THE OPPORTUNITIES FOR UKRAINE IN A LOW-CARBON FUTURE

BELLONA

December 2017

The Bellona Foundation, Kiev, Ukraine, December 2017

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Acknowledgement:
This report was supported by the Ministry of Foreign Affairs of Norway and the Embassy of the Kingdom of Norway in Ukraine.

Table of contents

Foreword

> ***We are proud of being among the first Parliaments in the world that voted for the ratification of the Paris Agreement.***

Nowadays, the leadership shown by the Verkhovna Rada should be taken as a sign by all the executive authorities for Ukraine to fulfill its global obligations. Renewable energy and energy efficiency technologies constitute a significant part of climate change mitigation policy. The existing Ukrainian legislation has created a niche for these technologies, but we aim to develop a vast low-carbon market. In 2017 renewable energy sources constituted around 7% (including big hydro power plants) in Ukraine's gross final energy consumption with a goal of 11% by 2020.

A feed-in tariff was introduced in 2008 in order to incentivize production of energy from renewable sources, and this is still one of the major incentives in Ukraine. A bonus for local content is also envisaged in the legislation. Still, further work on creating a comprehensive framework for the promotion of renewable energy sources and developing national low-carbon industries is yet to be done. We believe that the policy of promoting sustainable technologies should not be limited only to financial instruments. We should also work on stimulating the deployment of low-carbon technologies. Ukraine could use its expertise, knowledge and resources in order to become a carbon-conscious industrial hub. At present, there is wind turbine manufacture, solar-solutions production, and emerging simple lead-acid batteries fabrication in Ukraine. Moreover, Ukraine´s reserves of lithium and graphite are among biggest in Europe. This is a decent starting point to replace declining old industries with innovation.

This report reflects the initial diagnosis of existing industrial ecosystem in Ukraine, which could be a source of ever-increasing economic output. It clearly shows that there is a mutual interest in enhancing the transfer of advanced technologies from Europe to Ukraine. The edition also aims to be a thought-provoking contribution to the ongoing policy-making process of discovering the path towards sustained growth without compromising the climate. But, we should recognize that this is also a challenge to the industry itself: to make a transition to new products, new capacities, and new markets.

Promoting low-carbon solutions in Ukraine is a way of reducing dependence on fossil fuels and enhancing national security. Therefore, military aggression is not an obstacle for an energy transition, but a challenge and an impetus.

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Executive Summary

Ukraine has in recent years been dealt many more challenges than opportunities. The economic situation in the country has fluctuated over the previous decades, varying from times of struggle to renewed growth and to recession again due to external influence. Today the Ukrainian economy still rests on traditional core industries, with exports in the form of agricultural goods, metals and lower value-added products. These sectors are limited in growth potential, and potentially at risk from new disruptive technologies. It is important for Ukraine that industry, workers, education and legislators work together to take advantage of all emerging economic opportunities. What global trends in emerging technology, industry, services and energy can Ukraine take advantage of to create new, globally competitive, high value-added sectors?

The aim of this report is to provide an overview of the overlap of Ukraine's existing strengths and potentials with the projected future market growth of low-carbon technologies and products. The transition to a low carbon economy opens new commercial niches that Ukraine is well positioned to contribute to and profit from. The impetus of reaching climate targets is unleashing a wave of disruptive technological change. Rapidly increasing competitiveness of clean technologies and services are creating new industrial sectors that are anticipated to grow globally. The 21st century will require vast amounts of low-carbon inputs requiring new supply chains and producers servicing new commercial niches. The structure of the report reflects some of the major technologies that are projected to contribute to those inputs and provide significant emissions reductions and commercial opportunity to stay within the 2-degree target.

Just as wind generation capacities, the solar market has exceeded its projected growth year after year. With the exports of solar components from China dropping, Ukraine will be able to make use of the drop-in supply for the ever-demanding European market.

The investment required for further electricity storage technologies worldwide will range from 380-590 billion USD. The growth of the lithium-ion battery market will be particularly noticeable in Europe. With abundant natural resources and a highly qualified population, Ukraine has large potential to tap into the expanding energy storage market.

Energy efficiency measures are key to both enable the future growth of renewables and complement their CO_2-emissions-reduction potential. Only the renovation of buildings in the European Union will require average annual investments of approximately 130 billion EUR. By developing the production of products such as heat pumps, Ukraine can contribute to this developing market both domestically and in Europe.

By 2040, wind power is projected to increase from the current 4% to 17% of total electricity generation worldwide. With an annual investment between 146-170 billion USD for global additions. As growth in European wind market shifts eastward, Ukraine will be able to use its existing industrial ecosystem to meet export demand for wind power infrastructure.

Technologies such as Carbon Capture and Storage will be crucial to achieving deep emission reductions in energy intensive industries in Europe. Only capturing the CO2 from the cement industry will require additional yearly investments of 6 billion USD. With its natural resources and experience in producing metal products, Ukraine could contribute to building a CO2 transport and storage network in Europe necessary for reaching the 2-degree goal.

PAST & CURRENT ECONOMIC AND INDUSTRIAL DEVELOPMENT OF UKRAINE

Since Ukraine's independence, its economy has to a great extent been based around the inherited industry of the Soviet Union. Sectors like mining, both for ferrous- and non-ferrous metal, in addition to coal, have been and are cornerstones in the Ukrainian economy. Agriculture has also traditionally been very important in the country, and the infamous black earth still produces large amounts of grain for both domestic use and export.

The goal of this report is to show how Ukraine can adapt and prosper from the changes happening in the international economy. Therefore, this chapter will give a quick overview of the past and current development of Ukraine's economy and industrial complex with the goal of providing a background for further discussion of Ukraine's potential.

After its independence, expectations were high for Ukraine not only to become a prosperous free market democracy, but also a full member of the European Union (EU), North Atlantic Treaty Organization (NATO) and Organisation for Economic Co-operation and Development (OECD). The fifth-biggest European nation by size of population, and the largest country geographically wholly European - today, Ukraine is seen as an underachiever economically, being referred to as a sick man of Europe.

In 1991, Ukraine's GDP was relatively low. Notoriously uncertain statistics of the time make it hard to get reliable numbers, but the best ones show Ukraine's GDP per capita at just US$1,307 just after its independence (Carnegie, 2012). Soviet practices had helped the traditionally agrarian country modernize its mining and metallurgy-sectors, and made it dependent on oil, and later, gas, from Russia. Still, despite its lack of wealth, Ukraine inherited a relatively good infrastructure and capital stock from the USSR.

In Soviet times, Ukraine held an industrial course that allowed it to develop the industrial sector of its economy. In 1992, industry accounted for almost 51% of Ukraine´s GDP; in 2010 – 25.7% and in 2016 – 23.3%. Processing (production) in 1992 amounted to 43.5% of GDP, and in 2015 it accounted for a bit more than 14%. In 1990 machine-building was an important part (30.5%) of Ukrainian industry (Ukrainian State Statistic Service, 2017).

Between 1991 and 1996, the country experienced hyperinflation and a big decline in production. Annually, its economy contracted between 9.7% and 22.7% during the first five years of independence, and official GDP was almost halved from 1990 to 1994. This was in turn followed by a slow decline, which continued throughout the 1990s, and Ukraine did not see economic growth until the year 2000 (Carnegie, 2012).

Ukraine's economy has grown with the rest of the post-Soviet region, with considerable rate after the devastating 1990s. At one point in the mid-2000s the growth rate of its GDP was a whopping 14.3% (Trading Economics, 2017). But, the foundation for this growth was by no means sustainable.

In trying to explain this growth, many point to Ukraine's large-scale capitalists – the oligarchs, former Soviet-era industrial managers who were able to obtain enormous assets during the push for privatization in the 1990s. At the time, Oligarchs were perhaps the best available owners within Ukraine in terms of productivity enhancement (Carnegie, 2012). Still, their business formula was loosely based around a strategy of converting cheap energy and raw materials into metals and manufactured goods. As such, one could argue that

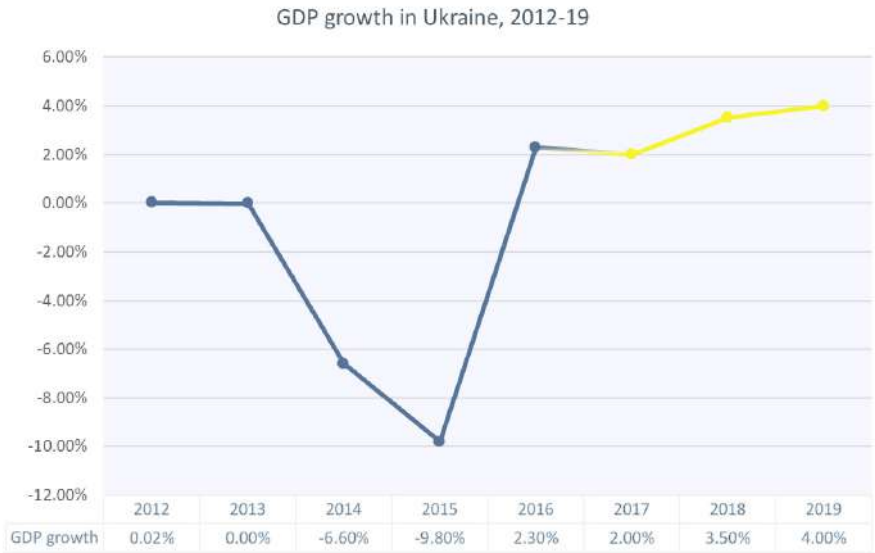


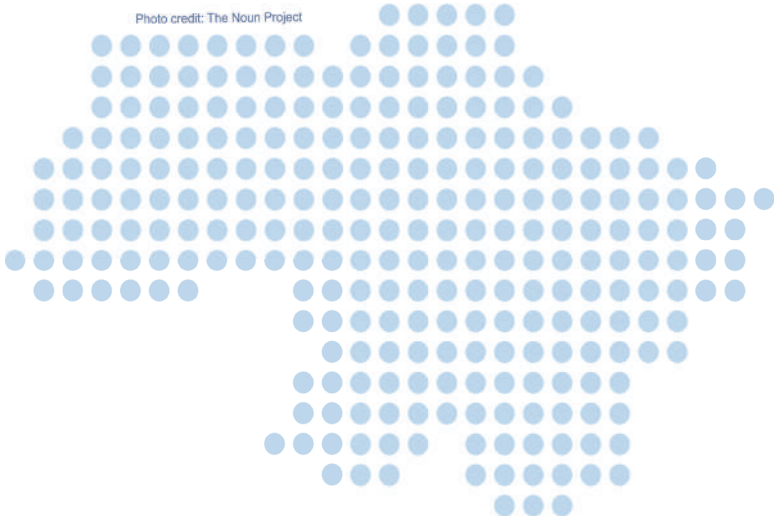
Figure 1: GDP Growth in Ukraine, 2012-16 with projections 2017-19 (World Bank, 2017)

Ukraine's economic growth after the turn of the millennia was based on transient factors, and not necessarily a result of productive reforms. Another time-specific factor was the boom in metal- and chemical prices after the turn of the century. This, coupled with gas imports from Russia, which at the time still was low-cost, gave very high export revenue from Ukraine's traditional industries (Carnegie, 2012). The prices for gas in Ukraine were low until around the mid-2000s, when it started rising rapidly, peaking in 2014, before falling again (EPravda, 2015).

In 2000, metals, minerals, food and chemicals accounted for just over 70% of Ukraine's exports. Metals and mineral products alone accounted for 50% of the total. In 2008, the shares remained quite similar (Carnegie, 2012). This is a sign that the Ukrainian economy has had a hard time adapting and renewing itself. Not much has been changing. The economic windfall that Ukraine enjoyed from the turn of the century and up until the financial crisis of 2008 led the industry to rest easy, and demanded little of them in the ways of diversification or sophisticated improvement – two things needed to stay competitive in today's markets. Where diversification either entails that investments in several different industries or that one type of industry produces several different products, sophistication in this context is technological development within industries. Both contribute to the resilience of the given industry, and thus the economy as a whole.

This lack of development is visible in several industries in Ukraine. Ukrainian agribusiness targets mass production of basic grains, not boutique production of very high-value ecological produce and other specialties, increasingly demanded by neighbouring European consumers. The share of high-tech goods in Ukrainian exports is lower than in other former Soviet states, such as Lithuania, Bulgaria, Kazakhstan, and Poland, and hugely behind that of other emerging markets like the Philippines and Malaysia (The World Bank, 2017). Ukraine does have some high value-added export commodities in aircraft components, helicopters, electrical machinery, and some pharmaceuticals (OEC, 2017). These are strengths inherited from the Soviet Union. However, export volumes of such goods are not on the increase and Ukraine has made little improvement toward diversification and sophistication. In fact, all exports from Ukraine have dropped during the last couple of years, with the exception of export of agricultural products, which is rising (Export.gov 2017).

In 2009, during the financial crisis, Ukraine's economy contracted almost 15%, but stabilized again, seeing slow growth from 2010 to 2013. Following the Euromaidan, the annexation of Crimea and the conflict in the east of the country, Ukraine's economy took yet another blow, contracting by 6.6% in 2014 and by 9.8% in 2015 (See Figure 1). In 2016 it again saw growth of 2.3%, and is projected to increase by 2% in 2017. The economy is expected to continue to grow by as much as 3.5% in 2018, mainly due to an increase in domestic demand (Export.gov, 2017)



1.1 Ukraine's economy and the rest of the world

The EU has replaced Russia as Ukraine's largest trading partner after the EU and Ukraine enacted the Deep and Comprehensive Free Trade Area on the 1st of January 2016, and since Russia imposed a series of trade restrictions in the runup to and the aftermath of the Euromaidan that resulted in the Russian occupation of Crimea and ongoing military conflicts in the Ukraine's east (CIA Factbook, 2017).

Ukraine's trade with the Commonwealth of Independent States (CIS)[1] countries fell noticeably compared to the volume of trade with the EU. Exports to Kyrgyzstan decreased by 70%, to Azerbaijan - by 53%, Turkmenistan - 44%, Tajikistan - 53%. For some categories of goods, exports fell by more than 90% during the first four months after the transit sanctions on products from Ukraine through Russia to Kazakhstan and Kyrgyzstan were introduced. Decline in Ukraine´s export of parts for nuclear reactors, boilers and machines to Kazakhstan decreased by more than 60% in the first quarter of 2016. In view of the new trade barriers imposed by Russia, the volume of trade will certainly fall further. One cannot exclude the possibility that the next steps of the Russian Federation could be the ban of transit to other countries of Central Asia (Apostrof, 2016).

Ukraine's recent economic recovery and stabilization is heavily supported by the IMF. In March 2015, a four-year Extended Fund Facility (EFF) program for Ukraine was opened by the IMF, totalling approximately US$17 billion (bn). Ukraine is currently on track with reforms required by the IMF, and will receive its fifth transfer of funds under this program in 2017. Further assistance will depend on additional reforms. According to the IMF, Ukraine's per capita GDP is just 20% of the EU average, and the second lowest of all Central and Eastern European countries (Export.gov, 2017).

The potential of Ukraine as a transit country could play a predominant role in the international transport system and could boost development of the national economy.

Ukraine´s infrastructure with its 13 seaports, 170,000 km roadways, 22,000 km of railways, 20 airports and its geographical location on the crossroads of major transportation routes from Europe to Asia offer advantages for a trade and export orientated economy. This is enhanced by Ukraine's DCFT Agreement with the EU (UkraineInvest, 2017).

In the World Economic Forum's yearly survey of competitiveness around the world, Ukraine ended up in 81st place out of 137 economies surveyed (WEF, The Global Competitiveness Index 2017-2018 edition, 2017). Among 12 indicators for the global competitiveness of the country, Ukraine scores well on higher education and training (35th among 137), market size (47th), and health and primary education (53rd). But it does poorly in financial market development (120th), goods market efficiency (101st), performance of institutions (118th), business sophistication (90th), and technological readiness (81st). When it comes

Ukraine and the EU

The cooperation between Ukraine and the EU mainly revolves around the Deep and Comprehensive Free Trade agreement (DCFTA) and the overarching Association Agreement (AA). The latter came into force on the 1st of September 2017.

- The EU is Ukraine's largest trading partner, accounting for more than 40% of its trade in 2016. Ukraine accounts for 0.9% of EU's total trade, with a turnover of EUR 29.6 bn in 2016.
- Ukraine's exports to the EU amounted to EUR 13.1 bn in 2016. Ukraine's main exports are raw materials (iron, steel, mining products, agricultural products), chemical products and machinery.
- The EU is a large investor in Ukraine. EU investors held investments worth around EUR 16.1 bn in Ukraine in 2015.

The AA/DCFTA aims to boost trade in goods and services between the EU and Ukraine by gradually cutting tariffs and bringing Ukraine's rules in line with the EU's in certain industrial sectors and for agricultural products. To better integrate with the EU market, Ukraine is harmonising many of its norms and standards in industrial and agricultural products. Ukraine is also aligning its legislation to the EU's in trade-related areas such as:

- competition
- public procurement
- customs and trade facilitation
- protection of intellectual property rights
- trade-related energy aspects, including investment, transit and transport

Small and medium sized Enterprises (SMEs) in Ukraine can receive support from the EU's SME Flagship Initiative. This initiative allows SMEs in Ukraine, Georgia and Moldova to access approximately EUR 200 million of EU grants. This funding adds to the new trade opportunities with the EU that have been created by DCFTA.

