HYDROGEN-CCS VALUE CHAIN

De-Risking the Hydrogen-CCS Value Chain Through Law

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The integration of hydrogen (H_2) and carbon capture and storage (CCS) technologies within common value chains can contribute to the effective decarbonization of the energy system and hard-to-abate sectors where electrification may not be possible or cost-effective. The H_2-CCS chain is taken as an example of strategic value chains in the process towards a low carbon and increasingly integrated energy system. The successful realization of H_2-CCS integrated chains requires the mobilization of vast quantities of domestic and international private capital. This article looks at how legislation and contracts, separately and in combination, can be used to manage and mitigate risks and incentivise private sector investment along the H_2-CCS value chain in Europe. First, it discusses the role of national governments and the EU in developing legislative measures such as climate change targets, market design, liability regimes and how those could remove some of the risks preventing private sector investments. Second, it considers how the design and standardization of contracts can mitigate risks faced by the private sector by allocating, transferring and sharing risks between private and public parties. The article concludes that the law has an important role in de-risking investments and that further policy steps are necessary to refine the legislative and contractual regimes needed for the successful deployment of such strategic value chains.

Keywords: CCS, climate change, hydrogen, de-risking, legislation, contract, risk mitigation, risk allocation, risk transfer, public-private partnerships

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1 Introduction

The successful deployment of low-carbon technologies requires the mobilization of vast quantities of domestic and international private capital in addition to the financial support that governments can provide. Risks determine the attractiveness of investment opportunities by indicating the expected level of returns.[1] The development of an effective risk mitigation strategy is therefore crucial to leveraging the level of private sector investment needed for the successful deployment of low-carbon technologies and infrastructures. Carbon capture and storage (CCS) is an essential component to reducing CO_2 emissions from fossil fuels (like natural gas processing) and industrial processes (like cement or steel production, waste management). Yet, the lack of a viable business model for CCS has prevented industrial uptake. The introduction of hydrogen (H_2) for low-carbon fuel for heating, cooling, transport and industry could enable business opportunities for CCS, and open the door to H_2 generated from spare capacity in renewable energy sources.[2] However, the deployment of H_2 technologies has also been slower than desired. It is therefore necessary to develop risk mitigation strategies for the H_2-CCS chain, as one of the *strategic value chains* for a low carbon, cost-effective and reliant energy system in Europe.[3] Extensive literature is available on the types of financial measures that can be utilized to de-risk low-carbon investments, yet very little is focused on the role of law within these mitigation strategies. With this in mind, this article considers the role of legislation and contract in risk mitigation strategies for the integrated H_2-CCS networks (chains) in Europe. It is limited to discussion on how legal instruments can de-risk private sector investments, and risk mitigation strategies for public sector investments are not covered.

In the context of H_2-CCS, there are different types and degrees of risk and different levels of market maturity along the supply chain. The exact design of the H_2-CCS chain is

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[1] Ward Goldthorpe et al., *D3.3.2: Interim Report Detailing Policy Issues, Business Risks, De-Risking Instruments, and Incentive Mechanisms Relevant for Case Study Countries*, Sustainable Decisions Ltd 3 (ELEGANCY 2018).

[2] SINTEF, ELEGANCY research project, www.sintef.no/elegancy/.

[3] In its conclusions from Dec. 2020, the Council called the European Commission to support and facilitate cooperation between Member States on 'strategic value chains', in this context centred on hydrogen. Conclusions of the Council of the European Union, *Towards a Hydrogen Market for Europe* (11 Dec. 2020).

also evolving and different scenarios – 'chains' - must be considered: onshore or offshore storage, blended H_2-natural gas (NG) or pure H_2 grids, shipping or pipeline transportation, location of H_2 production and the end use of H_2.[4] Risk mitigation strategies must seek to align these commercial and non-commercial interests (like storage) across the entire CCS chain in combination with H_2, taking into account that different de-risking strategies may be needed for different types of H_2-CCS business models. Developing an understanding of risks requires actors to consider all aspects of a project life-cycle, from construction to operation to decommissioning. For law, it requires mapping classic legislative compliance and contractual enforcement risks, as well as identifying new types of regulatory risks to ensure appropriate classification and mitigation.

This article begins by discussing the interaction between legislation and contract within risk mitigation strategies to demonstrate that a combination of these tools is needed to de-risk private sector investments in H_2-CCS (section 2). Second, it considers the role national governments and the European Union (EU) could play in developing legislative measures which de-risk investment decisions. In particular, it will consider how the adoption of national and regional policy objectives which provide a clear vision of the low-carbon transition, in association with a predictable regulatory framework, could remove some of the risks preventing private sector investment (section 3). Third, it considers how risk-allocation mechanisms within Public-Private Partnership (PPP) contracts and the standardization of contractual provisions could be used to mitigate risks along the H_2-CCS value chain (section 4).

2 Interaction Between Legislation and Contract within Risk Mitigation Strategies

An important starting point for risk mitigation is to identify the scope of application of the different de-risking measures. Not all risks can be mitigated or managed by the same types of tools and not all risks can be addressed through law. It is therefore important to consider the interaction between different types of de-risking instruments to establish mitigation strategies that most effectively reduce or remove investment barriers. In the context of law, legislation and contract are two very different approaches to de-risking and the preferred mitigation measure will depend on the circumstances of the case. The size of the project (large infrastructure, distributed systems, local supply), the type of actors, the types of risk being targeted, the legal tradition of the State (civil or common law) and the preferred procedural methods (legislative processes or bilateral negotiations) will alter the appropriateness of the chosen legal de-risking tools. The interaction between legislation and contract is therefore an important factor for the elaboration of effective risk mitigation strategies.

Contracts provide customisable, case-specific information necessary for investors to make realistic predictions of revenues prior to final investment decisions and secure other forms of de-risking instruments such as insurance coverage. Contractual de-risking measures are preferred by some investors because they avoid the implementation of overly-restrictive government-imposed regulatory measures which can stifle competition and innovation.[5] Contracts also allow for increased flexibility through negotiation and renegotiation processes, compared to legislation which can involve complex and timely processes. Legislation on the other hand contributes to the creation of a predictable and transparent legal framework and ensuring a level playing field for competitors. It can also address specific investment barriers for national market conditions by mitigating risks that cannot be re-allocated through commercial arrangements such as uninsurable liabilities or regulatory barriers posed by existing energy market design rules.[6]

With these considerations in mind, a combination of legislative and contractual mechanisms will be necessary to allow a targeted approach in which contracts and legislation are used as independent but supplementary measures to de-risk private sector investments. Structuring the interaction between those mechanisms requires good collaboration between government and private entities.[7]

3 De-Risking the H_2-CCS Value Chain Through Legislation

Legislation could prove effective in de-risking barriers to private sector investment in the H_2-CCS chain by setting a common decarbonization objective and bringing clarity to the operational rules of a project through its lifecycle. Legislation can also offer cost-effectiveness by directing scare public resources towards the reduction and removal of risk profiles. This section considers how the development of clear, predictable and long-term climate policy commitments, enabling energy market design legislation, legal liability sharing mechanisms and harmonized standards for products and processes could prove effective in de-risking strategic value chains.

3.1 Target setting in climate change legislation

A key market driver for the deployment of low-carbon projects and essential infrastructures is the presence of a supportive, stable and clear policy environment. An

[4] Catherine Banet & Alice O'Brien, *D3.1.1: Legal Input to the Interim Report Detailing the Regulatory, Fiscal, and Macro-Economic Background for Each Case Study* 2 (University of Oslo, ELEGANCY 2020).

[5] Abdushelishvili Ng & Martin Loosemore, *Risk Allocation in the Private Provision of Public Infrastructure*, 25(1) IJPM 66 (2007).

[6] Ward Goldthorpe et al., supra n. 1, at 37.

[7] The regulatory model adopted in Norway for offshore petroleum resources, combining legislation and standard contractual terms, can serve as useful example.

effective de-risking measure for the H_2-CCS chain is therefore, on the one hand, the definition of CO_2 emissions reduction targets in the legislation and, on the other hand, the formation of climate change policies which clarify the intended role of H_2 and CCS in the future market for low-carbon technologies.[8] This requires: the definition and monitoring of legislative targets as well as specific policy support for H_2 and CCS in achieving these targets and the adoption of strategic roadmaps detailing how essential infrastructures will be delivered.

3.1.1 *Definition of CO_2 emission reduction targets and the role of H_2-CCS*

Existing climate change policies largely focus on defining and monitoring long-term, CO_2 or greenhouse gases (GHG) emission reduction targets set in legislation, in accordance with international commitments. Indeed, the Paris Agreement sets an international target to limit global warming to 2-degrees above pre-industrial levels, with an additional aspirational 1.5-degree target.[9] The Paris Agreement also defines a *climate neutrality* objective by 2050.[10] At EU level, an interim emission reduction target of 40% reduction in GHG emissions by 2030 compared to 1990 levels was defined as part of the 2030 Climate and Energy Framework.[11] Thereafter, the Commission adopted a strategic long-term vision to achieve emission reduction targets of 80–95% by 2050.[12] As part of the European Green Deal,[13] the European Commission adopted a legislative proposal for a European climate law (formally a regulation) that would set a legally binding target of net-zero GHG emissions by 2050, in line with the climate neutrality goal of the Paris Agreement.[14] According to the proposal, as revised in September 2020,[15] EU institutions and Member States will be responsible for taking the necessary measures for reaching the target, but, as a necessary step, the Commission also proposed to enshrine in the law a revised EU emissions reduction target for 2030 of at least 55% compared to levels in 1990. Once the European Climate Law is adopted, the European Commission will propose revising all necessary legislation and policy instruments to deliver the additional emissions reductions.

The climate neutrality by 2050 objective and the revised EU emissions reduction target are creating important incentives. They encourage both public and private actors to pursue efforts to reach targets, whilst offering flexibility in how emission reductions are achieved by being non-technology prescriptive. Formal targets level the playing field between the private and public sector with regards to policy-making intentions by introducing government accountability and increased reliability.[16] Additionally, an emphasis on the adoption of economy-wide emission reductions in the Paris Agreement[17] indirectly supports investment in CCS and H_2 technologies due to their potential to decarbonize a broad range of sectors – heating, electricity, energy storage, transport and industry.[18] Economy-wide targets also balance the burden between actors along the value chains.

To ensure that Parties will comply with targets over time and in time, both the Paris Agreement and the EU legislation define compliance monitoring mechanisms based on *emissions trajectory*. Notably, the Paris Agreement requires Parties to maintain successive nationally determined contributions (NDCs), while EU legislation defines several planning and reporting obligations on Member States through its governance system for the Energy Union.

