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Luxembourg towards a smart nation
Providing the keys to unlock our country's potential

Key message

Luxembourg is facing a series of challenges through the globalized economy, increasing levels of international regulation leading to a reduced margin of manoeuvre, not to mention the technological and societal disruption through digitalization. This whitepaper highlights the current state of play in Luxembourg in relation to the six core building blocks of a smart nation:

01. Technology and infrastructure
02. Data
03. Skills and competencies
04. Innovation culture
05. Attractiveness
06. Public-private ecosystem

While Luxembourg is well prepared in a majority of these areas, the coordination and connection of these building blocks are in need of strengthening to address key aspects designed to reinvent Luxembourg's business model. A truly smart nation is first and foremost defined by a strong cooperation between all stakeholders and an alignment of interests from the government, the companies and society.

State of play

Words like "technological disruption" and "Big Data" are dominating today's headlines. They represent a trend that is changing the way we live and do business.

Advancements in computing, communication technologies, and data processing are generating disruptive breakthroughs in many industries. Data is at the core of a revolution that has vast implications for nearly all sectors of the economy. Not only private companies, but also entire nations are feeling the pressure to adapt to this changing environment. Technologies are challenging today's social climate, while simultaneously offering many new opportunities to governments, businesses, and citizens. By developing innovative approaches designed to utilize technology for societal benefits, nations can meet the challenges of the future.

Luxembourg always faced a unique set of challenges that influenced its society and economy: its small size, its lack of certain natural resources, and its landlocked geographical location. Nevertheless, over the last century, Luxembourg was able to redesign its economic model twice. The steel industry took root in the second half of the 19th century. However, it was only due to the construction of large-scale integrated steelworks in the 20s and 30s that enabled the success of this particular economic sector as well as the country as a whole.[1] Since the 1970s, the economic structure of Luxemburg underwent a fundamental change. The collapse of the steel industry and the rise of the banking and financial services industry since the 80s have both had widespread consequences whose impact on society and the economy are still evident. The emergence of new industries have always been preceded by the decline of former ones, usually resulting in social and economic shifts. In Luxembourg's case, the country so far has been forward thinking in its approach, enough so to spot trends early, giving way to early groundwork for substantial economic growth and social welfare.

While the first and second industrial revolution started the transition from trade based economies to industrial societies, the often-cited "third industrial revolution", based on digital technologies and new manufacturing methods, promises similar transformative changes to businesses and societies. Digitalization is all-pervading and is changing our way of working and living on a daily basis. Today, we pay our bills by bank transfer from our home computer, or we call a taxi via an app on our smartphone, but so far, the effect on our country and its governance has been limited. Despite many promising projects, the expected positive outcomes have not yet materialized.

If Luxembourg maintains its support of economic concepts that are highly susceptible to disruption and fading business models, it will most probably face an unforgiving future.

Technology is an important element of globalization and competition is increasingly shaped by the deployment and use of these technologies.[2] Developing nations are leap-frogging traditional development steps by using relatively cheap technologies such as mobile internet to compensate disadvantages in the cost of capital and labour.[3,4] Technological advances are set to further drive competition between nations and could be the cause for social and economic upheavals, similar to those of the last industrial revolution. To meet the goals of their economies and societies, some leading nations have adopted a "smart" strategy such as Singapore, Switzerland, and Estonia as depicted below.

Luxembourg has reached a point, where vital sectors of its economy—especially the banking industry—are undergoing core transformations. For example, digitalization influences the relevance of fund industry back office tasks making them potentially redundant in a few years. A counterexample to the banking industry is the manufacturing industry. This industry is largely affected by the emergence of artificial intelligence (AI). AI is being used to bring down labour costs, reduce product defects, shorten unplanned downtimes, improve transition times, and increase production speed.[6] This process is likely to continue in the coming years with drastic consequences for Luxembourg's economic model. It is thus reasonable to argue that Luxembourg, as a nation, might be facing considerable obstruction in terms of future growth.

Singapore

"Singapore for example already expressed its wish to build a smart nation with initiatives such as the national digital identity, e-payment, or smart urban mobility." [5]

Switzerland

"Zug, a wealthy community in Switzerland is becoming attractive to investors and start-ups by adopting the latest technologies to create an ecosystem that fosters innovative companies."

Estonia

"Estonia seized the moment after independence in 1991 and created the foundation for a technologically advanced and smart society by investing in digital infrastructure in the 1990s."

Since financial services represent 24.7 percent of GDP and 11.7 percent of employment, large disruptions to this sector would drastically affect the economy.[7] If Luxembourg maintains its support of economic concepts that are highly susceptible to disruption and fading business models, and continues to rely heavily on industries that are in decline globally, it will most probably face an unforgiving future. Without a strategic repositioning, socially and economically, Luxembourg will struggle to defend its positon as leader of the pack.

Acknowledging these developments, Luxembourg is already a breeding ground for many local initiatives that aspire to contribute to the digitalization of the country. One of those initiatives is Digital Lëtzebuerg, whose mission is to harness digitalization as a tool for positive transformation. More precisely, it is developing Luxembourg into a digital hub fit for the future, by focusing on modernizing and future-proofing five key areas: government, skills, policy, infrastructure and ecosystem.[8]

Aside from Digital Lëtzebuerg, a Ministry of State initiative, the government has launched other ventures such as the Third Industrial Revolution (TIR) strategy study and the High Performance Computing (HPC) initiative, both of which are encouraged through the Ministry of Economy. The TIR "aims to make the existing economic model more sustainable and interconnected for future generations by working with ICT, energy, and transport as part of an intelligent network".[9] HPC on the other hand aspires to accelerate the research performed in intensive computing and large-scale data analytics (Big Data).[10] Many initiatives in the digital sphere have been launched over recent years and significantly contribute to the advancement of Luxembourg's future digitalization.

In order to sustain its current living standards, Luxembourg will need to compete with other nations by developing its capabilities in several key areas and leverage on digital competencies. Consequently, it is important to understand the dimensions involved in building and implementing a successful "smart" nation.

Luxembourg

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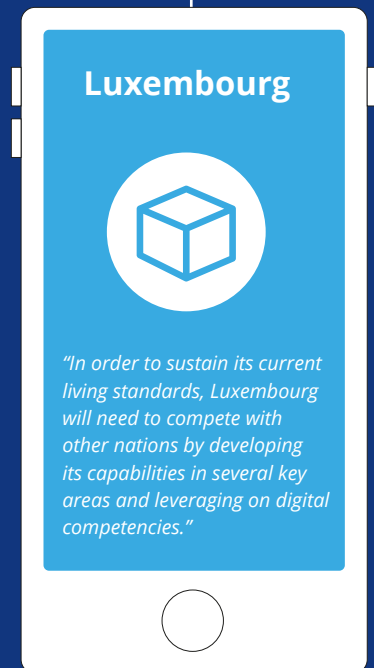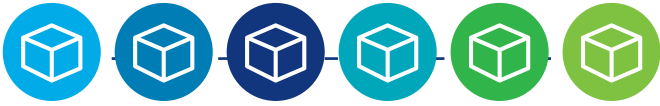
The building blocks of a smart nation

By constantly developing its competences and abilities as an innovative economy and creator of prosperity, as well as responding to the trends and shifts on a global level, Luxembourg may still be able to retain its competitive position.

