European Creative Synergy
Application for Energy Transition Efficiency

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Abstract

Air Liquide is an industrial company, whose activities are part of several energy and manufacturing value chains. In the past 20 years, Air Liquide has participated in or led a number of collaborative initiatives within the EU and national innovation frameworks to accelerate energy transition for example in the transport sector by introducing hydrogen as an energy for electric vehicles. Leveraging this experience, and in collaboration with Meetsys and 2B1st Consulting, two French SME the authors present in this paper their vision about possible ways to accelerate energy transition in Europe through new ways of collaboration facilitated by digital technologies and Industrie 4.0. We believe that giving experts and innovators the possibility to build structured knowledge networks inside an organization and beyond has a significant effect on their capability to innovate. To deploy new technologies with benefits to the environment, business models usually need to be re-designed. Based on the concept of the German Industrie 4.0 value network approach, a smart platform easing collaboration between several partners through the modeling of business scenarios is also presented. We have in Europe the complete ecosystem which allows creating a sustainable energy transition. The challenge is to associate expert skills across organizations, including public institutions and private companies to close the loop connecting technologies, business models and policies. Small Businesses can act as agile connectors to reduce large organization resistance to change.

Key words
Creative Synergies, Knowledge Network, Information Sharing, Innovation Ecosystem, Value Network, Disruptive Innovation, Innovation AAA (Agility, Appetite, Adoption), Collaborative Business Models, Tryptic Energy - Manufacturing - Digital transition, Digital Connectors, i2Kn/i4Kn, Industrie 4.0 Smart Platform, Industrie 4.0 Standards Ecosystem, Intellectual Properties (IP), Data Management, Hydrogen Mobility, Local Experimentations, Public policy design.

I. Introduction

In this paper four managers from Air Liquide and two start-ups - MeetSYS and 2B1st - are sharing their experience in creating knowledge ecosystems to favor collaborative innovation, as well as their vision on the way this type of synergy could be developed in the next decade in Europe where disruptive technologies challenge organizations, social relationships and regulations.

Air Liquide's 15-year experience in the development of hydrogen economies in Europe, Japan and North Americas are inspiring this holistic approach based on Knowledge Network [1], [2] and Industrie 4.0 collaborative practices as established in Germany [3] .
In the first part of the paper, the authors will present elements of their respective companies' innovation profile and their experience and vision to further develop effective collaborative mode and cooperative agreements, leveraging individual capacities for action on the one hand and Industrie 4.0 concepts for open innovation on the other hand.

In the second part, the paper will describe how knowledge networks and advanced open innovation Industrie 4.0 digital platforms could create value in complex value chains such as the hydrogen energy for transportation, an example of European Creative Synergy Program managed by Air Liquide over the past 15 years in the framework of European innovation programmes.

From these advanced experiences, the third and last part of the paper will propose concrete key factors of success we have identified to drive innovation and industrial dynamics in Europe.

In conclusion, we expect this paper to inspire take-aways that can help European actors to develop the most fertile ecosystem and create value for themselves and the communities through Responsible Innovation.

II. Companies Innovation Strategies

A. Air Liquide

Air Liquide has grown its activities over the past 115 years thanks to constant discoveries on how to produce, purify, efficiently store, transport, analyze and safely use oxygen, nitrogen, hydrogen, argon, helium and other "essential small molecules" as well as their mixtures.
This sector of technical & medical gas is delivering technology based services to a large variety of markets. The recipe of successful BtoB innovation includes four ingredients : a favorable ecosystem including early customers and technology partners with innovation investment capacities, the shared conviction that a new value chain is needed and feasible, a team of experts with skills in sciences, technologies and business, and last but not least, peer-to-peer trust-based working relationships. Today, given its company activities worldwide, Air Liquide is committed to work with its customers and suppliers to participate in key societal transformations contributing to energy & environment transition, climate change mitigation, air quality, healthcare and wellbeing and to the business and work

transformations induced by digital technologies[1].

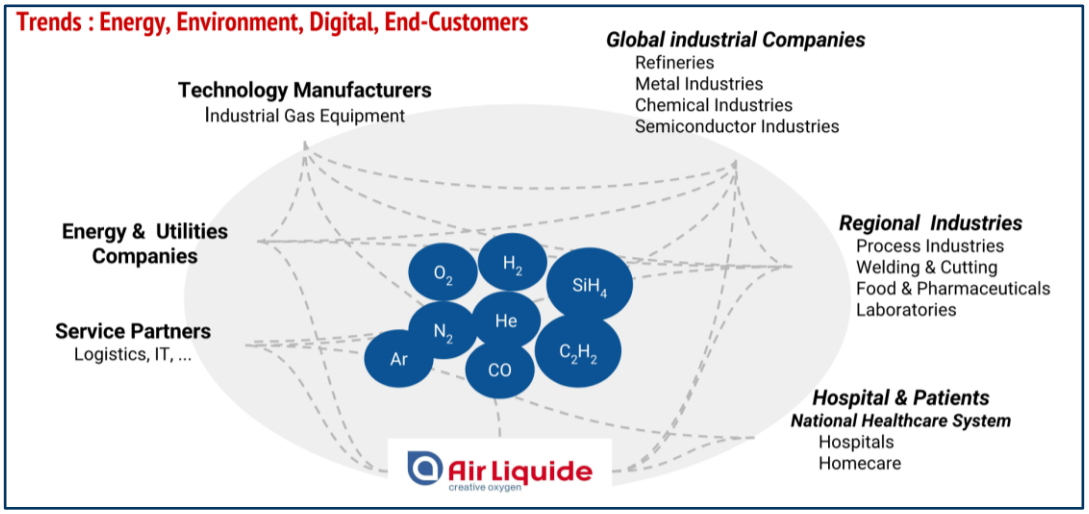

Fig. 1 : Air Liquide Value Network is multi-polar and transforming

Thanks to its participation in 20+ collaborative EU projects over the past 15 years, Air Liquide has grown its ability to engage early in complex and disruptive scientific and business innovations with partners. With a culture of developing talents through expertise career paths or through mobility across functions, Air Liquide is activating individual motivations at the heart of successful innovations. To further leverage this strength, Air Liquide is developing new ways of innovating by leveraging individual capability for action [3] through knowledge networks and collaborative digital platforms.