However, emissions reduction targets alone may not be sufficient to stimulate the timely investments in strategic low carbon technologies and infrastructures, such as the ones along H_2-CCS chains, but are likely to first encourage the deployment of more mature low-carbon technologies.[19]

A policy shift away from emission reduction targets to net-zero, climate neutrality or even negative emission targets – as currently observed – could prove more effective in de-risking private sector investments along value chains such as the one for H_2-CCS. This is because targets which set timescales for the achievement of a carbon neutral society will likely scale-up mitigation efforts compared to those which require the progressive reduction of emissions. In particular, they encourage policy support for a more diverse portfolio of low-carbon technologies in order to drive decarbonization across the economy. CCS is essential to achieving net-zero because it is the only technology which can effectively

[8] Commission Staff Working Document, Impact Assessment accompanying the Communication, *Stepping Up Europe's 2030 Climate Ambition Investing in a Climate-Neutral Future for the Benefit of Our People*, SWD(2020) 176 final (17 Sept. 2020), at 12, 79 and 81–82.
[9] Paris Agreement, Art. 2.1(a).
[10] *Ibid.*, Art. 4.1.
[11] European Commission, *A Policy Framework for Climate and Energy in the Period from 2020 to 2030*, COM(2014)15 final, at 15.
[12] European Commission, *A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy*, COM(2018)773 final, 4.
[13] Communication from the Commission, *The European Green Deal*, COM(2019)640 final (11 Dec. 2019).
[14] European Commission, Proposal for a Regulation of the European Parliament and of the Council on establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999, COM(2020)80final (4 Mar. 2020).
[15] Amended proposal for a Regulation of the European Parliament and of the Council establishing the framework for achieving climate neutrality and amending Regulation (EU) 2018/1999, COM(2020)563 final (17 Sept. 2020).
[16] European Commission, *supra* n. 9, at 124. World Bank, *'Dealing with Public Risk in Private Infrastructure' Latin America and Caribbean Studies* 31 (World Bank 1997).
[17] Paris Agreement, Art. 4.4.
[18] Banet & O'Brien, *supra* n. 4, at 5.
[19] Parliamentary Select Committee, *Energy and Climate Change: The Role for an Emissions Performance Standard* (UK Parliamentary Publications 2010), para. 45.

decarbonize certain industries where emissions are hard-to-abate or where electrification is not possible, such as cement or steel production or heavy duty transport. Net-zero or climate neutral targets are therefore sending a strong message to industry that CO_2 storage and H_2 technologies must be deployed at scale, providing investment clarity for high capital infrastructure costs. It would also allow investors to consider cost-benefit analysis based on mid to long-term returns.

3.1.2 *Target compliance strategies: specific target setting and policy roadmaps for H_2 and CCS*

For net-zero targets to be effective in de-risking investments, they must be backed by specific, ambitious and credible government commitments to CCS and H_2 technologies. This requires legislative support for H_2-CCS in target compliance strategies through specific EU-wide targets and timelines for the deployment of H_2 and CCS infrastructures. A first question in this regard is how those targets should be formulated. A second question is whether independent targets for H_2 and CCS would be sufficient or whether joint targets for the separate technologies would be more effective in fast-tracking low carbon H_2.

First, it must be recalled that the definition of more technology specific targets cannot contravene the principle of Member States' free choice over the energy mix,[20] but, once agreement is reached, the EU legislator can adopt harmonized legislation, in compliance with the subsidiarity and proportionality principles. The EU renewable energy (RES) targets[21] have been effective in providing a specific mandate for developers to scale-up investment in renewable energy. In contrast, there are no specific legislative EU or national targets for the deployment of CCS. At the national level, there has been a lack of consistency and confidence in the political message that CCS is central to target compliance, with stop-and-go policies.[22] The existing legislation is primarily an enabling one, implementing and completing the provisions of the CCS Directive 2009/31/EC.[23] The situation is different and almost reverse for hydrogen, where there is now strong political and industry support, but still an insufficient legal framework.[24] Many EU governments have adopted national hydrogen strategies and deployment roadmaps, the European Commission has adopted a European hydrogen strategy in July 2020[25] and the Council of the EU called in its December 2020 conclusions for further legislative initiatives to upscale the market for sustainable hydrogen in the EU, particularly from renewable sources.[26] As developing a European hydrogen market will interact with and build on internal energy market legislation, harmonized measures at EU level will be necessary. To that respect, the EU hydrogen strategy of the Commission proposes a step-wise approach structured around three phases with concrete hydrogen deployment targets: phase 1 (2020–2024), with the installation at least 6 GW of renewable hydrogen electrolysers in the EU and the production of up to 1 million tonnes of renewable hydrogen; phase 2 (2025–2030, with the installation of at least 40 GW of renewable hydrogen electrolysers by 2030 and the production of up to 10 million tonnes of renewable hydrogen; phase 3 (2030–2050), with a mature market for hydrogen technologies.[27] As part of this three-phase roadmap, the European Commission recognizes the strategic enabling role that low-carbon hydrogen will play, and thus the need for integrated H_2-CCS chains.[28] Specific targets for CCS infrastructure deployment and H_2 production can efficiently help monitoring progress along emissions reduction pathways towards carbon neutrality. Finally, the general EU targets could be supported by other specific targets, such as connection or end-of-use targets.

On the second question, current legislative commitments signal a policy preference for independent targets and timelines for the separate infrastructures. For example, the Alternative Fuel Infrastructure Directive requires States to develop national frameworks for the market development of alternative fuels and includes 2025 targets for H_2 recharging and refuelling infrastructure.[29] Meanwhile the CCS Directive imposes specific rules on CCS operators, including capture readiness requirements for

[20] As enshrined in Art. 194.2 TFEU. *See* Catherine Banet, *The Technology Neutrality Principle and Free Choice Over Energy Mix in EU Law*, Indian J. L. & Tech. (forthcoming 2021).

[21] The target set in Directive 2018/2001 of 11 Dec. 2018 on the promotion of the use of energy from renewable sources (REDII) is to increase the share of renewable energy consumption in the Union's gross final consumption of energy to at least 32% by 2030 (Art. 3.)

[22] In the UK, the cancellation of CCS funding has created political uncertainty and instability regarding national commitments to CCS. The Government's ambition to 'have the option to deploy CCU at scale during the 2030s, subject to costs coming down sufficiently' has also been criticized for not providing the precision necessary to drive CCS deployment. *See* Ward Goldthorpe & Shabana Ahmad, *Policy Innovation for Offshore CO2 Transport and Storage Deployment*, 114 Energy Procedia 7547–7548 (2017); BEIS, *The UK Carbon Capture Usage and Storage Deployment Pathway: An Action Plan* 7 (UK House of Commons 2018); BEIS, *Carbon Capture Usage and Storage: Third Time Lucky? Twentieth Report of Session 2017–19*, 3, 10 (UK House of Commons 2019).

[23] Directive 2009/31/EC of the European Parliament and of the Council of 23 Apr. 2009 on the geological storage of carbon dioxide.

[24] On the legal barriers to hydrogen deployment, *see* HyLAW Online Database, https://www.hylaw.eu/; Banet & O'Brien, *supra* n. 4.

[25] European Commission Communication, *A hydrogen Strategy for a Climate-Neutral Europe*, COM(2020) 301 final (8 July 2020).

[26] Council of the European Union, *supra* n. 3.

[27] European Commission, *supra* n. 25, at 5.

[28] *Ibid.*, 5. In the Communication, 'low carbon hydrogen' is defined as fossil based hydrogen with carbon capture and electricity-based hydrogen, at 4.

[29] Directive 2014/94/EU of 22 Oct. 2014 on the deployment of alternative fuels infrastructure, Art. 4(1)(2).

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operators of large combustion plants.[30] These separate legislative pathways encourage national governments to develop action plans for H_2 transport infrastructures while also countering the current lack of confidence in the political message that CCS is central to decarbonization. However, if separate pathways are further developed for H_2 and CCS it is important that these pathways implement a holistic policy approach to ensure a coordinated delivery of essential infrastructures at all levels of the value chain. Existing quotas for recharging points as a result of the Alternative Fuel Infrastructure Directive have been criticized for focusing solely on light-duty vehicles (by excluding medium- or heavy-duty applications), as well as creating a mismatch between infrastructure deployment and uptake of fuel cell vehicles (FCEVs).[31] Capture readiness requirements have also been criticized for failing to scale-up investments in essential storage infrastructures. Targets for individual H_2 applications must consider the ultimate goal of establishing a H_2 economy with synergies across all sectors and in combination with other markets such as CCS.[32] This requires establishing further legislative commitments to H_2 beyond transport applications such as target setting for injection and consumption of low-carbon gases in national gas networks.[33] Additionally, it requires the adoption of CCS-specific targets such as requiring States to inject an agreed percentage of their annual CO_2 emissions. Coordination between the H_2 and CCS markets could also be achieved through the adoption of joint targets. A clear example is the adjustment of the EU's renewable energy targets to allow it to be met through a selection of low-carbon technologies which includes H_2-CCS.[34] This would allow States to develop technology-neutral, economy-wide targets which take advantage of their unique national circumstances and protect the subsidiarity of States over their national energy mix. Additionally, it would encourage States to support a portfolio of mitigation options, including H_2-CCS, whilst also paving the way for target alignment between renewable energy, H_2 and energy efficiency.

In any case, whether separate or joint policy pathways are preferred, it is essential to establish communication streams between governments, manufacturers, industry and consumers to ensure a coordinated roll-out of H_2 and CCS infrastructure across the chain. Targets should be coupled with the adoption of long-term strategic roadmaps detailing how governments and industry will drive and deliver essential infrastructure.[35] This will encourage governments to clarify the long-term position of H_2 and CCS within national decarbonization strategies. It will also facilitate the establishment and consolidation of the necessary end and appliance markets as well as oil and gas infrastructure re-use opportunities. A specific element in the EU is that States are encouraged to collaborate for the purposes of target compliance. This dimension should be utilized to establish roadmaps for cross-border H_2-CCS infrastructures. This is important in the context of the H_2-CCS chain which is thought to be not only national but pan-European. Indeed, States situated around the North Sea, such as the UK, Norway and the Netherlands, identify regional CCS clusters and cross-border transport options as a key market driver for their national H_2-CCS supply chains.[36]

3.2 Classification of and principles for evaluating 'sustainable' investments

A lack of clarity among investors regarding what constitutes a 'sustainable' investment is a contributing factor to the low-carbon investment gap.[37] There is no unified classification of a 'sustainable' investment and it is not clear exactly what investors take into account when making final investment decisions. A wide range of green finance bodies and indices for monitoring and assessing low-carbon performance exist across different jurisdictions, with different degrees of quality and integrity (e.g., OECD Centre on Green Finance, British Green Finance Institute, ASEAN Green Bond Standards, People's Bank of China guidelines).[38] Investors have cited reputational risks, stemming from negative market perceptions in the media where deals are considered insufficiently green, as a central barrier to low-carbon investments. Additionally, existing investment rules do not impose duties to consider sustainability factors across sectors. There is therefore a lack of transparency with regards to how environmental, social and corporate governance (ESG) criteria is included in decision-making processes.

