Common European interest, (IPCEI) concerning the implementation of an action plan to develop European HPC infrastructure and world class Big Data, to catch up with other countries such as the US and China.

The objective of the initiative is the implementation of a trusted High Performance Computing (HPC) and Big Data ecosystem and the provision of equal and affordable access to next generation data driven applications for every stakeholder in a transparent and democratic way, regardless of their social-economic background.

The IPCEI initiative is designed to strengthen Europe's position in the global digital economy by making HPC-Big Data infrastructures and applications accessible for private companies; with a specific focus on SME's. Establishing a European HPC-Big Data ecosystem will enable efficient cross boarder data transfers and unlock new sources of value creation in a Digital Single Market. Applications will be developed in favour of the concept of a 'smart nation'. The idea is to use the potential of HPC-Big Data capacities for improving everyday life and boosting the European economy.

Privacy, data protection and ownership are important issues in the context of a functioning Digital Single Market. The IPCEI initiative aims to close the gap between data protection obligations on one side and innovative business opportunities on the other side, by applying new conceptual frameworks and paradigms such as "Data Security and Privacy by Design".

III) Implement a light-house project on "Smart Cities"

Luxembourg is well positioned to act as a testbed for smart city applications due to:

- A high performing IT infrastructure (high connectivity, low latency and highly secured data centers);
- Public research activities in the field of big data analytics and cybersecurity (LIST and SnT);
- A dynamic ICT sector with national champions (POST, SES) and internationally renowned companies;
- A strong political commitment.

Luxembourg, and in particular Luxembourg City, has exceptional strengths to serve as an ideal laboratory to deploy large scale demonstrators which validate not only technology solutions but also new business models which may find their replication in similar cities.

In this context, Luxembourg, together with two other major cities, aims at participating in the European project Horizon 2020 – "Smart Cities and Communities lighthouse projects".

2) C3- Cybersecurity Competence Center

SECURITYMADEIN.LU's future "Cybersecurity Competence Centre (C3)" aims at making cybersecurity tangible and accessible to all stakeholders (citizens, start-ups, SMEs and other public or private organisations). The center acts as a catalyst for the cybersecurity community strengthening competences and sharing of expertise, fostering and building synergies between key players and encouraging smart and flexible regulations.

C3 has been designed as a public-private partnership to provide threat intelligence, cybersecurity skills and know-how as well as training and testing facilities to the vibrant and fast growing smart economy. It will increase the competitive advantage of Luxembourg and help secure the emerging ecosystem in areas like **Internet of Things** (IoT), **space technologies**, **FinTech** and **autonomous driving**. Building on existing success stories, like CASES and CIRCL, C3 will provide three important infrastructures: **Threat Intel, Training and Testing**.

- Threat intelligence is vital to a modern economy. The capability of providing threat intelligence to the economy reduces individual effort and costs for cybersecurity while increasing efficiency and effectiveness of protective measures. The center will not only provide technical intelligence, but also insight into contextualized threats and protection mechanisms, as well as metrics and figures needed for governance.
- The training and testing goes beyond what is available today. It implements a smart infrastructure, enabling companies and other entities to train their people and test their procedures and measures against current and emerging threats. This new infrastructure combines classical class-room training with high-notch technology to simulate, in a close to real-world manner, participants' environments, transferring technical, organisational, behavioural as well as legal skills needed to identify, contain, and mitigate cyber risks based on realistic scenarios.

B) RESEARCH, DEVELOPMENT AND INNOVATION

3) Involve the local tech industry and strengthen partnerships with applied science institutions

Since the beginning of 2000 Luxembourg has steadily increased the percentage of GDP invested in public research. These massive investments allowed the University of Luxembourg and LIST (Luxembourg Institute of Science and Technology) to build up competences in different areas.

However, in terms of public research, three major challenges need to be addressed:

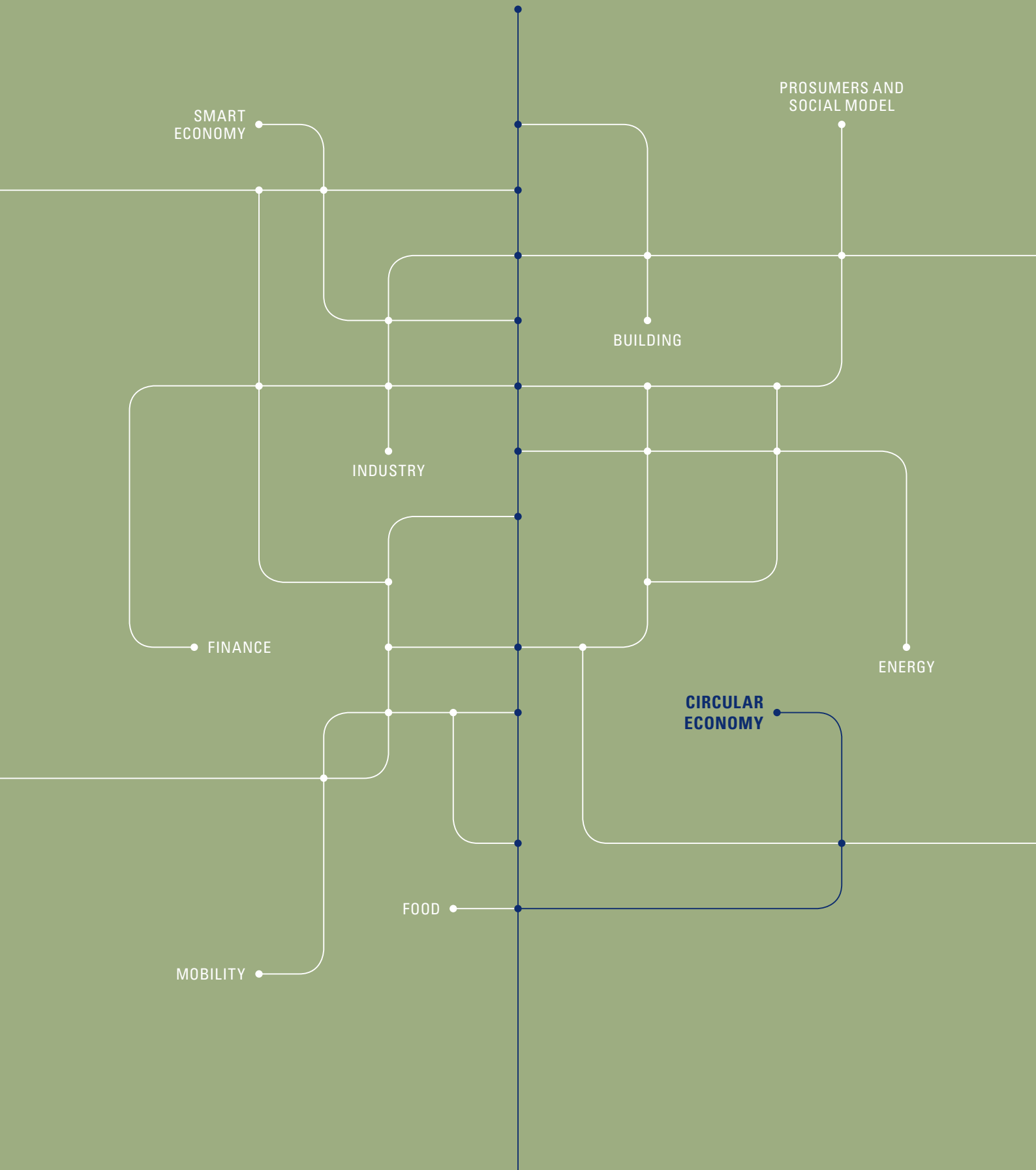
- Focus more on a limited number of research topics related to the different pillars of the Third Industrial Revolution (Smart City including Mobility and Energy, Smart Space, Fintech and Smart Manufacturing including Composite Materials and 3D Printing);

Cover the whole range of TRL's (Technology Readiness Level) by putting a special emphasis on applied research. As a small country, Luxembourg should concentrate on the funding of activities which may have an immediate impact on economic development. However, in parallel, the University and LIST need to develop fundamental research activities in key areas in order to ensure the long run quality of research.

- Improve the collaboration between University and LIST. It is of utmost importance that both institutions work in a collaborative way and pool resources on the different research topics.

On the funding side, public private partnerships (PPPs) should be promoted in order to provide financial support to RDI, with the primary purpose of using public funding to leverage an equal or higher investment by the private side. Luxembourg should formulate an alternative form of PPP with a view of the distributed collaboration schemes that will characterize the post-Third Industrial Revolution society.

CIRCULAR ECONOMY



CIRCULAR ECONOMY OVERVIEW

2016
TODAY

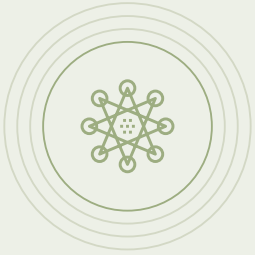
STATE OF PLAY

- 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.

1 — STATE OF PLAY

These days our thinking is largely dominated by linear mindsets where the increase in consumption is at the center of economic growth. Most of the companies operate their businesses based on traditional economic concepts. All existing infrastructure is designed around this linear model. Continuing to design, construct and operate the economic infrastructure and built environment in linear fashion incurs greater risks and expenditures, including failures to future proof against system shocks, uncertainties and surprises. In sharp contrast, shifting to a circular model in designing, constructing and operating infrastructure and the built environment goes beyond restorative features and enhances the qualities of resilience, which are best positioned to respond to future uncertainties. Neglecting or delaying the shift results in more expensive retrofits in the future, or worse, close out retrofit opportunities because of excessive costs.