With MeetSYS[2], Air Liquide has deployed an internal scientific Knowledge Network connecting researchers to experts and innovators working in business and operations close to the customers. Using the Innovation to Knowledge Network (i2Kn) methods and digital solutions[3] to build common fundamental knowledge, expertise make themselves visible to business developers and operation managers, who are in the position to create innovation opportunities with customers. The i2Kn methodology takes Air Liquide beyond knowledge capitalization by driving its experts to express their cognitive skills and ways of reasoning on a given question. Air Liquide relies on this structured internal knowledge network of 800 members, called m-Lab[4], to enhance open innovation with its business partners. In a second step, Air Liquide plans to use the i2Kn solution to build “shared knowledge clean rooms” with key customers and suppliers to ease joint innovation projects.

With 2B1st solutions, Air Liquide is currently exploring new ways of co-building projects with a set of suppliers or with a group of customers sharing a common industrial and market ambition. Thanks to the best practices embedded in the digital collaborative open platform built on Industry 4.0 concepts, Air Liquide anticipates to gain efficiency by co-

[1] https://www.airliquide.com/group/improving-air-quality-better-environment-and-health
[2] http://meetsys.com/en
[3] http://i2kn.com/en/
[4] https://www.airliquide.com/connected-innovation/essential-small-molecules

building business scenarios with its partners in a structured manner, while managing confidentiality and trust. Simulating the value creation of the complete value chain has always been the first step to make decisions on collaborative innovation projects. Appetite for transformation is shared, however the complexity of decision requires to adopt structured modes of cooperation to leverage the knowledge and vision on sciences, technologies, markets and end customer willingness to adopt new solutions. Building local hydrogen economies as well as conducting ambitious energy transition programs critically need an Industrie 4.0 approach to cooperation to be implemented involving energy utilities, industrial gas companies, technology manufacturers, vehicle OEMs, users and customers, local authorities, fuel station operators…

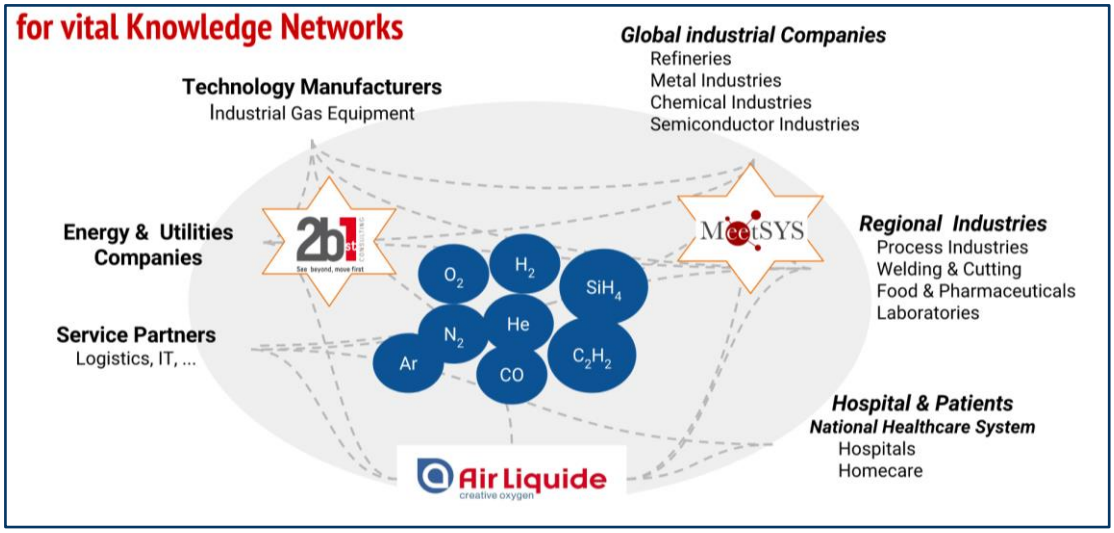

Fig 2 : Metsys and 2B1st Consulting are two agile innovation connectors for Air Liquide

B. MeetSYS

Since 2003, MeetSYS has provided scientific problem-solving services to industrial innovation teams. In 2013, the company put on the market a new service called i2Kn (Information To Knowledge Network), a high value-added solution combining a methodology and a digital platform to capitalize and share scientific and technical knowledge and know-how.

Rooted in the return of experience acquired through numerous Innovation workshops, i2Kn provides both the method to transform tacit organisation knowledge into comprehensive information and the tool to connect experts, researchers, marketers and business developers around this common knowledge.

The i2Kn digital platform enables its members to easily navigate between knowledge, people, projects and discussion through a smart “connection algorithm”. These automatic connections allow i2Kn users to save time in feeding the knowledge base and automatically link a new piece of knowledge to the core of the existing database. Once deployed in an organisation, the i2Kn solution transforms informal expert networks into a powerful implicit

knowledge network.

