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Review

Skills Demand in Energy Intensive Industries Targeting Industrial Symbiosis and Energy Efficiency

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Abstract: Technological development, closely related to the implementation of industrial symbiosis and energy efficiency, affects all areas of energy intensive industries, and involves the whole industrial workforce. This paper deals with a part of the work developed in the early stage of a current Erasmus+ project, which aims at developing an industry-driven and proactive skills strategy to assist the implementation and exploitation of industrial symbiosis and energy efficiency across the energy intensive sectors. The paper presents the current state of workforce in the context of industrial symbiosis and energy efficiency implementations. The most recent literature on the effects of new skills requirement and training needs for the European process industry workforce is analyzed and discussed. In addition, implementation advantages and barriers as well as possible solutions to satisfy ongoing and future skill demands are considered. Through skill integrations and workforce attraction and training, new skills, and greater abilities for working across sector boundaries can be achieved. In addition, policies on green economy and on skills development can enable anticipating labor market changes, by identifying skill requirement impacts. This can be achieved by introducing new training programs, revising existing ones and by monitoring the impact of trainings on the labor market.

Keywords: industrial symbiosis; energy efficiency; energy intensive industries; workforce; training and education programs

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Citation: Branca, T.A.; Fornai, B.; Colla, V.; Pistelli, M.I.; Faraci, E.L.; Cirilli, F.; Schröder, A.J. Skills Demand in Energy Intensive Industries Targeting Industrial Symbiosis and Energy Efficiency. *Sustainability* **2022**, *14*, 15615. https://doi.org/10.3390/su142315615

Academic Editor: Radu Godina

Received: 11 October 2022
Accepted: 22 November 2022
Published: 24 November 2022

1. Introduction

Industrial symbiosis (IS) concerns the transaction of residual materials, water and energy of a production process as inputs of other processes, within the same company or among different companies [1]. In IS, waste, or by-products from one industry or industrial process, become the raw material of another industry (see Figure 1).

IS represents an opportunity for ecological innovation [2], leading to possible reductions of production costs while achieving environmental and social benefits for industries [3]. In particular, IS is mainly focused on establishing multidimensional synergies across different industries, that can cover economic, social, or environmental aspects. On the one hand, economic synergies concern the generation of marketplaces for underused resources to produce revenue streams and cost savings [4]. On the other hand, environmental performance concerns synergies aiming material and emissions efficiencies to achieve resource conservation and to avoid associated environmental impacts [3]. On this subject, the assessment of different industrial emission reduction strategies from a business model perspective can be achieved [5].

Finally, the social impact concerns jobs creation and the enhancement of the relationships with communities living in the surrounding industries by promoting the fruitful transaction of energy and material flows. In order to improve their competitiveness, energy intensive industries (EIIs) should accompany their investments on new technologies for

IS and energy efficiency (EE) with measures for adjusting the related skills, competences and experiences of their workforce. Furthermore, collaborative approaches are needed to improve resource efficiency, and an increased institutional capacity is crucial for supporting these goals [6]. In particular, IS and EE implementation can be promoted by policies and regulations, but also by economic incentives and by new synergies among sectors [7]. With the support of the European Commission (EC) [8] IS has already been introduced to the agenda of some countries. In addition, as in the last few decades, energy consumption has doubled and it is expected to further increase by 30% between now and 2040 [9]; the effort of EIIs is also focused on improving their EE practices. On this purpose, EU regulations and policies are focused on reducing emissions, improving EE and encouraging renewable energy to improve sustainability and economic competitiveness, as well as social achievements, such as job creation. Concerning emerging policies in the context of EIIs, over the last decades emerging worldwide and European policy recommendations have focused on actions to reduce greenhouse gas (GHG) emissions and resource consumption [10]. In this context, the Paris Agreement at the Climate Change Conference in 2015, involving 195 countries, was based on the limitation of global warming below 2 °C above pre-industrial levels and the efforts to limit the temperature increase to 1.5 °C [11]. Consequently, some important EC documents were released, such as the recent 2050 Climate and Energy Policy [12], the Energy Roadmap [13] and the EU's 2020 strategy [14]. On this subject, policies and strategies to a more sustainable economy were taken by the European Commission, such as the EU Green Deal [15], which includes some main elements, such as climate action (for 2030 and 2050), clean and secure energy, sustainable industry, buildings and renovations, sustainable and smart mobility, zero pollution, from "Farm to Fork", preserving ecosystems and biodiversity, research and innovation, and preventing unfair competition from carbon leakage (see Figure 2). On the other hand, Climate Law [16] is focused on managing material and resources in a more sustainable way to achieve climate neutrality by 2050. In addition, based on the circular economy (CE) concept, the New Circular Economy Action Plan mainly concerns resource preservation [17], underlining the importance of IS. In this regard, the role of EIIs is crucial [18], as they reduced their GHG emissions by 36% and accounted for 28% of the total economy-wide emission reductions by the EU [19], even though they represented 15% of EU total GHG emissions in 2018 [20]. For instance, refineries, steel, cement, petrochemicals and fertilizer sectors represent almost 70% of the CO_2 industrial emissions in the EU [21].

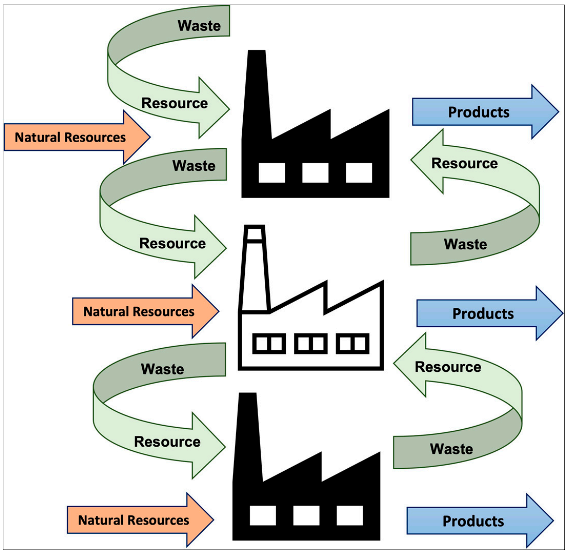

Figure 1. Industrial symbiosis: scheme of the transaction of waste/residual materials among different industries/sectors.

Figure 2. The main elements of the European Green Deal [15].

In this context, the National Energy and Climate Plan (NECP) has underlined occupation changes in the near future [22], particularly new jobs in the renewable sector and in the fossil fuels sector, and new skills will be required in EIIs in order to reach carbon neutral status by 2050 and the zero-pollution goal [15], as well as workforce up-skilling and reskilling for the energy transition into their National Recovery and Resilience Plans [23].