Existing supply chains are very often highly complex and long and make it almost impossible for the final producers to identify all the materials, components and ingredients, which have been used in the goods they sell. Most companies have suppliers from outside Luxembourg, and even from outside Europe. Today, it is nearly impossible to know the exact composition of end user consumer products (down to parts per million [ppm] levels). If the goal is to maintain high quality circularity throughout the use and re-use (up-cycling) phase, it is essential to know the exact composition of the material. This issue is further complicated by the protection of intellectual property.

In addition, implementing circularity across the value chains in Luxembourg is complicated by the issue of storage and security of data. The prevailing protection of product recipes by the companies prevents a transparent exchange of information. As a result, many of the components that make up the supply chain remain unknown even to the final manufacturer of a finished consumer good. Blockchain could be a solution. A distributed collection of data allows every enterprise across a specific supply chain to track information on materials and to store it in a secure way. With Luxembourg's strong ICT commitment, it could easily take on general data storage and material information tracking.

Luxembourg's IT infrastructure is among the best and most secure in Europe and the world. It should be fully exploited to generate economic activity on a cross sectorial basis. While our current thinking in Luxembourg is technology-driven, there is not enough focus given to chemical and biological resources; i.e. how chemicals and biological materials flow back and forth through the technical supply chain cycle. In addition, in some instances, current national and international regulations prevent a circular approach.

Existing infrastructure is poorly designed for reverse logistics. The result is that large-scale recycling units are blending many different products within only one material category. In this way, all the different material compositions get lost and the quality and economic value of the resulting blend tends to be poor.

Big players like the telecommunication company POST have meanwhile recognized the issue and developed a business case around reverse logistics. There is an opportunity to invest in reverse logistics and to combine it with either technical skills (repair services) or lower skilled jobs around the dismantling and recovery of resources.

The general awareness about the circular economy in Luxembourg is still in the starting blocks. Luxembourg's business community is increasingly interested in the circular economy as it is beginning to understand the business case and the accompanying economic advantage of implementing circularity across the value chains.

Education and communication will be critical to the success of a circular economy in Luxembourg. To date, however, only a few CE training centers are operational. Efforts should be undertaken to prepare Luxembourg's workforce with circularity principles and practices. Teachers have to be retrained as well. Luxembourg has several organizations (like "SuperDreckskëscht") that currently reach out to a high number of companies and citizens, and which could be key actors in spawning a growing awareness of the vast merits in introducing circularity.

Luxembourg's financial sector has a key role to play in the transition to a circular economy. Initial investments may be higher than those for the linear model and full economic benefits can only be realized once all the elements are in place. The public sector could also play a critical role in encouraging the "pay for performance" concept in which return on investments are secured by the increase in aggregate efficiencies and productivity and reduction in marginal cost and ecological footprint.

Luxembourg is also developing the logistics infrastructure. Luxembourg's mobility landscape is evolving rapidly. At the same time, mobility is changing globally. Car and bike sharing initiatives are emerging in ever more cities, while owning a car is becoming less and less attractive. Access to mobility starts to replace ownership, taking transport into the circular realm.

2 — VISION

Luxembourg will be the first circular nation, where new business models based on the product-as-a-service principle become standard. All public procurement will be aligned around the circular economy. Contracts will be performance-based. Luxembourg will have developed know-how around eco-design and product life assessment. Luxembourg will have an adapted resilient infrastructure that promotes local renewable energy production, storage and sharing, short and local resource loops, a continuous water loop and reverse logistics. In addition, the new infrastructure, designed to fully integrate CE principles, will be able to manage (in terms of storage and calculation) a large set of data, linked to each product. Luxemburg will have created a legal framework that allows the exchange of product related information between suppliers, by guaranteeing a level of confidentiality. The national tax system will support companies implementing a circular approach. Luxembourg will gain the technical experience to make life cycle assessments and evaluate how circular a business is. An effective local network will be backed by a strong financial sector.

Moreover, Luxembourg will establish a detailed national measurement system to determine both quantity and quality of the different material flows. Luxemburg needs to become a key actor in the greater region in order to establish regional and/or local supplier communities and will contribute significantly to close these loops. In addition, Luxembourg will implement a series of seamless chemical and biological loops.

The above-stated goals will be achievable if we make eco-design and the basic principles of the circular economy part of our education and life-long training system. With the circular vision, the word ‘waste’ no longer exists. People will have a deeper systemic understanding of the chemical and biological cycles and be capable of using the latest technologies to create a virtuous circular society.