Source: (European Commission, 2017)

1The Commonwealth of Independent States (CIS) is close confederation of independent states, currently composed of 9 member states, including Russia, Central Asian Countries like Tajikistan, Uzbekistan, Kyrgyzstan and Kazakhstan, European states like Belarus and Moldova, as well as Armenia. In addition, Turkmenistan and Ukraine have status as associate states.

to overall infrastructure, Ukraine is ranked at 78th place, but when it comes to railroads specifically, it is ranked at 37th place (WEF, 2017). One of the many challenges facing the Ukrainian economy is its lacking ability to attract foreign direct investment (FDI). This inability has been attributed to both the conflict in Ukraine's eastern parts, and general social tension within the country. According to Ukraine's own Strategic Trade Development Roadmap of 2017-2021, what is regarded as a politically unstable situation definitely worries business (STDR 2017-2021).

Still, recent analyses suggest that concerns about war and political instability are not necessarily the main problem. Ukraine needs to solve economic issues first and foremost, like the lack of development of private property institutions and stock market; washout of capital and profits from domestic companies in favour of the related foreign companies; high interest rates on loans, and so on (Melnyk & Kasyanok, 2017). The need to address these areas is also backed up by the Export Strategy for Ukraine for the period of 2017-2021:

Respondents to the World Economic Forum's Executive Opinion Survey were asked to name the most problematic factors for doing business in their country. According to the survey, they were inflation, corruption, policy instability, tax rates, government instability, access to finances, inefficient government bureaucracy, foreign currency regulation, inadequately educated workforce, and restrictive labour regulations (WEF, The Global Competitiveness Index 2017-2018 edition, 2017).

> ***In addition to a context of an adverse geopolitical environment, important investment impediments include recurrent concerns about corruption, insufficient infrastructure development as well as a weak institutional framework and insufficient investors' protection. (Ukraine Export Strategy, 2017).***

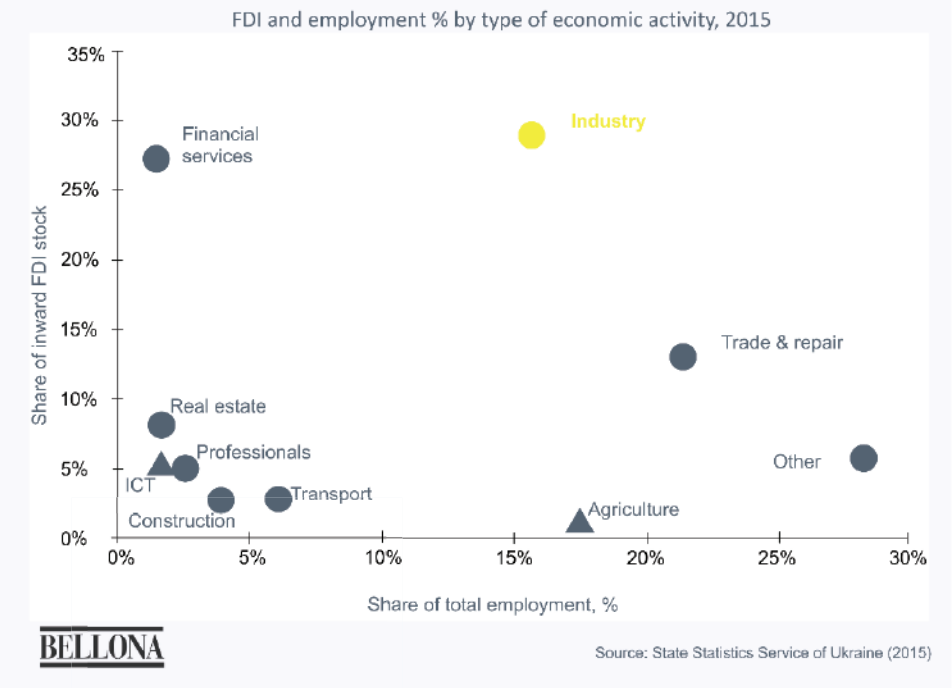


Figure 2: Share of FDI stock and total employment, % in 2015 (State Statistics Service of Ukraine, 2017)

Figure 2 shows that the financial sector, along with industry, is the sector with the biggest share of inward FDI stock to this day. This is a consequence of policy in Ukraine during the first two decades of independence, when financial services were the only sector that was actually made accessible to foreign investment (Carnegie, 2012).

Many young Ukrainians look to the IT industry for work. One of the reasons that this sector has a potential is that as of today, salaries for IT professionals in Ukraine are as much as 40 or 50% lower than in the West. Still, salaries for IT-professionals are a lot higher than for many other, traditionally well-paid jobs, like engineers. Sanctions have ruled out the Russian IT industry for Western companies, and many customers have instead opted for Ukraine (Atlantic Council, 2016). Ukraine is the leader in Europe in terms of exports of IT services. In 2015 Ukraine increased the amount of IT services export by 17%, in monetary terms this is US$2.1 bn (Ukraine, 2016). According to the World Economic Forum, there are 130,000 engineering graduates in Ukraine annually, the most in Europe. Ukraine is a leader in IT engineering in Central and Eastern Europe. Ukraine´s IT share in the Eastern European freelance market amounts to 33%, followed by Russia with 28% (Finance.ua, 2017).

PwC ranked Ukraine 5th among Top 25 IT services exporters (PWC, 2016). Furthermore, the country was included in Gartner's

Ukrainian education: Population highly skilled in technical disciplines

Along with an abundance of natural resources, Ukraine has a highly skilled workforce. It is ranked as the fourth most educated nation globally (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2015). Compared to countries Europe and Central Asia, the country has a substantially higher level of tertiary education; the percentage of total labour force with tertiary education in 2005 amounted to 45.2% of the entire workforce, while in European and Asian it averaged at 30.4% (OECD, 2012). Compared to its neighbours, Ukraine has a considerably higher rate of enrolment in universities and other post-secondary educational institutions (Figure 3).

Ukraine also has one of the highest rates of engineering, manufacturing and construction graduates in the world (World Economic Forum 2015). With a strong focus on technical disciplines, some Ukrainian universities have positioned themselves high up on global and regional rankings (Ministry of Foreign Affairs of Ukraine, 2015). Such a highly qualified work force will be crucial for developing engineering solutions for the low-carbon future.

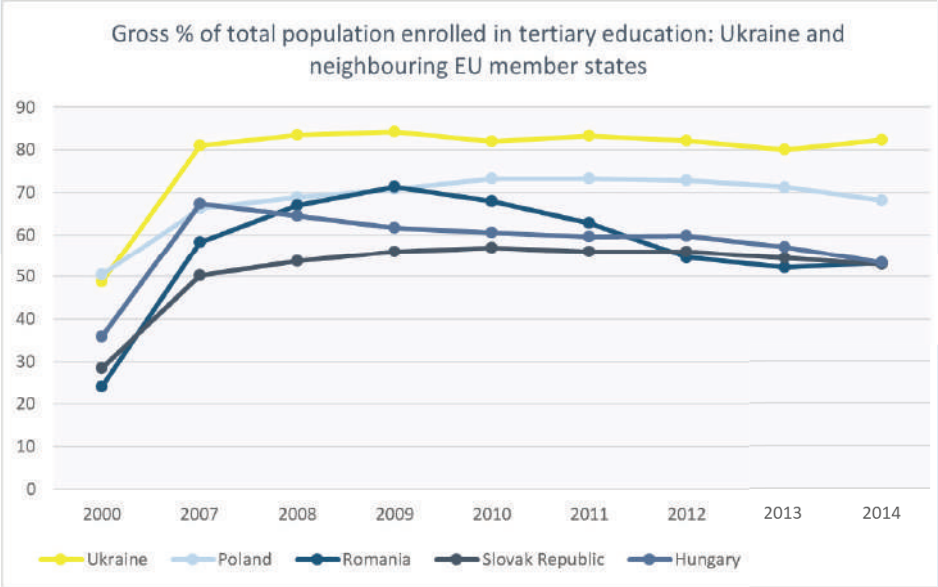


Figure 3:% of population enrolled in tertiary education, comparison between Ukraine, Poland, Romania, Slovak Republic and Hungary (World Bank, 2017)

list of top 10 emerging-market locations for offshore services (N-iX, 2017). In 2016, the IT sector generated US$2.9 bn which is 4% of the country's GDP. If the IT sector in Ukraine will be able to keep the same pace, it could double in size by 2020 (PWC, 2016).

Seeing Ukraine´s great IT engineering potential, more than 100 multinational tech companies established their software R&D labs and offices in Ukraine, among them BMW, Boeing, Oracle, Samsung, Siemens and Volvo (Forbes, 2017).

The study of the Global Competitiveness Report for the years 2016–2017 measured countries for their education and skills. Ukraine is ranked at 39 out of 135 countries covered by the study, in terms of the education level of its populace. But "skills of the current Ukrainian workforce" is ranked only at 46. The report´s study predicts positive dynamics and a slight growth in the country's human capital, moving Ukraine to 36th place among the world's countries (WEF, The Global Competitiveness Report 2016–2017, 2017).

This highly educated, low-cost workforce constitutes a significant competitive advantage for Ukraine. However, the country has suffered from a severe case of brain drain since its independence from the Soviet Union. This is true for all kinds of scientists and scholars (Euromaidan Press, 2016). The IT-industry in Ukraine has been thought able to slow the brain drain (Business Ukraine, 2016), but that does not necessarily entail that this sector can become a cornerstone of the country's economy.

Agriculture as the engine of growth

Another sector is very important in Ukraine is that of agriculture. Still, agriculture has had a receding share of the GDP of Ukraine since the fall of the Soviet Union (See Figure 4). Seeing as Ukraine primarily produces raw materials, this sector undeniably has little hope of becoming a sustainable cornerstone in the economy of the country, even though 30%of the population still lives in rural areas (World Bank, 2017).

Almost three-quarters of Ukraine's territory is agricultural land, more than half arable. Though the quality of legendary black earth deteriorated during the Soviet decades, it remains among the best globally. Barring large reductions in annual precipitation, immediate climate change is likely to result in gradual warming of the average winter temperatures in the region and could further improve Ukraine's competitive position in European food markets. Ukraine was able to reach acceptable food market access conditions in negotiations with the EU on the DCFTA, and since climate change will result in increased drought in Mediterranean areas, Ukraine will be the natural source of potentially increasing European imports (Carnegie, 2012).

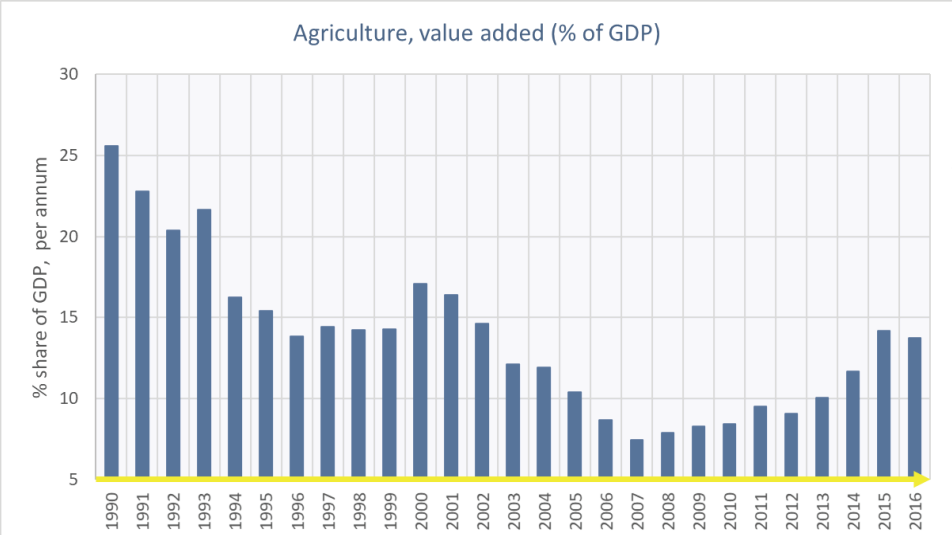


Figure 4: Receding share of agriculture in Ukraine's GDP (World Bank, 2017)

One of the main issues for Ukraine is that of attracting more FDI. This problem is complex, but according to potential investors, two of the main issues that are hindering them from investing in Ukraine are widespread corruption and a lack of trust in the judiciary. In addition, they are worried about restrictive capital controls and a complicated and bureaucratic tax administration (Financial Times, 2017). Furthermore, Ukraine has a challenge in enforcing property rights, even after attempts at reforms in 2016 (UA Crisis, 2017).

And lastly, there is an issue of monopolies in important sectors prohibiting real competition in the Ukrainian market (ICPS, 2015). These are issues that existed also pre-2014, and according to recent surveys, the ongoing conflict in the country's east is not necessarily the main reason Ukraine has a hard time attracting FDI (Financial Times, 2017).

According to Ukraine's own State Statistics Service, agriculture is not attracting huge interest from foreign investors, and Ukraine's agricultural infrastructure is in dire need of new investments, mainly in new, modern equipment. Only 1% of FDI went to the sector, as can be seen in Figure 5. Indeed, the same tendency can be seen with the information and telecoms sector, which only attracted 5.3% of FDI in 2015 (Ukrainian State Statistic Service, 2017).

Pre-2014, much of the FDI was not even "real" FDI, as much of the investments really were of Russian and Ukrainian origin, relayed to Ukraine through proxies in tax heavens like Cyprus (Vox Ukraine, 2017).

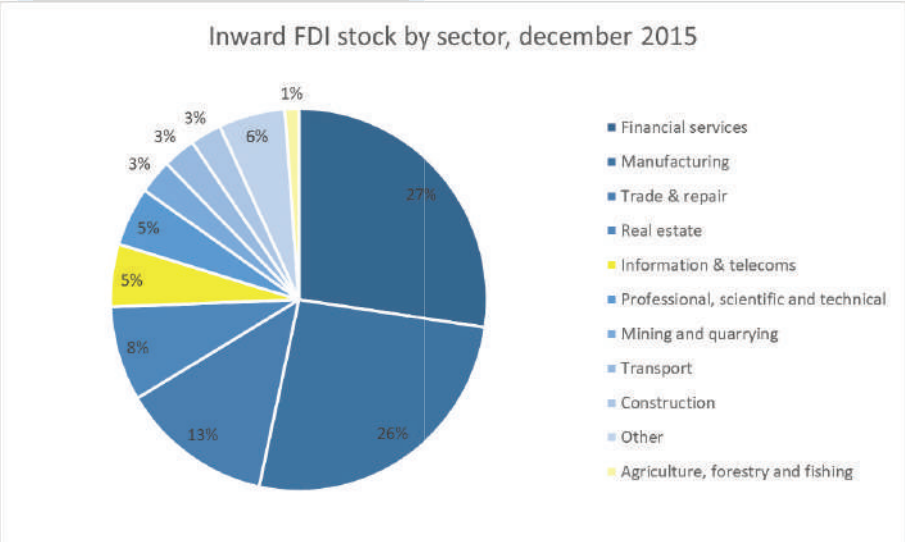


Figure 5: Inward FDI stock by sector, 2015 (State Statistics Service of Ukraine, 2017)

Today however, it looks like foreign investors have renewed interests in Ukraine. This concerns mostly European strategic investors and direct investments funds, looking at opportunities in the IT, energy and infrastructure sectors (Interfax, 2017).
It is not likely that sectors like agriculture and IT-services will be able to attract sufficient investments on their own. Today, Ukraine depends on exporting raw materials, but the country has different options to change its focus and render its market more attractive for FDIs. To be able to understand what path Ukraine can choose as an alternative to that of today, we will have to look at its economy and resources while taking into consideration the emerging markets of the world of tomorrow.

1.2 Ukraine's economy in the world of tomorrow

In less than three decades, Ukraine saw the strength of its economy drop from its height during the Soviet Union, to times of struggle in the 1990s, to renewed albeit slow growth by the help of oligarchs and monetization policies in first decade of the second millennia, giving rise to a financial market capable of supplying the needed capital for domestic investors. It has seen its economy crash yet again during the financial crisis, and then again in the aftermath of Euromaidan, the annexation of Crimea and the ongoing military conflicts in its eastern parts.
As of 2017, Ukraine's economy is yet again growing (Figure 1), but it is clear that coherent legislation and less than predictable mechanics in the market stand in the way of long term stability. However, reforms and anti-corruption measures are only one aspect of improving the country's long-term economic outlook. Crucially, it is impossible to build a thriving economy based only on the export of agri-food and IT-services. Little has changed in terms of what Ukraine produces and how well it is able to make money from exports.
In 2016-2017, Ukraine´s economy was ranked number 84 among 138 countries in terms of competitiveness. The study ranks countries' economy against three stages of development: stage 1-Factor–driven development; stage 2-Efficiency-driven development and stage 3-Innovation-driven economy. Ukraine´s economic development is considered to be in transition between a "factor-driven stage" and "efficiency-driven stage" (WEF, The Global Competitiveness Report 2016–2017, 2017). Undoubtedly, Ukraine has to alter its production focus to prosper, leading to the question: What should it produce in the future?

Nor can the West compete with the relatively low salaries of a highly educated Ukrainian populace. How can Ukraine make use of its inherent competitive advantages and resources?
What the country needs is an idea, a goal to work towards. This report aims to put Ukraine's potential in perspective, by showing how low-carbon and carbon-negative technologies and products will come to be a major business in the near future, and that Ukraine is well positioned to take advantage of this development.

Ukraine could be a prosperous country. No other European country comes close to having the same resources of coal, iron, gas and rich agrarian land.


Photo:Thinkstock

2

THE EMERGING GLOBAL LOW CARBON SUPPLY CHAIN

Along with its internal strengths and weaknesses, the political and economic context surrounding Ukraine is a crucial element to consider when deciding on the long-term socio-economic development of the country. Global trends in both emerging and established low-carbon markets in the present offer the Ukrainian economy numerous development opportunities. The following sections of the report aim to identify where these global tendencies[1] overlap with Ukrainian expertise, knowledge and resources.