This paper presents a part of the work carried out during a current EU co-funded Erasmus + project entitled "Skills Alliance for Industrial Symbiosis: A Cross-sectoral Blueprint for a Sustainable Process Industry (SPIRE-SAIS)" [24]. The project aims at developing an industry-driven and proactive skills strategy to support the implementation and exploitation of IS and EE in the EIIs. The current state of IS and EE solutions implementation in the European process industry is assessed, through the analysis of forthcoming technologies, and also considering the major levers of the CE transformation. Furthermore, a consolidated approach to anticipate skills demands for IS and EE is provided, in order to create suitable training and curricula and to identify, promote and develop recruitment and upskilling schemes at sectoral level. In particular, this paper presents the current state of the workforce in IS and EE contexts, as well as its effects in terms of new skill requirements and training needs for the European process industry workforce.

The paper is organized as follows: Section 2 briefly presents the methodological approach pursued for the developed analysis; Section 3 overviews the skills demand and opportunities in EIIs in the perspective of the improving sustainability, as well as the main barriers to workforce upskilling and talents attraction. Section 4 presents the current results and the discussion on workforce both in IS and EE contexts, including also some examples of training and education in the considered contexts. Finally, Section 5 includes some concluding remarks.

2. Methodological Approach for the Pursued Analysis

The methodology applied for the present work concerns a detailed desk research of publications, cross-sectorial European frameworks and projects. In particular, related material was selected and analysed by identifying, evaluating, and synthesizing the existing literature. In addition, the desk research performed during the development of the related deliverable of the SPIRE-SAIS project was exploited.

In order to provide a common framework as a starting point, a detailed literature review was carried out to identify publications associated with the effects of IS and EE on workforce, also including training/education projects/case studies in the field. Concerning the workforce adjustment for IS and EE related to their technological and economic developments, mainly featured by a multidisciplinary approach, the importance of green and digital skills and new skills to manage the complexity of cross-sectorial cooperation was considered in the performed analysis. In addition, the importance of soft skills for IS and EE was taken into consideration in a pro-active skills strategy. Furthermore, retrieving information on drivers, barriers, and enablers of workforce involved in IS and EE in EIIs, including training activities, was considered in the selection.

After the collection of an initial sample of about 80 references, an in-depth analysis was carried out, resulting in the identification of 42 references related to the main topics. A systematic review was carried out in order to identify, classify, evaluate, select and analyze the most recent literature, industrial reports and projects related to these topics. The methodological approach includes the different steps, as shown in Figure 3.

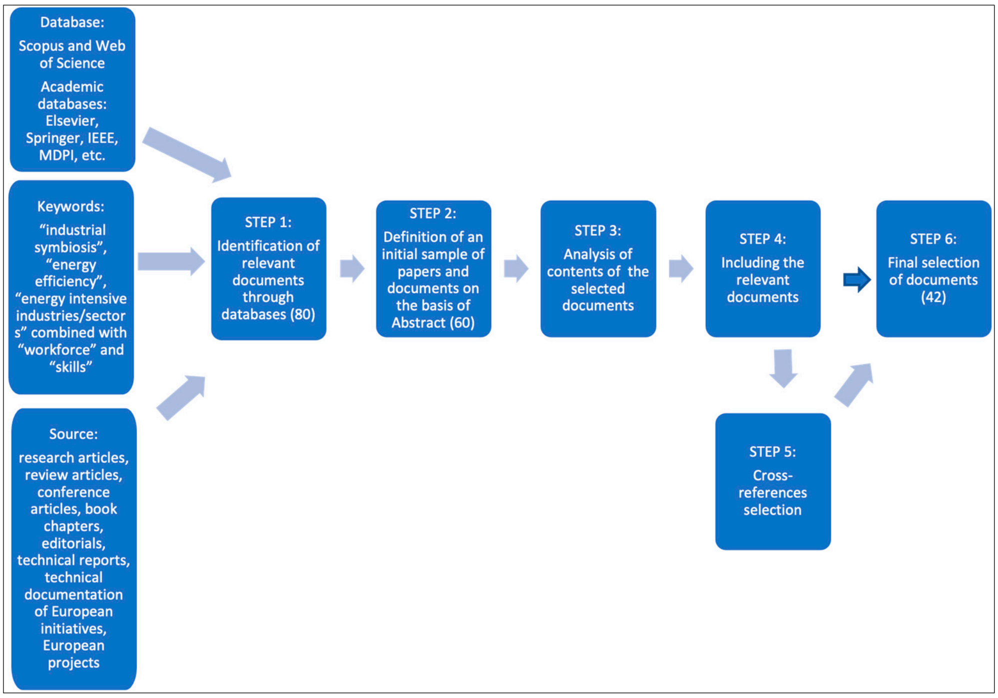

Figure 3. The methodological literature review approach.

In this sense, a search was conducted in the search engines Scopus and the Web of Science, including academic databases such as Elsevier, Springer, Institute of Electrical and Electronics Engineers (IEEE), Multidisciplinary Digital Publishing Institute (MDPI), etc. This work was developed by identifying and using the keywords directly connected with the main analysed topics. In particular, the main selected keywords, such as "industrial symbiosis", "energy efficiency", "energy intensive industries/sectors" combined with "workforce" and "skills", were applied for the title, abstract, and the keywords of papers.

In particular, in the first step relevant documents were identified through the analysis of databases by using the selected keywords. Scientific peer-reviewed journal articles have been pre-selected when containing at least two combined keywords. Afterwards, the selection of papers was mainly focused on excluding those, which resulted irrelevant with respect to the main topics analysed in the work, and not recent works, by considering only a few less recent literature documents that are very relevant to the conducted analysis. Mainly articles written in English were considered, excluding papers published in other languages. In addition to research articles, review articles, conference articles, book chapters, and editorials, complementary research was developed through Internet searches for technical reports and technical documentation of European initiatives, such as European projects, to identify critical aspects that were not taken into account by the scientific literature. Results from scientific literature, official and public documents concerning the current state and perspectives of workforce related to IS and EE implementation in the EIIs were analysed and described. In particular, the 8 SPIRE (Sustainable Process Industry through Resource and Energy Efficiency) sectors mainly involved in the SPIRE-SAIS project were considered, such as iron and steel, chemicals, minerals, non-ferrous metals, water, engineering (with a cross sectorial role), ceramics, and cement.