So far, the nation's inherent nature to innovate and adapt to global trends has made it successful. Losing this spirit would no doubt lead to dire economic and social consequences, risking to undermine the success established over the last decades. Digitalization forces each country to reinvent its business model. Hence, the debate is no longer about if a country should become a smart nation, but rather how to become a smart nation — and thus a leader of the 21st century. A piece-by-piece approach is not enough to meet today's challenges, to position Luxembourg to compete with the frontrunners. In order to become a smart nation, a unified strategy supported by all stakeholders and government contributions is indispensable. Fortunately, Luxembourg has realized the necessity of taking action. In order to continue being able to compete on a global scale in the future, Luxembourg has already started investing in multiple projects and initiatives.

Smart nation framework
Each nation has a unique set of competitive advantages and social structures that define it. Having a clear economic, social, and environmental vision allows a nation to focus its energy and resources on what brings the most value and long-term benefits. A smart nation harnesses the power of technology and social innovation to increase existing strengths, to solve persistent challenges, and to create success through the leveraging of new opportunities.[11] However, success is dependent on recognizing the individual circumstances faced by a nation and how best to utilize technology in conjunction with these challenges.

Even though there is no "one size fits it all" approach due to individual growth patterns and regional trends, the below smart nation framework is an effective structure for creating value and sustainable growth in a country.[12]

The following pages will describe in detail each of the six buildings blocks; technology and infrastructure, data, skills and competencies, innovation culture, attractiveness, and public-private ecosystem.

Smart Nation Capability Framework
Strategy & Vision

01   Technology and infrastructure

02   Data

03   Skills and competencies

04   Innovation culture

05   Attractiveness

06   Public-private ecosystem

Source: Smart Cities, how rapid advances in technology are reshaping our economy–Deloitte 2015

01

Technology and infrastructure

Technology, digitalization, and innovation are not only causing waves of change, but have also become some of the driving forces for a country's economy.

Indeed, technology is rapidly becoming as essential as the three traditional utilities of water, gas, and electricity. Similar to a well-maintained power grid, "a nation without an ICT (information and communication technology) master plan is simply not relevant anymore."[13] The challenge for many developed countries is to maintain and build on legacy infrastructure systems that they cannot simply abandon due to many reasons such as costs and space. In his famous "law", Gordon Moore emphasizes this by stating that computing power doubles every two years and decreases in relative costs since 1970 making all infrastructure outdated pretty fast.

The availability of modern and open networks is the foundation to all infrastructures of smart nations and key for digital connectivity.[14] Networks for digital connectivity are required in three different forms:

01. Fixed broadband network
02. 4G and 5G networks
03. Internet of Things network (IoT)

Figure 1: Data center locations in Luxembourg
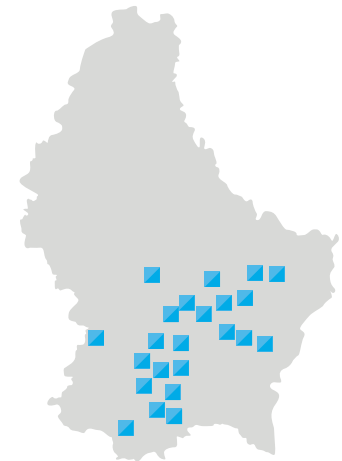
Source: *Datacenters-in-Europe*[15]

25 percent of all European Tier IV Uptime Institute certified data centers are located in Luxembourg.[16]

Over a decade ago, Luxembourg began laying the foundations for a digital economy by implementing fibre and broadband deployment as a priority. Having achieved its initial goal of becoming the first country with 100 percent nationwide fixed broadband coverage, Luxembourg is nowadays known for its Tier IV and multi-tier data centres. A Tier IV data centre is built to be completely fault tolerant and has redundancy for every component.[17] In fact, Luxembourg offers no less than 23 data centres (Figure 1), of which 30 percent are Tier IV Uptime Institute certified, ranking the country in first place in terms of Tier IV density in Europe (providing the ultimate level of redundancy and reliability as certified by the Uptime Institute).[18] Subsequently, Luxembourg has Europe's most modern data centre park.

As can be concluded from above, Luxembourg has long been committed to top-notch digital infrastructure and will continue to invest with the intention of remaining a competitive contender in the future.

In late 2015, Luxembourg presented the idea of a pan-European approach on High Performance Computing (HPC) to the EU Council of Ministers as it has realized that Europe has been lagging behind in this field.[19] A High Performance Computer is a computer with the ability to analyse billions of pieces of data in (near) real time.[20] This type of computer is typically used for solving advanced problems and performing research activities through modelling, simulation, and analysis.[21] For example, in the healthcare sector HPC are used to simulate effects of new drugs. The EU Council of Ministers quickly understood the urgency of having such powerful HPC infrastructures. In an effort to fortify the digital competitiveness of Europe, in March 2017 the government signed—together with six other countries—a European high-performance computer cooperation declaration (Figure 2). Since then, a further eight countries have also signed.[22]

Figure 2: Signatory countries of the European high-performance computer cooperation declaration
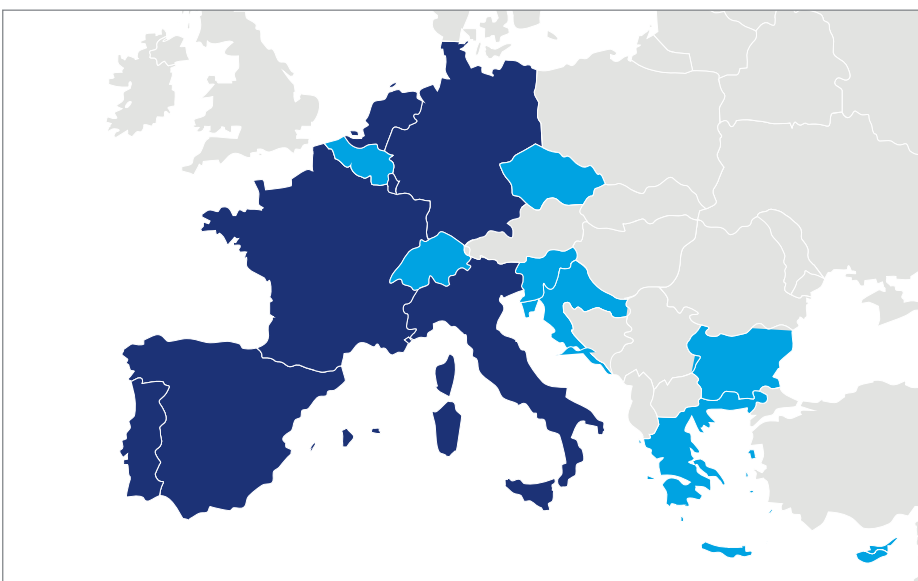
Seven countries – France, Germany, Italy, Luxembourg, Netherlands, Portugal and Spain – signed the declaration in March 2017. Since then, another eight countries – Belgium, Slovenia, Bulgaria, Switzerland, Greece, Croation, Czech Republic and Cyprus – have also signed.

01

5G will bring with it a sharp reduction in latency and increased bandwidth, critical for future breakthroughs, such as autonomous vehicles.