In order to reach the current climate targets and transition to a more carbon-conscious economy, the world will need vast amounts of low-carbon inputs (World Economic Forum, 2014). The shift towards low-carbon products will necessitate large investments in infrastructure and capital goods (Ernst&Young, 2014), which will in turn favour Ukraine's potential to be the production centre of decarbonised global value chains. Particularly in neighbouring Europe, a diverse portfolio of low-carbon technologies such as renewables will play a vital role in the transition. These technologies will take up an ever-increasing share of economic output. Consequently, the demand for expertise, materials and products will increase significantly by 2030 (JRC, 2016). With new competitors around the corner, Europe as a whole faces the challenge of moving to a new, higher value-added growth model (Zachman, 2016). Developing these higher-value added goods and services and gathering expertise in the near neighbourhood will surely be prioritised.

2.1 The societal pull and the commercial push

The low-carbon markets are being shaped by two major categories of drivers: market signals and political targets. Over the past decades, low-carbon targets set by both countries and businesses have driven innovation, prompted new industries to develop and helped create new employment opportunities, in some cases replacing declining employment in other sectors (EC, 2050 low-carbon economy, 2017). The developing low-carbon procurement practices, created due to the growing importance of climate change in public policy, drive ingenuity in products and services. Legally binding carbon targets and related regulations are also important elements that shape supply chains (Correia, 2013). The EU aims to achieve an 80% reduction of its emissions by 2050, thereby calling for a yearly investment rate of 1.5% of the EU's GDP, amounting to 270 bn EUR (EC, 2050 low-carbon economy, 2017). Large international banks, such as the European Investment Bank, have been active in mobilising finance needed for such investments (EIB, 2016). Policy targets will also provide opportunities in the private sectors by increasing long-term savings, lowering the risk of investment and enable the scale-up of low-carbon businesses (Morgan, 2015).

Apart from policy targets, businesses themselves play an important role by pushing low-carbon standards in the very supply chains they are embedded in. Complying with policy targets, companies aim to streamline their production processes, develop efficient technologies and use climate goals to develop innovative products.

The transition to a low carbon economy opens new commercial niches, disrupts the entrenchment of global players in business and leads to increasing digitisation, new ownership models and state supported markets (Goldman Sachs, 2010).

Since private businesses also rely on good corporate image as an asset, they will and already are proactively marketing their climate change strategies (GWEC, 2016). This in turn, alongside with transparency, acts as reassurance for investors, consumers and other interested stakeholders. Compliance to climate targets and regulations in the future will also keep costs of low-carbon products and services down, making low-carbon pathways even more desirable (Morgan, 2015). Surveys of global businesses have shown that they believe a sustainability strategy lowering emissions helps them improve processes, unlock higher productivity rates, pursue growth, and add more value to their standard product or service (McKinsey&Company, 2011).

2 The projections used in the analysis are in line with the Paris agreement goal of limiting global temperature rise to 2 degrees Celsius above pre-industrial levels.

Even though the details of the future market remain unknown, the combination of the societal and commercial pressures described above will inevitably drive the development of global markets in the low-carbon direction.

2.2 The products of the 21st century

The technologies needed to reach a low-carbon economy are experiencing a stark increase in investment. The share of low-carbon products, such as wind turbines and electric vehicles has increased six-fold since 2000, whereas the export of photovoltaic cells for solar power purposes tripled in size during the same period (Zachman, 2016).

In Europe, investment in renewable energy generation grows at a steady rate of 2.6% per year on average up until 2040. This implies a yearly average investment of US$40 bn, totalling to 1 trillion (tn) over the entire period 2017-40 (Bloomberg, 2017).

Figure 7 shows how the change in deployed technologies will affect electricity production in the world. The biggest changes will no doubt be seen in the fossil-fuel industry, as the share of gas and especially coal will be significantly reduced in the world's electricity production.

This scenario gives ample opportunities for several other industries to take their place. Solar Power and wind power will have to be deployed in massive amounts. In addition, electricity production with Biomass and Natural Gas coupled with Carbon Capture and Storage (CCS) will be significantly more important and widespread in the future.

The International Energy Agency (IEA) argues that the reduction in use of fossil fuels will come mainly due to deployment of renewables and that e.g. in 2015, 90% of new electricity generation came from renewable sources (IEA, 2016). In other words, this shift has already started.

Finally, energy efficiency measures will have to be deployed in great magnitude across the globe.

According to the International Panel on Climate Change (IPCC), a better everyday energy habit and energy efficiency measures could cut the developed world's demand for energy for buildings in half by 2050. This potential will create a huge market for equipment for new buildings, as well as for retrofitting older infrastructure (CSMonitor, 2014).

In this report, we will have a look at the potential within several of these markets, and show how Ukraine is well positioned to contribute with products to meet the growing demand for low-carbon solutions.

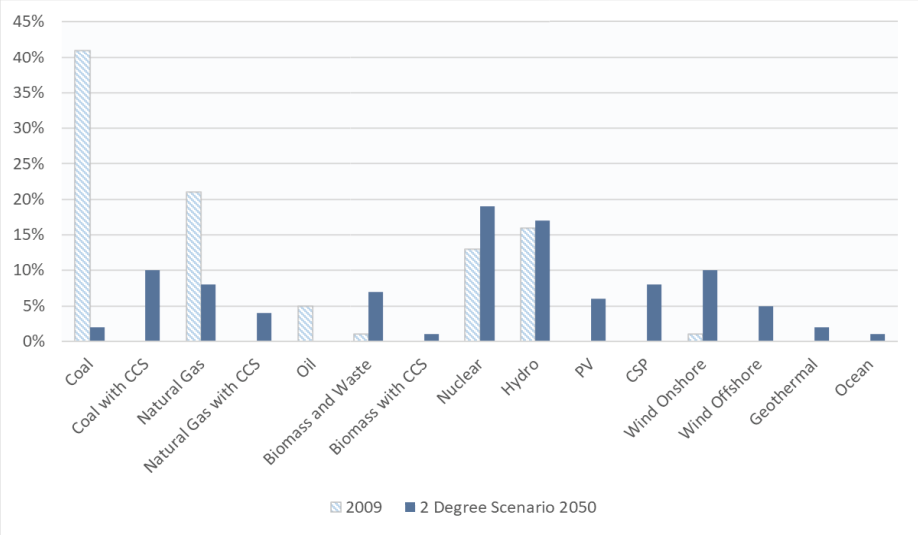


Figure 6: Global electricity production by energy source, 2-degree scenario projections, IEA data (IEA, 2012)

Why Renewables and not Nuclear energy?

There is a great deal of uncertainty associated with the development of nuclear energy. In comparison to renewables and other low-carbon sectors, nuclear power has seen dwindling development. According to the newest International Atomic Energy Agency projections, the future development of nuclear energy generation will be highly dependent on safety, available fAunds, developments in the electricity markets, nuclear waste management and public acceptance (IAEA, 2017).

Since these factors render the future of nuclear energy uncertain, predictions range from high to low levels of future nuclear generating capacity (IAEA, 2017). Instead of focusing on the sectors with low development potential such as the nuclear sector, the Ukrainian economy would benefit from focusing on increasing energy efficiency and directing its expertise into more promising sectors, such as renewables.

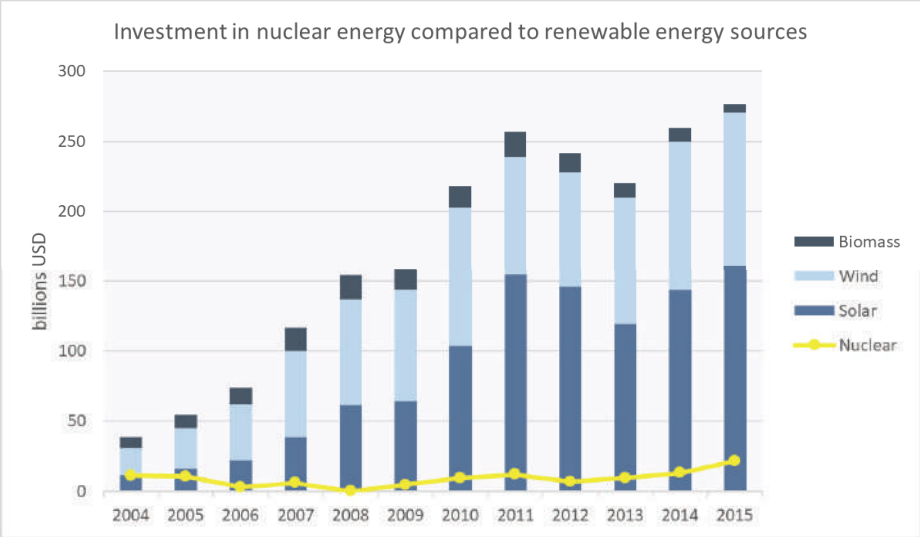


Figure 7: Low investment in nuclear energy compared to renewable energy sources, global data in USD billion 2004-2015 (Schneider & et al., 2017).

We will look at the following sectors in our analysis:

- Wind power
- Solar power
- The transport sector and batteries for energy storage
- Energy efficiency solutions
- Low carbon infrastructure required to enable CCS-deployment.

Our main focus will be the opportunities that Ukraine has to export to the EU.

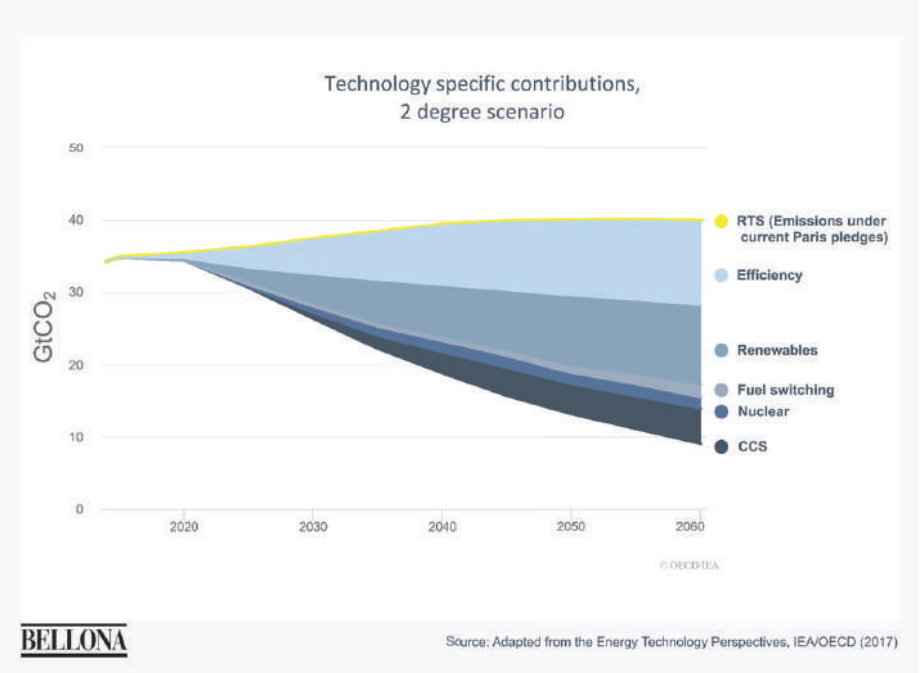


Figure 8: How each technology contributes to CO2 emissions reductions, adapted from the IEA Energy Technology Perspectives (IEA, 2017)

2.2.1. Wind turbine market

The market for wind turbines is expected to quadruple by 2040, with wind generation expected to increase from 4 to 17% of total electricity generation worldwide (FT, 2017).

The global expansion of the wind market that is currently setting off offers ample opportunity for those who are willing and able to capitalise from it.

Since 2008, the global share of wind generation saw an average annual increase of 0.3%. The amount of wind power integrated into the grid thereby doubled over the past nine years (IEA, 2013). Yet, in order to reach global climate targets, these growth levels are needed and expected to increase multifold over the coming decades. The estimated growth rates in global electricity production for renewables in general and wind power in particular, as seen in Figure 7, are therefore substantial (IEA, 2012).

With notable offshore wind potential, there is still room for significant growth driven by reduced costs and the development of appropriate large-scale systems. Just as with onshore wind, political support will be crucial to stimulate the deployment of the technology.

As the political consensus for the development of offshore wind energy is certain, so is its political support. For instance, European targets include the development of large-scale turbines in the range of 10-20 MW especially for off-shore applications. The EU will focus particularly on producing offshore technologies and structures for large-scale turbines and deep waters. As their research and development efforts result in manufacturing processes suitable for mass production, the path towards large-scale production of wind technologies is wide open (EC, 2017).

The Global World Energy Council (GWEC, 2016) confirms the growth pattern in wind power generation; in 2016, wind power became the second largest form of power generation capacity in the EU with a total installed capacity of 153.7 GW. In Europe, the expected drivers on the demand side are estimated to shift to the private sector, as an increasing number of corporations will directly purchase the output of wind farms (GWEC, 2016).

The global climate targets will also help in creating a pull for an increase in new wind generation capacities, since compliance with the 2-degree scenario will necessitate a scale-up from 486.8 GW of currently installed capacity to somewhere between 2,346 GW and 2,777 GW in 2050. Such an expansion will require an annual investment of US$ 146 bn to US$ 170 bn (IEA, 2013). Other projections confirm the magnitude of expected investments and predict an average annual increase of 3.4% in wind investments (Bloomberg, 2017).

The wind power market will be open for new players, as political support and financial means available for the creation of new wind capacities continue to grow.

As markets in Germany, Denmark, Spain and the Netherlands mature, opportunities for more demand will arise in markets closer to Ukraine, i.e. in the Eastern EU member states such as the Baltic States, Czech Republic and Hungary (Pullen, 2009). As the focus shifts away from the maturing markets of the west of Europe towards the Eastern member states aiming to fulfil their National Renewable Energy Action Plan targets, Ukraine will have an opportunity to fill that gap.

Currently, the top global wind turbine manufacturers are the Danish Vestas, German Enercon and Siemens, Spanish Gamesa, Chinese United Power and General electric from the US (Energy Business Review, 2017). With roughly half of them based in Europe, shifting their production of wind turbines to Ukraine could be a favourable choice. Some companies have already set up manufacturing sites in Ukraine: over a half of the components for Fuhrlander Windtechnology's wind turbines are produced in the country (Euromaidan Press, 2017).

Current state of the wind sector in Ukraine

Even though wind energy has been present in Ukraine since the beginning of the 20th century, with 30,000 windmills generating up to 200,000 kWh of energy per year, the modern wind power industry dates back to 1992. The first plan to construct wind farms in Ukraine was introduced in 1997, with a focus on setting up domestic production for wind turbines, the plan has steered the development of wind in Ukraine, as the production of licensed wind turbines has

been the main path of the sector in the country. Since the program was discontinued in 2010, all new wind capacities have been put into operation through private investments (UWEA, 2017).

There are several success stories when it comes to the manufacturing of wind turbines in Ukraine. In the following, we outline some of these stories on companies, such as LLC Fuhrlaender Wind Technology (FWT) and Wind World ("Світ Вітру»), that already produce not only small wind, but also utility scale equipment for larger wind farms.

Utility scale wind turbines manufacture (100 kW capacity and larger)

The group "Wind Farms of Ukraine" invested heavily in the manufacturing of licensed wind turbines in Ukraine. Since 2012, the company FWT, part of the group "Wind Farms of Ukraine", is the first and at the moment the only company in Ukraine and in the CIS manufacturing modern windmills (Wind Parks of Ukraine, 2017). The company is a joint venture owned by small German turbine builder Fuhrländer and Ukrainian partners (Wind Power Monthly, 2012).

In 2017, at the Kramatorsk plant of FWT produced the first wind power turbine with a capacity of 3.2 MW. This model is the most powerful ever produced not just in Ukraine, but also across the CIS. FWT's plans are to improve the production of wind power plants by increasing capacity - up to 4.5 MW (Wind Parks of Ukraine, 2017).

Technology development in Ukraine continues, in some cases through imported technology from abroad. In 2013, FWT acquired a license from the German design and engineering company W2E (Wind to Energy) for the production of wind turbines with a capacity between 2MW and 3MW and are as of today producing four different types: 2.0; 2.5; 3.0 and 3.25 MW (Wind Parks of Ukraine, 2017).

Small and Micro Wind generation

Small wind turbines[3] are also being produced in Ukraine; the company Wind World is located not far from Kharkov - in the village of Oktyabrskoe. This company produces wind turbines and all related equipment from blades to generators, electronics and so on.
Wind World manufactures "ready-to-operate"-turbines and provides service and technical assistance. It is an all-stage provider of services within wind power. Currently the company produces five different wind generators with a capacity ranging from 1 to 6 kW. The smallest wind generator can produce 20-40 kWh monthly, and the bigger ones between 1,200-2,400 kWh (Wind World, 2017). The director of Wind World, Alexander Lyushnya, said in 2016 that the Kharkov wind generators are of a better quality than those produced in the EU, and cost less (EkoTechnika, 2016). The company's wind turbines produced are used for power supply of private and commercial real estate, heating and lighting of greenhouses, pumping water and so on. Since its establishing in 2001, the company has produced about 600 wind turbines. Most of them are installed in Ukraine; one third is installed abroad, mostly in Europe. In 2016, the company officially exported a 4 kW windmill to Germany for the first time. The demand for such equipment is now huge, and rising (Wind World, 2017). Wind World had to significantly reduce its production after 2016. Still, this company managed to export products that will be in even higher demand in the time to come.

Wind turbine towers

Other companies are not necessarily focused on the whole supply chain, but still contribute with building parts for wind mills. One such important part is the wind turbine tower, on top of which the turbine and rotors are placed. The height of the tower greatly affects the potential generation of power, as higher towers give access to more powerful and stable winds. Towers are usually made up of steel structures with small amounts of pre-stressed concrete and aluminium. Concrete can also be used in bigger amounts. This leads to higher CO_2 emissions during manufacturing, but increases the overall lifespan of the unit (IEEE Spectrum, 2013).