In the second step, after a systematic review of the selected abstracts, an initial sample (80) of papers and documents were selected and duplicate articles were eliminated. Furthermore, in the third step full articles were analyzed, texts were examined, analyzing their contents. Consequently, in the fourth step, a sample of relevant articles was defined. In addition, in the fifth step, references cited in the analyzed papers were used to search for other references related to the topic. Finally, the achieved selected documents (42) were used for the review paper preparation. Among the 42 identified references, 4 are dedicated to skills policies [25–28], 10 to digitalization and skills [29–38], 5 to green skills [24,26,39–41], 9 to skills in IS and EE [23,42–48] (where reference #23 was analysed twice, as it includes both skills to IS and skills to EE), 14 to training/education projects and activities focused on IS and EE [49–62].

3. Skills Demand and Opportunities Related to Sustainable Energy Intensive Industries

In the process of implementing IS and EE concepts, European EIIs face the need to improve their performances by upgrading or implementing new technologies, as well as some measures such as good management, education and behaviour changes. In this context, it is crucial to update qualifications, knowledge and skills that can support cross-sectoral activities. To this aim, the main aspects to be considered are skills shortages in the involved sectors and the tools to be provided to develop future job profiles. Industries can enforce their sustainability, resiliency and competitiveness only by actively involving their workforce in a transition phase characterised by new skill requirements, as well as by attracting and retaining talented people. In the next few years, in EIIs, an increase of new jobs is expected, accompanied by the attraction of young talents, the development of new business lines and higher workload [7]. In this context, skill demands are present in any category of workers, and to fill the emerging and future skill gaps internal and external training activities should be identified. Furthermore, attracting and retaining talented people can contribute to the sustainability and competitiveness of EEIs.

To improve their environmental and socioeconomic conditions, EIIs should implement a green economic development by combining economic, social, and environmental agendas [25]. The achievement of a greener economy can lead to create opportunities for new technologies, investment and jobs. On this subject, it was estimated that efforts to meet climate change can produce new "green jobs" in the future [26]. In addition, skill shortages can limit the transition to a greener economy, and in the next few years the need of new skills will be increasingly crucial [27]. In this regard, innovative strategies aim at addressing emerging skill needs, while other approaches aim at adjusting existing mechanisms and systems. In particular, systems of skills development should play a key role in the future economic growth and resilience, taking advantage of opportunities and mitigating the negative impact of change. A highly-qualified workforce can be achieved by: establishing a sectoral skills strategy; defining the foreseen skills requirements; identifying the skills mismatch between the job profiles and the labor force; developing continuous training programs; and the reskilling and upskilling of the workforce through well-developed training programs [29]. In particular, the integration of specific topics based on sustainable development and environmental awareness into education and training modules can lead to changing consumer behaviors and triggering market forces towards the greening agenda ahead. By going into details, the green transition can affect skill needs in three ways:

1. Due to the green transformation, industrial activities are moving toward more efficient and less polluting processes and practices. This process, indicated as "green restructuring", can lead to structural shifts in economic activity and therefore in employment.
2. Structural changes, new regulations, and new practices and technologies lead to some completely new occupations. This implies the need to provide new training courses and an adjustment of qualification and training systems.
3. New skills will be required in many existing occupations and industries in the process of greening existing jobs. This implies stronger efforts to revise existing curricula, qualification standards and training programs of education and training.

The transition to a greener economy will provide a high employment potential in the long term, due to the creation of large direct and indirect jobs through supply chains. In the context of new technologies, the digital transformation is an ongoing process of the industrial revolution named Industry 4.0, which refers to the innovative production processes, partly or completely automated through technologies and devices autonomously communicating with each other along the production chain [63]. Industry 4.0 is characterized by the development of smart technologies, such as advanced robotics, a new generation of sensors, Artificial Intelligence (AI), Big Data, the Internet of Things (IoT), Machine Learning (ML), and Cloud Computing, Machine to Machine (M2M) communication etc. In particular, the intelligent networking of machines, electrical equipment and novel information technology (IT) systems enable process optimization and increased productivity of value creation chains [30], and can be applied to lower the environmental footprint of production processes [31,32].

Digital technologies can impact the workforce in two different ways. On the one hand, they can relieve workers from physically strenuous work: process monitoring and control, automation as well as novel robotic solutions can improve workers' health and safety conditions through the combination of technological and social innovations [33], by also promoting upskilling of the technical personnel on digital skills [34]. On the other hand, digital technologies can produce unemployment and workforce de-skilling [39]. On this subject, the digital transformation has led to increasingly requirements to obtain a workforce highly qualified, specialized, multi-disciplinary and multi-skilled. In particular, digital skills are crucial to achieve a pro-active skills strategy based on IS and EE in different sectors. This process has increased its importance over the last few decades, mainly focused on building science, technology, engineering, and mathematics (STEM) skills to develop competences for the future workforce in the process industry. Studying STEM is crucial for developing sustainable technologies and processes in the context of CE; not only for the European EIIs workforce [35], but also more generally for the transition to a sustainable society. In addition, the importance of "soft skills", including collaboration, teaming, ethical judgement, and communication has also been increased [36].

However, skill shortages represent the major barrier to transitions to green and digital economies and to creating green jobs. This process is expected to increase in the future. In particular, skill shortages for green jobs are due to different factors, such as the underestimated growth of some green sectors, a general shortage of scientists and engineers, the low attractiveness of EIIs for young people, the general structure and the shortage of teachers and trainers in environmental awareness topics in green sectors (e.g., renewable energy, energy efficiency). In addition, a further barrier is represented by the lack of policy coordination.

In order to ensure sustainability of operations linked to CE and Industry 4.0, it is important to adopt a holistic approach for handling sustainability barriers in the present business environment [37]. Among the observed major barriers there is a lack of skilled workforce, ineffective performance framework and short-term goals of an organization, as some of the existing workforce is not familiar with the emerging technologies of Industry 4.0 being able to help meet the objectives of the CE. Developing an effective and integrated strategic approach can foster sustainable operations through the utilization of improved knowledge of Industry 4.0 and the CE. Some barriers and benefits were identified in developing and updating the curriculum to incorporate the EE concept [49]. In particular, barriers can be represented by the lack of knowledge of content and industry contacts, limited information and preparation time, and “an overcrowded curriculum”. The perceived benefits concern improved pedagogy and the marketability of courses, the cross-functionality of content, new research opportunities, and networking and professional development.

In this context, the foreseen digital and green transition will require a strong policy support to share the technological and economic risks, and a careful consideration of workforce upskilling and recruitment of new talents [38]. In the next few years, to overcome some of these barriers, an important further step will be the recruitment of young talents. This will result in strengthening competitiveness and in improving cross-sectorial cooperation, mainly leading to increase energy and resource efficiency. In particular, the increasing rate of change in skill needs in some sectors requires upskilling, both on a national and on local and regional levels. On this subject, skills developments should be anticipated by implementing fundamental activities, such as: securing talents; training needs to address transversal skills; the supporting of governments to a green and just transition; close collaboration with universities and research networks; more investments in training on environmental awareness; enhancing social dialogue; establishing channels for workers to report their training needs and concerns on the lack of skills; anticipating changes involving governments, companies and regional authorities [40].