MeetSYS also manages i4Kn (Information For Knowledge Networks), an open source database of generic technologies & scientific phenomena. This open database is accessible from i2Kn private databases and provide innovators with alternative ideas on how to deliver a technical function, helping them to think out of the box.

Large industrial actors like Air Liquide, Arcelormittal, Total, Hutchinson, Andritz Hydro, and LVMH are already deploying i2Kn across R&D and operational teams.

C. 2B1st Consulting

2B1st Consulting was established in France in 2012 to develop digital solutions for the energy sector. The first application, trademarked as www.projectsmartexplorer.com, is a projects pursuit tool dedicated to the Oil & Gas and Petrochemical industries. Using complex algorithms, this tool evaluates by reverse engineering the content of each project for 200 different products and services (mechanical, electrical, automation, piping, …). The purpose is to guide market analysts on the best routes to market to their own products and services.

2B1st Consulting developed in 2016 a collaborative tool branded "**Industrie 4.0 Smart Platform**". This internet application helps the players of complex value chains to work together on collaborative mode. It can be for technical subjects (Collaborative Innovation, Collaborative R&D, Claim Resolution, …) or for business development (Go-to-Market together, Packaged Offer, Local Content Value proposition, …). Based on the German **Reference Architecture Model Industrie 4.0 (RAMI 4.0)** for modeling (twin concept) and for communication along the supply chain, this tool speeds up collaborative processes while protecting intellectual properties and proposing guidance for data management.

The success of these two digital solutions relies on aligning innovation with fundamental market needs. The very conservative energy sector is affected by the emergence of new business models. In this disruptive environment, the innovation process becomes challenging. To manage it, we practice lean innovation where, on the demand side, we gather customers' feedback continuously, and on the supply side, we question our worldwide network of a thousand experts in their respective fields. Our lean organization is responsive and deploy innovations on quarterly basis to maintain a short learning curve and prepare the next steps at low risks.

The **Industrie 4.0 Smart Platform** is designed for large operating companies such as Air Liquide, Cloud services providers and Clusters of companies such as the French "Pôles de Compétitivité". The RACE cluster in the Auvergne-Rhône-Alpes (AURA) region is considering using this collaborative platform to model and deploy the production and distribution of hydrogen solutions for energy storage and transportation in center-east of France.

III. Open Innovation Agility: Examples of Good Practices

A. Creative European Platform Synergies : example of Hydrogen Economies

For more than 15 years, Air Liquide has been one of the leading actors in the emerging

hydrogen energy sector, leveraging its expertise and experience in the production, storage, distribution and use of hydrogen by final customers to design and deploy a hydrogen delivery market for electric vehicles. Japan, California, Germany, France and Denmark are countries where public-private initiatives are enabling coordinated investments in hydrogen stations and vehicles to happen. To further develop this transition towards hydrogen fuel cell vehicles, many simultaneous levers need to be activated : the appetite of citizens for electric mode of transportation, the investment by vehicle manufacturers in fuel cell powertrain manufacturing lines, the development of renewable electricity and biomethane plants as sources for hydrogen, and the design of policies giving market value to the environmental benefits generated by this new transport energy : CO_2 reduction, air quality improvement and noise reduction in urban areas.

Given this complex value network, Air Liquide has since 1999 engaged in collaborative initiatives to co-build knowledge, technologies, business models and infrastructure with other stakeholders, such as car manufacturers and fuel distribution companies.

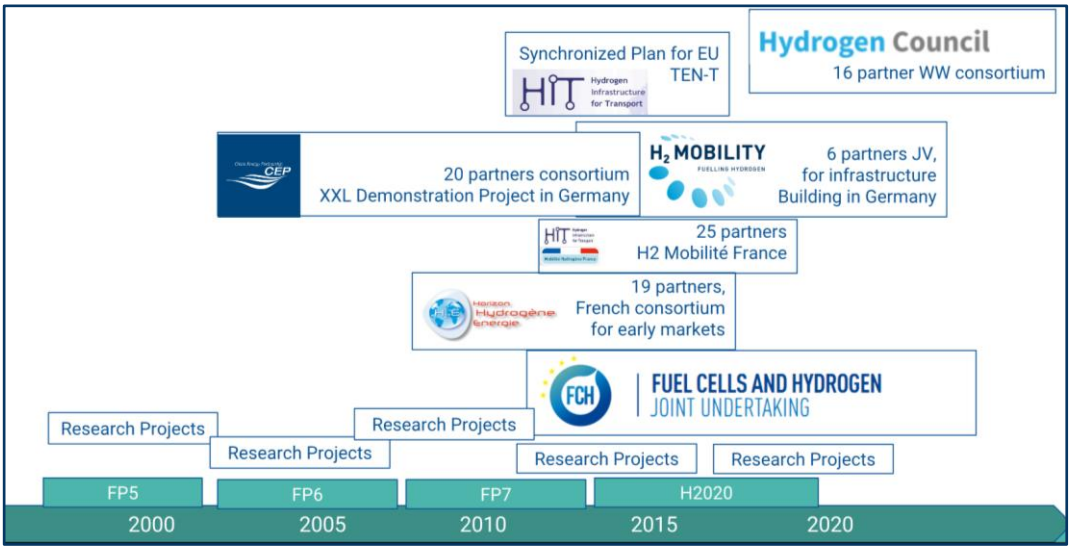

Fig 3: Use case : building the Hydrogen Energy value networks in Europe and beyond.