The development of an internationally agreed and clearly articulated definition for 'sustainable' investments would allow investors to better assess the risk profile of

[30] Directive 2009/31/EC, Art. 33; Element Energy, *Global Best Practices in Assessment and Readiness for CCS Retrofit: Final Report* 2 (European Union 2016).

[31] Commission, DGMobility and Transport, *Clean Power for Transport Infrastructure Deployment: Final Report* 10 (European Union 2017); Hydrogen Council, *How Hydrogen Empowers the Energy Transition* 13 (Hydrogen Council 2017); Francesco Dolci et al., *Incentives and Legal Barriers for Power-to-Hydrogen Pathways: An International Snapshot*, 1 Int'l J. Hydrog Energy 6 (2019).

[32] Goldthorpe et al., *supra* n. 1, at 19.

[33] Hydrogen Europe recommend a minimum of 7% of NG volume is replaced by H^2 in gas networks by 2030, increasing to 50% by 2050. Hydrogen Europe, *Vision on the Role of Hydrogen and Gas Infrastructure on the Road Toward a Climate Neutral Economy* 22 (2019).

[34] Camilla Svendsen Skriung, *Moving CCS Forward in Europe* 7–8 (ENGO Network on CCS 2013).

[35] Committee on Climate Change, *Hydrogen in a Low-Carbon Economy* 6–7 (UK Committee on Climate Change 2018); OECD, *Risk and Return Characteristic of Infrastructure Investment in Low Income Countries* 16 (OECD 2015).

[36] Northern Lights project.

[37] Commission, *Action Plan on Financing Sustainable Growth*, COM/2018/097 final 2 (European Union 2018).

[38] Global Green Finance Council, *Global and European Green Finance Policy Directory* (Association for Financial Markets in Europe 2017).

low-carbon technologies and support investment decisions. This is important in developing classifications for the different types and definitions of H_2 (grey, blue, green, renewable, low-carbon, decarbonized) and would allow investors to clarify the sources of H_2 which meet requirements for financial incentives and target compliance.[39] Internationally agreed definitions would also enhance the monitoring and understanding of these investments by paving the way for the development of principles for assessing sustainability factors or supporting guarantees of origin for gases and certification processes for sustainable investments. For example, defining decarbonized hydrogen in relation to an ambitious emission reduction threshold will allow for a clear and unambiguous distinction between renewable and non-renewable production sources.[40] This would allow investors to assess the quality (and risks) of H_2 investments, strengthen requirements for the provision of information on ESG criteria and provide a basis for the treatment of hydrogen technologies in legislation on energy market design (unbundling, grid access, pricing).[41]

The benefits of developing classifications and principles for evaluating sustainable investments has already been recognized by the International Standardization Organization (ISO).[42] This work could support proposals by the British Standards Institution (for the United Nations to adopt a resolution on sustainable finance in line with achieving the Sustainable Development Goals (SDGs).[43] At the EU level, the Commission have adopted an action plan on sustainable finance as part of the Capital Markets Union project which focuses on reorienting private capital to more sustainable investment.[44] A key feature of the action plan includes the development of a regulation on a unified EU taxonomy to define sustainability.[45] Ahead of the adoption of the Taxonomy Regulation, the Commission established a Technical Expert Group to provide a first taxonomy for sustainable finance, incorporating 'high-level fundamental principles' into sustainable finance decision-making processes, with a particular focus on climate change mitigation activities. Its intention is to channel capital flows towards assets that contribute to sustainable development by integrating the taxonomy into EU legislation.[46] These legislative initiatives will better clarify the role of decarbonized H_2 within EU energy policies by providing increased legal certainty on whether it is defined as a 'sustainable' investment. However, there is also an underlying risk of lock-in, with the exclusion of certain technologies, depending on the classification chosen, but in the case of CCS technologies, those are recognized by the Taxonomy Regulation as making substantial contribution to climate change mitigation.[47]

The action plan also comprises of several other proposals including: the development of a voluntary EU-wide labelling scheme for green products through an Ecolabel Regulation, Green Bond Standards, a regulation on the obligations of investors to integrate ESG criteria into risk and decision-making processes and a new category of financial benchmarks for assessing low-carbon performance of investments.[48] The EU Council and Parliament have already agreed upon two new types of financial benchmarks: climate transition (low-carbon) benchmarks aiming to lower carbon footprint of standard investment portfolios and Paris-aligned (positive carbon impact) benchmarks which select components contributing to attaining the 2°C emission reduction target under the Paris Agreement.[49] These proposals would de-risk H_2-CCS investments by allowing investors to easily measure the performance of financial products, compare the sustainability of portfolio allocations and identify investments that comply with low-carbon criteria.[50] A labelling scheme is highly relevant in the H_2 and CCU retail markets for investors who express investment preferences towards green products, as a lack of labelling of financial products prevents investors from channelling funds into green investments. Labelling will address the risk of 'greenwashing' and prevent low-carbon indices being equally promoted despite having different characteristics.[51] Additionally, the measures will harmonize existing climate finance tools and increase transparency in decision-making processes by obliging investors to provide explanations of how ESG criteria and target compliance is reflected in their investment strategies.[52] This will integrate ESG criteria into investment decisions and

[39] Hydrogen Europe, *supra* n. 33, at 6.
[40] *Ibid.*, at 16–17.
[41] OECD, *Aligning Policies for the Transition to a Low-Carbon Economy* 55 (Meeting of OECD Council at Ministerial Level 2015); Green Growth Platform, *Financing the Global Low Carbon Transition* 2 (University of Cambridge 2015).
[42] ISO/TC 322 - sustainable finance.
[43] UN SDGs, *Finance*, https://sustainabledevelopment.un.org/topics/finance (accessed 25 Feb. 2021).
[44] Commission, *Financing a Sustainable European Economy: Final Report of the High-Level Expert Group on Sustainable Finance* 41 (European Union 2018); Commission, *Investment Plan for Europe: The Juncker Plan* (2014).
[45] Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088.
[46] COM/2018/097 final, 4; Commission, *supra* n. 44, at 12.
[47] Regulation (EU) 2020/852, Art. 10.1(e).
[48] Commission, *Report of the Technical Expert Group Subgroup on Green Bond Standard: Proposal for an EU Green Bond Standard*, Interim Report 9 (European Union 2019).
[49] European Union Press Release, *Sustainable Finance: Presidency and Parliament Reach Political Agreement on Low Carbon Benchmarks* (25 Feb. 2019).
[50] Commission, *Proposal for a Regulation of the European Parliament and the Council Amending Regulation (EU) 2016/1011 on Low Carbon Benchmarks and Positive Carbon Impact Benchmarks*, COM/2018/355 final, at 1–3; Commission, *Consumer Financial Services Action Plan: Better Products, More Choice*, COM(2017)139 final, at 7.
[51] COM/2018/355 final, at 3.
[52] COM/2018/097 final, at 8–9; Commission, '*A Proposal for a Regulation on Disclosures Relating to Sustainable Investments*

more closely align financial decision-making with longer-term perspectives of risk.[53] This is vital to the scaling-up of private sector investment in sustainable technologies such as H_2-CCS.

3.3 Energy market design legislation

3.3.1 *Developing an enabling legislative framework*

Two types of regulatory need can be identified: (i) the *clarification* of the currently applicable legal framework, where legislation is in place but needs interpretation in view of facilitating H_2-CCS activities although they do not hinder the latter, but create legal uncertainty; and (ii) *adaptation* of current framework or need for new rules, where legislation excludes or prevents the development of H_2-CCS activities.

As concerns energy market design legislation, the following is deemed essential to enable the H_2-CCS chain. First, the qualification of certain activities needs to be clarified, as they do not necessarily coincide with the current legislation on energy market design (electricity, gas and heat). An example is unclear coverage of the temporary storage of CO_2 and hydrogen. Second, the complexity of existing permitting processes for H_2-CCS also appears as an important risk factor preventing private sector investment because a number of separate permits must be obtained through the supply chain: CO_2 capture, transport and storage licenses, permits for H_2 production, grid connection and transmission, emission permits and safety and civil protection permits.[54] Most of those procedures are also subject to strategic and environment impact assessment requirements. Third, the applicability of strict third party access regimes and unbundling rules to immature market segments could refrain or delay investments in more integrated chains. Regulatory incentives can be provided through the grid access regime, as has been the case for RES.

3.3.2 *Facilitating energy system integration through legislation*

Energy system integration refers to the planning and operating of the energy system 'as a whole', across multiple energy carriers, infrastructures and consumption sectors.[55] In Europe, it is closely linked to the ongoing technological transformation of the energy system towards a more climate neutral, decentralized, digital and reliant model. Therefore, the European Commission has adopted a dedicated EU strategy for energy system integration that includes hydrogen and CCS, separately, but also in combination.[56]

So far, national policies has largely focused on individual CCS and H_2 demonstration projects, without any specific regulation for the establishment of national capture clusters, storage hubs or shared transport infrastructure.[57] This creates cross-chain interdependency and delays as investment decisions for the separate infrastructures are needed before there is certainty that the capture plant will have access to storage sites or the storage site will be required.[58] Continuing to implement incremental, isolated demonstration projects will push the full-scale deployment of H_2 and CCS technologies into the future.[59] It is therefore necessary to move beyond single-source demonstration policies towards those which actively encourage the deployment of shared infrastructures.[60] This can be done through establishing specific government agencies with a long-term strategic vision for how and when shared CCS and H_2 infrastructure will be deployed.[61] This will reduce the costs of deployment and overcome coordination failures by setting policy ambitions for the delivery of infrastructure in the different phases. It will also remove scepticism regarding the viability of a full-scale chain by creating opportunities for multiple capture plants to have access to shared infrastructure for CO_2 storage and H_2 production.[62]

3.4 Legal liability regimes

At different levels of the H_2-CCS chain there are different liability risks that must be managed. This includes, but is not limited to: CO_2 leakage during transportation, injection or after 'permanent' storage and site closure; H_2 loss during temporary storage or transportation; third-party damages; H_2 or CCU consumer product liabilities; and life-cycle liabilities for CCU. The extension of traditional forms of liability such as third-party damage liabilities are unlikely to be real barriers to H_2-CCS deployment as the risks associated with these are familiar and can be managed by pre-existing de-risking measures (financial securities and insurance).[63] However, the imposition of new types of liability and a lack of practical experience in how they will be applied creates uncertainty for investors. Additionally, different types of project will require

and Sustainability Risks and Amending Directive 2016/2341, COM(2018)354 final, at 6–7.