The aim of this project is to have one of the three most powerful HPC infrastructures in the world.[23] This declaration fortifies the Europe 2020 Strategy by helping secure the computing capabilities needed for EU's competitiveness as a digital economy.[24]

Luxembourg will acquire a High Performance Computer with the power of one petaflop per second, which corresponds to 1,000,000,000,000,000 (one thousand trillion) calculations per second.[25]

Luxembourg has adopted a lead role in the Important Project of Common European Interest (IPCEI) on HPC and Big Data-enabled applications. As part of this project, Luxembourg will soon acquire its very own HPC. The signed declaration foresees that

such infrastructure will be made available across Europe for scientific communities as well as public and private partners.[26] It is of utmost importance to create such an ecosystem as this helps to collectively push a smart nation's agenda—this aspect will be discussed in detail in the building block public-private ecosystem. As soon as the HPC is operational, it will be put into practice, taking on large-scale, pan-European projects in multiple fields such as smart space, smart manufacturing, smart energy, smart mobility, personalized medicine, FinTech, artificial intelligence, and many more. Luxembourg demonstrated once more that it was able to identify a crucial gap and to invest in the infrastructure needed to remain competitive.

The mobile broadband networks 4G and the soon available 5G provide ubiquitous internet access to people using mobile devices. Even though Luxembourg does not appear in the top-performer group in terms of network coverage, it is ranked in sixth place in terms of performance worldwide, with an average 4G speed of 36.56 Mbps.[27]

In order to prepare for the future, a 5G taskforce has already been established to ensure that Luxembourg remains at the forefront of connectivity. 5G will bring with it a sharp reduction in latency and increased bandwidth (more than 1 Gbit/s compared to 300 Mbit/s for 4G), critical for future breakthroughs, such as autonomous vehicles.[28] Furthermore, the networks will pave the way for the long-awaited Internet of Things.

Smartness will be driven and enabled by the emergence of the Internet of Things (IoT) technology. Being at the forefront of technological development, it will transform the current internet into a network of interconnected objects. With the help of sensors, billions of devices will be permanently connected to the internet. However, the need of a mature IoT platform is still the necessary cornerstone to manage and process data gathered by these sensors.[29] The development of program interfaces will enable smart usage of this data. IoT ecosystems are thus key in order to grow the digital economy.[30]

One practical example highlighting this point is the smart waste management solution of Helsinki in Finland, which has cut the cost of waste management by half. The city uses sensors to track the optimal 'full' level of their bins, allowing the city to optimize routes for garbage collection trucks.[31]

Recent progress in remote sensors with higher resolutions have significantly increased data volumes, which in turn has led to a significant challenge when it comes to processing and analysing the massive volume of collected data in a timely fashion to support practical applications. High-performance computing will help to facilitate the analysis of remote sensing data for various applications.[32]

With regards to the latest technologies, Luxembourg has been well positioned in the past and should be cautious not to lose this strategic position now. Luxembourg should strive to use data and new technology to improve everyday life and boost the Luxembourg economy.

02

Data

Everyday 2.5 quintillion bytes of data are created, with a staggering 90 percent of data in the world gathered in the last two years alone.

Global consumer IP traffic will almost triple from 2016 to 2020 (Figure 3). This data is necessary and crucial for a smart nation to emerge. Better, smarter, data-based decisions can be derived when data is combined from multiple sources that have traditionally not been used in combination.

If there is one ingredient that makes a nation smart, it is data.

Data gathering is however still in its early phases. Several nations have begun deploying pervasive sensor networks to gather data that deliver simple but isolated solutions. For example, trafi.com connects and compares different mobility options within cities and shows them in real time. Thus, by jointly using four approaches, true value is delivered to citizens and businesses.

These approaches are:

01. A networked approach that combines node connections via low cost communications
02. A managed approach that analyses city and nationwide systems in real time
03. An integrated approach across cities
04. A smart approach where Software as a Service based services, applications, and management tools are delivered[33]

Although Luxembourg is globally known for having the world's highest GDP per capita, it is dwarfed by the world's most renowned technology companies. Some of the GAFAs (Google, Apple, Facebook, Amazon) and BATXs (BAIDU, Alibaba, Tencent, Xiaomi) companies have a market capitalization much higher than the Luxembourgish GDP, all built-up by the data people provide to them freely. Consequently, China and the USA have a huge advantage as they host multinational private companies collecting data.
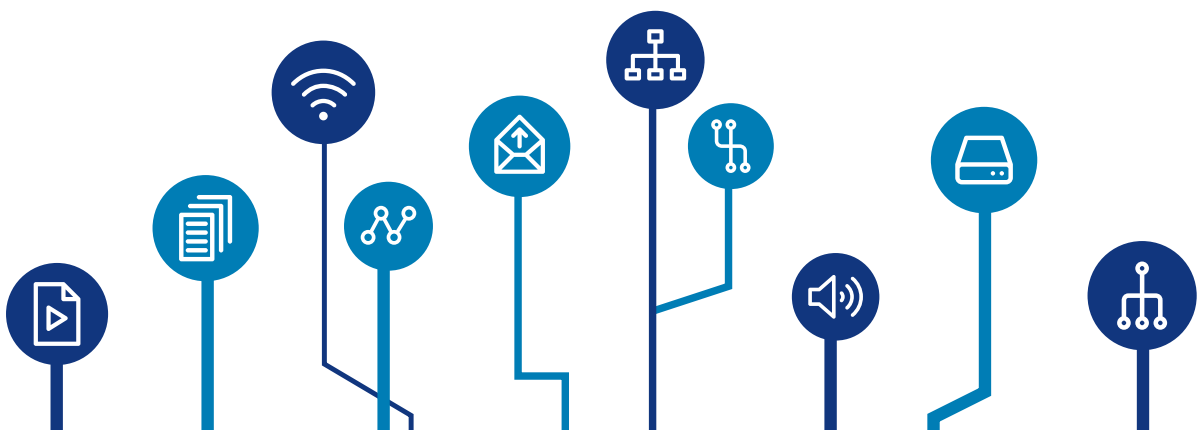
A smart nation should allow individual entrepreneurs and companies access to data that can unleash tremendous value. Luxembourg's government has already identified open data as a key success factor of the 21st century. As cited by Luxembourg's Digital Lëtzebuerg initiative "open data fuels economic growth and innovation by multiplying the applications and value of information."[35] Besides constantly working on policies enabling open data and transparency, it also launched the data.public.lu platform. This platform is a Luxembourgish open data website whose vision is to "strengthen democracy and head towards an open society willing to trust its institutions".[36]

Indeed, freely delivering data to citizens, companies, and organizations creates value not solely for the data owner, but for the whole community.

However, private or personal data should not be mistaken for public data. As the volume of data expands, so does the risk. Contrary to public data, which should be free and available to all, sensitive data must remain protected. As applications become more virtualized and adaptive, new cybersecurity gaps may appear, making the prevention of data breaches increasingly difficult.[37] As agencies extend their capabilities through cloud computing, IT outsourcing, and partnerships, they increasingly rely on complex infrastructures not fully within their control. Similarly, government efforts to engage citizens and employees through social media will introduce gaps and opportunities of which attackers will unquestionably try to exploit.[38] Security teams try to reduce the risk as well as data loss by making companies, citizens, and governments aware of the looming menace.