The public joint-stock company Kramatorsk Heavy Machine-Tool Building Plant (KZTC) is a developer and a manufacturer of industrial machines for metallurgy, the energy sector and transport. The company exports its products to more than 50 countries. The factory has recently mastered production of wind turbine towers with a capacity of 2.5MW - 3.0 MW. About 100 towers for wind turbines for FWT have been produced by the company (KZTC, 2017).

In 2016, the Smart Maritime Group and Windcraft-Ukraine were negotiating to produce components for wind turbines at the Kherson Shipyard (Smart Holding, 2016). Another Ukraine-based company, Metinvest, supplies steel products for wind towers,

3There is a wide range of small-scale turbines, ranging from micro (0.004 – 0.25 kW) and mini (0.25 – 1.4 kW) to household turbines (1.4 – 16 kW). The turbines are also classified as small according to their rotor diameter and swept area.

including the mainframe on top of the tower. Metinvest has been looking into the possibility of manufacturing towers for wind turbines at Ukrainian shipbuilding plants, and believes that this opportunity should to be considered (Metinvest, 2017). This speaks to the fact that the industrial legacy that Ukraine has at its disposal can be used to produce environmentally friendly products which are and will be in great demand in the coming years.

Why Wind Industry in Ukraine?

With the existing industrial ecosystem, proximity to the European market and cost competitiveness, the wind power manufacturing industry bears great potential for Ukraine.

Using existing industrial ecosystems

The potential reuse of shipbuilding facilities for production of wind turbine parts and towers is testimony to the fact that Ukraine could use its existing industrial ecosystem to produce low-carbon-technological solutions.

According to the director of FWT, Eugenyi Nikitenko, the production potential of domestic enterprises allows the manufacturing of more than half of the components of the wind power plant (FWT, 2017). Wind turbine production creates additional work load for current enterprises, while using already existing infrastructure limits costs.

Beyond gaining new workplaces in the direct manufacturing of parts for wind power plants, further positive effects can be expected for supplying industries. An increase in production will create new workplaces in the construction industry, as well as in metallurgy, as metals like steel and aluminium are the most used materials in current production (FWT, 2017). Such an increase would also lead to more green engineers finding jobs in Ukraine. The production needs designers for the power plants, researchers that can consider wind powers potential, IT-specialists and so on (FWT, 2017).

Some say that Ukraine is especially well positioned for the manufacture of small wind turbines. In 2017, Alexander Lushnya, director of Wind World, stressed that low production costs and high technical sophistication are key advantages of Ukrainian small-scale windmills (Wind world, 2017). Ukrainian wind turbines are, therefore, not some future dream but already possible and ongoing.

Proximity to established and emerging markets

Since transport costs can make up as much 10% of the entire capital expense of a wind project (Wind Power Monthly, 2013), having producers nearby will be important to European countries with ambitious RES targets.

According to the European Commission (EC, 2017), a recent study found that the supply of raw materials for wind turbines is subject to substantial risks, particularly when it comes to the offshore wind sector. Both risks surrounding costs and supply can be reduced by having more producers located closer to the EU.

In the beginning of 2016, the Russian Federation imposed a ban on transit for Ukrainian goods and products (Russian Government, 2016). This had a significant impact on Ukraine´s trade with CIS-countries. The sanctions remain in force at least until the end of 2017.

On this basis, it is clear that the increasingly closer ties to the EU will provide the most stable way for Ukraine to move forward. Manufacturing essential parts for wind power installations close to the final installation sites can significantly reduce costs, both for final shipments and for the production process. According to Andrey Konechenkov, the Chairman of Ukrainian Wind Energy Association, transportation of one wind turbine from Denmark or Germany to Ukraine by sea can increase costs of the project by 10-15% (Energobiznes, 2017). In other words, Ukraine's cost competitiveness could be further increased by producing all needed parts for wind turbines at home, having only to ship the final product to the deployment site in Europe.

Ukraine is already producing windmills for export. In 2014, 22 wind turbines, particularly designed for temperatures as low as -40C, and with a capacity of 2 MW each, were produced in Ukraine and commissioned in Kazakhstan (Wind Parks of Ukraine, 2017). The market is therefore poised for expansion and there is no reason for Ukraine not to begin exporting turbines to Europe as well.

Cost competitiveness

Projections for 2030 and 2050 expect a further decline in technology costs, resulting in lower capital investments in the mid- to long-term. Paired with existing climate targets, the installed capacity of increasingly cost competitive renewable technologies such as wind power is expected to reach more than 650 GW by 2030.

This means that almost the entire technical potential of those technologies will be cost-effectively exploitable (IRENA, 2017).

Given its size and capacity, as well as the above mentioned decrease in costs, Ukraine has the potential to deploy almost 320 GW of wind power. This is the cost-competitive potential within Ukraine up to 2030. The high share of renewables in the power sector, however, can also be achieved in other parts of South-Eastern Europe and as such, will give export opportunities for the Ukrainian wind industry (IRENA, 2017).

The industrial competitiveness of Ukraine emanates from several major strengths. High technical expertise of the workforce as well as cost competitiveness in several areas (OECD, 2012) are particularly beneficial for the development of the wind industry in the country. Compared to its highly qualified labour force, Ukraine has uncommonly low hourly manufacturing costs (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2015). Production costs and low prices of raw materials also contribute to the cost-competitiveness of the Ukrainian manufacturing sector. It is therefore possible for Ukraine to compete with other providers if it chooses to do so.

The investment requirements for

Figure 9: Wages in selected countries compared to Ukraine, per hour (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2017)

Putting the wind in the sails: Best case practices

1.1 Denmark

The conditions enabling the development of wind energy in Denmark were starting to take shape in the 1980s, and state support has propelled the wind sector ever since. Some of the most important mechanisms have been support for long term research and development, setting ambitious national goals and premium tariffs for renewable energy sources. Along with a clear and transparent pricing structure and priority access guarantees to renewable energy producers, Denmark has simultaneously developed strategies for industrial development, community buy-in and employment.

1.2 Germany

Similarly, Germany had combined instruments such as a feed-in tariff mechanism and priority grid access with strong political commitment. Yet in the German case, most of the employment opportunities came through the development of small- and medium-sized enterprises, which helped establish the positive image for the technology and gain public support.

1.3 China

Over the past few decades, China has developed some of the most elaborate installations and manufacturing capacities in the world. The policy framework that led to China becoming a market leader has included incentives for local manufacturing, a strong long-term renewables policy and a clear tariff structure. The local content requirement rule is particularly interesting, since it enabled the already existing industry to develop a local supply of wind turbines.

Source: IRENA (2012)

2.2.2 Solar cell fabrication market

upgrading and developing energy infrastructure will be substantial in the decades to come (Ernst&Young, 2014). Wind power will not be the only renewable upgrading Europe's energy infrastructure. The solar generation market[3] will match the wind generation market in cutting CO_2 emissions over the next two years[4] (IEA, 2014).

By 2050, global electricity production is predicted to be almost entirely based on zero-carbon-emitting solutions, and solar power will have a large role to play in the future low-carbon economy (Zachman, 2016). Even in the basic 2-degree scenario, renewables make up 66% of the total electricity generation (IEA, 2014). Still, the world reality is outpacing the predictions of the IEA's yearly World Energy Outlook-report (Hoekstra, 2017), and solar power's continued growth keeps on surprising experts, as we can clearly see in Figure 10.

To put this growth into perspective, the increase in added capacity of solar in GW per year since around 2009 until today might be comparable to the growth in shipments of smartphones during the same period, which has seen a tenfold increase over the last eight years. The difference is that the growth in smartphone shipments seem to be slowing down (Statista, 2017), but solar just keeps on growing at an unprecedented rate.

The drop in solar energy costs will be steeper in comparison to wind generation (EC, 2011).

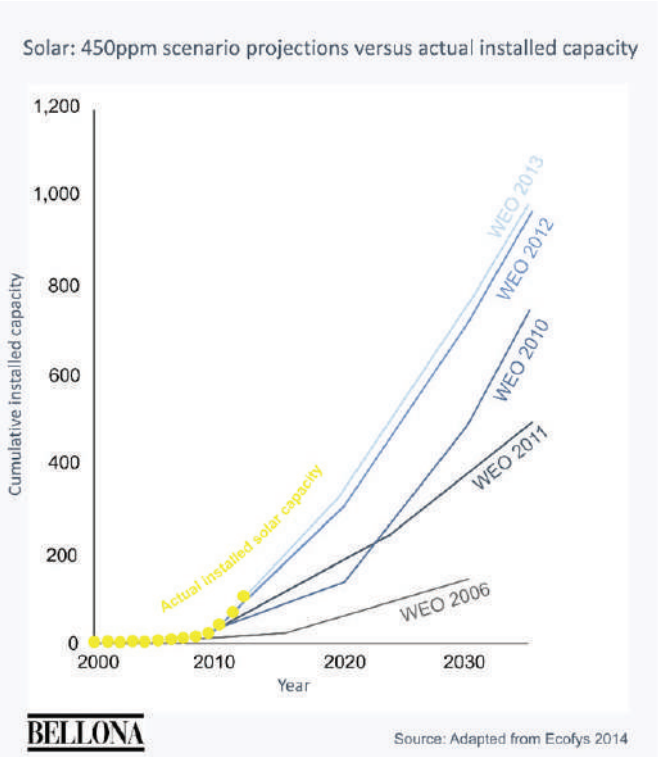


Figure 10: Annual added solar capacity: historic data vs IEA WEO predictions (Energy Post, 2014)

4 The paragraph refers to conversion of energy from sunlight into electricity both from photovoltaic (PV) and concentrated solar power (CSP) technologies.

5 These projections are in line with the IEA high-Renewable Scenario, which is a 2-degree scenario assuming a rapid deployment of solar and wind energy (predicting renewables to take up 79% of the global electricity production in 2050) (IEA, 2014).

Bloomberg, a financial analysis firm, predicts that by 2040 a dollar will buy on average 2.3 times as much solar energy than it does today (Bloomberg, 2017). The European Commission confirms this assumption, expecting a 70% (PV) capital cost reduction per kW between 2010 and 2050. By 2030, PV is expected to achieve grid parity with other generation sources (EC, 2011).

In 2016, the price for electricity produced by way of wind or solar power dropped below that of fossil fuels for the first time, making them not only greener, but also more profitable (Hargreaves, 2017).

This significant decrease in costs will act as a key driver for the projected proliferation (Figure 11) of solar generation in new and dormant markets. Other drivers of growth will include economic benefits of self-consumption, the increasing number of public tender programs, and EU regulations and targets (Solar Power Europe, 2017). In addition, PV deployment will be driven by consumers themselves: by 2040, rooftop PV is expected to account for approximately 15% of power generated in Germany (Bloomberg, New Energy Outlook , 2017).

As with wind power, the EU has set specific strategic objectives when it comes to photovoltaic energy, that is, solar power.

The targets of the European Industrial Initiative on solar energy prioritise the development of efficient manufacturing processes and the integration of PV-generated electricity into the grid: such policy-driven developments in research will enable the technology to be produced in

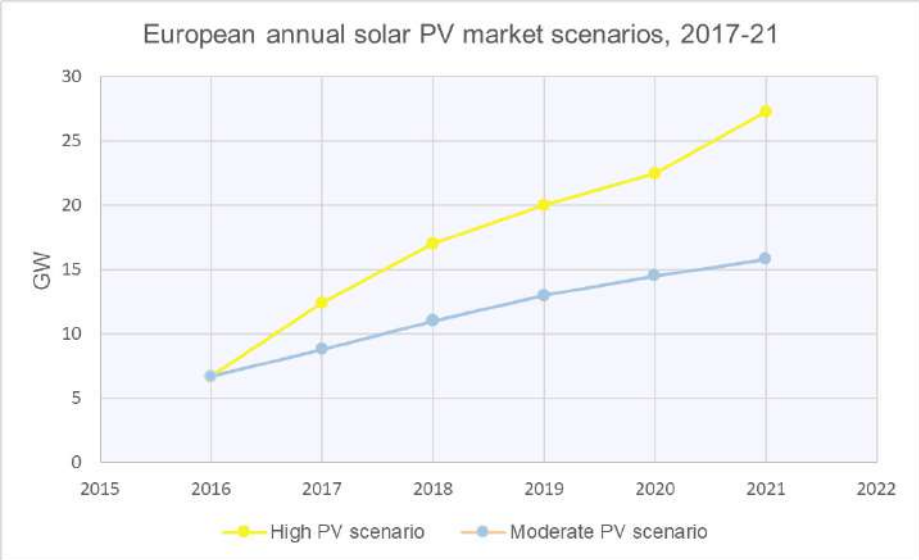


Figure 11: Projections for European solar market 2017-21 for a moderate and high PV uptake, GW per year (Solar Power Europe, 2017)

large quantities in the future (EC, 2017b).

Currently, some of the biggest players on the solar market are JinkoSolar, Trina Solar, Canadian Solar, JA Solar and Hanwha Q Cells (PV Tech, 2016). Leading solar module manufacturers and solar cell producers are predominantly based in Asia, where production costs are much lower than in Europe, enabling them to export their products at a low cost. Most of these companies were accused of dumping their solar products on the European market and now face trade barriers (PV Europe, 2017).

However, the current low cost of solar panels is a direct effect of the increasing production in Asia. China's solar industry alone made the prices for solar panels drop 80% between 2008 and 2013 (Scientific American, 2016). Competing with the production in Asia has proven difficult for European and American producers of solar panels (NY Times, 2017).

With costs of solar components decreasing and transport taking an increased share in their price tag, imports of panels from Asia to Europe are expected to drop (Recharge News, 2013).

With increasing demand and a gap in supply, Ukraine could take the opportunity to become a reliable producer of solar panels for the European market.

Ukraine benefits from an existing free trade agreement with the EU and great potential in local resources and knowledge (see Figure 12).

The DCFTA is already having a positive impact on the Ukrainian manufacturing sector by removing barriers for exports. Cost advantages are an important part of the growth of exports in Ukraine: with an average monthly salary below the average of neighbouring countries, cost-competitiveness makes Ukrainian manufacturing particularly agreeable for foreign investors (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2015). Other costs of production are also low in comparison to neighbouring countries, with for instance the price of electricity much lower than in neighbouring EU member states such as Poland (-25%), Czech Republic (-25%) or Slovakia (-37%) (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2015).

Current state of solar in Ukraine

As of January 1st, 2017, the total capacity of installed renewables in Ukraine (without taking into account the occupied territory of Crimea) is 1,117.7 MW. Installed capacity increased more than 2.5 times between 2013 and 2016 (SAEE, 2017). The country's installed solar capacity is up to 700 MW (Magazine, 2017).

The average period of sunshine on the territory of Ukraine is 1900-2400 hr/yr, and total average annual solar radiation varies from 1070 kWh/m2 in the northern part of Ukraine to 1400 kWh/m2 in the southern part (Sheffield, 2006). The potential of Ukraine's northern regions is comparable to that of Northern France, and the potential of the southern part of Ukraine is comparable to that of the Balkans or parts of Eastern China (Franz Trieb, 2009). In practice, solar power can be beneficially deployed anywhere in Ukraine (Rentechno, 2013).

There are several entrepreneurs working in the solar business of Ukraine today. Among them are KVAZAR and SolarGaps.

Solar solutions for homes are on the rise in Ukraine, according to the State Energy Efficiency Agency. In 2016, the number of households with installed solar panels increased almost fourfold and reached 1,019 houses. But their share in the total amount of houses is less than 0.02%. The market for PV systems installation in Ukraine is huge, taking into consideration that there are 6.5 million private households in the country (SAEE, 2017).

SolarGaps is a Ukrainian startup, producing smart solar blinds that automatically track the sun to generate maximum electricity. Their solutions are mean for home-use, and can be connected to a home battery storage solution. Their panels can generate up to a 100 watt for every square meter when mounted outside, and up to 50 watt per square meter when mounted inside, according to the company.

As such, one would believe business in this sector should be booming, however, the company SolarGaps is as of late 2017 producing only a few systems a month. They plan to scale up to manufacturing approximately 100 systems monthly before the end of 2017. The dynamics of the production will depend on the availability of investment, both foreign and domestic, as well as demand (Grygorenko, 2017).

SolarGaps sees the following three challenges for their continued business, especially regarding entry into foreign markets:

- Certification for access to other markets is costly in terms of financial burden and time consumption
- Export credits are hard to come by for start-ups without a credit history
- The practice of VAT reimbursement to exporting companies ends up "freezing" the working capital of said companies due to delays in reimbursements (Grygorenko, 2017).

SolarGaps is not alone in being concerned about these issues. According to a survey made within the framework of the Trade Facilitation Dialogue, sponsored by the EU, it is especially export permits, inefficient VAT-refund systems and the toll of bureaucracy that are standing in the way of increased Ukrainian exports. This particularly applies to smaller start-up companies (TFA, 2015).

The company KVAZAR on the other hand has underlined that the most important hurdle for solar-companies in Ukraine is that the state does not provide support for local producers of renewables. In addition, they have cited the fact that Chinese producers are outcompeting manufacturers all over the world. KVAZAR themselves used to have production facilities outside Ukraine, but these have had to close due to Chinese expansion into the European market (KVAZAR, 2017).

In practice, these conditions make it hard for Ukrainian companies to survive and expand their production. Without changes to this situation, Ukraine might miss its window to become a major producer of solar power long before the industry reaches maturity.