To meet the skills needs and to overcome skills gaps, education and training policies in low-carbon strategies is crucial [41]. The development of suitable formation and training paths, based on a multidisciplinary approach, including green and digital skills, can lead to a new skilled workforce managing the complex cross-sectorial cooperation in implementing IS and EE concepts. This is crucial to shape VET system responses to cope with the transition. In particular, vocational education and training (VET) must continuously respond to economic changes and to the green transition to a low-carbon economy, considering that the whole economy is influenced.

4. Results and Discussion

4.1. The Workforce in Industrial Symbiosis

In recent years, the mechanisms of policy intervention and the facilitation of IS have been explained, with particular reference to the way in which policy is conceptualized. It was underlined that a dynamic process perspective is crucial to show the effective mechanisms of policy intervention and facilitation affecting the evolution of IS. In particular, the identification of the sequence of events connecting policy process and IS practices represents the most important aspect [28]. During the IS promotion and implementation process, generally, the main priorities for industries are mainly focused on sustainability, cost reduction and economic competition. Consequently, industries are mainly committed to environmental impact reduction and potential job opportunities/creation. Among the different goals of IS implementation, the Sustainable Development Goal 8 (decent work and economic growth) is to “Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all” [64]. In the context of the social dimension of IS, it is fundamental to consider different organizational cultures already in the implementation phase of projects, because they will affect the strategic management, the staff management model and the organizational structure. For instance, corporate social responsibility (CSR) or human resources (HR) policies are fundamental for making viable any technological innovation or production model. In this regard, new organizational forms, new models of leadership and staff management should be considered for the activity with people, such as the development of knowledge, new skills, aptitudes and attitudes. In addition, companies should identify the required professional profiles, skills and competences for new business models and methodologies, such as IS models [42]. On the other hand, the transformation of the organization and the strategy of companies is an ongoing process. This is due to different factors, such as globalization, information and communication technology (ICT), and new demand. This new model requires new values (e.g., cooperation, equal opportunities, transparency, creativity, solidarity, tolerance) and, therefore, new corporative competences, such as communication, teamwork, innovation, adaptability, social abilities, stress and emotion management, willingness to learn, etc.

In this context, in the IS practice implementation, the traditional organization of companies could need to be modified. Particularly, the transition to CE is a process that needs to accept and adopt the principles of CE throughout the entire company. In addition, a change of attitude is needed on different levels, as follows:

- Strategic: openness to participate in a multi-stakeholder approach, flexibility and creativity;
- Financial: the creation of new funding opportunities for new business models and innovative projects;
- Legal: different and flexible approach to overcome legal barriers for new business models and cooperation agreements;
- Commercial: engaging in CE offers new selling opportunities to companies.

Furthermore, new skills/competences could be considered during the implementation of IS synergies. As a matter of fact, although specific skills depend on the symbiosis project developed, and on the sector, some key competences are required for all levels and sectors. According to the company survey across the different sectors carried out inside the SPIRE-SAIS project [7], the current level of skills is generally lower for IS than for EE (see Figure 4). In addition, the implementation of both in different sectors is expected leading to working conditions, green skills and performance of the workforce improvement and to new job implementations, higher for IS than EE.

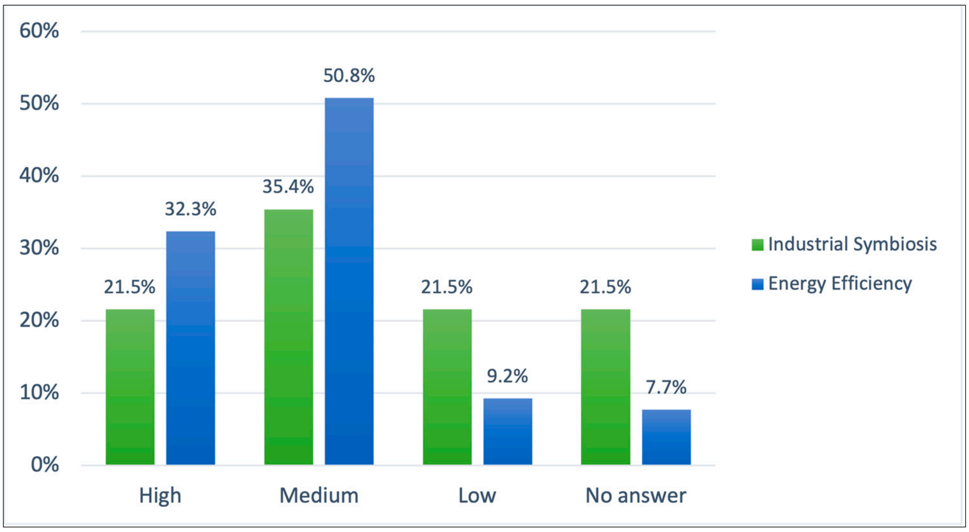

Figure 4. Current level of IS and EE implementation [7].

In particular, transversal skills/competences can be crucial for all sectors, as follows:

- Openness for information sharing;
- Co-creation and cooperation to involve different stakeholders;
- Knowledge of the composition and development of products (e.g., in developing innovative products based on secondary raw materials, residual waste or recycled materials);
- Management of a diversity of tasks;
- Application of innovative management tools to favor the transition to CE.

As in some cases of IS implementation, it is necessary to add intermediate waste/resource processing or treatment steps; the increase of workforce could be required, resulting in turn to increased employment. On the other hand, synergies due to the cooperation between sectors can impact existing jobs, becoming more complex and involving more cooperation and co-creation. New jobs can be expected in design, innovation and product development, disassembling, administrative handling of new service contracts, resource scout and information manager. In addition, in the IS implementation process, a coordination process is necessary.

The key actor can be an implementing agency/facilitator/independent matchmaking institute mainly engaged to develop and implement possible synergies. Although this actor could be either public or private, the facilitator should work in autonomous and independent ways. The work of IS facilitators could be helped by incentives, political support and stakeholder's engagement, as this role is seen as a "swiss knife" profile, providing knowledge (i.e., tools, methodology) to be able to foster trust between stakeholders and to perform a thorough analysis of involved flows. The IS facilitator profile includes crucial skills, competences and knowledge. On this subject, the Erasmus+ project INSIGHT aims at developing this new professional profile as well as the training curriculum necessary for it [43]. This project involves current and future workers of regional development agencies, technology centers, clusters, local and regional administrations, technology parks, and other entities related to the economic development of specific territorial areas. The involved sectors include cement, ceramics, chemicals, engineering, minerals, non-ferrous metals and steel industries. The expected meaningful outcomes concern the development of a new professional profile, the IS facilitator, and the training curriculum necessary for it.