Local competences in data analytics have been growing over the past few years, on one hand in the private sector, but also through substantial investments over recent years in the University of Luxembourg, particularly in the Luxembourg Centre for Systems Biomedicine (LCSB), the Interdisciplinary Centre for Security, Reliability and Trust (SnT), and the public research centres.

Fortunately, Luxembourg has positioned security and trust at the core of its ICT development strategy. Thanks to our country's advanced infrastructure as seen in the section before, as well as its steadfast security, Luxembourg will host the world's first data embassy.[39] Indeed, Estonia agreed to store sensitive government information in Luxembourg's data centres.

Although Luxembourg has been seen to be taking the initial steps, there is still a long way to go to increase the country's capacity to collect, merge, and make use of data to the best of the country's ability and in the interest of its citizens. With this in mind, Luxembourg has a real opportunity to become, in the coming years, a leader in this field.

Figure 3: Data volume of global consumer IP traffic from 2015 to 2021 (in petabytes per month)
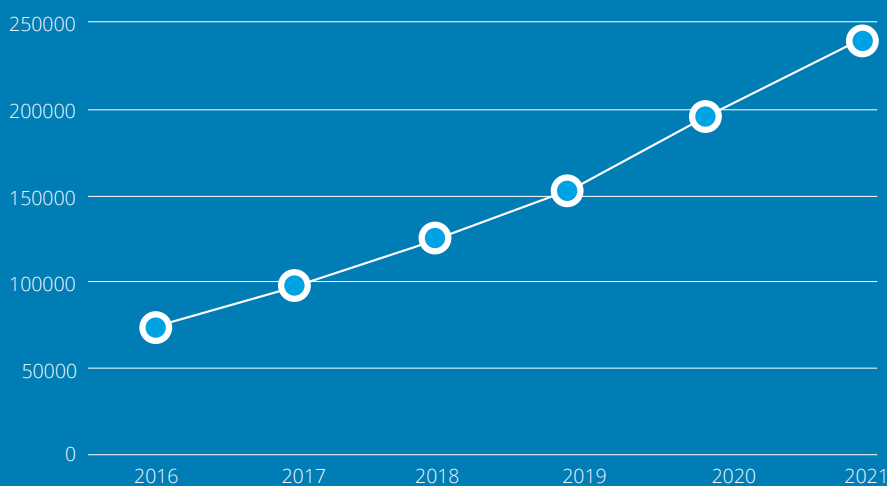
Source: Statista[34]

03

Skills and competencies

A smart nation requires smart citizens who are able to respond to the needs and challenges that come with the third industrial revolution. With the increased use of disruptive technologies and other innovations, a new set of skills and competencies becomes a requirement for successful application.

The most obvious skills gap can be identified in the context of analysing, understanding and processing data. Already in 2012, the relatively new job of "data scientist" was labelled the sexiest job of the 21st century, and this does not come as a surprise.[40] Data scientists are invaluable to a smart nation and many are needed. Data analytics means handling real time data and applying complex statistical methods to transform data into information that can be capitalized on.

At the same time, being a smart nation is much more than just being good at handling data. It is also essential to support our citizens in coping with the behavioural and societal changes that are linked to the increased use of data and technology.

So, what are the non-negotiable core competencies required in a smart nation? Baseline digital skills, computational thinking, and programming skills are just the beginning.[41] Mastering soft skills like being agile, adaptable and open to change only bring these skills to blossom.

In order to train both these technical and behavioural skills, we need to capitalize on two fundamental elements of our educational system: firstly, adapting our school curricula to a smart nation's needs and secondly, offering relevant lifelong learning opportunities to constantly support our citizens to have the required skills for their upcoming challenges.
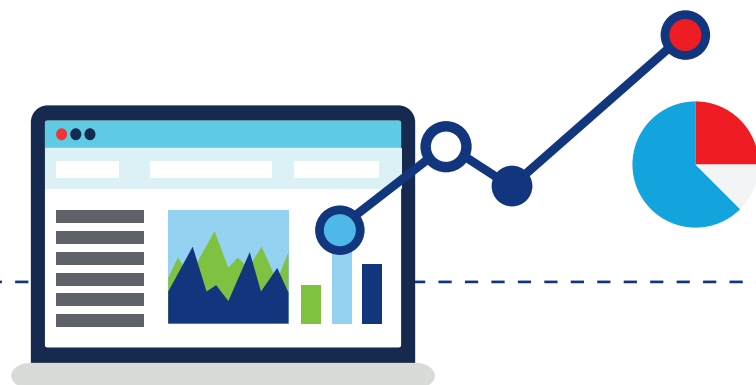
From a policy perspective, digital skills and competencies can only emerge in the right environment. As an example, if citizens and institutions have access to open data and know-how to use it to their advantage, it will increase engagement and therefore instigate skills development.[42] Creating the right environment within and beyond traditional learning institutions should therefore be the focus of a policy, to further develop the skills and competencies necessary to meet the demands of a smart nation.

As aforementioned, it is vital to have the necessary digital infrastructure (e.g. data centres, HPC, IoT,...) as well as software that supports the structuring of available data, so that it can be used as information. A nation that understands the value of data still however needs talent that understands the results in order for solutions to be implemented. Data sitting on servers has no value without people (or artificial intelligence) using it. Hence, data scientists and other emerging technology and big data related jobs become key in order to cope with the technological development and to interpret and leverage the collected data. A smart nation needs to identify the talent gap and build an education system that teaches data related skills, or alternatively attract the relevant experts from abroad—an aspect that will be discussed in the 'Attractiveness' building block.

Already in 2012, the relatively new job of "data scientist" was labelled the sexiest job of the 21st century, and this does not come as a surprise.

Luxembourg's Ministry of Education, Children and Youth launched the Digital (4) Education initiative in 2015, aimed at developing the know-how and skills that are crucial for the 21st century, and more specifically to prepare students for the rapidly changing professional landscape.[43]

As part of this initiative, the Bee Creative program's purpose is to improve the digital skills of Luxembourg's youth. Through available material, workshops, and coaches in the so-called "makerspaces", young people are invited to learn and experience aspects of digitalization that suit their interests—examples are learning how to code or using 3D-printers.[44]

More targeted towards secondary education, the new label "Future Hub" has been awarded to three high schools in the country, identifying these schools as competence and training hubs for new technologies, focusing particularly on computer science.[45] Simultaneously, these same schools have launched a new section for computer science and communication, preparing students to continue university studies in those fields.[46] These ongoing efforts will hopefully further improve Luxembourg's ranking in The Global Information Technology Report 2016, where it currently only ranks 23rd for the quality of the education system and 32nd for the quality of mathematics and science education respectively.[47]
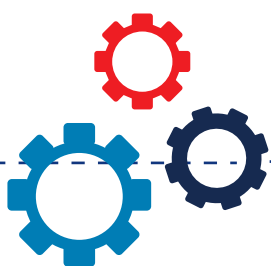
03

In 2016, a Eurostat survey revealed that 61 percent of companies polled in Luxembourg have encountered difficulties in hiring specialized ICT roles, the third highest percentage in the European Union.