A case in point:

One of the bigger domestic solar projects proposed in Ukraine is one in the Chernobyl exclusion zone. The plan is to build a one-gigawatt solar power plant on 2,500 hectares of land to the south of the Chernobyl plant. The Chernobyl energy project will cost around US$1.1 bn, a sum that means substantial foreign investment is required. It is part of Ukraine's broader ambition to step up renewable-energy capacity (Nature, 2016). Still, this project does not provide additional opportunities for local producers. The lack of funds allocated domestically has led this project to be taken up by Chinese manufacturers, more specifically Golden Concord Holdings (GLC) and China National Machinery Corporation (Sinomach), who will supply the panels, and run the plant, respectively. (Guardian, 2017)

Another Ukrainian company worth mentioning is that of Prolog Semikor (PS), which makes its own polysilicon, and has its own assembly line for production of solar panels with a capacity of 10MW/year (Prolog Semicor, 2017). Such capabilities might become the start of a Ukrainian solar industry that produces needed materials themselves, adding value to raw materials and making additional profit by supplying both domestic and foreign customers.

Why Solar Manufacture in Ukraine?

Ukraine is one of the few countries in Europe to operate with a relatively high green tariff, under which the state buys out all the electricity generated by solar power plants and other renewables (Elcom Ukraine, 2017). This form of long term power purchase guarantee was renewed in 2017, and is being handled by the state-owned company Energorynok, which is the principal operator of the electricity market in Ukraine (Baker & McKenzie, 2017). The state has pledged to maintain the green tariff until 1st January, 2030, providing a stable investment signal to suppliers (International Energy Agency, 2017).

In addition, Ukraine has several tax incentives in place for renewable development. Among them are:

- Exemption from import VAT and customs duties for renewable energy equipment
- 75% reduction in land tax for land used for renewable energy power plants
- Limits on rental payments for land leased from state and municipal authorities
- Exemption from the tax duty in

the form of a special mark-up on produced electricity (3 per cent of produced electricity)

- An exemption from corporation tax on profit derived from the sale of electricity produced from renewable sources (Norton Rose Fulbright, 2012)

These incentives have been criticized by the industry itself, as seen in the previous chapter, for being overly bureaucratic, and especially the VAT-incentives, for both export and import, have been thought to "freeze" companies' financial assets because of long processing time (Trade Facilitation Dialogue, 2016). The green tariff mainly promotes production aimed at deployment within Ukraine. Still, export-wise, the main challenge seems to be the VAT-exemption and refunds for exports of renewable equipment.

In January of 2017, a new law that regulates these tax-refunds came into effect. It changes the system so that it requires the State Treasury, and not the Tax Agency, to process VAT refunds. This entails a new system with one single register for VAT-refunds to be set up, and this will enable the State Treasury to process refunds automatically in chronological order. The change is expected to reduce much of the "freezing"-effect that the current system involves (Lexology, 2016).

Due to these incentives introduced by Ukraine´s government for renewables in general, and for solar power installation in particular, interest in solar demonstrates a rapid positive dynamic. The State Agency for Energy Efficiency and Energy Saving of Ukraine (SAEE) estimates that by the end of 2017, more than 300 MW of new solar power will be operating in the country (SAEE, 2017). This is a sign of increased domestic demand, and might help indigenous companies expand their business within their home market.

Rise in domestic demand is backed up by state plans. Ukraine has an ambitious plan to increase the share of renewables in its electricity production from an estimated 4.3% (1.9 GW) by the end of 2017 to at least 11% by 2020. (Baker & McKenzie, 2017). The latest addition to the government's plans is the Energy Strategy of Ukraine until 2035, approved by the Cabinet of Ministers in August 2017. This document sets the following goal for Ukraine's energy mix: 50% covered by nuclear power, 25% renewables, 13% hydropower and the rest covered by thermal electric power stations (The Ukrainian Government, 2017).

Some companies are following suit. UDP Renewables. part of the developer group UPD, has announced plans to build a number of renewable energy facilities in Ukraine with a total capacity of 300 MW, including both wind and solar power. By 2022, the company plans to invest about $300 million in renewable energy, as well as to seek opportunities to attract international partners and loans from international financial institutions for further project scaling (FrontNews, 2017). Whether they will make use of local manufacturers or not, is unclear.

There are incentives in place that should motivate developers to use local producers of equipment. In 2015, a so called "premium" was introduced as an addition to the green tariff in Ukraine. This addition enhances the benefits of the green tariff for projects that use a certain amount Ukrainian-made equipment during construction, and will be viable from 2015 until the end of 2024 (Arzinger, 2017).

Renewables are not only going to be important in Ukraine. The big pull factor in Europe is the dynamic growth potential for renewable energy deployment in less mature markets in Eastern and Southern Europe, which have only recently introduced renewable energy incentive mechanisms and are just embarking on an extensive build-out phase.

Major European players are less established in these markets, making it easier for Chinese renewable equipment manufacturers to make an instant impact (Global Solar Council, 2017).

It is important to note that this does not necessarily mean that Chinese manufacturers will have a monopoly in the European market in the future.

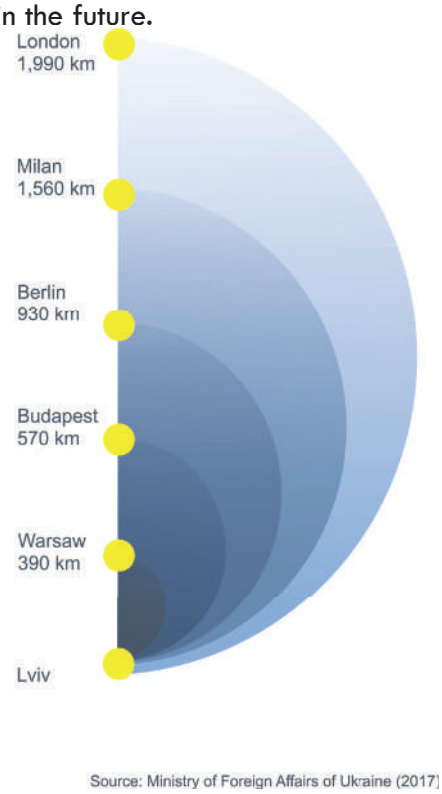


Figure 12: Distance to selected cities demonstrating the proximity of Ukraine to the European market (Ministry of Foreign Affairs of Ukraine, Top Reasons to Invest in Ukraine, 2017)

Competing with China

When it comes to export, Ukrainian companies seem to perceive the competition from China as one of the biggest challenges to enter the international market for solar energy equipment. This is, perhaps, a truth with modifications.

China's renewable energy manufacturing industry is indeed the largest in the world, and there are very few opportunities for European companies to invest in China itself. To date, the emphasis among Chinese manufacturers has been on scaling up as rapidly as possible, with less focus on quality or technological innovation. The principal opportunity for European firms to access China's burgeoning market is through technology licensing (Clean Energy Pipeline & Taylor Wessing, u.d.).

However, for Chinese companies to succeed in licensing technology from Europe they will need to allay fears over Intellectual Property (IP) exploitation. Chinese renewable energy equipment manufacturers are being pushed and pulled into European expansion (Wessing, 2011). It is possible that through closer ties with the EU, Ukraine could become a trusted partner and thus take over the current position of Asian manufacturers in relation to the European market for solar power manufacture.

An alarming consequence of this growth and cost-competitiveness in solar has been an increase in the use of lower quality, unproven materials that threaten the long-term reliability of solar panels (Global Solar Council, 2017). In a market where a group of manufacturers, like Chinese companies, have a big impact, competition is important to keep the quality of materials and production as high as possible. If the solar industry is going to continue to grow and thrive, it must be vigilant in ensuring the reliability of modules well into the future. The market dynamics will thus tend against the likelihood of a single manufacturer monopoly in the solar sector.

A decrease in quality of production and materials has a potentially huge effect on the reliability of investments in solar equipment all over the world. After analysing more than 70 solar installations accounting for more than 200 MW and over 900,000 individual modules throughout North America, Europe, and the Asia-Pacific regions *DuPont Photovoltaic Solutions* found that roughly 41 % of these modules displayed notable defects[6] (Global Solar Council, 2017).

With this potential pitfall for solar in mind, expanded solar equipment production and export from countries like Ukraine, with big potential for such production and a highly educated work force, is indeed a potentially crucial part in the global development of the solar industry. For this industry to succeed in Ukraine, indigenous companies need proper support to get through their incubation phase.

Starokozache Solar Park, Photo credit: Activ Solar

According to the Ukrainian Association of Renewable Energy (UARE), the Ukrainian government is discussing whether they should replace the current feed-in-tariff for larger solar projects with an auction based system. UARE are worried that this system might discourage investors instead of attracting them, as they believe such a system is too complicated to implement (UNIAN, 2017). On the other hand, the EBRD is of the opinion that such an auction based system would be beneficial if implemented in Ukraine (Interfax, 2017). Still, it is important that Ukraine's government does discuss potential changes to their system, as the current one is not necessarily sufficient to facilitate the development of a Ukrainian solar industry. Even with solar power's and other renewables' decreasing costs and increasing competitiveness, reaching the goal of 25% renewables in the energy mix by 2030 will most likely require that Ukraine step up their efforts.

6 The most commonly seen defects were related to cells, backsheets, encapsulants, and glass. Most commonly seen defects for backsheets included yellowing, cracking, and delamination.

2.2.3 Transport Batteries and Energy Storage Market

Renewable energy sources will be a large part of the low-carbon transition, but other products are also rapidly emerging that are related to low-carbon growth. One sector that will see increased growth in the near future is that of batteries, both for transport purposes and for energy storage (Figure 13).

After a long domination of pumped hydropower in electricity storage, batteries are being increasingly used in modern electricity production and storage (IRENA, 2015). Supporting the high level of penetration of renewables to the utilities markets will require resources such as batteries to contribute to the systems flexibility. By the mid-2020s, the integration of renewables into the utility sector will provide around 40% of the entire revenue for battery storage (IRENA, 2015).

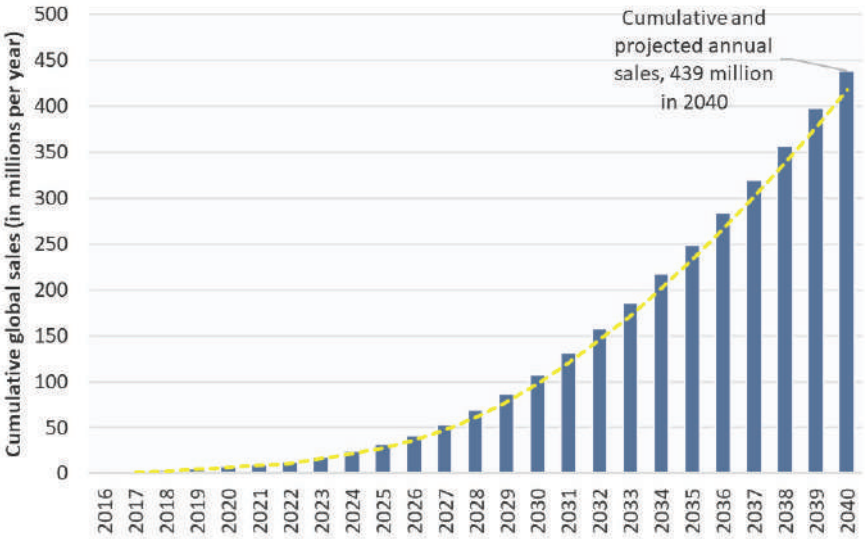


Figure 14: Projected accumulated sales of electric vehicles, annual in millions (Bloomberg, 2016)

Apart from the role of integrating renewables into the grid, batteries will have a key role to play in the automotive sector.

The latter is currently the single biggest driver for the growth of the lithium-ion battery technology and is projected to take up more than half of the market in 2020 (Statista, Market estimates for lithium-ion battery market 2020, 2017). Even though batteries were most commonly used in consumer electronics, the recent impressive growth in sales of electric vehicles (IEA, 2014a) has also been key for the increasing demand for lithium ion-batteries (Bloomberg, 2017).

By 2040, the number of electric vehicles on the road is anticipated to represent 35% of all the new cars on the market (Bloomberg, 2016).

Tellingly, the forecasts of the oil extraction companies include increasingly more electric vehicles (EVs): current predictions include more EVs than they did a few years ago (Economist, 2017). The conclusion is that EVs are continually exceeding expectations as to their future market penetration.

Combined with a growing need to control and store variable renewable energy generation and a rise of technical developments, the demand for lithium-ion batteries will have plenty of drivers propelling its growth in the future. Batteries are part of the low-carbon supply chain because they make it possible to use renewable energy sources to power vehicles, in addition to providing energy storage for electricity from such sources, making both transport and other power consuming activities less dependent on fossil fuels.

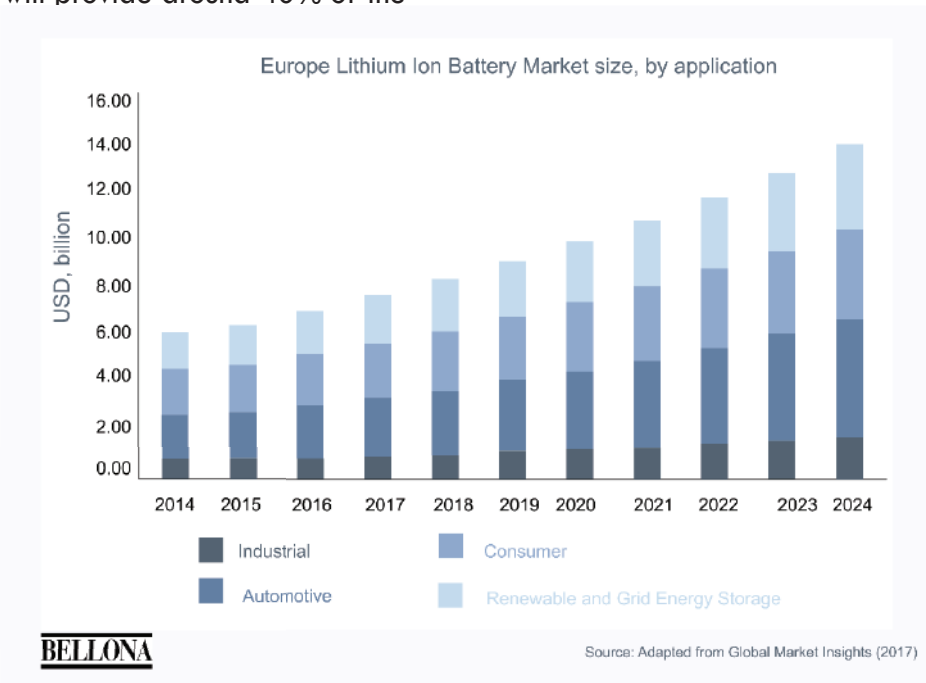


Figure 13: Lithium ion battery market in Europe, by application (Global Market Insights, Lithium Ion Battery Market Size By Technology, 2017)

How green are batteries?

The mining of lithium and the production of batteries for transport and energy storage does lead to CO2-emissions. The process of mining is responsible for a fraction of overall emissions throughout the life cycle of a battery. Around 50% of CO2-emissions comes from manufacturing the battery. The carbon intensity of battery production is greatly dependant on the electricity mix available at the production location (Mia Romare, 2017). A production process based on electricity produced from low carbon sources will therefore lead to a lower total of emissions throughout the life cycle of a battery.

The deployment of batteries for energy storage will have to be backed with substantial financial support.

Globally, the investment directed to electricity storage technologies deployment will range from USD 380 bn[2] to USD 590 bn[3] (IEA, 2014a).

The race for access for the raw materials required for the production of large energy storage systems has already seen large price spike in both lithium and cobalt (Sanderson & Hume, 2017).

The opportunities within the energy storage and battery market are already being seized by others in Europe. This year in October, the Czech Republic announced that an Australian mining group called European Metals is to develop a large lithium resource in the country. The Czechs have declared that they want to extract their lithium reserves as well as refine it within their borders. In addition, they hope to attract production of lithium batteries by making lithium carbonate available locally. The Czech state that they seem to have all that is needed for this to happen: An educated workforce, promising scientific capacities and a great tradition in the automotive industry. In addition, they have sufficient input stocks. These are all things that Ukraine also possesses, except for the latter investment capability. If the whole value chain from mining to battery production were to end up in the Czech Republic, it reckons that 5,500 jobs could be created by this industry alone (Financial Times, Czech lithium mine to help fuel Europe's car battery demand, 2017).

Furthermore, Poland has been able to attract LG Chem, a leading global producer of batters, to construct a large new battery plant to the country. A factory that, according to plan, will be in operation as of 2018. The reasoning behind this localization from the company's side is that Poland is close to core markets in Europe, where electric vehicles are not just being assembled, but also sold in great quantities, and they expect this market to grow (LG Chem, 2016). The plant will only be able to produce enough to cover a small amount of the expected market in the future, but the logic behind LG Chem's investment in Poland is parallel to the logic which would make it invest in Ukraine.
Currently, the battery industry is dominated by companies such as Toshiba, Samsung, Panasonic, GS Yuasa International, Automotive Energy Supply Corporation, A123 Systems, Hitachi Chemical, LG Chemical Power (LGCPI) and China BAK Battery. Some businesses in particular have been focusing on further research and development, while others have been busy creating large battery storage facilities, such as Tesla's Gigafactory in Nevada (Global Market Insights, Industry Analysis Report, Regional Outlook: Growth Potential, Competitive Market Share & Forecast, 2016 – 2024, 2017).

In such a rapidly expanding market, there is a potential for Ukraine to grab a piece of the energy-storage pie.

Current state of the batteries production in Ukraine

At present, there are several producers of simple lead-acid batteries in Ukraine. Among them are WESTA, SC "ISTA" and Megatex LLC. Still, the future of batteries and energy storage will demand more advanced technologies.