Luxembourg will become the global center for a “safe but transparent” approach to products as services. Such a transparent approach empowers prosumers and companies by providing the tools for a distributed and decentralized approach to marshalling local materials and creating seamless product loops in line with the philosophy of establishing a distributed, transparent, and democratic approach to economic development.

The IoT platform will help achieve many of these goals. Interconnectivity provides the necessary transparency to monitor the different flows. Internet platforms connect people and foster a Sharing Economy.

A. REGULATORY

1. Implement a taxation system that places the nation as the EU circular economy leader

A key part of the circular economy is internalizing the costs associated with externalities incurred during economic activities. Luxembourg already embraces the principles of polluter pays. An innovative tax system should be introduced over time that motivates actions to innovate on the production side through resource effectiveness. These systematic changes aim at increasing taxes on material consumption while encouraging the re-use of high quality materials/components with lower taxes. Through financial incentives like cutting the value added tax on repairs (footwear, textiles, bicycles) and making labor costs tax-deductible for fixing home appliances such as washing machines, fridges or stoves, society will be motivated to consume more sustainably. Moreover, these measures could provide labor opportunities for semi-skilled people and help the craft reinvent itself.

This anticipated additional tax income could be used to lower work related taxes in order to favor the "product as a service" approach. Theses changes in the tax system require shifting purchasing perspectives from the linear "take-make-dispose" model to "retake-remake-reuse-reduce-recycle" circular model. The specifics should be fleshed out through a public-private task force that reviews the experience and evidence of how such tax systems are working in other nations, and make recommendations for modifying Luxembourg's tax system.

B. PUBLIC POLICY

1. Government plays an active public role in promoting circular economy

- Barriers and impediments currently limiting public procurement practices from purchasing sustainable, resource efficient products and services should be identified and removed. A mid-term public procurement plan needs to be established for progressively procuring an increased percentage of products and services that work along the circular economy principles. A set of best practices should be established.
- We recommend that Circularity thinking be integrated into the public building sector, including reversible building design as well as business model innovations. New economic zone developments should take into account the circularity principles before building out the required infrastructure.

C. EDUCATIONAL

1. Promotion of new educational curricula that helps students to learn new aptitudes, skills and competences for circular product design and production as well as large-scale awareness campaigns for the general public

The 2017 CE Hotspot event should be used to make existing initiatives visible:

- Large-scale nationwide communication campaigns should be run to promote the CE ideas.
- CE training and competence should be integrated as part of the Luxembourg education system in the primary and secondary schools, universities, and in lifelong learning programs.
- Current teaching programs should be reviewed under CE aspects for each school level. Pilot projects could be launched in different schooling systems.
- Public RDI (University) and Private sector RDI need to align and leverage their efforts.

Research programs for technological solutions and innovation in technologies for renewable energy, energy storage, and energy transportation should be actively supported by the Government.

D. BUSINESS MODEL INNOVATION

1. Promote Circular-Design of products and new business models (product as a service) and circular supplies. Develop a material passport and solve confidentiality and IP issues

- Products with potential to be shifted from traditional "buy and own" to "use as a service" should be identified and promoted (via public procurement "Pay for performance" contracts or giving preference to 'usage' versus the possession of a product)

Some examples of product-as-a-service already exist in Luxembourg, e.g., agricultural machines and toys.

- Luxembourg should develop and implement minimum legal standards for healthy design and design for disassembly and implement infrastructure projects that could be dismantled for high quality re-use.
- Circular design should become a mandatory module in technical education.
- All buildings and large equipment items should have a material passport (legal requirement).
- A new circular economy (CE) EU label should be created and promoted.
- Material passports, integrated with blockchain technology could provide

continuous tracking of products (and its composition) while respecting and preserving the confidentiality of the author. Blockchain is a distributed ledger that encrypts transactions that are also auditable. It appears to be a useful tool for tracking, measuring and validating the flows of waste, pollution, and overall resource use. Material content and assembly methods would always be traceable and therefore contribute to determining the remaining economic value. Blockchain technology constitutes a solution for confidential product data which is vital for detailed material knowledge.

2. **Engage the farming community**:

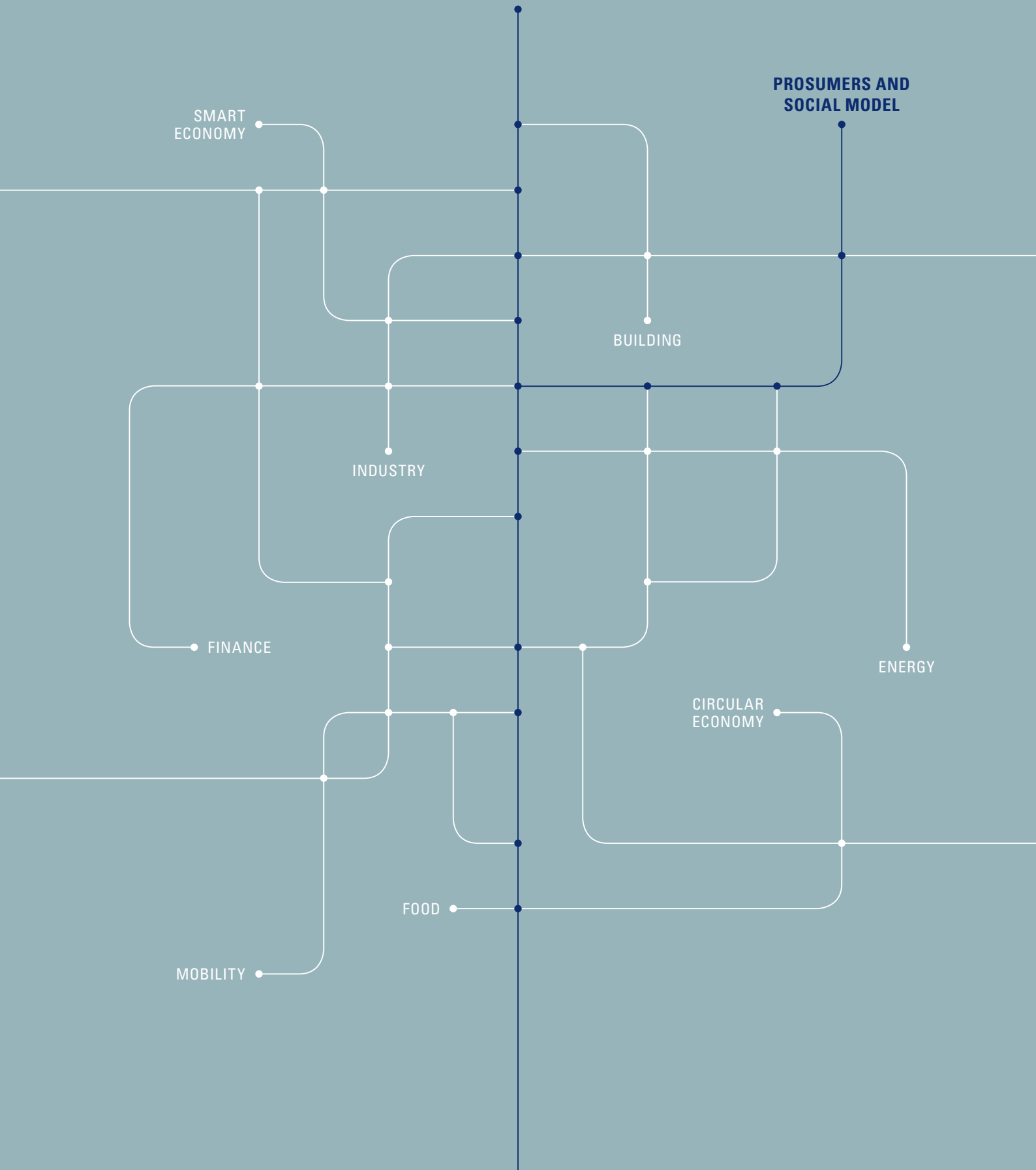
a) **In producing wind and solar PV power as "cash crops"**

Roughly 52,6 % of the nation's total land area consists of agricultural lands. The opportunities for transitioning to Renewable Smart Power by installing solar energy facilities and wind turbines could provide a valuable additional revenue stream for rural farmers. Cooperatives could be established to carry out this opportunity for the farming community.

b) **In bringing the carbon back into the ground while promoting local and organic products**

Regenerative cultivation methods could significantly improve the quality of the topsoil in our farmland. When building up humus-rich soil, carbon can be bound on a long-term base. Soils are globally the largest storage for CO_2, greater even than the oceans and forests. Photosynthesis brings carbon back into the depleted soil, where it plays a central role in humus formation and enhancement of soil life including mushroom cultures and bacteria. In addition, high-quality topsoil improves water holding capacities. This requires pilot projects to investigate and quantify potential positive impacts on topsoil quality and water retention capacity. What is needed is a greater support for the development of expanded organic/ecological agriculture and the promotion of local and organic products.

PROSUMERS AND SOCIAL MODEL



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.

1 — STATE OF PLAY

Although Luxembourg is a sovereign state, its membership in the European Union is crucial in expediting its transition into the Third Industrial Revolution (TIR). As a the cosmopolitan crossroad in the heart of Europe and driving force for the Greater Region, the country's openness and its ability to reinvent itself and adapt to changing conditions are key components in Luxembourg's successful socio-economic development.

