Since January 2020 Elsevier has created a COVID-19 resource centre with free information in English and Mandarin on the novel coronavirus COVID-19. The COVID-19 resource centre is hosted on Elsevier Connect, the company's public news and information website.

Elsevier hereby grants permission to make all its COVID-19-related research that is available on the COVID-19 resource centre - including this research content - immediately available in PubMed Central and other publicly funded repositories, such as the WHO COVID database with rights for unrestricted research re-use and analyses in any form or by any means with acknowledgement of the original source. These permissions are granted for free by Elsevier for as long as the COVID-19 resource centre remains active.
Security of supply, strategic storage and Covid19: Which lessons learnt for renewable and recycled carbon fuels, and their future role in decarbonizing transport?

David Chiaramonti\textsuperscript{a,b,⁎}, Kyriakos Maniatis\textsuperscript{c}

\textsuperscript{a} “Galileo Ferraris” Energy Department, Polytechnic of Turin, Corso Duca degli Abruzzi 24, 10129 Turino, Italy
\textsuperscript{b} RE-CORD (Renewable Energy Consortium for R&D), Viale J.F.Kennedy, Pianvallico, 50038 Scarperia e San Piero, FI, Italy
\textsuperscript{c} Independent expert, Brussels, Belgium

HIGHLIGHTS

- The analysis investigates the link among pandemic and energy security/resilience.
- The relevance of strategic storage and short supply chains is highlighted.
- Distinct programs should address Oil and Renewable and Recycled Carbon Fuels chains during post-pandemic recovery.
- Short-term plans should support the immediate impact of Covid-19 on fuel industries, protecting jobs and economic activities.
- Medium to long-term program should promote domestic bio-based and recycled carbon value chains.

ARTICLE INFO

Keywords:
Energy
Alternative fuels
Renewable fuels
Recycled fuels
Advanced biofuels
Security of supply
Single European market
Strategic Energy Storage
Energy System Balancing

ABSTRACT

The present work analyses the lessons learnt from the Covid19 (Coronavirus) pandemic that could possibly apply to the energy sector, with a special focus to decarbonizing transport. Distinguishing between short/medium- and medium/long-term options, the scope is to discuss how issues such energy security, energy storage and energy system resilience should deserve more attention. Today, fuel demand has fallen to unprecedented levels, with jet fuel demand being the most affected one. Oil price is at the lowest values recorded for many years while on 20 April it even reached a negative price in the US for the first time in history. While in the short-term low oil prices would be attractive, the long-term negative consequences could be very relevant, with significant associated costs for the EU economy and Member states (MS) related to the collapse of demand and to the socio-economic impacts. New measures should thus be considered in the post Covid19 strategy. In particular, while in a short- to medium-term view the oil sector will require specific support measures to overcome the economic and physical shock brought in by the pandemic, in a medium to long-term perspective domestic sources such as Renewable and Recycled Carbon Fuels (RRCF) should be regarded as a way to secure energy supply, leading to significant technical and economic advantages. Thus, EU should allocate adequate resources in the post-Covid recovery plans to definitely allow the transition to renewable energy sources and particularly to bio-based economy and sustainable transport fuels.

Decarbonisation of transport through RRCF and economic recovery do not compete, but rather represent a win-win solution in a well-designed and sustainable implementation strategy, especially when low or zero interest-rate investments are foreseen. The EU should take the opportunity to match the UN SDG (Sustainable Development Goals) and EU Green Deal goals with the need to inject economic and financial resources into the real economy improving the socio-economic conditions of EU populations. Both agroforestry and RRCF industry are ready to produce (biomass) or source (waste) the feedstocks as well as the technologies, systems and components needed by the industry along the whole value chain. The roadmap to cleaner transport fuels thus represent an evident opportunity to meet climate, economic and societal post-Covid19 goals, in a win-win-win approach.

⁎ Corresponding author at: “Galileo Ferraris” Energy Department, Polytechnic of Turin, Corso Duca degli Abruzzi 24, 10129 Torino, Italy.
E-mail address: david.chiaramonti@polito.it (D. Chiaramonti).

https://doi.org/10.1016/j.apenergy.2020.115216
Received 13 May 2020; Accepted 14 May 2020
Available online 03 June 2020
0306-2619/ © 2020 Elsevier Ltd. All rights reserved.
1. Introduction and scope of work

During the early-2020 dramatic weeks, the significance of the “security of supply and storage” for health and safety material and related instrumentation became evident in the world and all over Europe. The desperate search for protective face masks, whose production over the years shifted towards third countries, suddenly materialized and became a visible symbol of the importance of controlling strategic supply chains [1] through domestic channels as well as strategic storage. The race to recover as much as possible respiratory fans to support the sudden demand for intensive care even caused clashes inside and outside the European Union [2–4]. The Single European Market (SEM), a pillar of the EU, hindered. Even standard commercial supply chains were disrupted when the USA (later accused of piracy for this) confiscated in Bangkok a shipment of masks destined for Germany and diverted it to the USA based on a security Korean-war era legislation [5].

It appears therefore evident that the pandemic resulted in the disruption of common commercial practices and heavily impacted also on the SEM.

The availability of strategic and critical goods during financial and physical shocks (which are very different as regards their impact and duration) thus becomes a matter of (1) securing strategic supply chains, (2) securing sufficient strategic storage and (3) maintaining domestic production. Due to the pandemic, these are now very clear and understandable concepts even to non-experts. As regards supply chains in Europe, the best approach to secure these chains is through confining a significant part of them within the EU, and on the assumption that the SEM will not again hinder, with the first problem when Member States may take individual actions. If this really happens, then the Energy Union would likely collapse. The second one - on strategic storage - became prominent as of February 2020.

The question raised here is about the role of the European Institutions in managing and coordinating our response to global, physical and unforeseen disasters as this pandemic. Do the EU institutions have the power and authority to impose European Measures over National measures upon Member States?