Lithium-ion batteries are a key element of the electric automobile industry. Many also predict that graphene batteries might become the new back bone of the push for electrification of societies, especially with regards to large-scale energy-storage (NCBI, 2014).
In fact, large-scale applications of graphene for energy-storage might lead to a demand that is bigger than for all other uses combined. (US Geological Survey, 2017)

This means graphite, of which

2 The IEA EV scenario (IEA, Technology Roadmap: Energy Storage, 2014a)
3 The IEA 2 Degrees scenario (IEA, Technology Roadmap: Energy Storage, 2014a)

graphene is made, will be in high demand. Graphite in lithium-ion batteries could be replaced by silicone in the future, as silicone can store much more electrical charge than graphite, but this technology is still on an experimental stage (The Guardian, 2017). With the emergence of graphene batteries, graphite will still be a sought-after material even if silicone replaces it in lithium-ion batteries.

Ukraine has big reserves of both lithium and graphite. When it comes to lithium, Ukraine has some of Europe's biggest reserves, about 500 million tonnes, with deposits in the regions of Donetsk, Kirovograd and Transcarpathia. Still, there is no industrial extraction of lithium in Ukraine (Trust UA, 2017). Graphite deposits are also abundant in Ukraine, and in this sector the extraction is and has traditionally been substantial (MFA of Ukraine, 2017).

Why Battery Production in Ukraine?

The European battery industry is not especially large, and is in heavy competition with Asian manufacturers. Still, the predicted growth of the battery market is hard to compare to anything we have seen before, and might be accelerating further. The energy storage market in China had a growth rate of 110% over the period between 2011 and 2016 (Bellona.org, 2016).


Photo: Thinkstock

Europe and Batteries

Reversing the slow pace of battery innovation and manufacture in Europe is rapidly becoming industrial policy priority. The absence of European battery supply could place European automotive production at a disadvantage to emerging competitors.

> ***"The lack of a domestic, European cell manufacturing base jeopardises the position of EU industrial customers because of the security of the supply chain, increased costs due to transportation, time delays, weaker quality control or limitations on the design"***
> ***- Maroš Šefčovic, EU Commission Vice-President (EURACTIV, 2017)***

Due to the boom in sales of electric vehicles in the EU (Edie, 2016), European car manufacturers now realize that they need batteries and infrastructure to produce them. Even the European coalition of battery manufacturers, EUROBAT, admits that substantial measures must be taken for Europe to be able to keep up with the current production in Asia (EUROBAT, 2017). A strategy is expected to be ready sometime in early 2018, and a roadmap for a broader EU battery-alliance is to be ready in February of 2018 (EURACTIV, 2017).

It is obvious that European manufacturers might have a hard time making a quick turnaround and produce sufficient amounts to meet future demand for energy storage solutions on their own.

Ukraine and Batteries

Ukraine is perfectly positioned to take part in the growing lithium-ion battery market. Having one of the largest lithium ore resources in Europe (Industrial Minerals, 2012), Ukraine could become a leading cathode or battery exporter to the growing European market. In addition to the already well-known lithium deposits, further lithium resources are expected in less explored fields within the so called "Lipniazskiy granite dome" that could be used for extraction. (Smolin, 2009).

Batteries have been proclaimed as the future core of energy systems around the globe, and not just for cars, by, for example, Tesla's Elon Musk, amongst others. He famously stated in early 2017 that the whole world's energy needs could be covered by building 100 gigafactories like the one Tesla is building in the Nevada desert (Daily Mail, Just 100 'Gigafactories' could power the ENTIRE world with sustainable energy - but Tesla can't do it alone, Elon Musk tells Leonardo DiCaprio, 2017). The Ukrainian government has been trying to get talks with Tesla about allocating a factory for manufacturing of cars to Ukraine (TSN, 2017) .

Ukraine is not alone in trying to encourage battery companies to build production facilities in their country. This year, a South Korean-based company, LG Chem, announced that they will open what is to become Europe's largest lithium-ion battery factory in Poland in 2018. According to the company, the facility would include a research and development centre employing "about 400 engineers from various specializations: automation,

electronics, chemistry and IT". Still, the factory's planned capacity is just a fraction of expected future demand (Reuters, 2017).

The Ukrainian government still hopes to encourage production of batteries. In October 2017, it announced policies to stimulate such production and increased deployment rate of electric vehicles (EVs) in Ukraine. Most importantly, a policy of 0% corporate tax on lithium extraction and battery production will be introduced (GFEI, 2017).

The automobile industry and Ukraine

The global market for EV had an estimated growth of 60% in 2016, and plug-in automobiles are predicted to reach at least a 30% market penetration by 2030. According to the IEA, the world will need 600 million electric vehicles by 2040 to limit global warming to below 2 degrees Celsius, in accordance with the Paris Agreement (Bloomberg, 2017).

Although there is no complete industry for auto mobility in Ukraine, there are several enterprises that make parts used in big brands around the world. Sound systems for BWM, electronic systems for seat-heaters for Ferrari and Porsche, wiring for Volkswagen, Audi, Nissan and others, are all produced in Ukraine (TOPGIR, 2015). This well-won foothold within the industry could be expanded upon, especially seeing that Ukraine has access to domestic production of raw materials and metals required for the automotive sector in general, and also specifically for electric cars. Factories in Ukraine are e.g. producing carbon-fibre, which is an essential part of electric cars (Kramer, 2016).

Both domestic and external demand could stimulate a rise of electric cars production in Ukraine. According to the Tesla Club in the country, there are three incentives that could make more people buy electric cars locally: Free parking, the right for EVs to drive in bus lanes, as well as availability of free chargers (22 kW) (CleanTechnica, To-U EV Charging Leadership & The Fast-Changing Electric Vehicle World (CleanTechnica Interview), 2017).


Photo credit: North Sailing


"Opal", now an electric ship used for tourism in fragile Arctic areas

Photo credit: North Sailing

According to Ukrainian experts, production if lithium-ion batteries in Ukraine could well be a gold mine, by reducing transport time and costs compared to e.g. production in the Far East.

Batteries are heavy, and transport from the Far East can take up to a month (Maritime Executive, 2017). It takes two days to deliver battery shipments by train from Ukraine to Europe (UAWIRE, 2016).

2.2.4 Energy Efficiency in Industry and Homes

A part of the transition to a low-carbon economy that is perceived to be less obvious than battery technology and solar power expansion is that of energy efficiency measures. Energy efficiency is a key part of this transition, both in Ukraine, Europe and globally. It can reduce costs, increase productivity and aid attempts to increase energy security. (EC, 2017)

Energy efficiency measures can be implemented everywhere; in houses, industry, energy production and energy transport. They usually consist of simple technology improvements, like insulation, more efficient heating by way of heat pumps or heat exchangers, integration processes and automation. Globally, it is estimated that energy efficiency measures alone will be responsible for 38% of the CO_2-reduction needed up to 2050, within the framework of the 2-degree scenario (Huffington Post, 2015). In Ukraine, the goal is to reduce energy consumption by half by 2035 (The Ukrainian Government, 2017).

An important thing to note is that energy efficiency and renewable sources of energy are aiding in decoupling energy consumption and production from economic growth.

That is, in the past increased production has led to higher energy consumption, which in turn has led to higher CO_2-emissions from fossil fuel-powered energy production (Figure 15). Renewables reduce this direct connection, because the energy from these sources does not increase the carbon-footprint of increased production. Likewise, energy efficiency measures will help to reduce total energy consumption, both in sectors that rely on fossil-fuel-based energy sources, and for those depending on renewables. Thus, it not only reduces the need for more fossil fuels to be burnt, but it also frees up capacity for renewables.

Data from the IEA shows that already in 2015, there are signs that the rise in global energy-related CO_2 emissions have come to a halt (See Figure 15). The Agency argues that this is mainly due to deployment of renewables and that in 2015, 90% of new electricity generation came from renewable sources. (IEA, 2016).

Energy efficiency measures are also a contributing factor, and will help the ongoing exponential growth in renewables deployment have a bigger impact on energy-related emissions of CO_2. The economy is still growing steady globally, with a 3.1% increase in GDP in 2015 (IEA, 2016). Still, this is the first time in the 40-year history of carbon emissions recordings from the IEA that emissions stood or fell instead of increasing, without being associated with a global economic weakness. (IEA, 2016)

Some of the greatest energy efficiency potential lies in the built environment. With existing technology, European buildings can be retrofitted with equipment and appliances that would cut their energy consumption in half.

This renovation of EU buildings will require average annual investments over the period 2011-2050 of EUR 130 bn in the decarbonisation scenario of the European Commission (Ernst&Young, 2014).

These investments will cover everything from more energy efficient construction of buildings, space heating and cooling systems to energy efficient lighting and appliances (IEA, 2013).

All of these finished goods and appliances will experience an increase in market share as the targets are implemented. As an example; heat pumps are a high priority in the EU (IEA, 2013). Heat

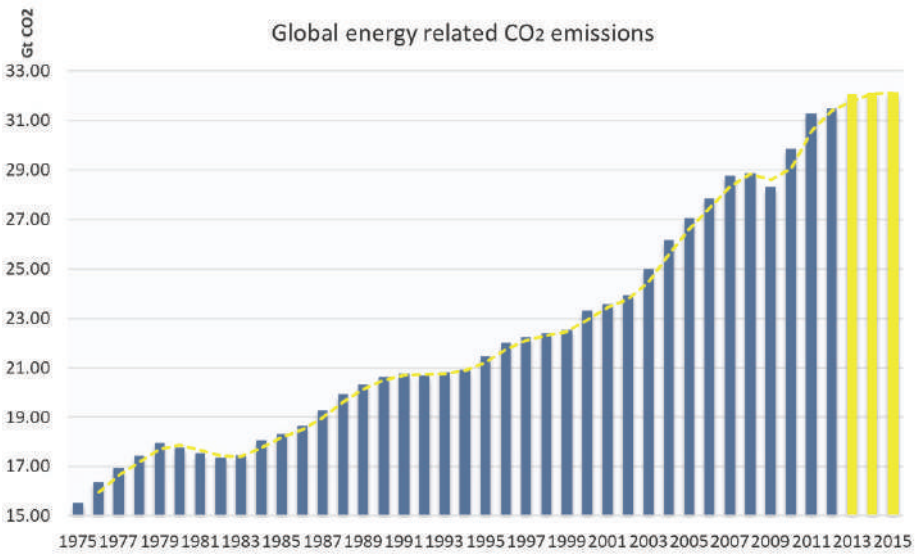


Figure 15: Global energy-related CO2 emissions 1975-2015 (IEA, 2016)

pumps work by way of moving heat from a building to cool it, or moving it from the surroundings and into a building to warm it. Thus, it is much less energy-consuming than traditional heating methods, as it does not have to generate heat (Energy.Gov, 2017).

Europe is considered to be the largest market for heat exchangers and similar technologies today. The market has had a relatively slow grow rate, but demand will be boosted due to increased replacement demand for heat exchangers. In total, the worldwide heat exchanger market is thought to be worth US$20.65 bn by 2022 (MarketsAndMarkets, 2017).

Current state of energy efficiency technology supply in Ukraine

The story of energy efficiency measures in Ukraine is not only one about potentially accessing a huge market for solutions and products abroad, but also one of a potentially very big efficiency increase at home.

Ukraine's residential sector accounts for 33% of the country's total energy consumption. Heating and hot water supply are responsible for 80% of the energy consumed by housing in Ukraine. Energy saving potential in the household heating sector is enormous. Energy waste in Ukraine's households is estimated at 9.1 billion cubic metres (bcm) of natural gas, which is equivalent to almost a half of the countries gas import or US$3.1 bn in 2014 prices (UNDP, 2016).

In other words, the question of energy efficiency is paramount to reaching climate goals as well as increasing energy security. As such, if countries are to keep to their proposed goals climate goals, they need to invest in energy efficiency. That includes Ukraine.

Heat pumps production in Ukraine

Ukraine lags behind EU countries in both production of heat pumps and their use.

There is no industrial scale production of heat pumps in Ukraine. This constitutes an untapped potential.

The Kyiv-based company EcoComfort, or ECOM for short, has operated in the renewable energy market for almost 10 years. The company manufactures equipment based on heat pump technology. (ECOM, 2017)

Currently ECOM does retrofitting of the largest waste water treatment plants Kyiv – The Bortnychiskoyi Waste Water Treatment Plant. A heat pump of with a capacity of 100-120 MW is to be installed there. This equals 1/3 of the capacity of one of the biggest boilers in Kyiv (in the Poznyaky city-district), which supplies heat to the Poznyaky residential sector (ECOM, 2017). ECOM also sees a potential to install the system in the chemical and metallurgical industries, saying they have untapped potential for heat recovery (ECOM, 2017).

ECOM has installed eight heat pumps of capacity 250 MW and ten heat pumps units of capacity of 100 MW in Ukraine. The pay-off period for these units is less than 2 years. That is, after 2 years, it saves costs equivalent to the cost of acquiring the CHP in the first place. According to the company, manufacturing of heat pumps can be scaled up. The company sees a potential for serial production of these solutions in Ukraine (ECOM, 2017).

The European market of heat pumps manufacturing is balanced on demand and supply (ECOM´s assessment). In terms of technology and products´ quality, ECOM does

Ukraine innovation in Europe: Energy efficiency export success

The retrofitting of existing structures and the construction of new buildings with high energy efficiency will required both in Ukraine and abroad to reduce the overall energy consumption in buildings.

PassivDom Corp is a technological manufacturing company producing autonomous self-learning module houses made using 3D-Printing. PassivDom is the first totally autonomous house in the world that doesn't need any fuel combustion even in Arctic climate conditions. The solar energy is used for all needs: climate control (heating and cooling), water generation, air quality and oxygen control. The house itself produces electricity for all household appliances.

The Daily Mail reported in 2017: "The solar-powered houses are made by Kiev-based firm PassivDom who use industrial 3D printing to manufacture the properties. The homes are the brainchild of engineer Dr Max Gerbut and his team, and are constructed from carbon fibre and fibreglass, which means the entire property is fully recyclable. Prices start at €30,000 (£26,000/US$32,000) and increase to €60,000 (£51,000/US$63,000), with additional extras available."

Source: (Daily Mail, 2017)

not envisage any barriers to enter the markets of other countries. The company considers its lower labour costs a competitive advantage

Company profile: PRANA

PRANA is a Lviv-based company designing and manufacturing ventilation systems. The company has been operating in the energy efficiency market for more than 15 years.

PRANA Climate Lab develops and tests various models of ventilation systems for the residential sector, public institutions, sport facilities and industry. All PRANA's heat recovery units are supposedly made of environment-friendly materials and the company has obtained a European Certificate of Conformity, according to the company itself.

PRANA's heat recovery system is characterized by a high rate of efficiency (up to 92%) and a low consumption of electric power (6-310 W/h), depending on model and operating mode. Their models for domestic use have an energy efficiency rating of A+, and their models for industrial use have a rating of A.

The company exports its ventilation systems with built-in heat recovery units to more than 20 countries, including: Italy, Romania, Slovenia, France, Georgia, Kazakhstan, Germany, Bulgaria, Estonia, Finland, Latvia, Serbia.

Source: (PRANA, 2017)

"The current situation in the heat energy market does not allow to stimulate and attract investments. National heat supply systems, built in Soviet times, require a global reboot. Implementation of the Concept will allow the optimal combination of individual, autonomous and centralized heat supply within the settlement, will open gateways for investments and the industry, solve the problems of interaction between market participants, clearing settlements, cash disbursement, accumulation of debts, will enable to decentralize heat supply"

Gennady Zubko, Deputy Prime Minister, Minister of Regional Development, Building and Housing and Communal Services of Ukraine (Ukrainian Government, 2017)


Photo: Thinkstock

(ECOM, 2017)

Policy initatives on Energy Efficiency in Ukraine

The Ukrainian government is by no means a stranger to the potential that lies in energy efficiency.

They do see it as an opportunity, not only for much needed energy saving, but also for investments and economic growth.

Ukraine´s Government approved a Concept for implementation of state policy in the field of heat supply, with the goal of reducing resource use in the production of heating energy, to financially improve the industry and attract investment, and to create a transparent heat energy market. (Government of Ukraine, 2017)

The Concept has a short-term, medium-term and long-term plan of action. Some main objectives are:

- Raising the technological level of heat supply systems,
- Increase of the share of alternative energy sources in the production of heat energy,
- Development of heat supply systems based on the optimal combination of different types of heat supply (centralized, autonomous, individual).

In August of 2017, the Ukrainian Government set a goal of reducing the energy consumption of the country by half until 2035, as part of the Energy Strategy for Ukraine until 2035 (The Ukrainian Government, 2017). This goal is ambitious, but might pave the way for a big push towards supplying both domestic and external demand for solutions required to reach this goal.

Why energy efficiency technology production in Ukraine?

Energy efficiency measures could directly help reduce the Ukrainian natural gas consumption (IRENA, 2015). Low efficiency is the major challenge to Ukraine's district-heat sector. Nearly 60% of the heat produced is lost in production and distribution, and both heat-distribution pipelines and generation systems need replacing (IRENA, 2015).

Precise billing is also a challenge because historically individual gas consumption has not been measured by meters. Only six percent of all households have meters, and fewer than 20% of buildings have functioning metering today. Today more meters are being installed and the amount of free gas per consumer is being reduced. Efficiency improvements to the district-heat sector stand out as one of the most important potential contributions to Ukraine's energy-intensity reduction goal of 50% by 2030. Improvements could include rehabilitation of the boiler houses, replacing network pipes, installation of heat substations and installing heat meters (IRENA, 2015).