In order to implement IS, skills, competences and the roles required have been identified. The role of the IS facilitator concerns the facilitation and the cooperation among different stakeholders, and the stakeholder engagement. Other tasks include: providing knowledge (tools, methodology), an analysis of the industrial ecosystem, management and coordination. To sum up, the IS facilitator should have multiple tasks and skills, that promote evolution over time and the integration of competences in a team. In addition, as the facilitator's skills are transversal technical skills and knowledge, his/her role can be seen as a bridge between different stakeholders, also requiring soft skills and networking skills. On this subject, the identified skills of an IS facilitator are [43] as follows:

- Networking—collaboration facilitation: developing the cooperation and commitment of stakeholders to establish and maintain strong relationships among companies and with local institutions and public bodies. In this context, the facilitator should bring the different actors together, establish contacts, gather opinions and ways for actions. These activities aim at implementing concrete synergies.
- System thinking: the IS facilitator work is based on cross-sectorial and multi-stakeholder approaches. As IS networks are complex systems, the general approach consists in subdividing problems into smaller or subproblems, despite being aware of the general framework. In addition, using system thinking approaches, it aims at solving possible problems or discovering possible "hidden" shared value. This can be obtained by defining common and realistic circular roadmaps, visions, interests and action plans at territorial level.
- Legislation (and environmental economics and policy): facilitators should be familiar with EU, national and regional regulations, legislation and policy on waste management and circular economy to develop regulatory compliance, and, consequently, to lead the project in the right direction.
- Waste and recycling, environmental skills: IS facilitators should have competences on waste management, waste prevention, re-use and recycling issues to assess impacts of the project. This is fundamental for helping facilitators to make bridges between different sectors.
- Soft skills: the most important soft skills for facilitators are team management, the ability to question oneself, change management, active listening skills, thinking outside the box, being willing to learn, creativity and negotiation skills.
- Entrepreneurship: this skill category includes significant competences, such as the ability to manage interpersonal relationships, creativity and innovation, goal setting, adaptability and flexibility (resilience), time management, willingness to take risks and to learn, leadership and teamwork.
- Financial management skills: information on the main relevant co-financing instruments available at regional, national and European level is very important for the facilitator, who should be able to prepare and submit different kinds of funding proposals.

- Material flow analysis (MFA) and life cycle assessment (LCA): these competences usually require technical skills. However, facilitators should essentially be able to understand the results of MFA and LCA analyses and to be confident with data collection and management.
- Marketing—communication: in order to gain trust and convince companies and public authorities of the relevance and importance of IS, facilitators should be able to have effective and empathetic communication skills. Furthermore, they have to promote the project and disseminate best practice processes in an effective way.
- IT skills: IT tools and skills are important for helping facilitators to be more efficient and organized in different tasks (e.g., data management and ecosystem mapping).

External actors play a crucial role in accelerating IS, thanks to their managerial, financial and regulatory support to companies. In this regard, their help aims at facilitating communication and cooperation among parties, and also providing a knowledge channel among industrial clusters. Furthermore, facilitators support eco-industrial development through the arrangement of collaborations between industrial clusters and research institutes and universities. On the other hand, synergistic relationships can be further supported by partnership to develop new business models. With regards to this, different components have been identified [44], as follows:

- Increasing the companies' biodiversity and involving underrepresented companies;
- Providing technical information for the potential use of available resources to companies to improve their abilities in reusing residues in their production processes in a sustainable way;
- Increasing the local stakeholders and control authorities' participation in operative meetings to ensure a greater confidence in the symbiotic approach as well as a greater awareness of stakeholders of the approach potentialities;
- Encouraging paths not financially attractive but that can have a significant positive impact on the environment.

Concerning the social impact of the IS implementation, trust between the workforce and their employers in the industrial context represents one of the main key aspects. In particular, to develop a mutual trust, time and regular meetings are required. Besides, a decision-making approach and a certain degree of reciprocity are needed [45]. Actually, the trust in developing IS synergies is mainly based on the local support in promoting social relationships between initiators of IS (e.g., the managers of a company). In this context, it is expected that IS improves social equity within communities by providing the need for professional and strong relationships between the involved actors. In addition, implementing IS in existing industries can lead to positive effects for the local communities (e.g., increase of well-being and job creation).

The industrial revitalization through IS can also produce an increase in workforce satisfaction, thanks to better working conditions, as well as the potential learning process for achieving new skills. In addition, the worker's commitment and trust can increase, and this can in turn improve industrial revitalization, leading to more job creation, an increase in satisfaction, commitment and the trust of the workforce. This positive loop can be established through appropriate education and its correct implementation. This is because the knowledge or skills gaps, job and skills mismatching, or a lack of incentive to the workforce, would hinder the industry revitalization. In this process, education design should also involve the local community; the development of the IS network should also involve institutions that are crucial for working activities of that community.

In general, relationships among employers, employees and the local community is fundamental for the successful establishment of an IS network. Furthermore, this process requires a certain degree of reciprocity and trust among employers, established in a strong and professional way. This will result in improving the social equity within communities and, consequently, in sharing a sense of collaboration and responsible orientation among communities. Initiatives based on the implementation of the IS concept can promote local economy and growth, providing new business opportunities, helping the transfer of knowledge and new skills, and contributing to the sense of community.

Against this backdrop, the most significant social conditions related to IS are as follows [46]:

- Trust, openness and cooperation among firm(s) personnel;
- Strong social network ties or social capital;
- Knowledge creation and sharing;
- Embeddedness (cognitive and social).

Overall, the adoption of IS needs to know multiple aspects, such as technical and organizational expertise. In addition, many people do not have awareness of IS concepts or sufficient understanding of IS terminologies. For all these reasons, training for implementing IS should overcome the lack of mechanisms to educate potential stakeholders [47].

4.2. The Workforce in Energy Efficiency

Future developments in EE are mainly focused on stimulating the growth of the industrial sector to achieve set targets and to enable a transformation towards a low-carbon economy [12]. This challenge can be achieved if energy managers have a clear and efficient vision of a future strategy for the energy development. It is crucial to provide the right background to decision makers when they are dealing with energy-related issues. The integration of EE into daily operational practice in a continuous process can favor these activities. The development and implementation of EE practices can potentially lead to building fuel cost reduction, to GHG emissions mitigation, to energy independence improvement, and to economic productivity enhancement. EE can be improved through [48]:

- The development of educational and awareness programs, that can influence individual energy consumption patterns;
- The implementation of policies and regulations that aim at applying the adaptation of EE practices;
- The introduction of incentive programs that promote the implementation of EE measures.