As much as the country invests in upskilling its future workforce, one could argue that these initiatives mainly target young people with prior interest in ICT, as most of these opportunities are seized by those already looking for them. In order to expose every child from a young age to these new skills, one approach could be to introduce programming through applications such as Scratch and teaching coding like a language that kids learn at primary school.[48] Moreover, a Big Data Analytics bachelor or master's study program could be offered at the University of Luxembourg. By integrating programing and data analysis into the school's curriculum, from pre-school up to higher education, Luxembourg would be able to coach its very own talent—talent that the country will need in the close future.

Luxembourg's labour market is currently working on overcoming the present gap in the market when it comes to digital skills. In 2016, a Eurostat survey revealed that 61 percent of companies polled in Luxembourg have encountered

difficulties in hiring specialized ICT roles, the third highest percentage in the European Union.[49] In line with this apparent skills gap, "skills" is listed as one of the priorities of the Digital Lëtzebuerg initiative, with a dedicated focus on ongoing ICT development for the labour force.[50] Similarly, companies are investing in training and employee development according to The Global Information Technology Report 2016, where Luxembourg is ranked second after Switzerland in the extent of staff training. In addition, in 2018 Luxembourg launched a new project allowing companies to apply for financial support from the government to reskill or upskill their employees according to their individual gap analysis.

Regarding the workforce, it is key not to neglect those who need most support: small and medium enterprises (SMEs), lower-skilled workers, and older workers. In OECD countries, SMEs offer only half of the training activities to their employees in comparison to larger firms.[51]

Overall, it is crucial to develop a culture of lifelong learning that starts at an early age and introduces a certain personal ownership over one's learning by empowering citizens via accessible resources. One example where such concepts are recognized, are the UNESCO Lifelong Learning Cities. In 2015 and 2016, Gelsenkirchen in Germany and Bristol in the United Kingdom were awarded by the UNESCO for taking a proactive approach to promoting inclusive access to learning for all levels of education through not only education itself, but also families, communities, and the workplace.

In Gelsenkirchen, the city's vision for the future ("Zukunftsstadt 2030+") is based on education and participation. The city, in collaboration with 110 organizations and institutions, has issued a joint declaration establishing Gelsenkirchen as a learning city, proclaiming their commitment to sustainable education and lifelong learning measures to promote the skills needed to shape the future of the city.[52]

In summary, to develop the skills and competences of a smart nation, the diverse learning needs of citizens at all education levels, at all digital literacy levels, and in every age group need to be addressed by a holistic approach to lifelong learning.[53] An inclusive ecosystem that reskills the workforce of today, together with a reviewed curriculum in schools, is necessary to develop all the data scientists and other new jobs of the 21st century required in Luxembourg. And what we should above all not forget: moving towards a smart nation does not only require teaching our children, students, or employees the hard skills – we also need to build an ecosystem that supports its citizens in coping with its societal and behavioural evolution to avoid an increase in psychological stress and an associated decreasing motivation and engagement of its workforce.

04

Innovation culture

Building a smart nation requires the creation of an innovation culture that is open to new ideas, willing to experiment, and ready to take risks.

Fostering an innovation culture in the minds of citizens is highly important, in order to drive public opinion in a consistent and positive direction. On one hand, innovation hovers steadily around technology, keeping abreast of relevant trends. On the other hand, innovation is for a large majority of the country a challenge. It is commonly understood that in general, the bigger or the older a company is, the harder it is to innovate. In the same sense, for countries, it is easier to optimize how they operate rather than reinventing themselves. Innovation starts with culture. It needs to be encouraged in all departments and followed up on a regular basis. It is a constantly evolving state.

Through these experiments, governments will develop an understanding of what works and what does not. This includes looking for partnerships beyond traditional and established stakeholders to drive experiments. Taking risks, however also means there will be failure, which is an essential ingredient to the advancement of knowledge. An innovation culture for the digital age means developing a culture that is willing to accept failure. By launching initiatives such as the "Third industrial Revolution", which should be the trigger for a series of innovative projects or by setting priority topics such as space mining, Luxembourg is encouraging controlled risk taking in specific areas. The right innovation is the one that aspires for greatness and is in line with a time and risk balanced portfolio of the country.

As described in the previous building block, education has an important role to play in the process of changing a culture. Schools and universities have to educate people in such a way that they are willing to explore new fields, experiment, and take risks. They need to be willing to advance by iteration, accept failure as part of the process, and be able to learn from it. Citizens of a smart nation have to be ready to challenge the status quo. In addition to those "soft skills", people also need to be equipped with the right technical skills in order to best harness creative and innovative ideas.

Innovation is about collaboration within and across domains. A smart nation can encourage this in many ways. As an example, Luxembourg has developed sector clusters bringing individuals together around common sector topics to exchange know-how and stimulate new developments. By 2020, the Luxembourg cluster initiative has the objective to contribute to the creation of 3,000 new jobs.[54]

Innovation also requires the right regulatory approach. Exponential change in technologies and resulting innovation presents regulators with unique challenges; when do you start regulating without stifling innovation? How do you encourage experimentation and risk taking in terms of new technologies, whilst protecting consumers at the same time? As the pace of technological change accelerates, governments will have to learn how to strike the right regulatory balance between an environment that fosters and rewards—as well as appropriately regulates—innovation. Enabling rather than limiting is a vital step for smart nations.

In recent years, Luxembourg has consistently invested in strengthening its research infrastructure and capabilities. The State's budget dedicated to R&D and innovation has continuously increased with the aim of reaching 2.6 percent of GDP in 2020.[55] The establishment of a university was a big step forward. Since its creation, the University of Luxembourg has made a lot of progress,

whilst also gaining international recognition. In the 2017 Young University ranking by Times Higher Education, the University of Luxembourg was ranked 11th.[56] Beyond academic research the government is encouraging private sector research, in particular the collaboration between private companies and public research institutions.

A topic that receives less attention is innovation within governmental services themselves. Whereas innovation is seen as necessary to the survival of private sector organizations, this is much less the case within public institutions. Disruptive innovation can help public organizations reduce costs or improve the quality of their services just in the way as for private companies. However, in a public institution this might be more challenging, public actors have to define their roles within the innovation ecosystem.[57]

In the 2017 WEF innovation index, Luxembourg is ranked number 12, showing that the country is on track with developing an environment that favours innovation.[58] We are well positioned in terms of infrastructure and political environment, not to mention, innovation linkages are highlighted as one of the country's strengths. However, we score low in terms of human capital and research. The initiatives mentioned above show that this has been recognized and efforts are being taken to ensure progress is made.

A good smart nation regulatory environment will provide the protection that companies need while being adaptable enough to allow for the risk-taking and trial-and-error that innovation requires.[59]

05

Attractiveness

Building a smart nation means enabling attractive ecosystems that facilitate the constant renewal (i.e. technology, regulation, etc.) required for success in a digital world.

The emergence of strong ecosystems is dependent on a smart nation's ability to attract the right types of talents and businesses.

In terms of attracting businesses, Luxembourg is putting much effort into attracting tech companies. As described in the previous section, one main goal is to develop Luxembourg into an innovation hub with a large mix of ICT related services.[60] In doing this, setting the right regulatory framework plays an important role. An attractive regulatory environment should be driven by policies that benefit a wide variety of stakeholders. Indeed, public opinion around given policies depends on how the policies affect the life of citizens and companies.[61] Largely this means eliminating unnecessary regulations to help pave the way for new smart solutions that create a climate in which innovation can flourish. Changes to legislation on ICT, data and privacy are being made to enable new strains of business. This in turn attracts innovative technology companies that will ensure Luxembourg's attractiveness by enabling new types of business and fuel development in existing sectors.