However, fully securing strategic supply chains is not possible anymore, given the globalization of manufacturing, nor the ability to guarantee adequate or at least reasonable cost-competitive conditions for EU consumers; therefore, in addition to the security of supply, adequate strategic storage of critical goods and products needs also to be ensured.

Similar misalignments among EU Countries already occurred in the past, such as the case of the Nord Stream 2 pipeline for Russian natural gas [6,7], a key energy infrastructure, but did not generate a similar impact on the EU populations or to the SEM; these were actually unknown. This is probably due to the very long-term effects of these high-level decisions on large infrastructures, that actually reach the EU taxpayers only after many years from when the decisions were taken.

In this period, the entire scientific community is engaged in analyzing the impact of Covid19 on many different sectors of daily life and economic activities, such as on the food system [8] or others, thus well beyond investigations on the EU health area only.

Given this background situation, it is definitely relevant to try to understand the similarities and differences between the COVID19 pandemic and energy security/resilience, appreciating its broader relationship. A key question thus becomes if the consciousness of the importance of energy security on our daily life and socioeconomic conditions has also grown, and which role Renewable Energies and in particular renewable and low carbon sustainable fuels can play in this context, at a time when all major economies are in lockdown.

The scope of this work is thus to carry out a first but focused analysis on EU-based sustainable Renewable and Recycled Carbon Fuels production (RCCF), and on the fact that policies stimulating this sector will:

- increase energy security through increased domestic production of transport fuels and diversification of supply
- increase protection from energy shocks through strategic storage of these sustainable fuels
- boost the decarbonization of the EU economy while at the same time securing energy supply through sustainable solutions
- mitigate the impacts of possible future economic and energy shocks, as happened with Covid19 and Countries’ lockdown
- support the local economy, in agricultural, forestry and energy industry, creating/maintaining permanent jobs and economic activities, and thus with a high return of the financial resources injected in the post-Covid19 EU economy
- strengthen and maintain the technological leadership of the EU industry
- in the long-term, reduce the financial burden of the EU Member States by reducing their oil bills due to the significant import of oil products in the European region
- improve the regional stability of the EU energy market

The latest European Directive on the promotion of Renewable Energy, also called REDII [9], defines “biofuel” as “a liquid fuel for transport produced from biomass”, while “Recycled Carbon Fuels” are those “liquid and gaseous fuels that are produced from liquid or solid waste streams of nonrenewable origin which are not suitable for material recovery in accordance with Article 4 of Directive 2008/98/EC, or from waste processing gas and exhaust gas of nonrenewable origin which are produced as an unavoidable and unintentional consequence of the production process in industrial installations”. Worth to note REDII also defined RFNBO (Renewable Fuels of Non Biological Origin (as it is the case of the Power-To-X chain), as well as the Advanced Biofuels category. Low-ILUC feedstocks are also defined in REDII.

The nature itself of these biofuels value chains is multidisciplinary by definition, that is a clear advantage when the EU goal is to inject resources on actual economy. Investments in RCCF will in fact impact on concrete EU economic activities, from supply of feedstocks (agriculture, forestry, and waste), to manufacturing (components and entire biorefining plants), building (construction of the industrial complexes), services (all indirect industrial and consulting activities to be performed during construction, commissioning and operation of biorefineries), to logistics, to certification, and some others. All these activities, in case of well-designed value chains, need to be implemented locally at MS or EU level.

As the Nobel Prize in Economic Sciences prof Joseph Stiglitz recently explained [10], the Covid19 pandemic will force countries “to make themselves less vulnerable, and this would lead to shorter supply chains and a greater emphasis on self-sufficiency in food and energy”. He also remarked the need for global cooperation to face both the pandemic and the climate crisis, calling for more resilient economic systems.

The reference condition is the oil market, which has been unprecedentedly shocked by the pandemic.

Our aim is to investigate, in parallel to the unavoidable short-term actions aimed at preserving jobs and industrial activities, understand why in a medium-to-long term scenario further developed domestic bioenergy and bio-based products chains are necessary.

The present work is therefore built around addressing the following key questions:

- How the pandemic relates to climate?
- Which impact from Covid19 on the electricity sector?
- Which impact has been observed, during these first weeks, on GHG and air quality?
- How pandemic impacted on the oil market, and which physical consequences? Are low oil-prices a real benefit in the short, medium and long term?
- How domestic supply chains for sustainable Renewable and Recycled Carbon Fuels (RRCF) could contribute to post-Covid19...
economical recovery in the medium-to-long term? How RRCF will – at the same time – contribute to decarbonization of the EU transport system?  
• Which can be the role of strategic storage for sustainable RRCFs in the EU?

We have based our analysis on the most recent and available information, i.e. data from last weeks. These are therefore predominantly available through expert statements, analysis from agencies as IEA, sectorial magazines, etc. When available, historical data have also been considered (as Eurostat).

Our final objective is thus twofold:

• To stimulate a science-based discussion around the consequence of Covid19 in the transport fuel sector, and how policy makers should consider the shock as an opportunity for driving EU toward economic recovery, higher competitiveness at global scale, and at the same time reduce GHG emissions (in line with REDII [9] and the EU Green Deal [11])
• To bring to the attention of the scientific and policy community the fact that well-designed chains for sustainable RRCF are not only good for the environment (i.e. decarbonization), but also positive for the economy. The economic value of RRCF should not be underestimated, focusing the attention only on the GHG effects. Thus, RCCFs should be regarded as an economic topic, and not just as an environmental one. And the low/zero-interest rate conditions that will likely occur in Europe in the coming months should be regarded as an unique opportunity for EU/MS to stimulate new business initiatives on RRCFs.

The hard times many observers predict for the renewable energy sector in times of very cheap oil is maybe true only in a short-term view, but the many medium-to-long term economic benefits of bioeconomy will instead create a more resilient and secure Europe in energy and economy, and should deserve the same attention as the previous ones.

We therefore propose to act at two different levels, allocating now resources to two different routes: a short-to-medium term one, which goal is to preserve jobs, industries, companies, and knowledge, and a second one on a medium-to-long term, diverting the chains to greener and more domestic ones (at least at EU regional scale), favoring also the role of strategic storage. Post-Covid19 resources should be allocated now to both pathways, and not only to the first one.