Air Liquide's experience in collaborating with hydrogen energy value chain actors within the EU innovation framework, and as participants in national innovation programs, has brought great benefits to its organisation resulting in a finer adjustment of business strategy to market and technology maturities. Through frequent meetings with other stakeholder representatives and market policy experts, Air Liquide managers enhance their capability to make decisions about new technologies, supply-chain models and market offers. By sharing its knowledge about hydrogen technologies as an energy vector, Air Liquide is in turn contributing to the policies and regulations required for the hydrogen economy to emerge [5] [6].

50 hydrogen stations are now in operation in Europe [7], with a total target of 1400 electric vehicles using fuel cells to generate on-board electricity from hydrogen in 2020. Despite these efforts, the hydrogen vector is rarely included in national energy transition reference scenarios of European countries.

Based on this experience, we believe that the efficiency of collaborative projects could be further improved by:

- early modeling of the value network and business scenarios using a digital solution such as the Industrie 4.0 Smart Platform. The business modeling produces targets for technology performance which in turn make the technology development efficient. To perform this business modeling, National Hydrogen Mobility consortiums have employed consulting firms with clean room approaches for confidential data sharing. When a consortium is sharing a value network quantitative model, go-no-go decisions on technology projects are made quicker, ensuring optimal use of public and private fundings. The use of a platform also triggers a more formal governance with mandates given to company representatives to make decisions in the name of their company.

- the implementation of clear and lean confidentiality rules within consortium contracts, allowing sufficient non-confidential space to build common knowledge. This common knowledge can be built using a knowledge network approach such as i2Kn, allowing dissemination and capitalisation of the technology solutions as well as the fundamental reasoning used to build those solutions. Individual experts would be easier to identify and call as support for future projects.

- the development of industrial economy & energy policy knowledge networks. Associating private company experts and institutional experts to co-design instruments sending market signals to investors and customers would accelerate the energy transition in Europe. By combining their financial contribution to private companies with economic & policy expertise, the institutions would enhance the efficiency of public funding relative to energy transition projects

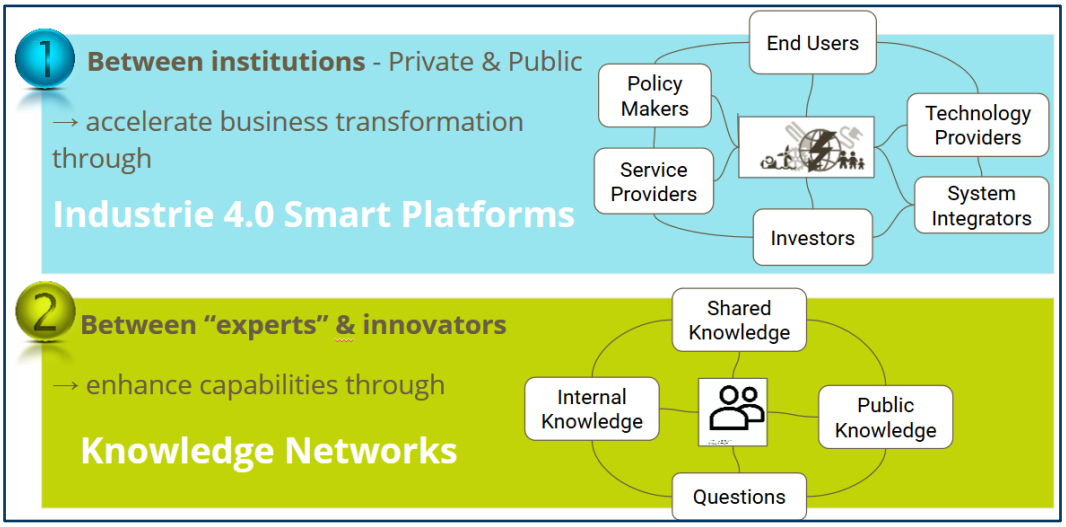

Fig. 4 : 2-level creative synergies to accelerate energy transition

A. I2KN - Intelligence to Knowledge Network

The i2Kn approach is a method of collecting and modeling expertise representing how experts think (reasoning paths) combined with a collaborative software, making the capitalization, enrichment and sharing of knowledge across organizational silos possible. In i2Kn, pages are automatically connected via hyperlinks, forming an automatic network of knowledge mimicking neurons in brains.

Faced with a challenge, experts arrange their knowledge and build reasoning pathways for finding existing or new ways to answer the problem. i2Kn modelize these pathways and help users to access and understand them[5].

Experts are linked to each other via their common areas knowledge. i2Kn makes it easier for experts to create joint knowledge. A user can identify an expert who has already faced similar questions.

A company can design a specific knowledge base addressing its business priorities. Company's private databases are enriched through access to the public MeetSYS knowledge base, i4Kn. i4Kn also gives access to a network of linked experts, companies and laboratories in open innovation, with shared technical and scientific knowledge.