[53] Commission, *supra* n. 44, at 13.

[54] Banet & O'Brien, *supra* n. 4, at 26, 45; Getica CCS, *Permitting report to the Global CCS Institute: Public Report - Demo Project Romania* 5–6 (Global CCS Institute 2011).

[55] European Commission, Communication, *Powering a Climate-Neutral Economy: An EU Strategy for Energy System Integration*, COM(2020)299 final, 2 (8 July 2020).

[56] *Ibid.*, at 12–13.

[57] John P. Banks, Tim Boersma & Ward Goldthorpe, *Challenges Related to Carbon Transportation and Storage – Showstoppers for CCS?* 15–16 (Global CCS Institute 2017).

[58] Alex Zapantis et al., *Policy Priorities to Incentivise Large Scale Deployment of CCS*, Thought Leadership Report 8 (Global CCS Institute 2019).

[59] UK Committee on Climate Change, *Net Zero: The UK's Contribution to Stopping Global Warming Committee on Climate Change* 9 (2019).

[60] Banks, Boersma & Goldthorpe, *supra* n. 57, at 17.

[61] OECD, *Risk and Return Characteristic of Infrastructure Investment in Low Income Countries* 16 (OECD 2015).

[62] Zero Emissions Platform, *An Indispensable Solution*, Pan European Networks (ZEP 2017); Zapantis et al., *supra* n. 58, at 17–18.

[63] Ian Havercroft, *Addressing the Liability Challenge* (Global CCS Institute, Insights 2019).

different approaches to liability risk management. Small-scale projects have lower liability risks but are more vulnerable to costs associated with these risks, compared to larger projects which can better absorb costs. The form and application of liability frameworks will therefore differ depending on the specifics of each project and the types of actors involved. With these considerations in mind, different legislative instruments can be developed to remove or reduce the liability risks associated with H_2 and CCS.

3.4.1 *Legislative allocation of liabilities*

It is unlikely that private actors will be prepared to invest in a project without a clear position on the allocation of liabilities. Liability frameworks can therefore de-risk investments by fairly apportioning risks associated with H_2-CCS activities according to each party's role and responsibilities.[64]

An important consideration for the allocation of liabilities in complex supply chains is how far an operator in one phase can be allocated losses arising in another. The nature of H_2-CCS chain means that all phases are interdependent on each other. If an accident occurs along the chain which prevents delivery of CO_2 to the storage site, then the upstream operator could be liable to the downstream operator for the market value of CO_2. However, it is not clear if the upstream operator would also be liable for the greater impact suffered by the project, as a result of their lack of performance, which prevents operation of the chain. Liability allocation rules must therefore be developed which clearly define the scope of an operator's cross-chain liability and how these kinds of losses will be compensated.

A related question is whether there are circumstances in which an upstream operator can be allocated losses in another part of the chain despite meeting their performance obligations. A fair balance of responsibilities and risks along the chain may require operators to be allocated cross-chain liabilities to protect the commercial viability of the separate infrastructures along the chain. An example of this is the emerging liability regime for CO_2-shipping. Under the HNS Convention, the storage operator can be held liable for third-party damage resulting from loss of contained CO_2 during the shipping phase of CCS where claim values reach the HNS Fund.[65] The allocation of liabilities in this way de-risks investment in the transport phase of CCS by allowing the potential for very large CO_2-shipping liabilities to be shared between private actors (the shipowner and the storage operator).

A separate dimension of liability regimes is how they can be used as tools to allocate risks normally borne by private actors to the public sector. This is important when seeking to manage risks associated with new types of liability, as private parties are reluctant to invest due to a lack of knowledge regarding the magnitude of risks. A fair allocation of liability by law must strike a careful balance between imposing undefined and unlimited liabilities on operators and imposing unreasonable liabilities on the public sector. When liabilities are solely placed on the private sector, the potential for undefined liabilities can prevent investment. It is therefore important to develop a H_2-CCS liability allocation strategy which ensures the private sector are not subject to undefined liabilities for CO_2 leakages (as the price of CO_2 fluctuates according to the market). At the same time, liability allocations should promote best practices and ensure adequate incentives to minimize risk for the duration of the project. Where liabilities are borne solely by the public sector there is a risk of introducing moral hazard behaviours, where the private party does not implement appropriate risk reduction strategies to minimize the likelihood of liabilities arising.[66] The formation of a clear and balanced risk allocation strategy for liabilities between the public and the private sector is therefore an important tool. One issue in this regard arises where CO_2 is shipped to the storage site. Shipping is not included within the EU ETS, meaning any CO_2 transferred to a ship for storage is currently added to the capture and storage installations total annual CO_2 emissions.[67] This has the effect of allocating CO_2 emissions liability under the EU ETS even where there is no CO_2 leakage. This removes the economic incentive under the EU ETS for engaging in CCS. A more satisfactory allocation of liability must therefore be developed to ensure liabilities imposed on CO_2 shipping operators correspond to the actual amount of CO_2 lost.

3.4.2 *Legislative risk-transfer mechanisms*

The question of long-term CO_2 storage liabilities remains critically important for the deployment of CCS. No insurance policies yet cover long-term CO_2 leakage risk from the storage reservoir and the unlimited nature of potential liability means comprehensive insurance solutions are unlikely to be developed. These uncertainties prevent the use of risk-transfer mechanisms in commercial arrangements because contractors will unlikely accept unknown, uninsurable risks. This limits the ability of the private sector to effectively mitigate against long-term leakage liabilities and could prevent investment because operators will retain responsibility for the storage site indefinitely, without a tool to reduce or transfer risk to another entity. The implementation of liability de-risking strategies in which governments provide guarantees for uninsurable elements is therefore crucial to incentivise CO_2 storage infrastructure investments.[68]

[64] Goldthorpe et al., *supra* n. 1, at 57.
[65] Convention on Liability and Compensation for Damage in Connection with the Carriage of HNS by Sea (adopted 3 May 1996) Art. 14.
[66] Behdeen Oraee-Mirzamani, Tim Cockerill & Zen Makuch, *Risk Assessment and Management Associated with CCS*, 37 Energy Procedia 4759 (2013).
[67] Alice O'Brien, *The Liability Framework for the Shipping Phase of Carbon Capture and Storage: A Critical Study of the Liability Regime for CO2 Leakage During Cross-Border CO2-Shipping Activities in the North Sea*, Marlus 512, 39 (2019).
[68] Goldthorpe & Ahmad, *supra* n. 22, 7543.

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Under the EU storage liability model, national governments agree to underwrite long-term CO_2 leakage liabilities after several pre-conditions are met: CO_2 is 'completely and permanently contained', a financial mechanism is in place for post-transfer obligations and a pre-defined time period has lapsed (twenty years or more after site closure).[69] The transfer of liability to the public sector is therefore not absolute or unconditional, retaining reasons for the private sector to employ best practice standards.[70] The project developer is subject to a form of strict liability until liability transfer and is required to obtain financial securities to cover their potential liability.

The EU storage model is an example of how risk-transfer solutions between an operator and a public authority can be implemented to overcome problems relating to undefined liabilities along the H_2-CCS value chain.[71] The framework allows private investors to cap the unlimited temporal nature of CO_2 leakage liabilities whilst assuring public actors that the level of risk at the point of transfer is low.[72] Nevertheless, a lack of practical experience regarding how the EU model will be imposed continues to undermine investment decisions. Financial securities and post-closure contributions have also been criticized for being prohibitively expensive and imprecise.[73] With this in mind, any risk-sharing model for undefined liabilities along the H_2-CCS chain must ensure the imposition of precise terms to equip investors with the tools to assess the liability risks and costs. This must include greater collaboration between regulators and project developers to ensure that an acceptable position on risk-sharing is achieved.[74]

3.4.3 *Liability exemptions and liability capping*

If risk cannot be allocated or transferred away from the private sector, then liability regimes can introduce exemptions or caps to reduce liability risks. At present, no level of CO_2 leakage is acceptable through the chain and this makes the liability risks high. Although leakage along the supply chain should be avoided, a failure to deploy CCS means 100% of CO_2 is emitted without any potential for mitigation. It may therefore be reasonable to exempt operators from liability where there are low levels of leakage through the supply chain. This raises the question of what level of leakage is acceptable. In the transmission of electricity, operational losses up to 15% are not unusual, depending on the distances travelled.[75] It could therefore be reasonable to allow similar levels of CO_2 or H_2 to be lost through the supply chain (provided there is no third-party damage).

If exemptions from liability are not acceptable then another option would be to introduce liability caps where the level of liability is limited in accordance with the risk posed by the operations. This method is common in the maritime industry where shipowners are often subject to strict but limited liability in accordance with the tonnage of the vessel. Similar limitations could be developed for liabilities along the H_2-CCS chain; for example, liability could be limited in accordance with the amount of CO_2 captured/transported/stored. Any liabilities above the pre-determined cap could be distributed to other private actors along the chain, or transferred to the public sector.[76]

3.4.4 *Legislative risk-sharing and pooling mechanisms*

Longer-term legislative solutions for liability risks could come in the form of risk-sharing and pooling mechanisms to underwrite large or unquantifiable liabilities. These mechanisms can limit the liabilities faced by individual investors by diversifying risk between private actors involved in the same types of activities. This is particularly attractive in circumstances where risks are complicated, highly technical or relatively uncertain.[77] This is because pooling is possible even if the magnitude of the risk is unknown.[78] Risk-pooling funds between operators can therefore overcome the difficulties associated with exclusions from insurance coverage by providing mitigation through the industry's own resources.[79] It can also be beneficial where the likelihood of risks emerging is low because they can be designed to require contributions only after risk transpires (retrospective contributions), in contrast to insurance premiums which are payable whether risk arises or not.[80] Risk pooling is also an effective way of encouraging best practices because all members of the pool share each other's losses and there is therefore an incentive for operators to employ risk management strategies.[81]

The handling of risk in the maritime, nuclear and oil industries demonstrates how risk pooling can be used to overcome extraordinary risks that the traditional insurance market will not cover.[82] The international regime for ship-sourced oil pollution at sea aims to establish a balanced liability regime for maritime incidents by sharing liability between shipowners and the oil industry.[83]

[69] Directive 2009/31/EC, Arts 18 and 20.