2. How do climate and pandemic relate?

Pinner et al [12] from the Mc Kinsey group in the last weeks elaborated a very interesting analysis on this linkage in their “Addressing climate change in a post-pandemic world” work. Authors identified similarities and differences among the COVID19 pandemic and climate change, such as the fact that both pandemic and climate relates to a physical shock, which can only be solved by addressing the physical reasons that originated it, differently from financial shocks. Interestingly, the pandemic case could provide insights on what the climatic crisis will represent. Among the differences, instead, there is the time scale of the effects, that are dissimilar for pandemic and climate. In their analysis, authors focus the attention to the significant near-term and long-term benefits that investing in climate-resilient infrastructure generate, in a near-zero interest rate moment. Climate change is a potential risk multiplier for pandemics: we need to develop models able to catch both environmental and economic sustainability at the same time. This is precisely the case of a new energy system based mostly on renewables and recycled carbon. This is also the medium to long-term objective of the EU and other OECD economies. Climate action could therefore accelerate the recovery by creating jobs, driving capital formation, and increasing economic resilience.

3. Which impact from Covid-19 on the electricity sector? the IEA analysis of the electricity sector

The International Energy Agency is closely following the implications that Covid19 is generating on the energy sector [13]. The Union of the Electricity Industry (Eurelectric) already in March 2020 observed a huge drop in electricity demand by ~20% in France and Italy, while changes in Germany were minimal [14]. Eurelectric also reported MWh prices across EU dropping to 20 €/MWh, and carbon prices by some 40%. However, the association not only called for supporting energy companies, but also to “ensure that European investment plans and economic recovery programmes are fully compatible with EU climate objectives and support electrification and decarbonization of the EU economy by targeting investment in technologies critical for the energy transition”. The recent (22nd of March 2020) analysis by the Executive Director of the Agency, Fatih Birol, highlights how the Covid19 crisis shows the urgency to increase world energy security [15]. It is worth to note how during 2019 renewable electricity production overtook coal fired power generation [16]. In short, the main observations and recommendations for the electrical sector by IEA were the following:

• The growing role of electricity in our economies - It is evident that modern societies are increasingly dependent on electricity, even more in this emergency situation.
• Variable Renewables Energies in a declining demand time - The sudden reduction in electricity demand that was observed following the spread of the virus and the consequent lockowns has been equal to ~15%. In countries with high production levels of Variable Renewable Energy (VRE), the fall in demand thus corresponded to a significantly increased share of these non-controllable production of renewable electric electricity.
• The flexibility of the electrical system: an inevitable development - The absolute need to reconfigure our systems towards highly flexible configurations is therefore even more necessary today. Lessons learned from this “stress test” (compared to current under-utilization) are very relevant to design our future grids and their management.
• Energy security and new flexible electricity markets – At a time when the energy transition to renewable and low carbon fuels is expected to be fully realized, the role of flexibility in fossil generation is becoming central, as well as the promotion of a shift to a balancing-services offered by non-variable renewables themselves.
• Extreme weather conditions and power generation – Fortunately, these extreme cases (e.g. fires in California and Australia during 2019) have not yet materialized at the same time as the lockdown due to the virus. But the vulnerability of current power grids is well-known, and this issue will need to be well addressed in the framework of increasing penetration of electricity on the energy mix.

It is a dogma that electricity has become indispensable for modern society.

4. Which impact has been observed, during these first weeks, on GHG and air quality?

The COVID19virus shock and the consequent lockdown obviously brought an immediate impact on global GHG emissions, given the impact on logistics and limited mobility (the impact on fuel consumption is discussed in the following section). As a result, first published analysis reported a decrease of emissions of nitrogen dioxide (NO2) and carbon and induced an improvement of the environment, especially on air quality [17,18] (see Fig. 1).

Recorded global CO2 emissions were over 5% lower in Q1 2020 than in Q1 2019, mainly due to a 8% decline in emissions from coal, 4.5% from oil and 2.3% from natural gas, according to IEA [19]. The expected decline is even more rapid in the next months, projected to
reach 30.6 Gt in 2020 (8% lower than 2019).

Even if no rebound effect has been observed yet in China [17], this may be due to the measures taken by Countries after the lockdown to reduce the risk of a new virus wave, keeping the situation under control. However, in a longer-term perspective, and even more when a vaccine will be available, GHG emissions will likely go back to December 2019 levels unless disruptive and systemic approach to our economies and energy systems (in particular, transport fuel) is implemented in the meantime.

As regards EU and decarbonization, the fossil fuels consumption will significantly decrease in 2020 as the months under lockdown have an impact on the year average (as reported in the IEA global energy review 2020 [19]). However, it is not at all certain that the same will happen in 2021 and even more afterwards.

Thus, even if during 2020 EU Member States will likely have a less challenging task in fulfilling their obligations and goals set in the EU Directives RED/FQD, this is a short-term consequence of Covid19, as GHG emissions will start to grow again as soon as a vaccine will be widely deployed if no action is take now to steer through policies transforming the energy and transport system to truly sustainable ones.

It is worth to remember that Transport is the most difficult sector for decarbonization, in which the GHG emission reduction was very weak in the past years. This also because of the complex infrastructure behind, and the rigid set of norms and standards in the engine and turbine sectors.

The European Environment Agency reports the statistics per end-use sector of CO2 emission from 1990 to 2016. It can be seen how transports, and specifically aviation, where the only sectors where CO2 emissions increased and not reduced. It can also be observed the growing share of biomass-related CO2, due to the growing share of bioenergy plant that replaced fossil ones in the past (see Fig. 2).

5. How pandemic impacted on the oil market, and which physical consequences? are low oil-prices a real benefit in the short, medium and long term?

Transport is a major component of our energy system, not only responsible for a large share of human-induced GHG emissions, but also vital for almost any daily activity.