Technology based approaches can be applied to further aspects of government to increase regulatory efficiency. We are seeing an increasing number of "RegTech" companies establishing themselves in Luxembourg. This is an area, where based

on the strong infrastructure foundations and the accessibility of its institutions, Luxembourg can build a leading advantage. Over the last few years, Luxembourg has made many efforts to promote entrepreneurship. Numerous incubators and support programs have emerged with the country managing to attract new innovative companies. Initiatives such as Luxembourg House of Financial Technology (LHOFT) has put Luxembourg on the international map of entrepreneurship.[62] According to the WEF networked readiness index, Luxembourg ranked number 1 in 2016 for political and regulatory environment.[63]

The disruptive potential of technology and data allows for the introduction of further innovation in the regulatory space. Data driven societal analysis, greater transparency, and competition combined with new types of digital democracy and co-creation can lead to outcomes that bring governments closer to citizens and foster a feeling of inclusion. Innovative methods of regulation are open access, relying on data to ensure accountability while traditional regulation is based on limited availability of data, low accountability, and therefore restricted access.[64]

Technological change and digital disruption are changing the talent profiles that will be required to create successful ecosystems in the years to come. Indeed, talent is often referred to as the engine of competitiveness and innovation for today's globally connected mobile economy.[65] Therefore, it is necessary to educate locals and attract talents with the needed skills for Luxembourg to hold its competitive position.

Due to automation and robotics, existing jobs will vanish or will undergo major transformations. Unfortunately, it is a matter of fact that many of the skill-sets required for the future are not taught today in Luxembourg. As it will take time to change the education system accordingly, it is therefore critical to be able to attract the required talent from abroad for both the public and private sectors.

Resources and attention should be focused on the type of talent that fits with the country's vision. Talent attracts further talent; it is thus a prime objective to become a hotspot for entrepreneurs, creatives and technology experts among others – residents and visitors alike. These are the people that will act as catalysts for the renewal processes through creative destruction and creation that we want to see in a smart nation. Recognizing and understanding these dynamics around the attractiveness of a nation is key.[66] This requires a holistic approach, taking into account all factors to create a climate of cultural diversity, including reputable knowledge institution, access to capital, and stimulation of start-ups.

As technology continues to substantially change today's environment, a major challenge for smart nations will be to manage this transition while addressing the social dilemmas associated with change. Ensuring social cohesion and inclusiveness for all citizens of a society experiencing rapid change requires particular attention. Moreover, one of Luxembourg's key strengths throughout the last decades was its efficient social security system. Without a doubt, a well-functioning social security system is an important selling point. Therefore, it is of utmost importance that Luxembourg is also able to guarantee the social security of its citizens in the future.

Many factors contribute to the attractiveness of a nation. Smart nations will leverage on digital technologies to improve their positioning. As an open country, experienced in integrating people from a large variety of cultural backgrounds, Luxembourg has good foundations to build on.

Entrepreneurs

Technology experts

Creatives

06
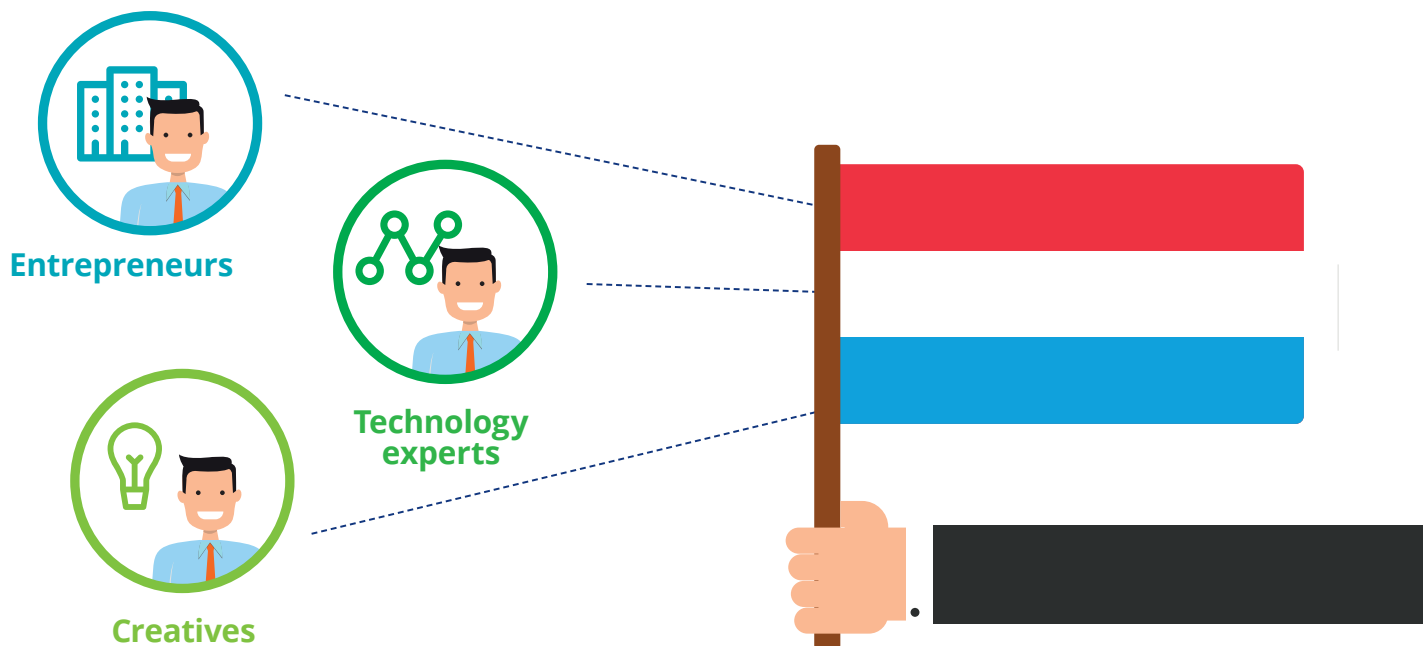
Public-private ecosystem

Co-creation is crucial to the success of a smart nation. Solutions to prepare for and adapt to changing environments, withstand, and recover from disruptions cannot be devised by individuals on their own.

Collaboration among all parts of civil society across any domains of expertise is necessary. We will see governmental organizations and businesses working together with community groups, academics, and non-profit organizations towards these common goals.

Already today, we see progressive cities building on the combined power of ecosystems to identify innovative solutions to their priority topics. For some of its most complicated challenges in the fields of mobility and poverty reduction, the city of Amsterdam in the Netherlands initiated a series of workshops with experts across a broad range of stakeholders including city agencies, businesses, academia, research organizations, and citizens to define and prototype ideas. The results of these workshops produced projects on renewable energy for electric vehicle charging and innovative budgeting support for the poor.[67]

As demonstrated by the above example, for co-creation efforts to be effective, the role of the government is ideally to identify strategic fields of action that lack sufficient novel initiatives and act as a catalyst by bringing together relevant parties. The LHoFT is a good example of a successful PPP (Public Private Partnership). The LHoFT was cofounded by 13 leading private sector institutions who share the board with representatives of the Luxembourg Government. The LHoFT is very successful in fostering FinTech organizations and attracting start-ups to Luxembourg. It has been, and still is instrumental in establishing Luxembourg as a major FinTech hub, a centre where finance and technology interact to foster innovation and develop solutions to shape the future of financial services.[68]

In a digital government survey, 73 percent indicated that their organization's digital capabilities were lagging behind those of private sector organizations.