[70] Global CCS Institute and UCL, *Legal Liability and Carbon Capture and Storage: A Comparative Perspective* 37 (2014).

[71] Goldthorpe et al., *supra* n. 1, at 58.

[72] *Ibid.*, at 56–57.

[73] Adna Pop, *The EU Legal Liability Framework for Carbon Capture and Storage: Managing the Risk of Leakage While Encouraging Investment*, 6 ASLR 39 (2016).

[74] Havercroft, *supra* n. 63.

[75] International Electrotechnical Commission, *Efficient Electrical Energy Transmission and Distribution* 8 (2007).

[76] Zapantis et al., *supra* n. 58, at 20.

[77] *Civil Liability and Financial Security for Offshore Oil and Gas Activities* 229 (Michael Faure ed., CUP 2016).

[78] *Ibid.*, at 220.

[79] Simon Carroll, *Perspective on the Pros and Cons of a Pooling-Type Approach to Nuclear Third Party Liability*, OECD/NLB 87 (2008).

[80] Faure, *supra* n. 77, at 200.

[81] *Ibid.*, at 174.

[82] Michael Faure & Karine Fiore, *The Coverage of the Nuclear Risk in Europe: Which Alternative?*, 33 Geneva Risk Ins Rev. 291 (2008).

[83] International Convention on the Establishment of an International Fund for Compensation for Oil Pollution Damage

The shipowner is liable up to a predetermined limit (covered by mandatory insurance) and any claims over this limit are met by a fund made up of contributions from receivers of oil. The establishment of a two-tiered sharing mechanism allows potentially very high levels of liability to be mitigated by distributing risk between stakeholders involved in the maritime oil transportation industry. Similarly, the Price-Anderson Act (US) implements a mandatory two-tiered system of liability in the nuclear industry, with the individual operator being liable up to a predetermined limitation in first instance and all nuclear operators within the scheme then being retrospectively and proportionately liable for incidents reaching the second tier. This agreement reduces the level of risk faced by individual operators by sharing the costs of any claims between members. Finally, OPOL is a voluntary, non-legislative compensation scheme (although mandatory for the granting of an offshore license in the UK) which allows limited types of risk relating to offshore pollution to be diversified between offshore operators.[84] OPOL differs from the aforementioned risk-pooling mechanisms because the obligation for members to contribute for qualifying incidents is only engaged when the 'responsible' operator is unable to meet claims through its financial securities.[85] OPOL may therefore be better described as a solvency guarantee, with the pool only being liable in cases where operators become insolvent.

Similar legislative risk-sharing and pooling mechanisms could be developed for large or unquantifiable liabilities along the H_2-CCS chain. For example, the sharing of pre-transfer and/or post-transfer storage liabilities between CO_2 storage operators. This would offer a solution to the current impasse for long-term CO_2 storage insurance coverage. However, given a current lack of market players in CO_2 storage activities, it is unlikely the private sector would have the resources to create an industry specific fund. The role of the public sector in providing initial capital to establish and administer the fund would therefore be significant due to financial security requirements for CCS at the EU level.[86] These levels of public finance are perhaps unlikely for CO_2 leakages given the low risk of leakage and the small number of facilities likely to be requiring such a scheme. This is particularly true given that not all States will want to be involved in storage activities and will therefore not be in a position to contribute to a State-underwritten liability fund. Nevertheless, this does not rule out the creation of funds between individual States or within regions interested in accelerating CCS deployment such as the North Sea. This could serve as an instrument to allow a transition overtime from public to private underwriting and management of the fund. An alternative solution would be the broadening of existing funds within the oil industry to storage operators until there is a critical mass of ongoing projects and operators who can contribute to the fund (although the oil industry may not be prepared to underwrite these types of liabilities).

3.5 International harmonization initiatives on products and processes

A lack of regulation on technical appliance standards, product characteristics or quality control is a risk factor for investors.[87] De-risking measures could therefore be directed towards developing transparent and well-formulated international technical standards for the H_2-CCS chain. International harmonization practices are attractive to investors because they reduce both domestic and cross-border trading costs by minimising the technical barriers to trading and the volume of applicable legal requirements. Additionally, establishing common definitions for technical requirements provides increased certainty in the development phase of emerging technologies, increasing the speed and reducing the costs at which private actors can bring technologies to market.[88] International standards also enhance the business case for emerging technologies by establishing the reliability and repeatability of outputs as well as increasing the confidence of consumers in novel technologies.

During the initial stages of technology development, it can be costly for the private sector to test safety cases and develop universal standards. This means public actors have an important role in encouraging and leading harmonization initiatives. An important feature of this role is the development of regulatory monitoring systems and compliance certificates to ensure uniform verification of voluntary standards. It is therefore a critical role of national governments and the EU to ensure rules on implementation and monitoring are in place.

3.5.1 *Fuel quality requirements*

Fuel quality requirements are essential to determining the safety and reliability of H_2 through the supply chain. In an integrated EU fuel market, suppliers could have fuel rejected in States because national quality specifications are not met.[89] Harmonized fuel quality requirements can therefore enable the establishment of an EU-wide H_2

(adopted 18 Dec. 1971, entered into force 16 Oct. 1978) UNTS 1110(17146), at 57; International Convention on Civil Liability for Oil Pollution Damage (adopted 27 Nov. 1992, entered into force 30 May 1996) UNTS 973(14097), at 3.

84 OPOL, 'About OPOL', www.opol.org.uk/about.htm (Accessed on 25 Feb. 2021).

85 Faure, *supra* n. 77, at 181.

86 Goldthorpe et al., *supra* n. 1, at 56.

87 UNDP, *Derisking Renewable Energy Investment Selecting Public Instruments to Promote Renewable Energy Investment for the Tunisian Solar Plan*, NAMA Full Report 31 (UNDP 2018).

88 Beuth Verlag, *Economic Benefits of Standardization: Summary of Results Final Report and Practical Examples* 12 (DIN German Institute for Standardization 2000); Eoin O'Sullivan & Laure Brévignon-Dodin, *Role of Standardisation in support of Emerging Technologies: A Study for the Department of Business, Innovation & Skills and the British Standards Institution* 5–7 (Institute for Manufacturing 2012).

89 CCMC, *Sector Forum Energy Management/Working Group Hydrogen Final Report* 35 (European Union 2016).

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market because operators are assured their product will not be refused on the basis of local quality standards. Fuel quality requirements which monitor and account for GHG emissions across the full life-cycle of fuels (production-storage-supply-use) are particularly important because they ensure that fuels resulting in a net reduction in emissions can be recognized and rewarded under climate change policies such as the EU's fuel transport targets.[90]

At the international level, ISO has developed several standards for H_2 fuel quality in FCEVs and stationary appliances. These include ISO/14687 on H_2 product specifications, ISO/19880-8 on gaseous H_2 quality at fuelling stations, ISO/TS/20100 on fuel specification for HRSs for motor vehicles and ISO/17268 on H_2 quality for motor vehicle refuelling connection devices.[91] ISO is also currently revising purity requirements under ISO/14687-2.[92] These standards have been endorsed by the EU through Directive 2014/94/EU which requires hydrogen refuelling stations to comply with ISO technical purity specifications.[93] Additionally, the EU has advanced European standards for H_2 quality through European Committee for Standardization (CEN) Mandate TC268 which aimed to specify an EU position based on ISO/14687-2 and ISO/19880-8. They have also funded projects such as HyQ (2011–2014) and HyCORA (2014–2017) to develop comprehensive and harmonized purity requirements for application in transport and other sectoral applications as well as reducing the cost of implementing standards.[94] This has resulted in EU H_2 fuel product specifications and quality assurance standards for FCEVs.[95]

Despite these initiatives, there remains a lack of harmonization for the safe transportation of H_2 fuels.[96] Most States do not have national legally binding requirements for fuel suppliers to provide a specific H_2 purity level and the ISO standard requiring 99.97% purity level in fuel cells is not always complied with due to difficulties of identifying contaminants and the associated CAPEX.[97] These differences in application are a barrier to safe and efficient cross-border trading. With this in mind, there is a need for further efforts to not only standardize fuel quality requirements across States but also ensure harmonized application of these rules through cross-border compliance mechanisms.

3.5.2 *Fuel blending standards*

A major bottleneck to developing H_2 pathways in Europe is the lack of standardized gas composition and (maximum) blend concentrations for H_2 production, transmission, storage and distribution.[98] At present, international and EU standardization bodies do no regulate standards for use of H_2 in NG. This leaves the regulation of fuel blending to individual States. Maximum injection limits across Europe (set by specific national legislation or existing safety standards) range from 0.1%–10% in the existing NG networks.[99] These differences make it difficult to specify an amount or common Wobbe index which would be suitable across gas networks in Europe. The definition of harmonized fuel blending standards is therefore not possible due to disparities in current national standards. This leads to fragmentation of the gas market and hinders the establishment of cross-border H_2 transport networks by creating local barriers to H_2 adoption. Additionally, many of these national limits endorse much lower values of H_2 than are technically feasible by only allowing for insignificant levels of H_2 in NG networks. Indeed, up to 25% H_2 could be injected into existing NG networks, depending on the integrity of existing pipelines (with higher limits feasible after gas infrastructure upgrades).[100] In the UK, H_2 incorporation into the gas grid is restricted to 0.1%. This prevents large-scale H_2 injection into national gas grids and stalls 100% H_2 infrastructure because demonstration projects can only be undertaken in smaller, isolated networks. This is despite an ongoing Iron Mains Risk Reduction Programme which mandates the upgrading of pipeline distribution networks to polyethylene pipes which could safely transport 100% H_2. Key stakeholders have therefore recommended that the UK Government expediate safety demonstrations and establish evidenced safety cases for H_2 introduction in large-scale networks.[101] This would then be followed by the prioritization of amendments to allow for higher acceptable blends of H_2 into the national gas grid.

The modification of national regulatory standards requires States to be proactive in allocating the necessary time and resources. At the current pace, there is concern that

[90] Directive 2009/30/EC of 23 Apr. 2009 amending Directive 98/70/EC as regards the specification of petrol, diesel and gas-oil and introducing a mechanism to monitor and reduce greenhouse gas emissions. It requires a reduction of the GHG intensity of transport fuels by a minimum of 6% by 2020.