- A first question deserving attention should thus be: what does this experience of Covid19 tell about the fuel system and in particular the transport system? What is the role of Renewable and Recycled Carbon Fuels (RRCF)? Has the urgency for their market introduction increased?
- A second question could address the role of RRCF in stabilizing the ever more fluctuating grid.

This work focuses on the first point, as the balancing issue has already been well treated in the mentioned IEA analysis and other studies [21], clarifying the high relevance of developing renewable-based balancing services and in particular biomass-based ones.

5.1. Setting the scene: The oil sector during Covid19

Demand for oil in April is expected to fall by 20 million barrels per day, and perhaps more: anomalous situations are observed, as the lack of availability of oil storage capacity due to the collapse in demand [22]. Today, more than 80 large ships (tankers) wander offshore, waiting for better economic moments to land, despite this option being more expensive than conventional storage. It is the first time in oil history that the global oil system has to deal with such kind of problem. Even in presence of the collective 10 million barrels per day cut (about 10% of the world’s supply, a reduction never seen before), announced

![Pollutant drops in Wuhan during Covid19. No rebound effect observed till end of February 2020 [17].](image-url)
by OPEC++ major oil-producers [23], IEA [24] still expects an excess of more than 15 million barrels per day. IEA also estimates that the demand will be reduced by 9.3 million barrels per day in 2020, in spite of a OPEC-non OPEC production cut estimated at 12 million barrels per day [25]. Saudi Arabia, Russia and the US are joining efforts in reducing the oil production in an effort to stabilize the price of oil. However, the competition between producers from Russia and US did not allow a further reduction, and this created further clogging in the market channels. Brent\textsuperscript{1} prices almost halved compared to last year’s average values, reaching 31.11 €/bbl, while those of WTI have fallen to 28.34 €/bbl (5/4/2020) [26]. This situation also led to the first-ever observed negative oil price case on 20 April 2020 for the WTI barrel, at −6.79 US $/bbl on 21/4/2020 [26]. However, this very specific case was due to the closures of May contracts, a situation that - even if it could still happen in June - is probably not so relevant on a global scale and in particular for the EU Brent barrel. Instead, the global overall trend remains dramatic.

The very recent analysis of IEA in its Global Energy Review 2020, specifically focused on understanding the Covid19 possible impacts [19], estimates that oil demand could drop by 9%, or 9 mb/d on average across the year, returning oil consumption to 2012 levels. This is the largest drop, compared to all other primary energy demand (coal, gas, nuclear). Only renewable (electricity) will grow. No much is said, about sustainable alternative fuels of biological, non-biological, gas, nuclear). Only renewable (electricity) will grow. No much is said, about sustainable alternative fuels of biological, non-biological, or waste origin, RRCF (see Fig. 3).

5.2. Setting the scene: impact of Covid19 on transport modes

At global level, the impact on transport mode of Covid19 is depicted in the following graph [19] (see Fig. 4).

The collapse in oil demand will generate long-term economic implications, as already experienced in the past: as an example, during the 2008–2009 financial crisis, Italy recorded a loss of 23 Mt of re-energies, converted to storage areas or completely closed [27]. During March this year, jet fuel demand decreased by almost 90%, while gasoline and diesel falls were at around 50–60% or below. All this has serious socio-economic long-term implications, with losses of permanent direct and indirect jobs, as well as companies being pushed out of the market due to lack of demand. At global level, this could lead to the loss of 50 million jobs in the sector [28].

Forecasting the rest of the year is very difficult as of today, since the virus effects are very difficult to predict, depending on factors as new possible virus waves, medicines and vaccines, etc. IEA estimates that global reduction around 2.5–3% in December 2020 could be possible, with EU at around or below 1% reduction.

However, the consequence of the shock impact will indeed be a long wave for companies working in the oil sector. Moreover, in addition to possible rebound effects, also modal shift in transportation choices by customers could happen. For instance, people could favor for a while the use of their own car rather than using public transportations (today estimated at some 25% of the capacity to meet safety restrictions due for Covid19). Or wait for rather long time before going back to flying for not strictly necessary reasons, as for vacation through low-cost airlines. Making serious evidence-based predictions on these issues is almost impossible as of today.

Worth to note, on April 17 Royal Dutch Shell announced its commitment to net-zero GHG emissions within 30 years [29]. Similar announcements came from Total [30], and previously from BP [31] and ENI, with net zero carbon footprint by 2040 [32]. In this framework, the use of Advanced Biofuels made from sustainable biomass and waste is a measure supporting the decarbonisation strategy in case electrification of transport proceed slower than expected.

Thus, in the short-term it is necessary to support the fossil fuel sector in this moment of heavy shock, preserving industrial capacity and direct-indirect jobs, but a forward-looking strategy is indeed essential for the long-term.

5.3. Setting the scene: the false benefit from very low oil

Under these circumstances, the most obvious conclusion for the EU could be to try to store as much as possible cheap oil to meet the post-Covid19 recovery-demand at the best possible economic conditions.

However, in a wider perspective, it is an oversimplified conclusion and short-term thinking: in fact, this situation of low oil prices can
certainly be beneficial in the short term to facilitate the recovery of the EU economy. If it remains long-standing, it will generate other very relevant long-term economic and climate damages that collectively each EU Country will have to deal with and/or compensate with public funds. Moreover, it will not support decarbonization, and discourage investments in renewables. Looking at the medium to long term, instead, it is wiser to accelerate the deployment of Renewable and Recycled Carbon Fuels (RRCF) compared to current planning in the EU, increasing the ambition (as done through REDII), as this approach would promote domestic chains, reinjecting economic resources in local chains and favoring EU economic recovery. Thus, very cheap oil, although relevant for the post-Covid19 recovery, is definitely a questionable and undesirable benefit in the long-term.

On the other hand, one line of thinking to address is to ignore the fossil fuels industry and built the post pandemic recovery mainly on renewables. Austria became the second EU country to shut-down power and heat generation from coal when the Verbund’s Mellach coal-fired district heating plant interrupted its operation on 17 April 2020 [33]). In the long term, this trend must be followed and not only for ending the use of coal but also ending (or significantly minimizing) the use oil.