Demographics play a crucial role in Luxembourg. Population dynamics show a strong increase in total population, with a higher growth rate for foreigners than for nationals. Further, population growth is expected to almost double over the coming 35 years. On January 1st 2016, foreigners represented 46,7% of the population, most of them are from the EU. This leads to a complex situation of multilingualism in Luxembourg. Migration flows challenge societal development and living together.

Luxembourg's socio-economic model is based on a social market economy, driven by extensive economic growth and characterized by competition, self-interest, property rights, autonomy and the quest for material gains inherent to the capitalist economic order. The economic pattern and lifestyle are marked by a throwaway culture and mainly oriented towards resource intensive linear consumption.

The generous national social security system – in particular the pension scheme – requires a stable annual increase of Gross Domestic Product (GDP) to be viable. Conventional GDP metrics focus exclusively on itemising the total sum of goods and services produced with no attempt to differentiate between negative and positive economic growth. Neither production and consumption externalities – which can be economic, social or environmental — nor the usefulness, suitability or harmfulness of activities, products and services are considered when assessing economic growth. A GDP increase is either generated by raising employment or by boosting productivity. Currently, economic growth is mostly based upon the creation of new jobs, meaning that Luxembourg needs to attract, feed, transport and house thousands of supplementary residents or cross-border workers each year. This upgrowth comes along with negative and undesired, but yet hardly avoidable side effects such as mobility problems, environmental issues, constantly rising housing prices, and sociocultural challenges, notably in schooling and education. As space and most natural resources are limited, this system is not sustainable and cannot be kept up endlessly. The transition into TIR will dramatically increase aggregate efficiencies and facilitate productivity gains across economic value chains and lead to a more qualitative and sustainable economic development.

Luxembourg's labour market is dominated by payroll employment, while self-employment and entrepreneurship is lower. Just like the resident population, the active workforce is very heterogenic and includes a high and ever growing segment of cross-border commuters.

Although international benchmarks regularly rank Luxembourg among the richest countries in the world, poverty and social inequalities relating to income and property exist. According to Eurostat's Europe 2020 indicator 16,4% of the population in Luxembourg were at risk of poverty after social transfers in 2014. As the divide is growing, disparities risk a further erosion of social cohesion.

2 — VISION

People lie at the heart of the Third Industrial Revolution.

The working group "Prosumers & social model" approached the Third Industrial Revolution from the view of citizens, consumers and the working population, and with regard to economic, work-related, societal and regulatory issues. The aim was to identify and discuss related opportunities, challenges, and effects that could occur during the transition. As technological changes are inextricably linked to changes in mind-set and socio-cultural shifts, the consideration of the human dimension and the search for common values should frame the transition to a sustainable socio-economic model.

The involvement of all national stakeholders is a key factor for success and perfectly matches the "collaborative commons" paradigm inherent to TIR. Public authorities should aim to foster social protection and cohesion, environmental conservation and a stable quality of life, cover the needs of autonomy, health, housing, healthy alimentation, mobility, rest and resourcing, defend common welfare and the best interests of citizens, and take care of weak and vulnerable people. To enable and facilitate the transition, the state needs to provide the necessary infrastructure to allow economic activity to flourish, including material infrastructure such as roads, high-performance telecommunication equipment and adapted energy grids, as well as immaterial frameworks like legislation, regulation and policies. To support the transition, and in order to increase national ownership of the TIR, public authorities should further encourage proactive involvement of engaged citizens who are conscious of their responsibilities, rights and obligations in the economic, social, and political decision making process that comprises the Third Industrial Revolution. Raising awareness and, in particular, biosphere consciousness, is necessary to ensure that future development focuses on economic, societal and environmental resilience.

Literacy, through education and training, is crucial to introduce the third industrial and societal (r)evolution. Population should be familiarized with the holistic concept of TIR, including underlying principles like the collaborative commons, sustainability and circularity. Transversal skills such as adaptability, reactivity, critical thinking and reflection, networking, empowering and participation are key factors for bringing about positive economic and societal change. TIR changes the way knowledge is imparted. Digital classrooms, massive open online courses and open knowledge concepts make education a shared experience among a community of peers. Becoming digitally savvy means taking responsibility to enhance one's personal social capital, while engaging and networking both locally and globally to cultivate social, civic, and intellectual capital. The Digital(4)Education strategy by the Ministry of Education, Children and Youth supports new learning strategies and innovative pedagogic projects using digital technologies. The sciences and technology are promoted by developing, financing and initiating relevant projects. Young people's interest in ICT and related career opportunities is more likely to be stimulated by approaching

digitalisation not solely from an application on the user side, but also from a developer and producer perspective.