[91] ISO/DIS 14687-1 -2 -3 Hydrogen fuel quality – Product specification; ISO 19880–8 'Gaseous hydrogen – Fuelling stations – Part 8: Hydrogen Quality Control'; ISO/TS 20100 Gaseous Hydrogen Fuelling specification for hydrogen refuelling points for motor vehicles; ISO 17268 gaseous hydrogen motor vehicle refuelling connection devices standard.

[92] ISO/DIS 14687 Hydrogen fuel quality – Product specification [under development].

[93] Annex II.

[94] FCH-JU, *Fuel Cells and Hydrogen Programme Review 2011: Final Report* 44 (2012).

[95] EN 17124:2018 Hydrogen fuel - Product specification and quality assurance - Proton exchange membrane fuel cell applications for road vehicles.

[96] International Energy Agency, *The Future of Hydrogen: Seizing Today's Ppportunities – Executive Summary and Recommendations* 3 (2019).

[97] Commission, *4th International Workshop on Hydrogen Infrastructure and Transportation* 20–21 (JRC Conference and Workshop Reports 2016).

[98] Francesco Dolci et al., supra n. 31, at 4.

[99] Dennis Hayter, *Hydrogen Law and Removal of Legal Barriers to the Deployment of Fuel Cells and Hydrogen Applications: UK National Policy Paper* 65 (HyLaw 2018).

[100] Roland Berger, *Development of Business Cases for Fuel Cells and Hydrogen Applications for Regions and Cities: Hydrogen Injection into the Natural Gas Grid* 8 (FCH-JU 2017).

[101] BEIS, *supra* n. 22, at 15.

these changes may not happen quickly enough. However, initiatives to validate higher blends of H_2 are already being trialled through projects across Europe such as GRHYD (France) and HyDeploy (UK). The first phase of HyDeploy has been granted local permissions to inject up to 20% into private NG networks at Keele University.[102] Success at this location will then allow the next phase of trails to go ahead across Northern England. German standardization body, DIN, has also established a pilot study for standardization of H_2 gas quality in their NG networks.[103] These initiatives will not only encourage national governments to allow higher H_2 concentration limits but could lead to EU-wide standards for the injection of H_2 and H_2 blends into gas infrastructures.[104] The Commission have issued a request for CEN to perform standardization work covering the development of fuel quality requirements within NG grids, including when alternative fuels such as H_2 are injected into NG infrastructures.[105] The Commission also issued a call for research to define the admissible H_2 percentage for use in domestic and commercial applications both with and without modifications to existing ISO certifications.[106]

Ultimately, for these initiatives to prove successful, national governments must facilitate work at the international and EU level by supporting and advocating for the development of national H_2 fuel quality specifications. Close cooperation must be established between national legislators and industry to ensure a timely, comprehensive and coordinated approach to standardization across the EU.[107] This would enable the commercialization of large-scale domestic and cross-border H_2 transport and supply networks by providing an EU understanding of the acceptable H_2 content (beyond individual pipeline networks). It would therefore pave the way for a common H_2 supply framework and establish the position of H_2 in the single fuel market, making long-term infrastructure investments more attractive and accessible.[108] It would also facilitate the re-use of existing natural gas installations and bring clarity to H_2 safety across States, reducing costs and increasing public acceptance.

3.5.3 *CCU life-cycle assessments (LCA)*

It is possible that CCU processes could result in greater CO_2 emissions than the traditional fossil-fuel activity that is being mitigated.[109] The risk that CCU investments may not in fact contribute to meeting emission reduction targets prevents investment into these processes. ISO has developed a standardized methodology for monitoring LCAs of processes.[110] At the EU level, the Commission have developed guidelines on the Best Available Technique (BATs) to be used for preventing or minimizing emissions and impacts on the environment.[111] These guidelines require permits to specify emissions limit values and other environmental outcomes for installations in industrial processes (from their design to decommissioning). Additionally, a new life-cycle methodology has completed a pilot phase which, if adopted, will likely be applied to CCU case studies.[112] This could de-risk private sector investments in CCU by assuring project developers that CO_2 utilization will allow them to qualify for emission reduction incentive schemes.

4 De-Risking the H_2-CCS Value Chain Through Contract

Contractual agreements are an important tool for developing risk management strategies for the supply chain. This section considers the de-risking role of contractual risk allocation mechanisms. It discusses how contract negotiations, contractual structures and choice of law can alter the types of contractual risk allocation mechanisms used within contracts. It will then considers how risk allocation mechanisms within existing large-scale infrastructure agreements and with small and medium-sized enterprises (SMEs) can provide examples of risk allocation models for H_2-CCS chains. In particular, it looks at the importance of public sector involvement in de-risking initial infrastructure projects. Finally, it considers the benefits of standardizing contractual terms along the supply chain.

4.1 Contractual risk allocation mechanisms as a de-risking measure

Contracts can be used as a tool to de-risk investment by implementing risk allocation mechanisms which clearly assign, transfer or share risks between contracting parties. This is particularly important with regards to investments in clean energy technologies which are typically regarded as having higher risk due to the immaturity of the market and the need to develop new or adapt existing

[102] HyDeploy, *Positive Progress to Reduce UK C02 Emissions*, https://hydeploy.co.uk/ (accessed 25 Feb. 2021).
[103] DIN Subordinate Committee Gas Technology, NA 032-03-05-01 AK.
[104] NEN Netherlands Standardization Institute, *Normalisatieplatform waterstof voor de industriële en gebouwde omgeving* 28–32 (NEN 2018).
[105] Commission, *Mandate 400 to CEN for Standardisation in the Field of Gas Qualities* (European Union 2007); CEN/TC 234 Gas Infrastructure- Quality of gas- Group H.
[106] Horizon2020 Framework Programme, *Hydrogen Admixtures in Natural Gas Grids FCH-04-3-2019.*
[107] Hydrogen Europe, *supra* n. 33, at 15.
[108] European Financial Services Round Table, *Facilitating European Infrastructure Investment* 1 (EFS 2018).
[109] Niklas von der Assen et al., *Life Cycle Assessment of CO2 Capture and Utilization: A Tutorial Review*, 14 Chem. Soc. Rev. 7982 (2014).
[110] ISO 14040/14044 Environmental management – Life cycle assessment – Requirements and guidelines (2006).
[111] Directive 2010/75/EU of 24 Nov. 2010 on industrial emissions, Art. 13.
[112] Commission, *Building the Single Market for Green Products: Facilitating Better Information on the Environmental Performance of Products and Organisations*, COM/2013/0196 final.

infrastructures. At the starting point of any contractual risk allocation is the need to identify the types of risks that will be shared as well as consider how choices of contractual structure and law can alter the ways in which risks will be allocated and interpreted.

4.1.1 *Identification of risks and negotiation of contract*
Contractual risk allocation requires a clear understanding of the relevant risks and their potential effects.[113] The identification of risks is particularly challenging where contracts involve the deployment of new supply chains such as H_2-CCS, given a lack of experience of the specific risks and effects. The identification of unknown risks is not possible and so, it is important for contracts to establish effective recourse and dispute resolution mechanisms through the formation of a governance structure which allows disputes or contractual issues to be resolved quickly.[114] This should include provisions which limit the continued renegotiation of contractual terms, albeit the innovative nature of clean energy projects may make it necessary for unexpected project risks to be addressed after contract conclusion.

4.1.2 *Selecting an appropriate contractual structure: Integrated v. non-integrated contracts*
Multi-contractor structures create interface concerns which must be managed as a separate risk factor. The way in which project contracts are structured through the supply chain can dictate how far risks can be shared between actors. There is a distinction between fully integrated contracts and non-integrated contracts. Fully integrated contracts involve parties along the supply chain forming a single entity to carry out the project. In this model, all parties work together to achieve the desired result. They are all exposed to project risks over the whole chain, whilst individual exposure to operational risks arising in different elements of the chain are reduced. In contrast, non-integrated contract structures comprise of a set of separate agreements in which each party contracts separately. For example, where parties bilaterally enter into supply-or-pay and take-or-pay contracts which specify fixed payments and supply/purchase obligations. This model requires different actors along the supply chain to manage their individual operations, with each party bearing responsibility for their allocated risks[115] Non-integrated contracts therefore allow individual operators to guard their individual commercial interests.

In terms of private sector risk-sharing, there are benefits to adopting an integrated contractual model in the early stages of deployment. H_2-CCS activities involve the establishment of a new supply chain and it is not clear where the risks will arise. The interdependent nature of H_2-CCS operations also means that risks arising later on in the supply chain could be caused by earlier phases. Early CCS projects have thus far involved dedicated transport and storage infrastructure being matched with an individual capture source to deliver a fully operational end-to-end chain. This lends itself to integrated, end-to-end risk management by allowing risks to be diversified, reducing an individual operators' exposure to underperformance or failure and establishing a holistic business case for the entire chain.[116] For H_2-CCS, project structures may be more complex, involving CO_2 capture, treatment, transport, storage or utilization infrastructure and/or H_2 production, transport and supply infrastructure. It may therefore be challenging to establish an integrated contractual model because operators accustomed to operating in one sector may not be willing to accept risks at a different phase of the supply chain which they have no experience. It is also clear that once experience in large H_2-CCS infrastructure projects has developed, non-integrated contracts may become increasingly more desirable to enable non-interdependent regional CCS networks, where operators can obtain access to multiple transport networks or storage hubs for their supply chain.[117]

4.1.3 *Choice of law considerations*
A separate issue is the differences in legal tradition between common law and civil law jurisdictions. These differences are important to consider during contract negotiations because choice of law questions can materially change how risk allocations are interpreted.