Is it thus now the right time that instead of issuing Directives to gradually promote the use of renewables (RED & RED II) the EU should make a leap to disruptive legislation on gradually reducing the use of oil and natural gas as of 2025 to below 10% by 2050?

6. The relevance of domestic chains in bioenergy and bioeconomy for long-term securing the EU energy supply and strategic storages

6.1. How domestic supply chains for sustainable renewable and Recycled carbon fuels (RRCF) could contribute to post-Covid-19 economic recovery in the medium-to-long term?

In this context, the resilience offered by shale gas/oil in the USA is certainly an element that promotes long-term competitiveness in the Coronavirus times, if fossil fuel market will return to higher and more stable prices, necessary to make shale gas again cost-competitive. However, the question has to be raised whether the US administration can be trusted as a reliable energy partner given the erratic approach on any non-US-centered issue. Indeed, however, the shale revolution improved the US energy security.

Renewable and Recycled Carbon Fuels are the only energy vectors that could provide the same comfort on energy security in the EU as well as in other regions of the world. For instance, this is the case of India, where a strong push towards sustainable renewable fuels has been given by the Ministry of Petroleum and Natural Gas [34] to reduce imports and bring socio-economic rural development, in a moment when nuclear and hydropower made up 27% of India’s total generation, up from 22%, and coal shrank to 65% from 71%, as of 15 April [35].

The role of domestic sustainable low-carbon fuels, i.e., those produced from locally available renewable and sustainably supplied sources or from “recycled carbon”, becomes therefore even more
important today, targeting economic and social sustainability of the energy system, in addition to the environmental benefits.

Energy security for Europe is fully consistent with the objectives of the new EU Green Deal. However, it does not seem sufficiently prioritized nor communicated strongly enough, despite the strategic benefits it can offer. In fact, energy security in the transport sector has always been present in almost all previous energy directives, until the recent REDII [36] (in the process of being implemented at MS level). Nevertheless, it has never really become a central theme and priority focus in the EU, in combination with and complementary to the decarbonization efforts, as it is in other regions of the world. For example, security is mentioned four times in the premises of REDII, but only twice in the articles of the Directive itself.

Strategic storage not even mentioned at all and it is not addressed by any EU policy or legislation.

Similarly, the new Green Deal sets the fundamental focus on decarbonization, which is obviously a very welcomed motivation, but it does not give the same emphasis to the security of energy supplies, which is a complementary result linked to a greater volume of domestic sustainable fuels placed on the market. In the Green Deal, the theme of security of supply is mentioned in relation to raw materials and food, while not prioritized for energy.

Given the analogy with the pandemic, the issue would deserve more attention, given the high energy dependence of the EU area [37]. This is especially true for petroleum products and natural gas.

The lack of emphasis on energy security is a missed opportunity, not only for both the bioenergy and the circular/bio-economy, but for the EU economy itself in a wider context.

However, positive signals are also coming from Brussels. In the last days a ‘Green recovery alliance’ was launched in European Parliament [40] by 79 MEPS and supported by large EU Companies (including 37 CEOs, 28 business associations, the European trade union confederation, 7 NGOs and 6 think tanks). The alliance calls to place the EU Green Deal at the center of post-pandemic EU action, in particular as regards the reinvestment of EU resources to stimulate economy. This action thus has not only to do with decarbonization, but also with stimulating domestic and circular/resilient supply chains. This will bring more energy self-sufficiency of EU/MS and higher resilience of the energy supply system. Signatories are committing to invest in innovative solutions well aligned with climate commitments “to revive the economy after the crisis”. A “Petersberg Climate Dialogue” is on the same time taking place among Environmental Ministers from 30 Countries on how to organize a “green” economic recovery after the acute phase of the pandemic is over [41].

Biomass availability for both energy and circular economy will have to be carefully verified. A large amount of residual biomass is already available and largely not yet utilized in the EU, as reported by several studies, such as [42], but also sustainable rotations and agronomic models have the potential to deploy further feedstock without requiring additional land, but on the contrary supporting more sustainable agriculture in marginal or abandoned land. This is doable through well-designed crop rotations, improving soil resilience for food-feed-products and energy uses, and also increasing Soil Organic Carbon, a very important element given the huge amount of EU land suffering by loss of fertilization. In fact, marginal areas in the EU are estimated at some 8.5 Mha in Southern European Countries only [43]. Biomass supply thus will require detailed assessment and continuous monitoring, to track availability and use in due course of policy implementation and towards the achievement of targets. This analysis will also have to cover the implication on job and the agricultural sector, with assessment of the workforce available and needed, and calculating the impact on the rural economy. Biomass is by nature a mean to store energy, thus a mean to secure the strategic storages here discussed: this element will therefore be another positive consequence of the workers employed in the field and investments over the whole chain.

Well elaborated economic and environmental impact studies should thus accompany the EU Green Deal and its related actions, so to support binding and long-term roadmaps towards 2050 decarbonisation, necessary to secure investments.

6.2. How RCCF will – at the same time – contribute to decarbonization of the EU transport system?

EU depended on energy import by 58% in 2018 (increasing from the 47% share of 2000) [45]. More than half of the energy EU consumed is thus imported. Two thirds of energy imports in 2017 were petroleum products, followed by NG (26%) and solid fossil fuels (8%).

The share of extra-EU imports in 2018 and first semester of 2019 in
the energy sector is given in the following figures. Petroleum oils and oils from bituminous minerals dominates (almost 70%), followed by Natural gas an LNG (above 20%, combined) (see Fig. 5).

In terms of EU energy dependence rate [46], EU-28 in 2017 depended by 86.7% from import in the oil and petroleum product sector, thus transport in the EU is mostly dependent on these imported quotas [47] (see Fig. 6).