The alternative to reforming the district-heat sector is to restructure the overall system in order to promote individual heating systems in buildings or industrial facilities currently connected to the grid (IRENA, 2015). This is where appliances like heat pumps come in. ww

Not only is the market potential and the need in Ukraine huge, but production of such systems in Ukraine would also be very relevant for export to Europe.

The market for heat pumps and other energy efficiency measures is expected to continue to grow, especially in Europe.

Europe already stands as a global leader when it comes to legislating initiatives to increase building energy efficiency and bringing in new technologies. The EU already has two key pieces of legislation — the Energy Performance of Buildings Directive (EPBD) and the Energy Efficiency Directive (EED) — through which European countries are delivering their 2020 emissions reductions goals (CleanTechnica, 2017).

The importance of energy efficiency developments across Europe is highlighted in the energy efficient building technology market across the next decade through 2026. The market is expected to grow in Western and Eastern Europe from US$83.5 bn in 2017 to US$111.9 bn in 2026 (CleanTechnica, 2017).

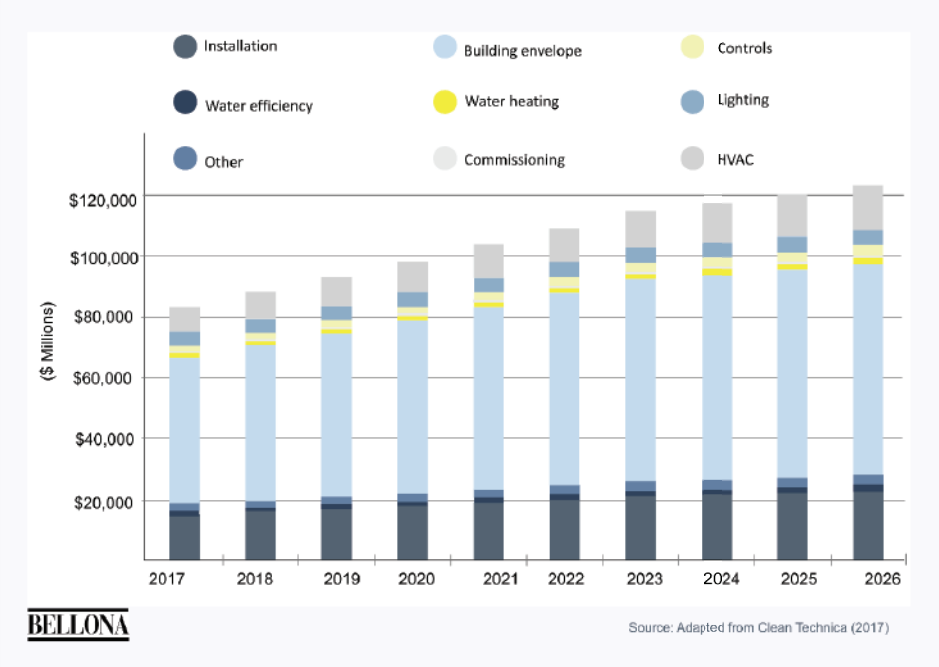


Figure 16: Energy Efficient Building Revenue by Product and Service Type, Western and Eastern Europe, 2017-2026 (Clean Technica, 2017)

2.2.5 Low carbon infrastructure (CO2 pipeline) Market

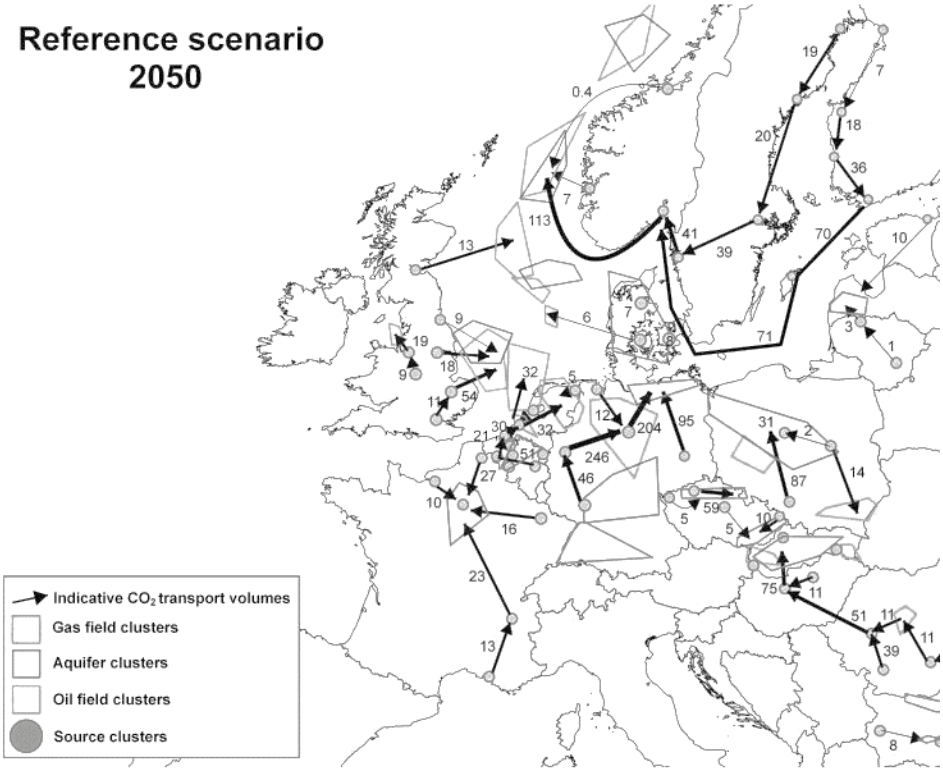


Figure 17: CO2 Europipe reference scenario 2050: CO2 transport networks (CO2 Europipe, 2010)

Technologies such as carbon capture and storage (CCS) will form the foundations of limiting temperature increase to 2°C (IEA, 2016). To materialize the low carbon transition and maintain a strong industrial base for decades to come, Europe will have to tackle its largest point sources. Not only will there have to be more wind turbines to replace fossil energy sources, but their production will have to be low carbon too. To enable this transition to net zero products, CCS networks and clusters will have to be developed across Europe (Figure 17).

The CO_2 pipelines needed for the large scale deployment of CCS, as described in the European Energy Roadmap 2050 scenario, will cover some 11,000 km of infrastructure by 2035 (EC, 2010). As Figure 17 shows, the CO_2 transport and storage clusters will allow shared infrastructure that will drive down costs of the projects to make them politically and economically feasible. Nevertheless, around 80% of the capital costs of CCS projects will remain for the capture facilities (GCCSI, 2016).

CCS is needed to achieve deep emission reductions in energy intensive industries in Europe. Steel and iron making, cement production, biomass conversion, refineries and other industrial high-purity CO_2 source sectors[5] all have high climate goals to tend to and no other option to tackle their emissions than with CCS (IEA, 2011). The 2-degree scenario trajectory estimates a rollout of 1,800 full-scale CCS projects in energy intensive industries worldwide by 2050. By then, 289 Mt of CO_2 should be sequestered annually, in Europe alone.

Such an ambitious deployment program will require considerable capital: as shown in Figure 18, investments in facilities that will capture the high-purity point source CO_2 will increase by a billion USD annually in the next two decades.

Despite the varying costs for capture facilities due to the diversity of existing industrial plants, the potential to produce components for the process is considerable.

	Number of projects (cumulative)				Additional investments, excluding transport and storage, in USD billion			
	2020	2030	2040	2050	2010-20	2020-30	2030-40	2040-50
High purity source sectors	3	5	10	25	1	1	1	2
Biomass conversion	0	3	17	33	0	2	4	5
Cement	1	12	25	38	1	7	8	8
Iron and steel	2	22	27	32	1	13	3	3
Refineries	1	5	7	9	1	3	1	1

Figure 18: Cumulative number of project and additional investments until 2050, in European OECD member states, from the IEA Roadmap targets for CCS in industry (IEA, 2011)

5 These include natural gas processing sector, hydrogen production, ethylene production, ammonia production and coal to liquids (IEA, IEA/UNIDO Roadmap targets: Industry foldout, 2011

According to the estimates of the European Commission, the size of the capture apparatus should be approximately similar to the plant itself:

> ***A standard 200 MW generator weighs 4,500 tonnes, most of which is steel and some high specification alloys. Assuming that half of this capacity would be upgraded, or replaced with, the implementation of CCS, it is likely that a similar quantity of materials would be required for each CCS plant (though these would all be produced from scratch) (EC, 2016)***

Hence, for each part of the CO_2 capture process there is a new piece of equipment needed, consisting mostly of products that Ukraine is already exporting. The rollout of technologies which would enable the decarbonised inputs to society, such as CCS, will require sustained investments for pipelines, infrastructure, equipment and machinery. Ukraine can use its long track record of industrial engineering to focus on added value products and tap into more profitable market segments in the future (World Economic Forum, 2014).

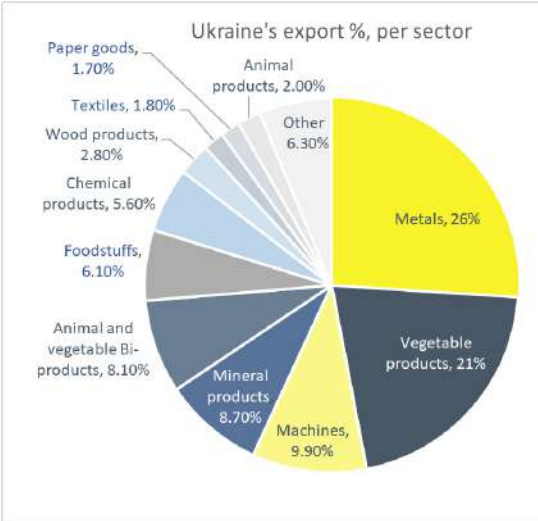


Figure 20: Export %, per sector (The Observatory of Economic Complexity, 2017)

The 2-Degree scenario suggests a steep deployment path for CCS technologies applied to power generation and a number of industries. Over 70% of all CCS projects take place in non-OECD countries by 2050 (Global CCS Institute, 2012).

> ***In addition to developing products that will provide a steady supply for the CO_2 infrastructure, there will be a gradual shift towards low-carbon products taking place in Europe.***

A shift from iron ore to scrap metal as a ferrous resource for steel making will provide an incentive for Ukraine to develop low-carbon solutions that will have a price premium on the market. With an increasing amount of metals being recycled and scrap metals becoming an ever-greater part of the market, Ukraine's metal sector will have to move up the value chain to remain competitive. This could be done for instance by producing low-carbon steel and storing the resulting CO_2 emissions in the existing gas storage sites.

Apart from piping, the CO_2 capture clusters will also need a steady supply of auxiliary equipment, compressors, valves and similar accompaniment. With respect to Ukraine's long tradition in industry manufacturing and its competitive labour force, the country is poised for success when it comes to addressing the demand for these products. With machinery comprising almost 10% of its exports already (OEC, 2017), Ukraine is in a position to start strategically developing capabilities that will match a more value-added approach to the already existing export base (Figure 20).

Substantial investments in low-carbon infrastructure will be needed as well, with the grand total of investments for the pan-European pipeline system amounting to EUR

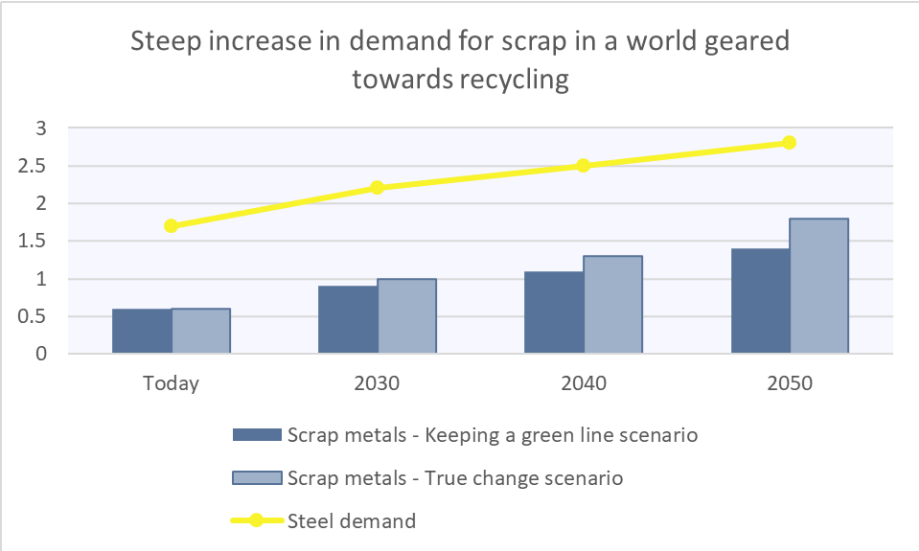


Figure 19: Increase in demand for scrap metals (World Economic Forum, 2015)

31 bn when storage in onshore aquifers is allowed and EUR 72 bn if aquifer storage is restricted to offshore reservoirs with corresponding specific cost of CO_2 transported (Kjärstad, Morbee, Odenberger, Johnsson, & Tzimas, 2013).

Current pipe production in Ukraine

Ukraine is not only well positioned geographically and ideally situated resource-wise to produce CO_2-transport pipes; it already hosts several companies that could ease the transition to produce pipes for CCS infrastructure.

One of the most notable is the company CENTRAVIS, whose history started already in the 1960s, and is a good example of how Soviet-era industrial projects can take a step up and become very relevant in today's low-carbon development. CENTRAVIS exports more than 95% of all its products (Delo, 2015). The company's production facilities are located in Nikopol, Dnepropetrovsk region. It is a leading global supplier of seamless stainless-steel tubes. The company takes the 1st place across the CIS, the 4th place in Europe and the 6th place in the world on sales volumes. With a production output of 34,000 tonnes of pipes per year, the company has a global market share of 3.8% (Centravis, 2017)

Why low carbon infrastructure production in Ukraine?

Ukrainian pipe production is already going strong, even throughout though times. This is an advantage, as they might have to wait some time for the market for low carbon infrastructure to mature on a global scale.

Despite the political and economic turmoil of Ukraine, its major stainless seamless steel producer CENTRAVIS saw favourable financial results in 2014, although 2015 proved more challenging because of overcapacity and the persistence of weak oil and gas prices. It estimates that it was able increase its global market share to 4.2% on the strength of its successes in hydraulic and instrumentation systems and refinery furnace tubes in 2015 (Stainless Steel World, 2016).


Photo:Thinkstock

> ***"The future belongs to those companies willing and able to make painful but necessary adjustments. Adaptability, a full product range and flexible response to customer demands and – dare one add? – luck and a good balance sheet: these appear to be the qualities needed to ride out the current market uncertainty" (Stainless Steel World, 2016).***

CO_2-piplines are not the only product that the low-carbon future will demand. A growing market for stainless pipes and tube is CPS (concentrated solar power) stations. CENTRAVIS supplied U-pipes for heat exchangers for one of the largest solar power station operators, Crescent Dunes Solar Energy (Tonopah, Nevada), and their CSP plants (Delo, 2015). According to the industry itself, the tubes and pipes industry is in transition.

The Ukrainian industry is aware of the dynamics of the current market, and pipelines for CO_2-transport will be one of the core demands that the industry must fulfil in the future. Ukrainian companies can, and need to adapt.


Photo:Thinkstock

3

INCREASING REQUIREMENTS OF GLOBAL LOW-CARBON MARKETS

Growing global climate action will entail risks for current Ukrainian staple exports, including metals and agricultural products for bioenergy. Increasingly stringent environmental trade rules in major markets such as the EU could in time reduce the competitiveness of Ukrainian exports that fail to improve climate performance.

3.1. Product standards – counting entrained CO_2 at the border

In advanced economies with ambitious climate targets there is growing concern that local climate policies could potentially disadvantage industrial activity with international competition. Carbon leakage, a concept that argues that growing costs on global commodity industries to comply with CO_2 reduction measures will in time reduce competitiveness and encourages investment in regions with more lax CO_2 legislation.

In response there is growing awareness of the potential role for border carbon adjustments and industrial low carbon standards for products that account of climate impact entrained in the product. Border carbon taxes are gaining traction with governments seeking to manage complex concerns on industrial competitiveness for CO_2 intensive industries with global markets and local climate legislation compliance costs. The application of such border carbon taxes could protect local low carbon industries from more climate intensive manufacturers. In this way, increasing global action on climate change committed to in 2015 at the Paris climate accord could decrease access to markets for products deemed to be overly greenhouse gas (GHG) intensive over time or exacerbate climate change in their production or use. Manufacturing processes that are unduly CO_2-emissions-intensive could be penalised through increased border trade taxes or failure to meet stricter environmental standards.

To date no evidence for carbon leakage from the EU to other regions, as defined by the ETS Directive, has been found. The EU CO_2-price (ETS) is currently ineffective, providing little incentive for industry to markedly alter process to reduce emissions or to migrate production to avoid carbon costs. However, many industries and politicians are concerned that an increasing CO_2 price within the European Union, rising from ~€6 today to an anticipated €35 in 2030, may provide a growing impetus for carbon leakage (Nix, 2017).

In early 2017, Lakshmi Mittal, CEO of Europe's largest steel manufacture, ArcelorMittal, called for carbon levy's to be applied to steel imported to Europe. Mittal, along with other manufacturers, is concerned that EU CO_2 emissions costs will discriminate against European producers (Clark, 2017).

Despite the complexity of the implementation of border carbon taxes an increasing number of academics and NGOs are calling for EU to implement such a system (Dieter & Hepburn, 2017). In September 2017, French President, Emmanuel Macron called for a European carbon tax at the bloc's borders to guarantee fair competition for its companies (Felix, 2017).