Civil law contracts allow for subjective interpretation of contract terms, including assessments of reasonableness and good faith, in an attempt to adjust outcomes and avoid unjust solutions.[118] Additionally, in some civil law jurisdictions, contracts concluded for public services are governed by specific administrative laws. Administrative laws stipulate compulsory terms with precise legal meanings to be included within the contract, including the right of a contracting party to unilaterally cancel a contract at any point during the contractual period, the right to compensation as a result of increased operational costs and the right of the State to make unilateral changes to contractual terms in the public interest.[119] The rights to change, terminate or continue contracts is therefore prescribed directly by the law and not by the contract. In contrast, common law takes an objective approach to contract interpretation,

[113] Chotchai Charoenngam & Chien-Yuan Yeh, *Contractual Risk and Liability Sharing in Hydropower Construction*, 17(1) IJPM 33 (1999).
[114] IRENA, *Unlocking Renewable Energy Investment: The Role of Risk Mitigation and Structured Finance* 75 (2016).
[115] SCCS, *Opportunities for CO^2 Storage Around Scotland – an Integrated Strategic Research Study* 38 (University of Edinburgh 2009).
[116] Banks, Boersma & Goldthorpe, *supra* n. 57, at 8.
[117] CarbonNet Project, *Developing a Business Model for a CCS Hub Network*, 13 (Global CCS Institute 2015).
[118] Giuditta Cordero Moss, *International Contracts between Common Law and Civil Law: Is Non-state Law to Be Preferred? The Difficulty of Interpreting Legal Standards Such as Good Faith*, 7(1) Glob Jurist 1 (2007).
[119] UNCITRAL, *Legal Analysis on Public-Private Partnerships Regarding Model PPP Rules* 9 (UNCITRAL 2012); World Bank, *Legal Systems Overview*, https://ppp.worldbank.org/public-private-partnership/legislation-regulation/framework-assessment/legal-systems (accessed 25 Feb. 2021).

considering only what a reasonable person would have believed the contract to mean at the time of concluding the contract. There are therefore few terms implied into common law contracts and parties are assumed to be able to assess their business risks. Contracts based in common law will require extensive due diligence making contract negotiations more challenging and costly. Some other key differences between the interpretation of common and civil law contracts relate to the treatment of bankruptcy, asset securities and dispute resolution. In common law, bankruptcy focuses on restructuring (debtor retains control of assets but the terms of the debt are renegotiated with creditors) whilst civil law focuses on liquidation (debtors seize assets to sell). Additionally, common law allows greater flexibility in granting security over assets, recognizes the principle of estoppel and is more likely to favour arbitration (as opposed to litigation).

Ultimately, the chosen jurisdiction for contractual interpretation will differ depending on the specifics of the project and the actors involved. In the initial roll-out of new infrastructure where unanticipated risks may arise, civil law contracts may be more desirable because courts focus on avoiding unjust solutions and protect rights to compensation where operational costs increase. Nevertheless, the treatment of bankruptcy, right to assert estoppel and the use of arbitration may appeal more to other developers.

4.2 Risk allocation models in large-scale infrastructure agreements

The design of risk allocation models will differ depending on the size of the enterprise and proposed project. In large-scale infrastructure projects, a complex organizational structure means there are a number of elements to consider when developing risk mitigation strategies. Larger enterprises, multi-layered relationships and a multi-levelled supply chain mean there is an increased likelihood of contractual disputes, accidents, cost overruns and delays.[120] Appropriate risk allocation mechanisms within these contracts can mitigate and balance the risks of H_2-CCS by allowing the private sector to invest in infrastructure whilst sharing risks with other private actors and the public sector.

4.2.1 *Involvement of the public sector*

In the initial stages of large-scale H_2-CCS, an element of contractual risk-transfer or sharing between the private and public sector will be necessary to de-risk areas the private sector is not willing to manage alone. There are different ways in which public-private contractual arrangements can be created and each option will involve different combinations of risk allocation. The chosen model will depend on the State, the diversity of actors involved, the specifics of the project and the intended H_2 end market.

A common tool used to de-risk private sector investment in major infrastructure projects is PPPs. PPPs involve the conclusion of a long-term, upstream contract between private and public parties (via. tender and competitive bidding) for the delivery of public infrastructure or services. Expanding the use of PPPs for the deployment of public energy infrastructure allows the government to capitalize on private sector technology, innovation and expertise, whilst minimizing their own expenditure.[121] PPPs can also de-risk private sector investments because they allow risks to be allocated, transferred and shared.. Of course, PPPs are not the only tool to de-risk energy infrastructure investments and it is critical that Governments examine and select the model which best suits their national and project specificities. Nevertheless, PPPs have been regarded as having a central role in mobilizing private sector finance in renewable energy across Europe.[122] They are therefore likely to form an integral part of de-risking strategies for other low-carbon investments, including H_2-CCS infrastructure.

The type and scope of the PPP contract will determine the level of risk allocated to each sector. Whole life contracts cover risks along the entire supply chain whilst individual service agreements will incorporate only specific elements of risk and responsibility. For example, the private sector can assume contractual responsibility for the design, construction and finalization of infrastructure, the financing of the development costs, ownership or transfer of the asset and/or the operation and management of the asset.[123] The differences in the chosen PPP model will substantially alter the levels of risk-transfer in the contract.

4.2.2 *Risk allocation strategies in existing large-scale infrastructure agreements*

Risk allocation models for existing large-scale projects in the renewable energy sector tend to favour placing a higher degree of risk on the private sector (normally acting through a SPV), with the idea that these risks can then be transferred elsewhere – insurance companies, subcontractors or suppliers.[124] The public sector will attempt to allocate as much risk as possible to the private sector, with the SPV typically entering into whole-life contracts such as Build-Own-Operate-Transfer or Design-Build-Finance-Operate.[125] The private sector is therefore

[120] Feng Guo et al., *Effects of Project Governance Structures on the Management of Risks in Major Infrastructure Projects: A Comparative Analysis*, 32(5) IJPM 817 (2014).

[121] Isabella Alloisio, *Public-Private Partnerships: a focus on Energy Infrastructures and Green Investments* 4 (International Centre for Climate Governance 2014); UNCITRAL, *supra* n. 119, at 4.

[122] United Nations Economic Commission for Europe, *Working Party on PPPs Proposed Draft on UNECE Standard on PPPs in Renewable Energy* 13 (UNECE 2018).

[123] CarbonNet Project, *supra* n. 117, at 32.

[124] Charoenngam & Yeh, *supra* n. 113, at 29.

[125] Jeff Delmon, *Understanding Options for Public-Private Partnerships in Infrastructure: Sorting Out the Forest from the Trees: BOT, DBFO, DCMF, Concession, leases …* , Policy research working paper no WPS5173 (World Bank 2010).

allocated a large proportion of infrastructure and commercial risks with the idea that costs can be recouped through revenues during the operational phase. This makes the long-term nature of PPP contracts (fifteen to twenty-five years) appealing to investors because market demand risks are minimized.

In practice, the SPV will transfer some of these risks under the upstream contract to sub-contractors through downstream service contracts and pass-through clauses.[126] EPCs and O&Ms are the most common form of contract used by the private sector to transfer risk in the construction and operational phases of large-scale infrastructure projects.[127] These are crucial documents for de-risking private sector investments in major infrastructure projects because they diversify risk between private stakeholders. For example, in EPCs the contractor will agree to deliver a complete facility to specified standards, for an agreed price by a guaranteed date.[128] Failure to comply with these requirements will result in high monetary liabilities and this ensures SPVs are not penalized by the non-performance of contractors along the supply chain. Any risks that the SPV does not want to bear and that cannot be re-allocated through private-private downstream contracts will then be transferred to insurance companies. The private sector will be reluctant to accept risks in the upstream contract that cannot be limited, transferred or shared in some way through a down-stream or insurance contract. In these cases, they will build high contingencies into the upstream contract to account for risk allocations which they cannot reduce or manage.

4.2.3 *Risk allocation strategies for large-scale H_2-CCS infrastructure agreements*

Existing strategies for risk allocation in large infrastructure agreements could prove useful for developing contractual risk allocation strategies for large-scale H_2-CCS supply chains. However, during the deployment of new supply chains, the public sector may need to bear a greater level of risk than exists in more established infrastructure projects. This is particularly true given that there are not yet comprehensive insurance products to mitigate against CO_2 leakage risks. In recent years, there has been a shift towards the public sector bearing greater risk in major infrastructure contracts involving new supply chains. World Bank guidelines on PPP contracts recommend that public actors assume a wide range of risks, including force majeure and performance failures, to better mobilize private sector investments.[129]

It is recommended that two principles for risk-allocation be adopted as a foundation for large-scale H_2-CCS contracts. The first principle states that the party which can assess and control the risk should bear it. The second principle states that if neither party can assess or control the risk, the party who can better mitigate the risk or bear the loss should bear it.[130] In practice, this generally means that the private sector should be allocated risks which the project developer has an element of control over in the sense that they can influence outcomes (endogenous risks), e.g., managing expenditure or ensuring compliance with technical requirements.[131] An effective example of this is through the use of warranty provisions where the private actor is compensated on the basis of quality and timely performance.[132] Alternatively, it is possible to include protective clauses where the public entity retains a right to take over the service where there is a serious risk to public health, safety or environment.[133] This should include any services delivered by sub-contractors via. downstream contracts. In return, the public sector will then bear risks which the private sector has no control over (exogenous risks), e.g., uncertainty surrounding national policy.[134] While the private sector may be prepared to accept general changes in law, retrospective changes to incentive schemes seen in several States in the renewables sector has created sensitivity. The public sector will likely have to underwrite the risk of policy or regulatory change surrounding CCS through stabilization or change of law clauses.[135] Another example of public sector risk-bearing is through the conclusion of PPAs which require the government to purchase some or all of the power produced. PPAs have been regarded as central to de-risking private sector investment in the renewable energy sector and it is therefore likely that PPAs will also play a central de-risking role in PPPs for H_2-CCS.[136] Any risks that neither party can control can then be allocated to the party best placed to protect against any potential losses or these can be shared, e.g., long-term CO_2 storage risks.[137] Designing attractive value sharing arrangements through this methodology can reduce the scale of risk

[126] DLA Piper, *Asia Pacific Projects Update: EPC Contracts in the Power Sector* 2 (DLA Piper 2011).
[127] D. McNair, *Investing in Infrastructure: International Best Legal Practice in Project and Construction Agreements – 2017*, 141 (PWC Australia 2017).
[128] *Ibid.*, at 105.
[129] Howard Mann, *The High Cost of 'De-Risking' Infrastructure Finance* Project Syndicate; World Bank, *Guidance on PPP Contractual Provisions, 2017 Edition.*
[130] Kiyoshi Kobayashi et al., *Risk-Sharing Rule in Project Contracts*, 23rd ISARC 382 (2006); World Economic Forum, *Risk Mitigation Instruments in Infrastructure Gap Assessment*, Global Agenda 8 (WEF 2016).
[131] Young Hoon-Kwak et al., *Towards a Comprehensive Understanding of Public Private Partnerships for Infrastructure Development*, 51(2) Calif Manage Rev. 68 (2009).
[132] APMG, Public-Private Partnership Certification Guide: Building APMG certified PPP professionals to tackle infrastructure challenges, at 19; Sadie Cox, *Financial Incentives to Enable Clean Energy Deployment: Policy Overview and Good Practices* 2 (Clean Energy Solutions Centre 2016).
[133] OECD, *Public-Private Partnerships: In Pursuit of Risk Sharing and Value for Money* 128 (OECD 2008).
[134] Hoon-Kwak et al., *supra* n. 131.
[135] World Bank, *Investment Contracts for Agriculture: Maximizing Gains and Minimizing Risks*, Agriculture Global Practice Discussion Paper 4 (World Bank 2015).
[136] United Nations Economic Commission for Europe, *supra* n. 122.
[137] Kobayashi et al., *supra* n. 130, at 382.

an investor may face in new supply chains whilst protecting against moral hazard and delivering cost minimization.[138]

As a final point, it must be noted that the chosen model for H_2-CCS risk allocation will evolve overtime in line with the maturity of the technology. As risks reduce or become more manageable, it will no longer be necessary for the public sector to bear risks along the supply chain and these will be transferred back to the private sector.[139] Risks can then be managed solely through private-private contracts; for example, down-stream contracts including CO_2 supply and storage guarantees. In the renewable energy sector, the progressive removal of government support schemes has seen a shift from the private sector using short-term PPAs to long-term PPAs. This demonstrates how contractual risk allocations develop in line with the maturity of the market.