A well-functioning public-private ecosystem has the power to deliver innovative new solutions that neither of the parties could have realized on its own.

A large part of a smart nation's processes and services will benefit from cooperation across traditional domains. Today's consumers have come to appreciate seamless user experiences that they are familiar with from many parts of their private lives. When confronted with governmental administrations however, citizens most often find themselves dealing with disappointing user journeys. In a digital government survey, 73 percent, out of 1,200 representatives from 70 countries, indicated that their organization's digital capabilities were lagging behind those of private sector organizations. To a large extent, the skills and knowledge of the digital world can be found within young private companies. Cooperation between public institutions and start-ups could be one way of bridging this skill gap. Beyond technical capabilities, this also includes ways of working and execution of methodologies.

We believe that co-creation efforts between the private and public sector deserve more emphasis and should be revisited for the digital age. Those aspects will be crucial to the success of smart nation projects. Whereas private companies engaging in such initiatives can profit from broader application fields, public sector organizations will initially mainly benefit from closer collaboration with digital companies in terms of skill transfer.

Luxembourg is ideally positioned to develop well-functioning ecosystems with public, private, and community initiatives. Over the last year, the country has gained experience in one such project. The Third Industrial Revolution, initiated by the government in collaboration with Jeremy Rifkin, was set-up to include and involve all elements of civil society. Moreover, Luxembourg is often praised for how (i.e. open and pragmatic) administrations and businesses work together. This sets a solid foundation for ecosystems in a digital age.

Vision for Luxembourg's future

To be successful, a nation must provide its citizens with a stable and sustainable living environment, a strong economy, security, education and mobility, as well as show a strong commitment to its citizens.[69]

These pillars represent the basis for Luxembourg's current and future success. As the previous section highlights, Luxembourg has already moved toward the direction of becoming a smart nation as it has launched multiple initiatives in various areas that have reached a level of advancement that gives our country a good starting position.

However, the attractiveness of the above-mentioned building blocks on their own should not be over-emphasized. To meet the challenges of the future, it is necessary to apply a structured framework and a dedicated national strategy that unifies and connects individual projects. The result should take the form of a vision for a smart nation rather than a dispersed set of initiatives in the country. The separate dimensions can exceed in this way the value their individual parts have. Luxembourg, with its short decision-making routes, inclusive social model, good infrastructure, historic sensibility toward current trends, and unique position in the global economy is best suited to apply such a vision and become one of the world's leading smart nations.
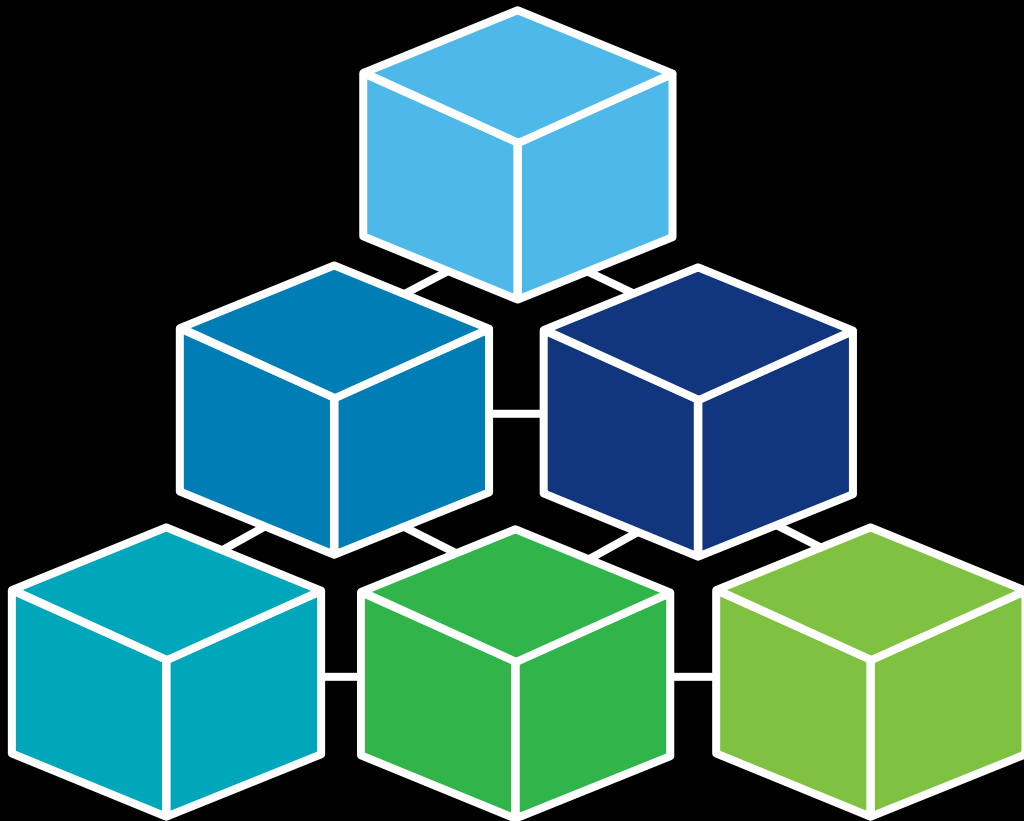
The real benefit of a smart nation is not reached through individual solutions, but through the creation of a holistic system where all solutions work together.

Vision
A center for digital clinical trials

Today, there are more than 30,000 clinical studies recruiting patients in Europe alone, with some requiring the recruitment of thousands of participants, all of whom need to fulfil precise criteria to join. Most clinical trials currently rely on antiquated, paper-based data collection and require their registered participants to regularly visit trial sites in hospitals or research centers.[70] From participant recruitment to data collection to adherence, the early stages of clinical trials is full of logistical challenges and inefficiencies causing delays in most of these trials and leading to billions of euros and countless hours of human effort spent each year validating new drugs, devices, and medical interventions.

Recent technological advances in software and hardware would allow to streamline and accelerate the above process and provide patients with the ability to participate in a trail from the comfort of their own home, additionally allowing for a more diverse trial population. While some large pharmaceutical companies like Sanofi and Pfizer experiment by using connected devices and technology disruptions, healthcare has so far been slow to incorporate these advances in its clinical trials.

By using its current assets to their full potential, Luxembourg could become the European hub for digital clinical trials under the leadership of the Luxembourg Centre of Systems biomedicine of the University of Luxembourg and the Luxembourg Institute of Health.

Healthcare start-ups, pharmaceutical companies, and research centers could benefit from Luxembourg's top-notch infrastructure in terms of network and IoT connectivity as well as computing power in the future HPC centers, setting thus the ideal testing ground for digital clinical trials.

Data is at the core of clinical trials, even more so when digitalized. Luxembourg based initiatives like Infrachain, could be fundamental building blocks of developing Smart Contract enabled clinical trials that provide patients with the full control over who uses their data and for what purpose. The security of the healthcare data generated through those trials will need to be assured through appropriate measures, competent people, regulation, and government controls.