7. Which can thus be the role of strategic storage for sustainable RRCFs in the EU?

EU has in place large programmes to develop sustainable fuels, from bio-based ones to recycled carbon, to renewable energy-based electrical transport, to waste-derived fuels. The average contribution at 2017 in the EU28 was set at around 7% of the renewable energy in transports The overall production of biofuels in 2018 reached the unprecedented dimension of 15.7 MTOE [48], with Germany leading with 3445 MTOE.

RED II [9] set new targets at 14% by 2030, while the new EU Green Deal [11] aims at rising the decarbonization effort in the EU to 50–55% reduction from the agreed 40%.

These fuels by definition represent a mean to secure energy volumes, thus a strategic storage and resource. The field is the ultimate energy tank, under this view, which is secured, distributed and resilient. As a reference, the pumped storage potential in Germany in 2010 was equivalent to 40 GWh, while the storage potential in the natural gas grid and in liquid fuels were 2170 GWh and 2500 GWh respectively: with 10 million electric vehicles, the average storage capacity would be 10 GWh [49].

Thus, while promoting all means for decarbonizing the system and specifically transports, it is indeed evident the significant potential offered by RRCFs in storing chemical energy. Bio-based production would reinject the resources necessary to produce and maintain this large storage capacity into Europe and its Member States, generating multiple benefits.

8. Conclusions

Based on the above analysis, it would therefore be reasonable and appropriate to allocate post-Covid19 financial resources at a significant level also to:

(A) promote and implement well-designed and reliable sustainable low-carbon fuel refiners
(B) promote and implement well-designed strategic storage of fuels, starting with cheap oil and gradually replenishing it with sustainable low-carbon fuels

9. EU has available all necessary human, financial, industrial and agroforestry resources to implement such ambitious programme, both on the feedstock supply and conversion sides.

Domestic sustainable and recycled carbon sources, if deployed at large scale, are a key stratagem to mitigate security risks, while deploying at the same time resources to the local economy and national production chains.

In addition, Variable Renewable Sources (VRE, mainly solar and wind), and controllable ones (especially biomass, hydropower, and deep geothermal) can and must play a complementary role, with the latter used to allow a greater degree of penetration at the former (VRE) in a virtuous integration. Balancing the whole energy system can be provided by controllable sources, such as those mentioned [50]. IEA has just started a new Task entirely dedicated to the flexibility of the energy system [51].

It is the right time to take action. In fact, the effects of the Covid19
on the Clean Energy Transition were also analyzed [52]. That is, the implications that the global pandemic situation may have on the ongoing transition to a more sustainable energy system.

The EU should now operate at two different timescales:

- Investment support to SHORT/MEDIUM-TERM goals – Assist EU fuel companies to overcome the collapse of demand and the economic shock, preserving EU direct and indirect jobs and business
- Investment support to MEDIUM/LONG-TERM goals – Increase the ambition and promote higher amounts of domestic Renewable and Low Carbon Fuels, injecting economic resources on green domestic supply and conversion chains.

As regards Renewable and Recycled Carbon fuels, combined with the Bio-Based Economy and in a long-term sustainable perspective, the Covid19 case should stimulate the relevance of Energy Security, deploying the benefits offered by a higher penetration of sustainable fuels (including truly sustainable – renewable - electrical transports).

The post-pandemic restart should thus be an opportunity to steer the energy system to more resilient, secure, competitive and sustainable systems.

As regards Renewable and Recycled Carbon fuels, increased attention should be given to their role in a sustainable energy system. The EU institutions should aim at strengthening the Energy Union, aiming to ensure that Member States cannot take unilateral and disruptive decisions affecting the Single European Market.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

Authors wish to acknowledge dr Laura Lonza (EC DG Clima), dr Theodor Goumas (Exergia), Prof Alberto Clò (University of Bologna), dr Filippo Clò (Rivista Energia), dr Matteo Prussi (EC JRC) and dr Philippe Marchand for their availability to provide comments and suggestions to our analysis.

References

[1] Xie J. World Depends on China for Face Masks But Can Country Deliver? VOA News, 19 March 2020. Available at: https://www.voanews.com/science-health/coronavirus-outbreak/world-depends-china-face-masks-can-deliver [last accessed on 15/4/2020].

[2] Financial times. European countries search for ventilators as virus cases surge. Available at: https://www.ft.com/content/5a2ac477-f21b-48e3-b12e-089a9f7d5d6a [last accessed on 15/4/2020].

[3] Bayer L, Deutsch J, Hanke Vela J, Tamma P. EU moves to limit exports of medical equipment outside the bloc. Politico, 15 March 2020. Available at: https://www.politico.eu/article/coronavirus-eu-limit-exports-medical-equipment/ [last accessed on 15/4/2020].

[4] Miller J. Germany, Italy rush to buy life-saving ventilators as manufacturers warn of shortages. Health News, Reuters, 13 March 2020. Available at: https://www.reuters.com/article/us-health-coronavirus-dragerwerk-ventil-gm184680e6b5 [last accessed on 15/4/2020].

[5] Miller J, Germany, Italy rush to buy life-saving ventilators as manufacturers warn of shortages. Health News, Reuters, 13 March 2020. Available at: https://www.reuters.com/article/us-health-coronavirus-dragerwerk-ventil-gm184680e6b5 [last accessed on 15/4/2020].

[6] Bloomberg. ENI CEO says Nord Stream 2 would raise gas prices in Italy. 23 May 2016. Available at: https://de.reuters.com/article/energy-nord-stream-2/eni-ceo-says-nord-stream-2-would-raise-gas-prices-in-italy-idUSL1N1848KG [last accessed 15/4/2020].

[7] De Maio G. A tale of two countries: Italy, Germany, and Russian gas. Brookes, 24 August 2016. Available at: https://www.brookings.edu/research/a-tale-of-two-countries-italy-germany-and-russian-gas/ [last accessed on 15/4/2020].

[8] Galanakis CM. The Food System in the ERA of the Coronavirus (Covid-19) Pandemic Crisis. Foods 2020;9:523. https://doi.org/10.3390/food9040523.

[9] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (Text with EEA relevance). Available at: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L02001&from=EN [last accessed on 01/05/2020].