Voluntary Agreements (VAs) contribute to delivering energy savings and emission reductions by enhancing EE practices in different sectors. In particular, the effectiveness of VAs highly depends on the political will and on investing resources as well as on efforts to design, implement and evaluate this policy tool [65]. VAs can be implemented through the cooperation between public authorities and the private sector. This can consequently benefit public authorities with respect to legislation, better flexibility, greater acceptance by industry, and possibilities for tailor-made solutions.

Although the gap between the available solutions and the actual implementation in industrial companies is present, the application of new approaches, thanks to the collaborations between academia and manufacturing industries, can enable the circulation of management approaches for EE across industry [66].

On the other hand, different policy measures (i.e., incentives for employers to hire additional workers, incentives for individuals to offer their labor, greater investment in research and development) added to energy measures at sectoral level, results in the decline in activity in conventional energy sectors using fossils and in EIIs (e.g., cement, chemicals, iron and steel) with often higher prices from products supplied by these sectors [41]. At the same time, this causes the expansion of sectors providing goods and services to manage energy more efficiently (by creating jobs in construction, mechanical and electrical engineering and their supply chains) and non-fossil based energy sectors. The considered measures are designed to generate employment in labor-intensive industries, that can benefit from the incentives provided.

In the context of the implementation of renewable energy (RE) technologies, they are thought to negatively affect employment. However, their real impact assessment depends on the applied methodology. Going into more detail, the transition from fossil fuels to RE is estimated to affect labor markets, and this will lead to [48]: creating new jobs; shifting from fossil fuel oriented sectors to renewable sector; eliminating certain jobs without direct replacement; redefining skill requirements for jobs.

It will be crucial to overcome problems for planning investment and for delivering the requisite skills training. The role of governments and industries in response VET programs should be to:

- Update or realign skills in the existing workforce, and those increasingly in demand (upskilling and reskilling);
- Develop training capacity and equip the young, and disadvantaged people with relevant skills, for their integration into the workforce (skilling);
- Develop supporting activities for the effective matching of supply and demand of skills.

In order to equip the workforce for the transition to a low-carbon economy it is important to get the right skills to manage managerial and technological changes. Along regular updating STEM related skills, the implementation of green skills learning activities depends on the specific nature of sectors and technologies, and their role in the low-carbon transition. Additional skills and interdisciplinary knowledge are related to energy management, renewable energy sources, energy auditing, building and facility management, energy trading, economics, financing, production planning and maintenance. In addition, due to local characteristics, flexibility and dynamicity in responses are needed at sector, local and regional levels.

However, when sector activities and technologies start or change quickly, gaps in skills supply can arise. Consequently, training and education providers cannot quickly react to these rapid changes in skill demands [48]. In particular, according to [7], in the next few years highly qualified profiles and attracting young talents are expected, due to the development of emerging technologies. On the other hand, future skill gaps will be overcome by internal and external training activities, particularly focused on specific job-related skills, digital and personal skills (see Figure 5).

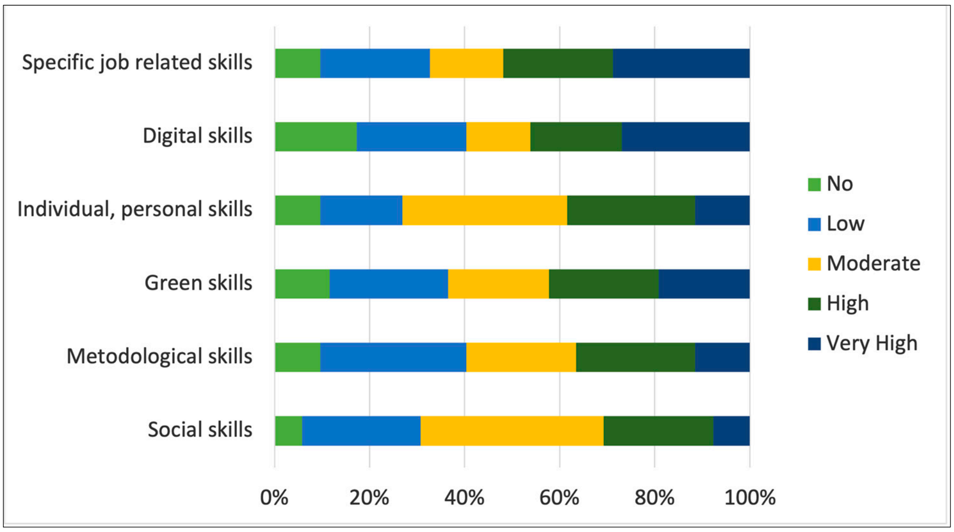

Figure 5. Skills to be updated in the next few years [7].

Designing courses and obtaining necessary approvals and funding need time; courses should be ad hoc prepared and course materials need to be continuously updated and further developed to attract students and trainees. When the demand for new skills quickly arises, a further constraint is the shortage in the availability of trainers and educators. This can be overcome by:

- Education and training courses for technical skills development through vocational training and education colleges and apprenticeship;

- University level courses changing the existing content or adding new ones to meet sector skill demand;
- Continuous education and training on technological advancements and a basic understanding of technological problems, and regulatory and legal implications;
- International linkages in renewable energy qualifications to standardize skills and qualifications requirements across countries and to allow international mobility.

In this context, it is crucial to improve and to make available training and certification programs linked to the operation of energy systems. Training programs focusing on EE should provide a reasonable level of technical depth, hands-on field training, and easily accessible information about the content. Besides, certification programs for industrial EE can allow developing a more qualified national and international workforce [50]. Based on a holistic approach, a model learning-factory for energy efficiency (ETA-Factory) aims at combining the real-life-experience of learning factories with the advantages of digitized learning [51]. In particular, this concerns the implementation of training concepts to transfer the multidisciplinary technical and methodical know-how on proposed EE measures to different target groups, such as engineering and architecture students as well as industry employees across all levels. In addition, to identify EE potentials in a production process, competences to transfer theoretical knowledge to practical situations, an approach with repeated exercises and transfer to new situations (based on the adaptation of the curriculum and the learning methods to the target audience and the topic) can lead to achieve new skills. This approach aims at integrating an intensive interaction with real technical equipment in a modern production environment, by direct process optimization and simulation tools to assess EE measures and technologies, and by combining the advantages of a "classical" learning factory with a new ambient learning experience by new media. Direct implementation can allow theoretically learned aspects of EE to be tangible and, consequently, it supports learners to consolidate knowledge and to develop new knowledge.