4.3 Risk allocation models for SMEs

SMEs are more vulnerable to risk than large enterprises because they lack the resource capabilities to respond as quickly to risk occurrence, leading to losses which may threaten their survival and the success of a project.[140] In particular, risks associated with time delays or cost overruns can be crucial for SMEs because they have smaller workforces and tighter access to capital than larger companies.[141] SMEs are therefore less willing to accept the levels of risk associated with large-scale clean energy projects. It is also important to be realistic about the capacity of SMEs in participating in long-term, complex projects.[142] Large enterprises have the same financing options available to SMEs (e.g., business loans) but will also more easily access the debt and equity markets and have additional access to schemes offered by larger banks and financial institutions.[143] For example, in the UK, whilst large enterprises can choose between feed-in tariff schemes or Contracts for Difference, SMEs are advised to pursue feed-in tariff schemes due to the higher entry costs associated with Contracts for Difference (CCfDs).[144] Additionally, regulatory compliance obligations often put larger time and cost pressures on SMEs.[145] They are also more sensitive to competition risks and may be reluctant to invest in novel technologies through fear that large-scale competitors could overtake and dominate the market.[146]

The types of contractual risk allocation in large-scale infrastructure projects are therefore unlikely to be acceptable to SMEs because they carry risks of incurring high monetary liabilities if requirements are not met and companies without a successful track record will less easily obtain favourable down-stream contracts or insurance cover to transfer these risks.[147] SMEs are more dependent on larger entities for inclusion within supply chains and may find it more difficult to influence down-stream contract terms as they are likely to have less access to legal resources.[148] SMEs will also more likely avoid bundled, whole-life contracts and instead favour separate contractual agreements for the different phases of projects. This diversifies responsibility for the different project phases to different actors, unlike Build-Own-Operate-Transfer style contracts which constrain responsibility for risks to one entity. The design of risk allocation models in large infrastructure agreements is therefore a barrier to the integration of SMEs in large-scale infrastructure projects. Protecting diversity of the supply chain is important and contractual arrangements should be framed to provide SMEs with fair access to large infrastructure opportunities.

SMEs do however have a significant role in developing emerging retail markets for the H_2-CCS value chain. Properly designed contractual risk allocation mechanisms could de-risk SME involvement in emerging (local) retail markets because they can shift risk away from areas in which SMEs are vulnerable and remove barriers to obtaining finance. In this respect, there is an argument for the public sector to bear greater risk in small-medium infrastructure contracts with SMEs because the risks are more marginal and the government can better spread small risks across taxpayers, meaning a relatively low cost of risk-bearing.[149] This argument is less convincing in large-scale projects where the cost of risk-bearing is more burdensome on public finances. In return for the public sector bearing a higher level of risk, SMEs can provide benefits such as lower contract prices, local knowledge advantage and local growth in terms of job creation and increased area income. This is not to suggest the public sector should bear all risks which may arise. Rather it is suggested that where neither the private or public party has control over risk occurrence, the public

138 Mateen Thobani, *Private Infrastructure, Public Risk*, Fin. Dev. 50–53 (1999).

139 Zapantis et al., *supra* n. 58, at 3.

140 Chiara Verbano & Karen Venturini, *Managing Risks in SMEs: A Literature Review and Research Agenda*, 8(3) JOTMI 187 (2013).

141 Kajsa Berggren, *Risk Management in Small Sized Construction Projects*, LTU 385 (2005).

142 World Bank, *Legal Issues on Small and Medium Enterprises and PPPs.*

143 Renee O'Farrell, *The Differences Between Large & Small Business Financing Options' Chron.*

144 Peter Bennett, *Energy Minister Tells SMEs to Use the Feed-in-Tariff Rather Than Contracts for Difference' Solar Power Portal.*

145 Elaine Conway, *Engaging Small and Medium-Sized Enterprises (SMEs) in the Low Carbon Agenda*, 5(32) Energy Sustain Soc. 186 (2015).

146 *Ibid.*, at 180; A. M. Blanc Alquier & M. H. Lagasse Tignol, *Risk Management in Small- and Medium-Sized Enterprises*, 17(3) PPC 273 (2006).

147 McNair, *supra* n. 127, at 106.

148 UK Government, *Late Payments, Retentions and Government Procurement* (2017).

149 World Bank, *Dealing with Public Risk in Private Infrastructure*, Latin America and Caribbean Studies 9 (World Bank 1997).

sector is likely to always be better placed to mitigate or bear that risk than a SME. It follows that risks relating to technical operations or financial management combined with monitoring duties to ensure best practices should remain with project developers even in small-scale projects.

4.4 Standardization of contracts for the supply chain

In the first H_2-CCS projects, there are likely to be few actors involved and contracts are likely to be bespoke and project-specific. However, complex contractual arrangements can lead to higher transaction costs and lengthy negotiation processes. Standardized contracts can be beneficial in overcoming these issues by establishing common features: thus, reducing due diligence and barriers to entry, increasing certainty for investors and providing a more efficient contractual review processes.[150] This could initiate a move away from project specific contractual agreements towards longer term agreements which provide both the public and the private sector with security regarding their investments. They can also enable final investment decisions by allowing foresight in the types of financing mechanisms projects will be eligible for.

The cost effectiveness of standardization depends upon the repeatability of project designs. Contracts for very large-scale storage sites are unlikely to be needed at a high volume, whilst contracts for smaller-scale storage sites will be needed more frequently. In this respect, standardization is particularly important in mid- to downstream contracts involving local actors because there is likely to be a proliferate of small projects which lack the resources to individually negotiate contracts. In large-scale projects, the standardization of contracts is more challenging due to the complexities of each unique supply chain and there are limits with regards to what can be templated. Standardized contract designs could lead to increased transaction costs where they are not fit for purpose and require continued renegotiation.[151] It is therefore foreseeable that standardized contracts for smaller-scale projects will be more comprehensive than those that can be developed in the short to mid-term for larger-scale projects.

Contracts used in initial large-scale H_2-CCS projects can serve as valuable examples for the creation of contract templates for future projects. In particular, initial PPP contracts will indicate to the private sector the kind of risks the public sector is willing to accept under different PPP models. This will expediate private sector investment by indicating the standards expected through tender procedures, project selection, contract negotiation and operations.[152] The UK already has experience in standardizing PPP contracts for large-scale infrastructure projects and the Norwegian Government are also pursuing the idea of standardized upstream contracts for CCS. It is therefore understood that the standardization of certain contractual provisions is possible for major H_2-CCS chains.

5 Conclusion and Recommendations

Direct legislation and contracts can be formulated to remove or reduce the risks faced by the private sector in low-carbon technology and infrastructure investments. The integrated H_2-CCS value chain has here been taken as one example of the *strategic value chain* in the process towards a low carbon and increasingly integrated energy system. Now that technology is not anymore the biggest challenge for those technologies, the conclusion is that law has an important role in de-risking such strategic chains and that a combination of contractual and legislative measures should be adopted. International policy steps have already been taken to de-risk the supply chain through law (net-zero targets, green finance initiatives, H_2 product standardization); however, further steps are needed to fully mobilize the level of private sector investments needed to deploy H_2-CCS at scale.

A supportive, stable and clear policy environment for CCS and H_2 across the different levels of the supply chain is a key market driver for private sector investments. Governments must act now to implement strategic roadmaps detailing targets and timelines for the deployment of essential infrastructure and consolidation of end-markets across the relevant sectors and industry. This should include the adoption of EU-wide net-zero targets as well as target setting for CO_2 capture and H_2 gas injection in coordination with existing renewable energy projections. This will demonstrate long-term commitment to the deployment of a H_2 economy in combination with CCS and thus, reduce political uncertainty surrounding support for CCS. This supportive policy environment should then be coupled by complimentary legislative measures which de-risk different elements of the supply chain.

De-risking private sector investments will also require clear and supportive contractual terms. This will mean involvement of the public sector to allow for the sharing and transfer of risks which cannot be managed or reduced by the private sector alone. PPPs are an important option in this regard, offering the possibility to adapt the level of contractual risk-transfer depending on the chosen PPP model and the specifics of the individual project. Lessons can be learned from existing risk allocation mechanisms in large-scale PPP agreements such as the allocation of risk to the public sector where the private sector cannot manage or mitigate the risk. Different risk allocation models will however be needed in the context of SMEs, where the public sector bear more risk, in return for lower contract prices and local knowledge advantages. Standardization of contract terms will also be an extremely

[150] Hoon-Kwak et al., *supra* n. 131, at 75.

[151] Rui Cunha Marques & Sanford Berg, *Revisiting the Strengths and Limitations of Regulatory Contracts in Infrastructure Industries*, 16(4) J. Infrastruct Syst 335 (2010).

[152] European Bank for Reconstruction and Development, *Insight and Recommendations from the Latest Public-Private Partnerships Law Assessment* 59 (Law in Transition 2018).

important tool for local contracts (mid to downstream) to remove lengthy and costly negotiation processes. This will ensure fair access to PPP contracts, consolidate the retail markets necessary for H_2-CCS to succeed and encourage diversity of the supply chain.

Overtime H_2-CCS specific legal de-risking measures can be phased out, with gradual transfer of risks back to the private sector as the market matures, to prevent an imbalance in the functioning of the electricity and gas markets. In the interim, it is necessary for national governments and the EU to implement the suggested legal de-risking measures to mobilize domestic and international private capital and enable the successful and timely deployment of H_2-CCS.