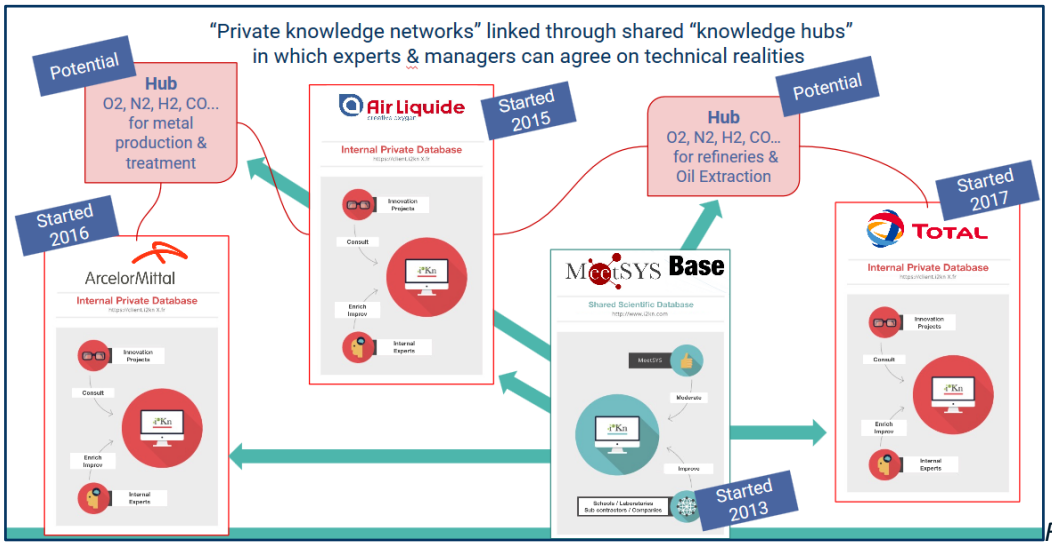

Fig. 5 : A multi-actor scientific knowledge network for innovation decisions

B. Industrie 4.0 Smart Platform

Companies such as 3M in USA or Seb in France release one new product per working day along the year in the consumers goods market. This innovation frenzy is fueled by an intense collaboration among employees of these companies. If this intra-enterprise agility for innovation is possible in consumers goods, this agility can be extended to inter-enterprises

[5] video : https://youtu.be/J4bJ2ES-ju4

innovation in the industry. The **Industrie 4.0 Smart Platform** has been developed for that purpose.

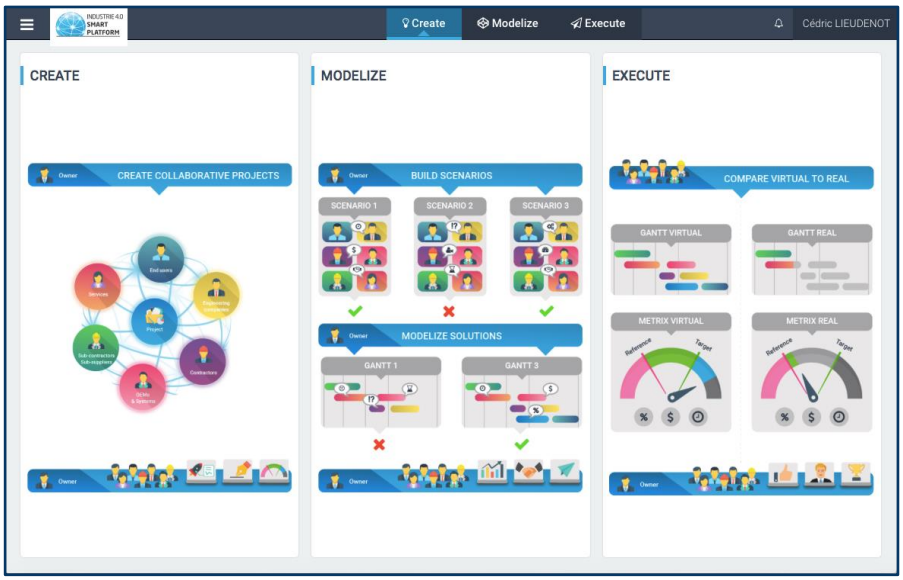

Fig 6 : User interface of the Industrie 4.0 smart collaborative platform

To do so, the **Industrie 4.0 Smart Platform** proposes a three-step process following the Reference Architecture Model Industrie 4.0 (RAMI 4.0):

- Step 1: Create
  - Describe the collaborative project
  - Select the partners
  - Choose legal status to protect each partner's intellectual properties
  - Define metrics to measure value creation
- Step 2: Model
  - Build scenarios
  - Optimize scenarios
  - Model scenario execution
- Step 3: Execute
  - Project execution
  - Compare with Model
  - Measure Value Creation

In the industry sector, Air Liquide is recognized for its optimizing its energy consumption and developing solutions to reduce the energy and environmental footprint of its industrial customers. The culture of the proof of concepts (POCs) is well-adopted. The collaboration between Air Liquide and 2B1st aims at increasing the agility for open innovation and speeding up the conversion from POCs to value creation. The differences between intra-enterprise and inter-enterprise innovation relies on trust between the partners, the protection and reward of the intellectual properties, the data management and the data storage. Therefore, agility in collaborative innovation requires simple processes. The

collaborative tool Industrie 4.0 Smart Platform facilitates and speeds up the industrialization of a good idea for Air Liquide and its partners.

IV. Challenges and Key Factors of Success to Drive Innovation and Industrial Dynamics in Europe for Energy Transition

Since Lisbon Treaty in 2007, industrial competitiveness stands as a very sensitive topic in Europe from political perspective. A decade later, the situation is getting even more complex with the ambitions to conduct the energy transition and the digital revolution. In the same time, Europe is engaged in a global competition for industrial leadership and correlated employment challenges. In the 2010s years Europe has proven to be innovative in energy and manufacturing industries, introducing new concepts mobilizing companies of all sizes, universities and governments in collaborative processes [8]. Below we propose a short list of key success factors we have identified as experts acting in the private sector.