In early 2017, the European Parliament has already deliberated on the implantation of a form of border carbon tax called a border adjustment mechanism (BAM). The proposal would have required importers of cement and clinker into the EU to surrender emissions permits corresponding to the embedded carbon in their products. The proposal was not supported by the European parliament, but renewed efforts to implement such measures should be expected with an increasing CO_2 price within the EU (Elkerbout, 2017).

If such a border carbon tax were imposed, it could reduce the competitiveness of low efficiency and CO_2 intensive exports from Ukraine to Europe. Of special concern would be the adverse effect on the Ukrainian steel sector. The importance of the steel sector as a basis for the future development for the Ukrainian economy is critical as it currently provides jobs to over half a million people, nearly 25% of GDP, and 40% of export revenue. At present Ukraine has the highest potential increase in energy efficiency of any steel sector globally (Shatokha, 2016). Failure to increase efficiency and thus reduce CO_2 emissions could lead to future commercial disadvantage due to higher border taxes for GHG

intensive steel producers.

3.2. Shifting markets and requirements for Bioenergy

Ukraine has a competitive advantage in the production of bioenergy based on availability of feedstock and fertile soils. The export of bioenergy from Ukraine has for many years been flagged as a green growth opportunity. Growing European demand for bioenergy feedstocks could be met in part through export from Ukraine, providing foreign capital and investments. The EU's Renewable Energy Directive set a target for the block to meet 20% of energy consumption and 10% of transport with renewable energy sources by 2020, and this has created a large market pull for bioenergy.

Bioenergy is diverse, including energy crops, food based biofuels, solid biomass from purpose grown wood plantations and wood wastes, and increasingly bioenergy based on agricultural wastes. This complexity leads to some policy risk in bioenergy development for export. Shifting compliance requirements of the EU can lead to some forms of bioenergy becoming disqualified from use. The changing perception of some forms of bioenergy have been driven by growing awareness and understanding of the effects large scale production may have in competition with food supply and land use change.

In recent years, within the EU bioenergy debate there has been a trend, with growing momentum, for more stringent environmental and climate standards to be applied to bioenergy. In particular bioenergy from food grade feedstocks and large-scale use of solid woody biomass for energy have become outspokenly controversial. To date Ukrainian biofuel feedstocks producers and traders which aim at the EU biofuels market have been seeking to comply with existing EU legislation (Ogarenko & Nivievskyi, 2011).

In 2017 Members of the European Parliament voted to ban the use of biodiesel from all vegetable oils by 2030 and of palm oil biodiesel as early as 2021 under the revised Renewable Energy Directive. The phase out of food grade feedstocks for transport fuels will have knock on effects for growing investments and exports of Ukraine oil seed crops. During the 2015/2016 harvests, rapeseed reached 1.4 million tonnes and soybean 1.5 million tonnes, both primarily exported to the EU to produce biodiesel (Janda & Stankus, 2017). In response Ukrainian producers will need to seek alternative markets, increase domestic processing and use or switch to alternative feedstocks meeting EU requirements.


Photo: Thinkstock

The solid bioenergy market, dominated by wood is also transitioning. Within the EU, perceptions and attitudes changing to large scale use of wood pellets. The use of wood in the large thermal power plants, particularly converted coal power station is meeting with increasingly stiff environmental resistance (Macalister, 2016). In 2017, the European Commission confirmed a range of environmental hazards from the use of wood energy imported from the U.S. (EC, 2017). Increased wood use for energy has been linked to deforestation and potentially higher CO_2 emissions then currently accounted (Brack, 2017). In addition, local use of wood pellets for heating has been linked to increasing air pollution in some regions.

In this atmosphere of increased scrutiny on the use of wood for energy and particularly imported solid biomass it is likely that EU Member States will require increasing sustainability requirements over time. On a positive note, Ukraine has become less reliant on exporter markets wood pellets and residual forestry waste. From 2012 to 2015 the export of wood pellets dropped from 80% to 30% of production thanks to higher utilisation within Ukraine.

At present, most Ukrainian producers do not meet current EU certification requirements for solid bioenergy. Thus, in light of ever more stringent standards increasing overall wood bioenergy production for export from Ukraine though increased dedicated energy plantations should be carefully considered.

4

DISCUSSION: UKRAINE AND THE LOW-CARBON MARKET

In this report, we have shown where some of the world's biggest markets are heading, and how they are changing to become based around low-carbon products throughout the whole value chain from energy production, via energy use, to end-product demand. We have also shown that Ukraine is well positioned to grab a share of this market. This constitutes a unique opportunity. These markets are either emerging or changing in ways that make it possible for players that are not well-established to embark on an industrial path previously unavailable to them. Ukraine is such a player, and has the right resources available to make this choice.

Ukraine has several well-known problems that it aims to solve. This includes corruption issues, monopolies in important sectors, brain-drain, issues with property rights, and a lack of trust in the judiciary among potential investors. It is imperative for Ukraine to solve these issues at it is hindering the country from receiving the investments it needs to create new industries that could employ its highly educated workforce.

While there are no novel findings when it comes to the general issues Ukraine is facing, the question is; how can Ukraine make use of their advantages to take steps in the right direction?

Ukraine cannot build its economy solely on its traditional industries, such as agriculture and the IT sector, and it cannot expect to thrive by only producing raw-materials.

The historic Paris Climate Agreement, adopted by nearly 200 countries, aims to achieve zero net emissions shortly after 2050.

Photo: Thinkstock

Investing in the energy transition to move from the two thirds of global emissions that come from fossil fuels today to a cleaner and more affordable energy future will boost the economy over the next 30 years by as much as US$19 trillion,

according to a joint report by IRENA and the IEA published in 2017 (NRDC, 2017). The targets of the Paris agreement provide the certainty for the increasing demand of several products necessary to achieve them.

Ukraine could make good use of its Association Agreement with the EU, but it must be aware of the pitfalls inherent in this close relation with Europe. Its western neighbours are changing their course, focusing more and more of their attention and investments on low-carbon products. If indigenous European companies are to work under a heavier carbon tax, and produce low-carbon products, it is likely that we will see trade barriers put up to prevent more polluting alternatives from entering the European market at a lower price. Thus, to mitigate export barrier risks to Europe (and other regions) in the future, Ukraine must follow the developments within the EU closely, and seek to adhere to the standards set within the European Community. Traditional industries in Ukraine, such as steel production and bioenergy products from agriculture and forestry might be the first sectors that face such challenges of increasingly stringent product climate standards.

Demand for low-carbon products is likely to grow fast in European countries. Ukraine is well positioned to adhere to their needs. It has a place waiting for it in the

low carbon supply-chain, but it requires a conscious change of path.

4.1. Ukraine's place in the future low carbon supply-chain

Our point of departure is the logic that Ukraine has plenty of resources available that will be needed in the future, as well as a highly educated yet low-cost labour force. In addition, the country is located close to one of the bigger markets for low-carbon products and solutions; the EU. In our analysis, we have touched upon several sectors that play a central role in Europe's low-emission transformation, and in which the Ukraine is poised to benefit from.

Renewables: The potential of the wind power industry and beyond

When it comes to energy production, the world is turning towards renewables. This is both due to concerns about the climate effect of traditional fossil fuel based energy, and the profitability of renewables, which in 2016 surpassed that of fossil fuels for the first time. The profitability is, indeed, only going to increase as cost fall and penalties for polluting increase.

Going forward, we see increasing opportunities on the European wind market, with political support and financial means for the new wind capacities. Not only is this true for the western part of the European market, but also for the rising economies of the Eastern EU, where Ukraine is well positioned to grab a part of the market. Most importantly, Ukraine is by no means starting at the bottom as there already is an industrial base to build on.

There are already several Ukrainian companies producing and exporting products essential to the wind power industry. Be it companies that produce all parts required for a wind-mill set up, like Wind World, or companies that just produce wind engines, like Fuhrlander Windtechnology, or yet again those that are producing parts for wind towers, like Metinvest; they are there and ready to expand their business. Ukraine can benefit from an existing production infrastructure which has the potential to be expanded by also using existing infrastructure of other industries, such as using shipyards to assemble equipment.

Indeed, as Ukraine has a big metallurgical industry, the spill-over effect from production of parts for wind turbines and towers is likely to create additional business opportunities for local metal producers as well. Further, since the facilitation of local production requires specialists, like engineers and IT-experts, investments in the sector can contribute to decreasing the brain drain issue of Ukraine.

One of the sectors we have covered where Ukraine does not have the same inherent advantages as the above mentioned, but still benefits from proximity to market, is the solar cell industry. However, such an industry is something Ukraine could make a bid for creating.

Worldwide, the drop in solar energy costs will be steeper in comparison to wind generation. As solar technology is becoming cheaper as the technology matures, an increasing number of markets will be able to afford large-scale investments. This development will naturally drive the demand for the manufacturing of solar panels that Ukraine can benefit from.

A significant decrease in costs will act as a key driver for the proliferation of solar generation in new and dormant markets. Other drivers of growth will include economic benefits of self-consumption, the increasing number of public tender programs and EU regulations and targets.

A growing issue with solar panels from low-cost Asian markets is a doubtful quality. Ukraine could balance this trend by being closely integrated with the EU, and thus introducing legislation and production standards that are on par with the ones within the EU itself. Ukraine could become a trusted supplier of solar cells to the EU. Companies like SolarGaps and Prolog Semicor represent the start of such an effort.

The main obstacle to this turn of events is a lacking efficiency of domestic incentives for solar cell production within Ukraine, and for companies producing renewable infrastructure in general. Many companies have a hard time making it past their initial incubation phase and need government support to ensure that their business is sustainable from the get go.

Bigger development programs for renewable deployment within Ukraine could be a great benefit for local producers, given that there exists a premium to the green tariff that increases with the amount of local equipment used during construction.

Currently there are incentives for renewables in place, like the green tariff and VAT exemption, but these are insufficient to drive the market forward, according to companies currently trying to do business in Ukraine.

Supplying Electricity Storage: Ukraine and the manufacturing of batteries

Both energy storage for renewables and a transition to electrical transport require increased battery production worldwide. At the moment, lithium-ion batteries, as well as graphene batteries are the technologies of choice. As Ukraine possesses some of the largest lithium deposits in all of Europe and has an established graphene extraction industry, the country is excellently positioned to benefit from this growing market. The Ukrainian government is already moving to take advantage of this, by introducing a zero-corporative-tax policy on lithium extraction and batteries production.

If batteries were to be produced in Ukraine, the geographical proximity to Europe would constitute a significant competitive advantage over other lithium-producing countries such as Australia. Batteries are heavy, and higher transportation costs follow suit. The same competitive advantage of proximity to growing markets relates all of the other sectors we have touched upon.

Batteries are also an essential part of the electrification of transport. The electro-mobility market itself is set to increase exponentially over the next decades, with current expectations seeing about 35% of total new car sales in 2040 to be of vehicles running on batteries. The market for electric cars is not yet mature, but emerging, and has been exceeding expectations so far. It is poised to put predictions to shame. The fact that Ukraine has not had time to react properly is thus understandable, but the emerging market is also an argument for striking while the iron is hot.

In addition to batteries production, Ukraine has a competitive advantage when it comes to entering the market for electric vehicles production. Not only do Ukrainian companies already produce a wide range of parts for other producers, but they are also especially proficient in carbon-fibre manufacture, which is essential for the new generation of electric cars.

For renewables to become competitive with other sources of energy, energy storage will need to become widely available in the form of batteries. This will contribute to the flexibility of deployed renewable energy resources, making power from sources that are either dependent on certain weather or a certain time of the day more reliable, as surplus energy gathered during peak hours can be stored for later use. As renewables are deployed in bigger amounts, energy storage will facilitate a quicker turnover from fossil fuels to renewables. Ukraine could put its eggs in both baskets, batteries and renewables.

Saving Electricity: A market for energy efficiency

Energy efficiency will have a big role to play in the coming shift towards low-carbon products. All around the world, there is a huge potential for energy savings, and one of the big markets is that of energy efficiency in households and for industry, which often revolves around saving energy when heating up infrastructure. In this regard, heat pumps and heat exchangers will be in huge demand in the coming years. Europe is considered to be the largest market such technologies and products today.

Ukraine itself has an immense potential for energy efficiency deployment, especially in the housing sector. There are already companies producing needed equipment in Ukraine, and by facilitating more such production, Ukraine can not only solve its own domestic issue with energy waste, but also export energy efficiency products to the neighbouring EU.

Enabling de-carbonisation: constructing CCS

Ukraine is also well positioned to contribute to another emerging market within the low carbon value-chain, that of infrastructure for Carbon Capture and Storage (CCS). This technology and its deployment is required to reach the goals inherent in the Paris Agreement.

The metal industry in Ukraine is already producing piping that could be used in the deployment of CCS infrastructure in Europe. In addition, a steady supply of auxiliary equipment, compressors, valves and similar products will be needed for this infrastructure to function properly. Ukraine's already existing expertise and capabilities within the metal industry makes it primed for covering these needs. The market is still maturing, but Ukraine should be ready to accommodate this demand when it arises.

In addition, CCS will be required in certain phases of production of many products that Ukraine also is or could be producing. This means that Ukraine could be well positioned to not only make products for the low-carbon market, but also deploy CCS themselves to accommodate increasing demands for products that are produced using carbon negative or low-carbon manufacturing methods.

5

CONCLUSION: UKRAINE HAS TO CHOOSE

Ukraine has been at the cross-roads between east and west, and have chosen their orientation. New, closer ties with the EU, paired with Ukraine's inherent resources and competitive advantages must give rise to a strategy for how Ukraine can prosper.

We argue that Ukraine could choose to pursue industrial success in each of the sectors we have outlined in this report. However, Ukraine needs to watch its steps. There are several pathways that may become dead ends as the EU changes its policy.

Calls are already being made to set up trade barriers for products that are made within the EU under a carbon-tax regime. Policies in EU change, and in the future, products such as bioenergy materials and metalwork, which are now core industries in Ukraine, might be hard to export to the EU without changing the production mechanisms in Ukraine to adhere to stricter climate regulations. Such a change can be achieved in all stages of production, from material choice to choosing climate friendly energy to power the production process.

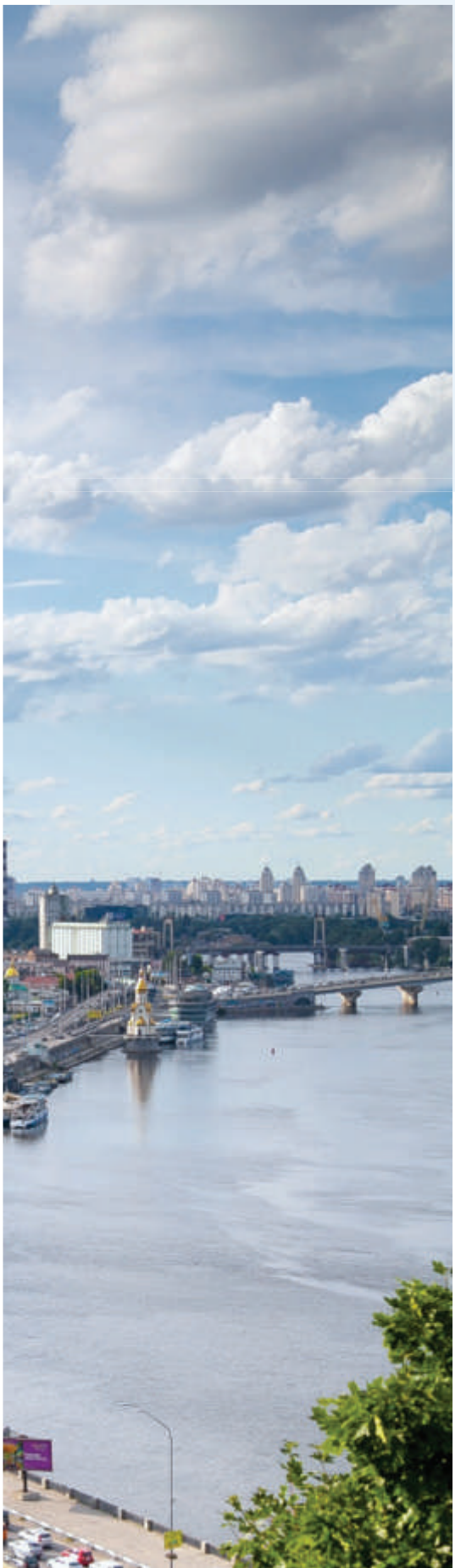
One thing is for certain: Renewable energy sources is inevitably a growing part of the future global market, along with other low-carbon products like energy efficiency equipment, batteries and CCS-solutions. All of these markets together make up the low-carbon supply chain. They are interconnected, and in solving the energy and climate issues at hand, they are dependent on each other for success.

Facilitation of a growth in indigenous Ukrainian production of required equipment for the low-carbon transition, both in Ukraine itself and in other countries, is not necessarily connected to Ukraine reaching its own energy targets. Ukraine can choose not to develop such manufacturing industry at home, and thus import the required products for their own transition.

What we argue is that Ukraine could profit both in terms of climate- and energy goals, as well as economically if it made a conscious decision to choose this industrial path. Attracting foreign investment is hard for Ukraine, but choosing to focus on the right sectors might help mitigate several of the problems associated with their lack of investors.

It is obvious that their current trajectory, where many say that agriculture and the IT-sector will be the country's saving grace, can be greatly supplemented by the potential that lies in the market for low-carbon products. Ukraine has several competitive advantages that are primed for such a transition, the most important of which is a highly educated, low cost workforce.

The world is going green, with or without Ukraine as an industrial hub. The question is; can Ukraine afford not to grab this opportunity? Ukraine should be an active participant in the future global economy, and having industries that contribute to the low-carbon shift is as good a thing as any to focus on. It might actually turn out to be Ukraine's best bet.



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