Over the last few years, a customized educational solution called EUREM (European Energy Manager) has been developed [52]. It is an educational solution for training energy experts in EE, covering almost all the energy relevant issues affecting companies and providing means to improve knowledge and skills of energy managers. Regular surveys and communications, involving former training participants, have highlighted strengths and weaknesses and the most important targets and challenges of the customized educational solution EUREM. This showed that the EUREM training program has motivated Slovenian energy managers to achieve significant energy savings in their companies. In addition, in order to meet the demands of a growing workforce in EE services [53], solutions provided included energy efficiency-related education programs and energy efficiency trainings for the building and construction trades.

4.3. Training and Education Examples

In order to achieve CE challenges, well-trained people with higher technical skills are required. They will be focused on interdisciplinarity, will assess, and model, the consequences of anthropogenic interventions in the biosphere, and will be committed to mitigating and reducing human impact on the environment, while ensuring the access to resources. In this regard, IFTS Circular Society [54] is a training course started on 1 January 2020 and it will end on 31 December 2023. It aims at addressing these challenges by implementing higher technical education, including a strong work-based dimension, an international training experience, integrated into the European qualification frameworks and systems.

The project objectives aim at developing and certifying a 1-year post-secondary non-tertiary education pilot course to be transferred at European level and to be adopted by the European Institute of Innovation and Technology (EIT) Raw Materials Academy as a general framework for future VET courses. The target is represented by 20 young students ranging from 18–24 years old, with a high school diploma as minimum requirement and coming from all EU countries. This pilot course has as final main objectives the deployment, its replication and transferability.

The higher technical education and training program (IV EQF) included an international partnership with the support of EIT Raw Material. It aimed at obtaining a qualification of high technical level. The course will equip participants with tools and skills in sustainable development, CE transition, management and implementation of intervention, impact evaluation methods, total quality management for environmental sustainability, as well as soft skills (i.e., entrepreneurship and digital literacy). The training course is developed under the IFTS Circular Society proposal, with a partnership of universities, VET and research and technology development organizations from Italy, Finland, Estonia and Switzerland. The training program is designed in collaboration with a European Faculty Board, including academy, VET organizations, industrial associations and clusters.

Expected impacts of IFTS Circular Society on trainees, include:

- Getting attractive and up-to-date training adapted to needs and with a hands-on methodology, based on European cooperation;
- Benefitting from a more adaptive market-oriented learning process;
- Learning about Circular Societies sectors skills requirements and being able to reach a knowledge of existing different jobs and careers offered by CE in Europe;
- Having the learning opportunity in close contact with industries and through in-company training;
- Getting an organized and certified training in CE issues, that is not currently available outside the university curricula;
- Increasing the possibilities of employability due to business and academy connections, and VET figures;
- Obtaining the validation of learning units and achieved learning outcomes, up to the recognition of credits in the case of attendance of further training courses, thanks to the coherence of the training program with EU standard and templates of ECVET.

In the context of IS, training offers should cover both the theory and practice, with studies on practical experimentations and visits. Moreover, trainer skills should be mainly focused on autonomous work, networking skills, combined with technical skills such as eco-design and life cycle thinking. Going into detail, some recommendations are proposed in the current Erasmus + project INSIGHT [43]:

- The introduction of the training with module on basic knowledge and concepts: IS core concepts, basic understandings, theoretical frameworks and methodologies;
- The most important skills are: interpersonal skills—the ability to network, collaborate, think systemically, develop an entrepreneurship mindset and other soft skills. These help to overcome social barriers;
- The trainees should have effective communication competences, and facilitation and collaboration tools;
- Legal barriers can be overcome by an in-depth knowledge of legislation (e.g., waste management, waste prevention, re-use and recycling) at EU, national and regional levels;
- Political support and financial incentives: the training should also take into consideration the development of a module on financial considerations, funding opportunities and business model skills.

Concerning EE, its achievement in different sectors is crucial to contribute to a productive, sustainable economy. The EE must be integrated into courses across a range of disciplines, not only engineering and science, while these groups should be educated to work with cross-disciplinary teams. Therefore, appropriate teaching resources and certification must be developed and introduced across most disciplines, while employers and recruitment consultants must be informed of the benefits [55].

Among European projects mainly focused on training and education, the GT-VET (Greening Technical-Vocational Education and Training) project [56] explored VET pathways to meet environment and health and safety skill needs in European industries. Within the project, an industry driven European sustainable training module was developed related to different national VET systems. The impacts of environmental legislation on the everyday work of mechanical/industrial technicians and electrical technicians (for today and the future) were identified. In addition, independent different VET systems of the member states, VET practices and learning outcomes about environmental skills, expertise and awareness were assessed. A European training module was developed to obtain identical European learning outcomes for green skills and sustainable awareness, that can complement current technical VET programs. Based on the steel industry and the VET of industrial, mechanical, electrical, and electronic technicians, the modules and the implementation process became a blueprint for other technical VET professions and production industries as well as for updating and implementation of training for new skills into the VET system.

A further EU funded project, GREEN STAR [57], developed a blueprint with relevant stakeholders in order to transfer GT-VET project results to supporting the change to eco-innovation in the cluster of automotive suppliers, mainly small and medium-sized enterprises (SMEs). In particular, the Sustainable Training Module for the European Steel Industry (large enterprises) and the blueprint were adjusted and modified for the implementation process of green skills in automotive industry clusters according to different national VET systems in Italy, Spain and Romania.

Technical workers and apprentices in SMEs were provided with knowledge and skills to manage and implement smart and sustainable growth by reskilling and upskilling schemes, and the integration of green skills in identified qualification levels. Thanks to the cooperation among VET, work systems and Triple Helix stakeholders, a Sustainable Training Module for Automotive Cluster suppliers was created and a cluster-driven approach to VET was adopted. The main outcomes of the project were mainly focused on Local Stakeholders Action Plans testing the adapted sustainable module. In addition, they included the short-term impact on automotive supplier clusters, workers and apprentices directly involved as well as the involvement and the assessment of external stakeholders for further transfer to other clusters and VET sectors. With the GREEN STAR project, the GT-VET blueprint developed for large steel companies was further elaborated as a blueprint for SME clusters along the value chain.