A. Understand Societal Challenges and Megatrends

Since 2000, the European transformation drivers have drastically evolved. The energy transition is opening a wide space for inventing a new world and creating new jobs. The digital revolution, with daily eruption of disruptive innovations, contributes in fine to give increasing possibilities for citizen to participate to societal changes.

Industrial companies, under the influence of their stakeholders (customers, institutions, employees, …), have engaged in the energy & environment transition, while integrating the new possibilities of digital technologies. While policies are designed and implemented, cooperation among industrial actors of the same value networks are essential to inventing a competitive energy system for tomorrow.

Our belief is that this cooperation could be further enhanced by intense human cooperation [9] and the co-building of knowledge to overcome current transformation challenges in energy, environment, manufacturing and digital. Knowledge Network platforms - which allow individuals as citizens selected through a peer-to-peer process - to interact and co-build new representations of current reality could accelerate such a process. Digital technology is an enabler of human cooperation when combined with an advanced governance model. In parallel to BtoB agreements and public-private dialogue, peer-to-peer interactions through social networks empower individuals as change agents and influencers for citizen and end-customer decisions.

B. Design smart business models to catalyze the transition

We see in the combination "**Energy** - **Manufacturing - Digital**" a unique opportunity to invent a "**Smart industry**" that can support the energy transition for a competitive European industry. Europe has indeed high levels of expertises in these three different sectors

Figure 7 is showing through Air Liquide example with its partners MeetSYS and 2B1st how to articulate Digital and Manufacturing to generate this Smart industry supporting the energy transition. Sharing knowledge through digitization can contribute to develop breaking technologies required for the energy transition together with new business models to make this new world viable.

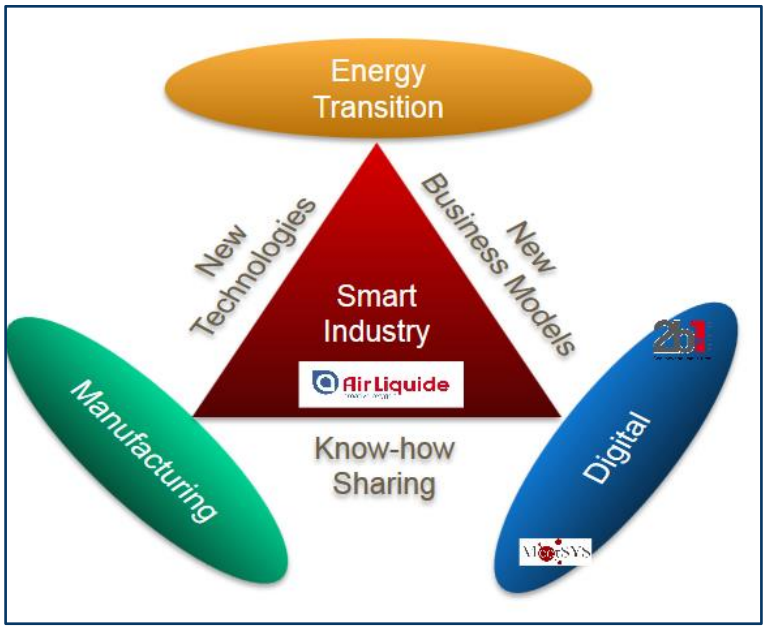

Fig. 7: Smart industry paradigm to support energy transition

For the next decade we see the opportunity in Europe to develop combined business models to accelerate the energy transition [10]. Current business models and energy market organisations do not fully take advantage of the Internet of Services (IoS). Current players need to understand how to build "smart contracts" while still getting the value back to maintain their assets and invest in new technologies. Countries where such new business models are favored are more likely to design competitive energy systems in terms of cost, reliability and renewable energies integration (smart grids).

Key factors of success rely on taking advantage of the digital revolution to (i) enhance innovation agility in shaping value chains into value networks and (ii) share data and reward knowledge in secured environment to accelerate energy transition.

In this perspective, the Hydrogen Energy projects are excellent use cases to implement this strategy in practice as it mobilizes multiple transversal competences from all manufacturing and process sectors on collaborative mode to redesign the industry for energy transition.

C. Qualify digital solutions, systems, products, services, … and personnel along Industrie 4.0 guidelines

Since the financial crisis in 2008, all industrial countries rivaled of creativity to stimulate their industry digitization with various incentive programs.

Country	Industry Programs
China	Smart Automation 2.0 / Made in China 2025
India	Make in India
Japan	Industry Value Chain Initiative (IVI)
South Korea	Creative Economy
USA	Industry Renaissance and Industrial Internet of Things
Europe	France: Usine/Industrie du Futur Germany: Industrie 4.0 Italy: Industrie 4.0 UK: Future of Manufacturing

Table 1: Review of national Industry programs [11]

These programs have the same goal to restore or consolidate the contribution of the in-country industry GDP. They are supported by tax incentives in favor of the local industry, but most of these programs do not allow for qualification and labelisation of digital solutions, systems, products and services. Japan and Germany are exceptions, where technical architecture models can be used as reference for qualification or branding.

Japanese **Industry Value Chain Reference Architecture (IVRA)** and German **Reference Architecture Model Industrie 4.0 (RAMI 4.0)** describe the technical concepts to be deployed for a digital industry in a connected world. The German program **Industrie 4.0** has started to list and review the main standards (local, regional, global), see Table 2 below, to be used as references for the harmonization of the solutions in an open environment.