[10] EUROSTAT. Energy, transport and environment statistics. 2019 Edition. https://ec.europa.eu/eurostat/documents/3217494/10165279/4781-19-01-EN.pdf [last accessed on 14/5/2020].

[11] European Commission. A European Green Deal. Available at: https://ec.europa.eu/info/strategy/priorities-2019-2024/european-green-deal_en [last accessed on 01/05/2020].

[12] Pinner D, Rogers M, Samandari H. Addressing climate change in a post-pandemic world. Mc Kinsey & Company, April 2020. Available at https://www.mckinsey.com/business-functions/sustainability/our-insights/addressing-climate-change-in-a-post-pandemic-world [last accessed on 15/4/2020].

[13] International Energy Agency. COVID-19 – Exploring the impacts of the COVID19 pandemic on global energy markets, energy resilience, and climate change. IEA, April 2020. Available at: https://www.iea.org/topics/COVID19 [last accessed on 15/4/2020].

[14] EURELECTRIC. Impact of COVID 19 on customers and society – Recommendations from the European Power sector. March 2020. Available at: https://cdn.eurelectric.org/media/45313/impact-of-covid19-on-customers-and-society-2020-03-26-01-1-e-E7E407BA.pdf [last accessed on 24/4/2020].

[15] Birol F. The coronavirus crisis reminds us that electricity is more indispensable than ever. IEA, 22 March 2020. Available at https://www.iea.org/commentaries/the-coronavirus-crisis-reminds-us-that-electricity-is-more-indispensable-than-ever [last accessed on 15/4/2020].

[16] Daugy M. Key electricity trends 2019 – Annual trends form OECD Countries. IEA, 14 April 2020. Available at https://www.iea.org/articles/key-electricity-trends-2019 [last accessed on 26/4/2020].

[17] Earth Observatory. Airborne Nitrogen Dioxide plummed over China. Available at: https://earthobservatory.nasa.gov/images/146362/airborne-nitrogen-dioxide-plumes-over-china [last accessed on 01/05/2020].

[18] The World Economic Forum. The world is the epicentre of CO2 emissions – Coronavirus had on air pollution all across the world. WEC, 21 April 2020. Available at: https://www.weforum.org/agenda/2020/04/coronavirus-covid-19-air-pollution-environment-nature-lockdown/ [last accessed on 01/05/2020].

[19] IEA. Global Energy Review 2020 – The impacts of Covid-19 crisis on global energy demand and CO2 emissions. April 2020.

[20] Elliott L. Top economist: US coronavirus response is like ‘third world country’. The Guardian, 22 April 2020. Available at: https://www.theguardian.com/business/2020/apr/22/top-economist-us-coronavirus-response-like-third-world-country-joseph-stiglitz-donald-trump [last accessed on 27/4/2020].

[21] Reed S. The world is running out of places to store its oil. The New York Times, 27 March 2020. Available at: https://www.nytimes.com/2020/03/26/business/environment/oil-storage.html [last accessed on 15/4/2020].

[22] Geiger J. Global Oil Producers Agree On Joint 10 Million Bpd Output Cut. Oil price, 9 April 2020. Available at: https://oilprice.com/Energy/Oil-Prices/Global-Oil-Producers-Agree-On-Joint-10-Million-Bpd-Output-Cut.html [last accessed on 15/4/2020].

[23] Simon F. Austria becomes second EU Country to exit coal. Euractiv, 17 April 2020. Available at: https://www.euractiv.com/section/politics/news/austria-becomes-second-eu-country-to-exit-coal/ [last accessed on 11 May 2020].

[24] Total ADOPTS A NEW CLIMATE AMBITION TO GET TO NET ZERO BY 2050. 17 April 2020. Available at: https://total.com/presse/total-adopts-a-new-climate-ambition-to-get-to-net-zero-by-2050 [last accessed on 11 May 2020].

[25] Total. “TOTAL ADOPTS A NEW CLIMATE AMBITION TO GET TO NET ZERO BY 2050”. 5 May 2020. Available at: https://www.total.com/media/news/total-adopts-a-new-climate-ambition-to-get-to-net-zero-by-2050 [last accessed on 11 May 2020].

[26] Ambrose J. “BP sets net zero carbon target for 2050”. The Guardian, 12 February 2020. Available at: https://www.theguardian.com/business/2020/feb/12/bp-sets-net-zero-carbon-target-for-2050 [last accessed on 11 May 2020].

[27] Eni. “Long-Term Strategic Plan to 2050 and Action Plan 2020-2023”. 28 February 2020. Available at: https://www.eni.it/en-it/media/press-release/2020/02/long-term-strategic-plan-to-2050-and-action-plan-2020-2023.html [last accessed on 11 May 2020].

[28] Simon F. Austria becomes second EU Country to exit coal. Euractiv, 17 April 2020.
Available at https://www.euractiv.com/section/electricity/news/austria-becomes-second-eu-country-to-exit-coal/ [last accessed on 21/4/2020].

European Commission, DG Energy. EU-India Conference on advanced biofuels. 7-8 March 2018, New Delhi, India. Available at https://ec.europa.eu/info/events/eu-india-conference-advanced-biofuels-2018-mar-07_en [last accessed on 15/4/2020].

Kumar Sing R. India’s lockdown sees clean energy sources gain at the expense of coal. The Print, 22 April 2020. Available at https://theprint.in/environment/indias-lockdown-sees-clean-energy-sources-gain-at-the-expense-of-coal/406373/ [last accessed on 26/4/2020].

DIRECTIVE (EU) 2018/2001 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 11 December 2018 on the promotion of the use of energy from renewable sources (recast). Official Journal of the European Union L 328/82-209, 21. 12.2018. Available at https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32018L2001&from=EN [last accessed on 15/4/2020].

EUROSTAT. https://ec.europa.eu/eurostat/cache/infographs/energy/bloc-2c.html [last accessed on 15/4/2020].

