ACT Project Number:
271498

Project name:
ELEGANCY

Project full title:
Enabling a Low-Carbon Economy via Hydrogen and CCS

ERA-Net ACT project

Starting date: 2017-08-31
Duration: 36 months

D3.4.1
Synthesis report on business case development for H_2-CCS integrated chains

Date: 2020-08-20

Organization name of lead participant for this deliverable:
First Climate (Switzerland) AG

ACT ELEGANCY, Project No 271498, has received funding from DETEC (CH), BMWi (DE), RVO (NL), Gassnova (NO), BEIS (UK), Gassco, Equinor and Total, and is cofunded by the European Commission under the Horizon 2020 programme, ACT Grant Agreement No 691712.		
Dissemination Level		
PU	Public	X
CO	Confidential, only for members of the consortium (including the Commission Services)	

Deliverable number:	D3.4.1
Deliverable title:	Synthesis report on business case development for H_2-CCS integrated chains
Work package:	WP3 Business case development for H_2-CCS integrated chains
Lead participant:	University of Oslo

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Keywords

Hydrogen-CCS, CCUS, Business case development framework; Case study parameters; Regulatory background; Market background; Business drivers; Market failures; Policy requirements; Policy assessment; Risk assessment; Investment barriers; Business risks; De-risking instruments; Government interventions; Investment incentives; Incentive mechanisms; Business models; Business model selection; Business structures; Commercial structures; Ownership structures; Business case; Business case assessment; Public private partnerships; Service contracts; Operating agreements; Business case template; Cost benefit analysis

Abstract

This Synthesis Report is the final deliverable under Work Package 3 (WP3) of ELEGANCY and summarizes the approach, findings and outputs in designing the business case development framework for H_2-CCS integrated chains. This framework is a collection of methodologies and workflows, assessment tools and guidance materials to develop and select business models, and to assess business cases for H_2-CCS projects. This suite of elements is made publicly available to use towards any H_2-CCS project. This report can also provide insights and a structured approach for business case development beyond H_2-CCS chains to any large scale CCUS networked infrastructure.

This report is organised around the various steps of the methodology used in WP3 and described in the individual interim reports (D3.2.1, D3.3.1, D3.3.2, D3.3.3, and D3.3.4). The overall methodology for business model development is characterized by a number of steps to i) define the scope of the H_2-CCS chain subject to a particular ELEGANCY case study, ii) perform a focused market background review and gap analysis, iii) identify business and investment risk and corresponding risk mitigation strategies, and iv) develop business models. Steps i) and ii) are addressed in Report D3.2.1, step iii) in Report D3.3.1 and D.3.32, and step iv) in Report D3.3.3. The final interim report, Report D3.3.4 describes the framework, templates and tools for developing a business case, and performing a business case assessment, associated with a given business model.

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1 INTRODUCTION

The ELEGANCY project is dedicated to the novel concept of using integrated Hydrogen and Carbon Capture and Storage (H_2-CCS) networks (chains) as a means of increasing the business value proposition for CCS infrastructure deployment and simultaneously delivering a large scale low (or zero) carbon gaseous energy carrier for abatement of distributed emissions. Indeed, the major barrier to deployment of CCS is no longer technological, but commercial, regulatory and political. Technical challenges associated with the successful development and operation of CCS systems remain, but the general agreement is CCS at industrial scale is technically feasible. Rather, there is now a recognized need for policymakers to reduce investment barriers and utilize business models comprising practical commercial structures and agreements to remove project risks.

For optimal chain integration, the focus in ELEGANCY is placed on combined work on regulatory, commercial and technology issues. Apart from research on particular technological elements (Work Packages 1 and 2) and techno-economical modelling (Work Package 4 (WP4)), the project includes business case development work (WP3) and societal research. The outputs and methods from Work Packages 1-4 are then applied in Work Package 5 (WP5) to five case studies that are tailored to the needs and context of the five participating countries Germany, the Netherlands, Norway, Switzerland, and the UK.

WP3 is about developing a risk-centred framework applicable to any H_2-CCS case study or project to facilitate the development of suitable business models, i.e. those which allow a practical risk allocation and delivery of profitability and value in order to facilitate the necessary private and public investment in an effective manner. WP3 focuses on providing the methodology, tools and guidance necessary to allow private and public entities to discuss and determine the appropriate business model which works in the specific context of the country and case study, rather than providing a recommendation on the ideal business model. WP3 also seeks to define the concept of business case for H_2-CCS projects and provides a methodology for iteratively assessing the business case for an investment proposition once a business model is selected. Taking into account the multiple attempts at CCS in Europe over the past 15 years, this framework is structured to facilitate engagement between public and private sector parties as early as possible in the project development process for the joint definition of suitable business models and business cases.

The **main objectives** of WP3 are to develop a business case framework comprising:

- a number of guided assessment tools for the legal, market, macro-economic, fiscal and policy background relevant to integrated H_2-CCS chains; and
- a suite of optional elements for constructing business models, which can be applied:
  within ELEGANCY in the WP5 case studies; and
  beyond ELEGANCY in any other European country wishing to explore opportunities for H_2-CCS chains.