This standardization approach has motivated the most industry-intensive countries - such as China, Japan and Italy - to align on the German model **Industrie 4.0**. Born in Europe and now mobilizing experts from all the world in working groups, Industrie 4.0 could be developed as a giant hackathon to be used for the qualification and labeling of solutions, systems, products and services with respect to international standards.

In the same way, all the universities and engineering schools propose new educational programs, even degrees, on digitization and related subjects like IoT. Most of these programs are different from one another, internal initiatives of the dean in charge, and far from being standardized by accreditation criteria. The positive aspect of this situation is the diversity of the education, generating the opportunities for disruptive innovations change all over the world. The challenge of this confusion is then to evaluate and compare the true competences of the students or young engineers from these programs and their employability.

Instead the German schools can graduate their students from programs in agreement with Industrie 4.0 standards as this program relies on technologies and standards. Even today, such graduation is seen as career accelerator.

Most European countries are adopting these Industrie 4.0 technologies for digitization, and benefiting from each other's successful experience. Our recommendation is to encourage the mutual recognition of the educational programs in Europe around this Industrie 4.0 technology.

D. Measure collaborative value creation in value networks, the Hydrogen Economy use case

Figure 8 illustrates how industrial organizations have evolved in one century from fully-integrated business models to the creation of supply chains, then the globalization of the outsourcing in the value chains, to today's complex value networks.

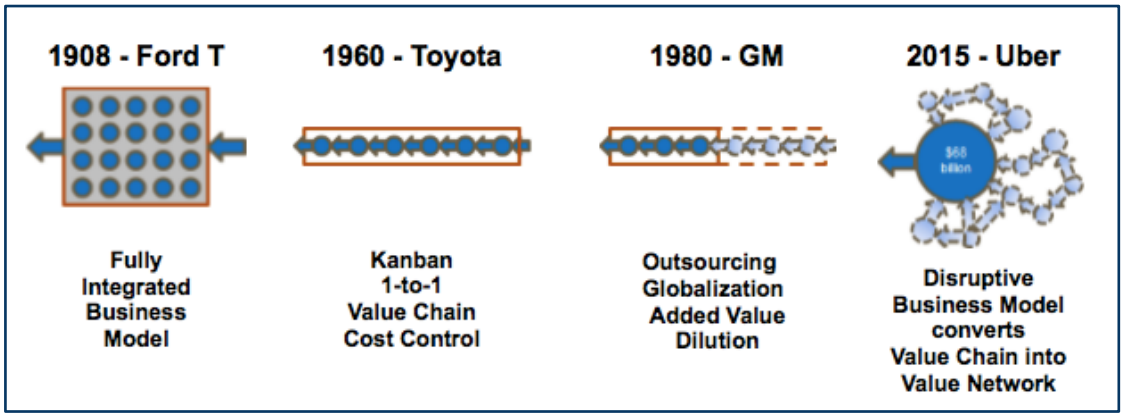

Fig. 8 Evolution of industry from a fully-integrated business model to a value network.

Over the last decades, industry optimization has led to endless value chains due to globalization and outsourcing. Over the last few years, the digitization eruption further amplified the dilution of value chains where all companies are connected in one way or another, converting conventional linear value chains into complex multi-dimensional value matrixes. The positive consequence of this evolution is the emergence of new business models in conventional industries. In that respect, the Hydrogen Economy use case is a perfect example. On figure 3, we can see the complexity of the value network by the number of players and their position in the value creation process which has nothing to do with conventional value chains.

Therefore we see the opportunity to use the Hydrogen Economy experience to encourage multi-modal deployment of complex value chains as a key factor to success in driving innovation and industrial dynamics in Europe. At the same time, measuring value creation has become a challenge in such a chaotic environment and among ever more collaborative processes.

From our experience, measuring collaborative value creation in complex value chains requires following key steps to define:

1. the specific subject and aim of the collaboration
2. the most conducive legal environment to govern the:
    - 2.1. intellectual property resulting from the collaboration
    - 2.2. data management and storage
3. the contribution of all partners involved
4. quantitative or qualitative key performance indicators (KPIs) to measure the value creation at:
    - 4.1. collaborative level (same goals to be shared by all partners)
    - 4.2. individual level (belonging to each company in the partnership)

With this information it is possible to **modelize the collaboration** between all players in the Hydrogen Economy initiative before execution and test the viability of the project in terms of risks and value creation at both the collaborative level and individual level before execution. During the project execution, using the digital twin concept will help to compare the actual value creation with the model to implement corrective measures and to draw lessons learnt for continuous improvement and more agility on this hydrogen business model.

E. Establish guidelines for a regulation ecosystem in Europe (Directives, Legal, Tax, Standards, Patents) to favor collaborative innovation, sharing, rewarding knowledge

To propose guidelines favoring collaborative innovation, sharing and rewarding of joint knowledge creation, a preliminary key question regarding the ownership of the data to be answered first. Disruptive practices usually conflict with the historical definition: should the data belong to the one who created it or the one creating value out of it? What is the true societal value created by the data ?

With the European Directive 2016/943 on the protection of undisclosed know-how and business information (trade secrets) against their unlawful acquisition, use and disclosure, the European Parliament recognized the emergence of wrongdoing on intellectual properties, relative to the conventional definition of data.

If in this decade we have seen the emergence of these practices, we can anticipate that they will escalate over the next decade as all companies or organizations aim to protect their own data even while at the same time they look for value creation from combining their own data with others' data, breaching themselves the legal wall they have elevated to protect their intellectual property.

On this question, the new US Administration has made the clear choice to favor the disruptive approach under the lead of their internet giants. Europe made a first step with this Directive 2016/943, but must prepare for new adjustments in the next decade.