Simon F. ‘Green recovery alliance’ launched in European Parliament. Euractiv, 14 April 2020. Available at https://www.euractiv.com/section/environment-news/green-recovery-alliance-launched-in-european-parliament/ [last accessed on 15/4/2020].

Harrabin R. Coronavirus recovery plan ‘must tackle climate change’. BBC News, 25 April 2020. Available at https://www.bbc.com/news/science-environment-52418624 [last accessed on 26/4/2020].

Harrison P, Malins C, Searle S, Baral A, Turley D, Hopwood L, Wasted: EU-urope. Available at https://www.s2biom.eu/en/.

European Environment Agency. Total greenhouse gas emission trends and projections in Europe. EEA, 19 December 2020. Available at https://www.eea.europa.eu/data-and-maps/indicators/greenhouse-gas-emission-trends-6/assessment-3 [last accessed on 01/05/2020].

EUROSTAT. EU imports of energy products [2018]. Available at https://ec.europa.eu/eurostat/statistics-explained/pdfscache/46126.pdf [last accessed on 15/4/2020].

Buffet L. Europe increasingly dependent on risky oil imports. Transport & Environment, July 2016. Available at https://www.transportenvironment.org/sites/te/files/publications/2016_07_Briefing_Europe_increasingly_dependent_risky_oil_FINAL_0.pdf [last accessed on 15/4/2020].

https://www.statista.com/statistics/332510/biofuels-production-in-selected-countries-in-europe/ [last accessed on 01/05/2020].

Karl J. Research in bio-fuels in Bavaria. SECOND GENERATION BIOFUELS WORKSHOP: Exploring technical cooperation among Regional Leaders, Cape Town, Western Cape (ZA), 12 March 2014. Available at https://www.rls-energynetwork.org/uploads/5/5/4/4/55448469/presentation_research_in_bio-fuels_in_bavaria_j%CE%Bcgen_karl_2014.pdf [last accessed on 01/05/2020].

Arasto A, Chiaramonti D, Kiviluoma J, van den Heuvel E, Waldheim L, Maniatis K, Kai Sipilä K. Bioenergy’s role in balancing the electricity grid and providing storage options – an EU perspective. IEA Bioenergy: Task 41 P6, 2017. Available at https://www.ieabioenergy.com/wp-content/uploads/2017/02/IEA-Bioenergy-Bioenergy-in-balancing-the-grid_master_FINAL-REVISED-16.02.17.pdf [last accessed on 15/4/2020].

IEA Bioenergy Task 44. Flexible Bioenergy and System Integration. Available at https://www.ieabioenergy.com/task/flexible-bioenergy-and-system-integration/ [last accessed on 15/4/2020].

Birol F. Put clean energy at the heart of stimulus plans to counter the coronavirus crisis. IEA, 14 March 2020. Available at https://www.iea.org/commentaries/put-clean-energy-at-the-heart-of-stimulus-plans-to-counter-the-coronavirus-crisis [last accessed on 15/4/2020].

Anderson A. Will low oil prices affect renewable penetration? Energy Watch, 2015. Available at https://energywatch-inc.com/will-lower-oil-prices-affect-renewable-penetration/ [last accessed on 01/05/2020].

Ball J. Why the Coronavirus crisis could make Big Oil greener. Fortune Magazine, 20 April 2020. Available at https://fortune.com/2020/04/20/big-oil-price-war-investments-green-renewable-energy-climate-change/ [last accessed on 01/05/2020].

Ambrose J. Covid-19 crisis will wipe out demand for fossil fuels, says IEA. The Guardian, 30 April 2020. Available at https://www.theguardian.com/business/2020/apr/30/covid-19-crisis-demand-fossil-fuels-iea-renewable-electricity [last accessed on 01/05/2020].

Elliott L. Top economist: US coronavirus response is like third world country. The Guardian, 22 April 2020. Available at https://www.theguardian.com/business/2020/apr/22/top-economist-us-coronavirus-response-like-third-world-country-joseph-stiglitz-donald-trump [last accessed on 27/4/2020].

Reynard C. Will the low oil price dent the prospects for renewables. Forbes, 30 April 2020. Available at https://www.forbes.com/sites/cherryreynard/2020/04/30/will-the-low-oil-price-dent-the-prospects-for-renewables/#1108f5b214d8 [last accessed on 01/05/2020].

Hurst L. Oil slump may no longer be a curse for renewables. Bloomberg Green, 25 April 2020. Available at https://www.bloomberg.com/news/articles/2020-04-24/oil-slump-may-no-longer-be-a-curse-for-renewable-energy [last accessed on 01/05/2020].

Further reading

[20] Arasto A, Chiaramonti D, Kiviluoma J, van den Heuvel E, Waldheim L, Maniatis K, Kai Sipilä K. Bioenergy’s role in balancing the electricity grid and providing storage options – an EU perspective. IEA Bioenergy: Task 41 P6, 2017. Available at https://www.ieabioenergy.com/wp-content/uploads/2017/02/IEA-Bioenergy-Bioenergy-in-balancing-the-grid_master_FINAL-REVISED-16.02.17.pdf [last accessed on 15/4/2020].

[38] Reynard C. Will the low oil price dent the prospects for renewables. Forbes, 30 April 2020. Available at https://www.forbes.com/sites/cherryreynard/2020/04/30/will-the-low-oil-price-dent-the-prospects-for-renewables/#1108f5b214d8 [last accessed on 01/05/2020].

[39] Hurst L. Oil slump may no longer be a curse for renewables. Bloomberg Green, 25 April 2020. Available at https://www.bloomberg.com/news/articles/2020-04-24/oil-slump-may-no-longer-be-a-curse-for-renewable-energy [last accessed on 01/05/2020].

[44] Ministero dello Sviluppo Economico, Ministero dell’Ambiente e della Tutela del Territorio e del Mare, Ministero delle Infrastrutture e Trasporti. Piano Nazionale Integrato per l’Energia e il Clima. Dicembre 2019. Available at https://www.mine.gov.it/images/stories/documenti/PNIEC_finale_17012020.pdf [last accessed on 15/4/2020].