In the health and care sectors, personalized medicine is a growing trend. ICT applications and sensor technology allow self-tracking of body parameters to quantify biometrics, including heart rhythm, insulin and cortisol levels. The technology can be used for remote monitoring and medical assistance. ICT and Internet of Things Networks technology also enables health care professionals to track the spread of epidemics and inform the population in situations where public health is at risk. With the creation of a national agency on shared information in the domain of health (Agence eSanté), Luxembourg made a first, but important digitalisation step in public health. The agency makes available individual electronic health records (Dossier de Soins Partagé) to facilitate information exchange between health professionals and patients, and to improve healthcare assistance to the patient.

Digitalisation and TIR impact the working environment. The massive diffusion of digital tools changes the way work is being organized, structured and executed. Digitalisation creates new opportunities such as remote working, flexible working hours and virtual teams. On the other side of the coin, there is an acceleration of work, new command and control procedures, and the risk of information and communication overload. In addition, new challenges occur with regard to management and training. To benefit both employers and employees, related work-life balance and legal issues will need to be tackled.

TIR impacts employment opportunities as well. New jobs are created (new sectors, products, services etc.), while others are being destroyed (automation, computer-based algorithms etc.). Technological progress also transforms the tasks (digitalisation, smart man-machine interfaces etc.) and can contribute to the outsourcing of jobs (digital intermediation platforms, crowdsourcing etc.). In addition, service on demand is rising and may lead to a decrease in permanent employment contracts while self-employment and project-specific flexible and temporary recruitment could become more common. The net effect on the number of available jobs is difficult to assess as it depends on different factors such as macroeconomic developments and spillovers, the sector of activity, the potential degree of automation of the task, and the qualifications of the work force. Over the next decades, the build-up of a TIR infrastructure will need a skilled workforce, not only in commerce, construction and industry, but also in R&D to develop adequate technology and materials. Qualified personnel will be indispensable to service and manage this infrastructure. Once TIR is fully implemented, the economic circuit will be largely automated and a transfer of jobs into the social sector is likely to happen, including health and care, education, cultural activity and arts, environmental protection, sports and entertainment et cetera. These sectors require human-to-human engagement and social capital which cannot be robotized.

The TIR heralds a collaborative age characterized by lateral power, distributed scaling, peer-to-peer interactivity, social capital, participation on open commons and access to global networks. A hybrid economy has already emerged, partly made up of a capitalist market and partly a sharing economy on the collaborative commons.

The shift to a prosumer sharing economy is as much about the values a society shares as it is about the technological framework. Collaborative sharing requires high levels of confidence and trust between actors. The basic principles of this new economic model are to optimize the rate of utilisation of underutilized assets, enable access over ownership (product as a service), set incentives to extend life expectancy of produced goods and contribute to a reduction of resource consumption. The collaborative aspect refers to distributed and cooperative networks of connected individuals and communities, fostering collaborative consumption based on sharing, swapping, trading or renting products and services. The purpose of sharing activities as well as people's motivation to participate can be economic (monetary gains, cost reduction etc.) or based on non-monetary values (societal, environmental, fair and local trade etc.). Given the multitude of organisational forms and business models, the sharing economy still lacks a shared definition. A useful classification can be established along two dimensions: first, the ownership and control of the infrastructure which can vary between centralized and distributed, and secondly the polarity between capital buildup and commons accumulation. The Sharing Economy takes multiple forms from global wealth-extracting business models to local, wealth-creating cooperative models.

The use of a digital platform is the prevailing organisational form. The platform economy creates new business opportunities, jobs, and sources of income. From the view of workers, working conditions and social security are main issues, notably the status of the workers (employee or independent). The classification depends on the degree of subordination or dependency between service provider and intermediation platform and is crucial in terms of social insurance coverage, working hours, work place safety and the like. The quality of the job (formal or informal) and the income possibilities are connected issues. As sharing activities often consist of micro transactions with limited turnover, they may increase inequality as well as stimulate new economic opportunities. The outsourcing of work to an undefined public (crowdsourcing) causes competition between workers on a global level. Here, it is important to prevent the circumvention of social standards.

Establishing a level playing field between the market and sharing economy is becoming an urgent priority. Equal regulations and legal obligations should oversee similar activities to ensure fair competition. In the sharing economy, however, a distinction must be made between professional actors and private persons operating only occasionally. Corresponding criteria should be fixed by

regulation. One approach could be to differentiate using thresholds, taking into account the level of income generated or the regularity with which the service is provided. It is important to make sure that all actors comply with their legal, tax and social obligations; a corresponding framework should be clarified or specified if necessary. The above distinction also matters in consumer rights, warranties, product quality, imposed security and sanitary norms. Relevant information to the consumers should be clear and freely accessible.

At present, official figures on the extent and acceptance of the Sharing Economy as well as statistics on its contribution to GDP and tax revenues are still missing in Luxembourg, just as is reliable information about people's motivation to participate or not in the Sharing Economy. Missing data hinders the elaboration of pertinent policies. However, digital intermediation platforms have created new opportunities to partly solve this problems, thanks to increased collection, traceability and measurability of data.