If Europe wants to take the global lead in innovation, existing regulations need to be adapted

to new realities. From the German example, we see that part of the success of Industrie 4.0 and its early adoption by manufacturing countries is precisely the fact that it is built on international standards such as and not limited to ones listed in the table below.

Topics	Main standards supporting Industrie 4.0
Functional Safety	IEC-61511, IEC-62061
Products Classification	IEC-61360, ISO-13584
Communication Protocols	IEC-61784, IEC-62541
Interfaces Configuration	IEC-61804, IEC-62453
Engineering	IEC-61131, IEC-61987, IEC-62424, IEC-62714, ISO-17506
Digital Factory Reference Model	IEC-62794, IEC-62832
Architecture	IEC-61512, IEC-62850, IEC-62890, IEC-62264
Cybersecurity	IEC-27000 series, IEC 62443

Table 2: Main standards supporting Industrie 4.0 [12]

German engineers try to develop solutions based on existing international standards, while the international community on the Technical Committees for these standards are working hard to evaluate proposed solutions and adapt these standards where that may create value. This balance of power between technical communities feeds a virtuous circle of collaboration and knowledge-sharing favoring innovation. Being based on standards, this virtuous cycle sustainability attracts investments with less risk.

Regarding the impact of tax incentives on digital innovation, the US and German examples speak for themselves with billion of US dollars of direct or indirect tax savings for companies investing in IT and manufacturing technologies. If these tax programs continue to favor investments, the digital revolution remains driven by the companies themselves, deploying disruptive innovations sometimes ahead of the government's' regulatory capacities.

V. Conclusions

In this document we have seen how the industry revolution and the energy transition are closely connected together and how the digital technologies can facilitate these evolutions jointly by building and sharing acute knowledge among experts. We also highlighted how Europe benefits from a unique advantage with the concentration of expertises in the tryptic Energy - Manufacturing - Digital to take the lead of the smart industry as well as the energy transition in the global competition.

The example of cooperation between Air Liquide and its agile innovation connectors MeetSYS and 2B1st shows that the tools and processes are available with collaborative Industrie 4.0 digital platforms to share knowledge, manage value network and model business scenarios to speed up the cooperation, optimize the value creation in secured conditions for intellectual properties and data management and in line with public policies.

Figure 9 below shows how Public Policies, Technologies and Business Development interact together. Here the Public Policies set the preliminary conditions for success stories in energy transition. They act at different levels: global, European or local, through regulations, incentives and standards. Local experimentation with the private sector fine-tunes the new business models, technologies, standards and market regulations to accelerate the energy transition. This virtual loop between public policy makers, technology experts and business developers would speed up learnings from field experience to adjust public policies to the deployment of the digital revolution in the smart industry and energy sector.

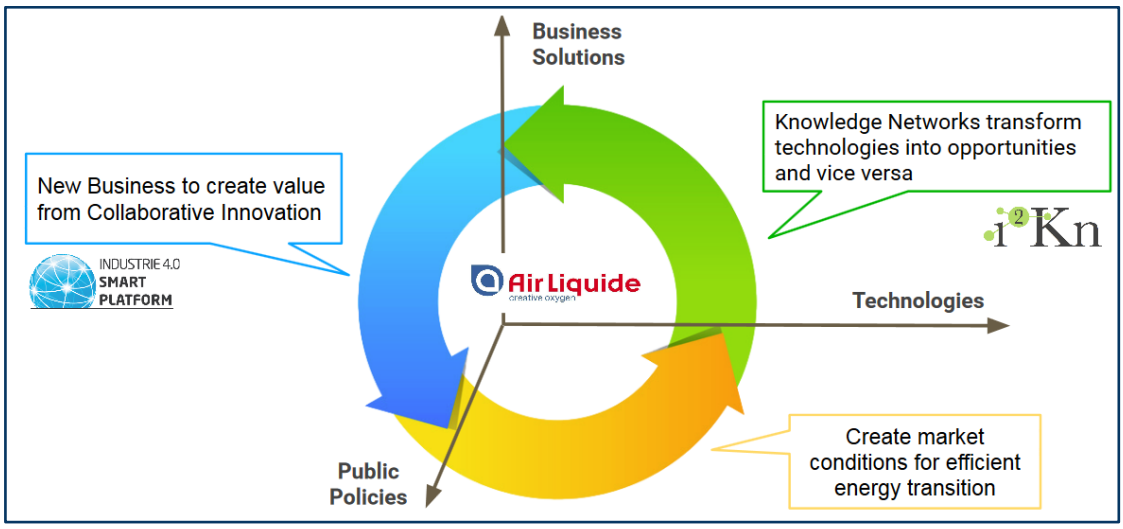

Fig. 9: Collaboration scheme through digital platforms for Industrie 4.0 innovation in energy transition

The complexity of energy systems and their impacts on the industries, services and citizen are such that experimental data is needed to confirm the effectiveness of strategies. Those experiments would also be the opportunity to work in “3D” competences network, bringing together experts in technologies, business models with public policies, for example on the next steps of the H2 initiative.

In parallel to public-private partnerships, in which the public partners would also bring their expertise in policy/market design, peer-to-peer interactions beyond the border of the institutions and private companies could be the catalyst Europe needs to reinvent its energy

system. To boost this process Europe could organize some kind of **Industrie 4.0 giant Hackathon** through a common knowledge network platform powered by today's available digital technologies, as well as the social science research results on collective intelligence and "Wisdom of Crowds" [13].

VI. References

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