The ENACT project (ENergy Auditors Competences, Training and Profiles) [58] was funded within the EU ERASMUS+ programme and aims at contributing to the definition and implementation of a common European frame for qualifying and related competences of energy auditors. The main results concerning training pilot action on the energy auditor for the residential sector were mainly focused on new ideas to improve methodologies and enlarge to other professions in energy saving and efficiency, according to the national/regional standards. In addition, new initiatives are developed to implement advanced tools and methodologies to meet training and practical experiences needs in this sector.

Another ERASMUS+ project, RECYCLE ART [59], consists of preparation, implementation, training, project management monitoring and controlling activities, to achieve a proper project management, young people engagement and future advances in the project. The project aimed at promoting waste reduction and high-quality separation by consumers, and at creating markets for recycled materials. In addition, it aimed at developing CE and social enterprises of recyclers as well as training youth people in the field of reuse and recycling activities. Meaningful outcomes were mainly focused on impacts on young people, in particular by enhancing interest in the field of energy waste, recycle and reuse as well as by creating job opportunities and networking in Europe and developing intercultural attitudes and peacemaking abilities. The project partner organizations provided innovative education activity and had the opportunity to share best practices, ideas, and methodologies, as well as to create a basis for further advances.

The KATCH-e project [60] aimed at addressing the challenge of reinforcing the skills and competences on product-service development for the circular economy and sustainability in the construction and furniture sectors. For this purpose, the project goals were to develop training materials, focused on competences to produce product-service-systems based on a circular economy model. In particular, the project aimed to analyze the training needs, trends and policies regarding "design for CE", to set up a stakeholder network to support the transfer of knowledge, to develop and test a problem- based and multidisciplinary course, to create of a Massive Open Online Course (MOOC) and implementation in academic and company contexts. The main results consisted in promoting and supporting dissemination of circular design and sustainability among higher education centers and companies, demonstrating the practicability of the materials, their benefits and innovation potential.

A further example is provided by the SUPERMAT project [61], which aimed at creating a virtual center to boost IMNR (Institutul National de Cercetare-Dezvoltare pentru Metale Neferoase si Rare) position in the Bucharest-Ilfov region of Romania by increasing the knowledge and technology degree on innovative potential for sustainable advanced materials operating under extreme conditions. In this context, a work package concerned education and entrepreneurship topics by: short training stages and two summer schools in ab-initio design and modelling advanced materials and coatings with designed properties; training by research on new sintering and forming methods to obtain high quality bulk nanostructured materials parts for critical environmental conditions; training by research on new coatings processing to produce surfaces with controlled properties for high temperatures and corrosion conditions; implementation of one international PhD curricula in the field of materials for extreme environments; MOOC.

New educational and training programs have to be embedded or enhanced by new research activities in the context of social innovation, focusing on several topics, such as regional, cultural and social context; the outcomes and impacts of new practices to enhancing favourable social change; relationship to technological and business innovation in processes of transformative change; a specific focus on the ambivalence of social innovations [62].

5. Conclusions

This paper treats the assessment of current skills and gaps to be filled, competencies to be provided to personnel and eventual new professional profiles. New challenges from technical developments in IS and EE implementations are considered, which can be faced by promoting skill integrations as well as by attracting and training a workforce with new skills and greater abilities to work across sector boundaries. According to technological and economic developments, the workforce adjustment for IS and EE is characterised by multidisciplinary approaches, complementing green, digital skills and additional (technical and transversal) skills.

In the context of IS and EE in the EIIs, policies mainly focused on green economy and policies aiming to develop skills should be connected. The starting point is represented by labor market information anticipating and monitoring skill needs for green jobs. This can allow governments and businesses anticipating changes in the labor market, identifying the impact on skill requirements, incorporating changes into the system by revising training programs and introducing new ones, and monitoring the impact of training on the labor market. In this context a trained workforce capable of learning can encourage investment, technical innovation, economic diversification, and job creation. On the other hand, leadership and management skills should enable policy-makers in governments, employers' associations, and trade unions to allow conditions for cleaner production and services. Furthermore, new jobs creation is expected to balance unemployment due to the decline in more carbon-intensive industries. Nevertheless, ensuring opportunities to disadvantaged groups to access new green jobs will be a priority, as renewable energy could also cause more job losses indirectly. Concerning talent attraction towards EIIs (e.g., the steel sector), a strong collaboration among industries, public bodies and education providers is fundamental to find and retain talents and to up-/reskill the workforce. In addition, it is important to elaborate a long-term skill strategy (such as aimed at the Skills Alliance for Industrial Symbiosis—SPIRE-SAIS) based on the assessment of the current state of the

IS and EE implementations in EIIs and the determination of future skills requirements. This strategy is based on the implementation of training programs for the workforce to obtain the required skills. Sectors–academia cooperation is of utmost importance to design appropriate education path that overcome the inconsistency between industry needs and human resources' actual capabilities.

To sum-up, according to the analysis carried out in this review, future skills related to IS and EE will be related to a complementary upskilling of existing occupations and job profiles, but also considering new job profiles. In addition, different skills will be focused on EE (lower level demand) and on IS (higher demand), that will be mainly managerial (business and regulatory) and operational skills (technical, transversal/individual).

Author Contributions: Conceptualization, T.A.B., V.C. and B.F.; methodology, T.A.B. and V.C.; validation, V.C., A.J.S. and T.A.B.; formal analysis, T.A.B., V.C., F.C. and M.I.P.; investigation, T.A.B., B.F., M.I.P. and E.L.F.; resources, V.C. and A.J.S.; data curation, T.A.B. and V.C.; writing—original draft preparation, T.A.B. and V.C.; writing—review and editing, F.C., M.I.P. and A.J.S.; visualization, V.C. and T.A.B.; supervision, V.C.; project administration, A.J.S. and V.C.; funding acquisition, A.J.S. and V.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the European Union through the Erasmus Plus Programme (Grant Agreement No. 612429-EPP-1-2019-1-DE-EPPKA2-SSA-B).

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The research described in the present paper was developed within the project entitled "Skills Alliance for Industrial Symbiosis: A Cross-Sectoral Blueprint for a Sustainable Process Industry (SPIRE-SAIS)", and was based on a preliminary deliverable of this project. The SPIRE-SAIS project was funded by Erasmus Plus Programme of the European Union (Grant Agreement No. 612429-EPP-1-2019-1-DE-EPPKA2-SSA-B). The sole responsibility of the issues treated in the present paper lies with the authors; the Commission is not responsible for any use that may be made of the information contained therein. The authors wish to acknowledge with thanks the European Union for the opportunity granted that made possible the development of the present work. The authors also wish to thank all partners of the project for their support and the fruitful discussion that led to successful completion of the present work.

Conflicts of Interest: The authors declare no conflict of interest.

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