While classic clinical trials require patients to fill out excessive paperwork or journals while regularly traveling to and from a clinical site for check-ins, digital clinical trials would be built around an innovative patient-centric app combined with wearable devices that would greatly improve the quality of trial data and reduce

dropout rates. Conversely, such an app would need to be combined with a data management system that would allow pharmaceutical companies and research centers to monitor collected data in real-time and automate data analysis in a secure environment.

The development of such a digital clinical trial center would require a large amount of highly qualified people with experience in the latest technologies and healthcare to be trained at the University or research centers and recruited from abroad. In the favorable Luxembourg setting, such a center could attract a wide diversity of start-ups, companies, big pharmaceutical organizations, and research centers that would either contribute with their own innovative solutions to the services of this center or make use of the center's capacities to test their new drugs or devices. In its early stages, such a center would need to rely on a strong public-private partnership between the Luxembourg government, universities, and research centers as well as healthcare companies in order to boost the level of activities.

By joining forces and building on our unique set of assets, Luxembourg could become the enabling factor for disrupting classical clinical trials and providing patients with efficient access to the latest drug developments at a lower cost.
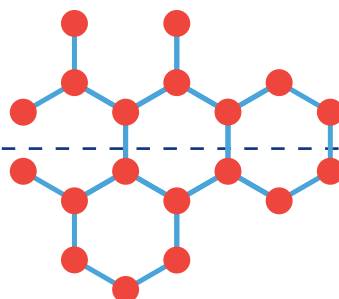
By applying a structured approach using the synergies gained from the building blocks, a truly new and smart business case can ensure that Luxembourg sustains its economic model, thus enabling it to maintain its competitive leading position.

Vision
Green finance

After signing the Paris Agreement on climate change (December 2015 – 195 countries[71]) and adhering to the Sustainable Development Goals (SDGs), many developed nations see the urgent need for investment to limit climate change. This shift in the global mind-set implies that many developing countries have to rethink their current economic development path. Decision makers (public and private) are forced to consider sustainability issues more deeply and frequently.

Significant momentum has been gained around the world, and until 2030, US$90 trillion are being triggered in order to reach the SDGs.[72] Furthermore, over the last 13 years, investment into green energy and sustainable solutions has grown exponentially to around US$335 billion in 2017.[73] This shows undeniably that the sustainable finance sector is growing and will continue to grow further in the future. From a European Union perspective, recommendations have already been made to place sustainability at the heart of Europe's financial system. A plan to build international cooperation among financial centres on climate action and sustainable development has been agreed on by the international network of Financial Centres for Sustainability (FC4S).[74]

Green finance is central not only to the world's development, but also to Luxembourg's quest to persist as a world-leading financial services centre, with half the world's green bonds already listed in Luxembourg.[75] While initially focused on microfinance, over the last years, Luxembourg has developed into Europe's current leading domicile for responsible investment funds, as well as the leading centre for listing green securities. In 2007, the Luxembourg Stock Exchange has listed the world's first green bond with the European Investment Bank (EIB).[76] As of today, the Luxembourg Finance Labelling Agency (LuxFLAG) labels more than 20 ESG (Environmental, Social, Governance) funds and 8 Environment Investment Vehicles.[77]

Leveraging on the established asset management industry and its generally strong ICT infrastructure, Luxembourg should continue to invest in relevant initiatives like the recently established International Climate Finance Accelerator.[78] Furthermore, in terms of innovation, Luxembourg should reinforce its role as a FinTech hub attracting top-notch start-ups from across the world while nurturing local actors. They will provide access to the latest digital technologies that will support the transition of the incumbents into the Green Finance market.
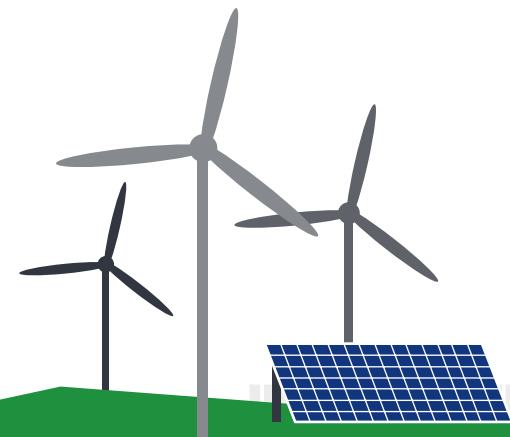
Green finance is central not only to the world's development, but also to Luxembourg's quest to persist as a world-leading financial services center.

However, a lack of consistent data is a barrier to reaching further green finance opportunities as it prevents investors from managing risks and analysing business models. It might even be the biggest challenge faced by the sustainable finance space, as accurate information is the key element for investment decisions. For a long time, environmental externalities have been considered lightly, in the management of risks, in valuations and in business decisions. The impact of externalities is well known and big data analysis is key in order to be prepared in the best possible way. Therefore, further research and innovation are necessary to develop adapted assessment methodologies and indicators.

By committing to green finance and an adapted regulatory framework, Luxembourg would attract new specialized companies and FinTechs that have climate change at the heart of their organizations.

While the Luxembourg financial place hosts highly qualified employees, this development would require to attract and train specialists that would be able to assess the impact of individual investments on the SDGs.

Luxembourg currently holds a favourable position in the global green finance market.[79] Coordination between public and private is key though, should Luxembourg want to build on its role as an international centre for climate finance and surpass London as the preferred listing venue for green financial instruments.[80]

Continuing its green finance strategy based on the six pillars of a smart nation would give Luxembourg the necessary edge to stay on top of its competition and to become established as a go-to partner when investing in green growth.

Conclusion

To achieve its goals, meet its challenges, and become a smart nation, it requires a vision and an alignment of the building blocks.

Luxembourg is, per capita, the wealthiest country in the European Union and its citizens enjoy a high standard of living. With a fading business model, Luxembourg is on the verge of missing out on opportunities presented by the digitalized world. Luxembourg has to stay economically competitive, sustainable, and further increase its citizen's quality of life. By leveraging on and interconnecting the before mentioned building blocks, a superior level of prosperity and sustainability can be achieved.

However, it is clear that these building blocks will not start working together from one day to another; a certain level of guidance is required. It might thus be interesting to consider centralizing the management of digital initiatives in a single place with sufficient "firepower". Such a place may be a future digital ministry that will lead the government's digital policy. A digital ministry will not only ensure that the building blocks are working together in a homogenous way, but it will also create an environment that further facilitates the use of ICT as well as the development of smart ideas and solutions within the government itself as well as at national level. Competences could encompass at least the following three areas: cybersecurity to make sure the country is well prepared to face future digital threats, regulation to develop a regulatory framework that fosters innovation as well as economic competitiveness while protecting citizens, consumers, and society at large, and last but not least, the ministry should ensure the smooth operation of the government's IT activities.

If we want to become a truly smart nation, we will need to be able to reinvent the business model of Luxembourg through a series of major initiatives that combine the six building blocks described above in an intelligent way. The conditio sine qua non is that all stakeholders (companies, public entities, society and citizens) join forces and act in the common interest of the country.

To meet the challenges of the future, it is necessary to apply a structured framework and a dedicated national strategy that unifies and connects individual projects where all stakeholders work together.

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