The transition towards TIR should go along with the implementation of "quality of life" indicators to assess socio-economic performance. Corresponding efforts are already being carried out within Luxembourg's Economic and social council (Conseil économique et social). The "PIBien-être" project and recent work on a new set of indicators should allow Luxembourg to link economic, social and environmental issues and performance to assess Luxembourg's competitiveness. These ongoing efforts are soon to enter their implementation stage.

The release of the TIR study affords the opportunity for a broad and fundamental public debate on Luxembourg's future configuration. To make TIR successful it is important to involve all the stakeholders and the population as a whole in the process. Due to the heterogenic resident and workforce population this could become a particular challenge for Luxembourg. Possible misgivings and concerns about the ubiquity of technology, data tracking and mining, big data analytics, mass surveillance and similar issues must be taken seriously to foster acceptance of TIR within the population. To strengthen social cohesion and reduce inequalities, realized gains from TIR should be distributed in a fair manner and benefit the society as a whole. As TIR is very capital intensive, the split between capital and labour taxation would need to be reviewed. Incentives for investments in cleaner TIR technologies could activate the transition. Elaboration of balanced policies that enable innovation and sustainable economic development, while maintaining social achievements and protecting public interest, will be an ongoing challenge.

A. REGULATORY

Individual VAT number for sharing economy entrepreneurship

To foster Sharing Economy entrepreneurship, public authorities could systematically provide an individual VAT number to each citizen or resident, or an entry into the Trade and Companies Register, acknowledging de facto everyone as a social entrepreneur and prosumer. To allow dynamic prosumption, the VAT number should be attached to the person, not to a specific activity, meaning a social entrepreneur could practice simultaneously, or over time, in different sharing economy activities under the same VAT number.

Regulation of sharing economy

By enacting the appropriate legislative regulations, Luxembourg could support both consumers and businesses to engage confidently in sharing economy activities, as legal certainty is a prerequisite for sound economic development. The European agenda for the collaborative economy presented by the European Commission on June 2nd 2016 could give guidance. The regulations would need to cover different aspects of the Sharing Economy. The distinction between professional actors and private persons operating only occasionally should be established by explicit criteria and thresholds. To ensure fair competition, professional Sharing Economy activities should have to comply with comparable legal obligations that regulate market economy businesses. This concerns, for instance, business permits, safety and security standards, warranty deeds, as well as fiscal and social security obligations. In addition, regulation should be aimed to create formal employment for Sharing Economy workers – where applicable – to ensure a maximum of social security. It is important to prevent the circumvention of labour laws and social standards.

B. PUBLIC POLICY

Analyse sharing economy activities in Luxembourg

To be able to develop well-grounded and pertinent policies, it is necessary to assess the extent and impact of Sharing Economy activities, in particular its contribution to GDP and tax revenues, as well as the number and quality of jobs generated. These and other information on sharing activities will need to be tracked and included in an expanded data set to inform public policy. The establishment of a specific survey about people's motivation to participate in the Sharing Economy should also be carried out. This could help evaluate the economic, social, and environmental impacts of the collaborative economy.

Sharing economy web-platform

A digital platform to operate Sharing Economy activities should be developed. This should be designed as a national one-stop shop for all things related to the Sharing Economy. This web-based tool would need to include several functions and applications.

First, the platform should be used to track and measure Sharing Economy activities to facilitate the task of collecting economic statistics and assessing taxes. The use of the platform should be mandatory for every actor (intermediation websites, owners/workers, sellers/buyers, producers/users, prosumers, etc.). Blockchain technology could be used as a tool for registering purposes, in order to build security into the value chains and record the transactions.

Secondly, the platform should be used to inform all the actors of the Sharing Economy about their legal rights and obligations. It should broadcast specific information for platform operators, providers, and users.

Finally, the platform could serve as collaborative innovation network (CoIN) and perform a key educational, informational and motivational service to help build the Sharing Economy by leveraging human, social, civic and intellectual forms of capital and by securing sufficient financial capital (crowdfunding). The CoIN platform could facilitate lively interaction among citizens already active in or desiring to become active in some facet of the Sharing Economy. In addition, the platform could provide a continuously updated inventory of sharing economy activities in Luxembourg.

TIR communication campaign and public debate

The study on Luxembourg's TIR strategy should become the centerpiece of a broad and fundamental public debate on the nation's economic and societal future. To support an economic transition and the associated socio-cultural shift, a multilingual communication campaign should be undertaken in order to familiarize the population and all socio-economic actors not only with Luxembourg's TIR strategy, objectives and motivations, but also with the general concept of TIR and its holistic approach, including underlying principles like the collaborative commons, sustainability and circularity.

NOTES

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