Three **sub-objectives** are defined as follows:

1. Assess the regulatory background relevant to integrated H_2-CCS chains with focus on the five case study countries.
2. Assess the macro-economic, market and fiscal background relevant to integrated H_2-CCS chains with focus on the five case study countries.
3. Develop business models and business case templates that identify value, responsibilities and allocation of risk through the integrated chain and between the public and private sectors.

This Synthesis Report brings together the collective work performed under WP3 of ELEGANCY to achieve the aforementioned objectives. The intention is to summarize the approach, findings and outputs described in detail in the individual Interim Reports or deliverables of WP3. Furthermore, this report can provide insights and a structured approach for business case development beyond H_2-CCS chains to any large scale CCUS networked infrastructure. The report is structured as follows.

Chapter 2 introduces the methodological approach deployed in WP3, including the concepts and terminology used, engagement with internal and external stakeholders, as well as outputs of the process.

Chapters 3 through 7 summarize each of the five interim reports of WP3 (D3.2.1, D3.3.1, D3.3.2, D3.3.3, and D3.3.4). These interim reports describe the development of the business case framework.

Chapter 8 describes the Business Case Development Toolkit and the structure of the various assessment tools.

2 WP3 METHODOLOGY

2.1 Overview

The approach used by WP3 to develop the business case framework follows a structured stepwise process defined in the ELEGANCY proposal. The development of the framework builds on work conducted by European CCS stakeholders to date around risk mitigation and commercial structures, in particular the experiences in Norway and the UK. WP3 project partners comprise **University of Oslo** (UiO), **Sustainable Decisions Limited** (SDL), and **First Climate** (FC).

The overall approach consists of the following key steps:

1. Establish the theoretical basis of the business case framework by identifying and defining key concepts and terminology derived from literature and commercial experiences with H_2 and CCS;
2. Define the methodological elements: business model development methodology and business case assessment methodology, as well as accompanying workflows, which together set the structure for assessing H_2-CCS case studies or projects;
3. Develop Excel-based assessment and visualization tools to accompany the methodologies and serve as customizable templates to H_2-CCS project developers broadly;
4. In building out the structured framework, conduct focused dissemination and outreach activities to solicit input and feedback from stakeholders within and beyond ELEGANCY;
5. Create guidance products (e.g. recorded webinars, reports) to support users in autonomously applying the framework.

The resulting business case framework integrates the breadth of perspectives beyond technical considerations necessary for assessing H_2-CCS chains, including legal, regulatory, policy, market, economic, financial, and strategic elements of a project, case study or investment proposal.

2.2 Definition of concepts and terminology

The terminology used in developing the business case framework is broadly considered standard for commercial projects and commonly used by public and private sectors alike. It has nevertheless been adapted to suit the specific purposes of H_2-CCS chains. As a result, some concepts are developed or refined. Definitions are provided through the chapters of this Synthesis Report as they arise. An overview is presented in Table 2-1.

Table 2-1 Overview of WP3 concepts and terminology

Concept or terminology	Succinct definition in ELEGANCY	Reference for full description
Generic H_2-CCS chain parameters	Characteristics of H_2-CCS chains	Report D3.2.1
H_2-CCS chain business options	Classification and structured representation of services and end-use markets available along the H_2-CCS chain	Report D3.2.1
Business drivers	Trends, factors, or conditions positively or negatively affecting the development of a business option	Report D3.2.1
Market failures	Situations, mechanisms or activities that change or affect the dynamics of a properly functioning market and distort the ability of the market to achieve equilibrium between supply and demand without intervention	Report D3.2.1 Report D3.3.1

Concept or terminology	Succinct definition in ELEGANCY	Reference for full description
Policy gap analysis	Qualitative and quantitative assessment of existing regulatory, market-making, innovation and technology delivery policies and financial support mechanisms against expected requirements	Report D3.3.2
Risk assessment methodology	Two-level risk assessment (investment barriers, business risks) followed by a consistency check	Report D3.3.1 Report D3.3.2
Risk mitigation	Identification of risk mitigation measures as well as preferences for risk allocation and transfer of responsibilities	Report D3.3.2 Report D3.3.3
Business model	Two-tier business model definition: system business model, operational business model	Report D3.3.3
Business model selection drivers	Trends, factors or conditions impacting preferences and feasibility of selecting business models	Report D3.3.3
Business case	Characterized by six business case dimensions	Report D3.3.4

2.3 Internal & external stakeholder engagement

The business case framework in ELEGANCY is developed alongside targeted dissemination and engagement activities with internal and external stakeholders. These efforts intend to communicate the developments in WP3 with public and private sector actors in H_2-CCS projects and to solicit their input to and feedback on the approach developed, concepts elaborated, and tools designed. Stakeholders were also engaged to sense check and test WP3 outputs. Interfaces were established between WP3 and other WP members, for instance with the national case studies in WP5 and the chain tool development in WP4.

Synergies were sought in particular with organisations with working groups on subjects of relevance to the ELEGANCY case studies (i.e. European Zero Emissions Platform (ZEP), International Energy Agency Greenhouse Gas programme (IEAGHG)) and the sister ACT ALIGN-CCUS project.

Dissemination activities conducted in WP3 involved formal milestone workshops, as well as informal workshops and webinars. An overview of these activities and stakeholders involved is presented in Table 2-2. In addition, direct discussions and interviews with selected stakeholders were also held on an informal basis throughout the project.

Table 2-2 Overview of dissemination activities and stakeholder engagement

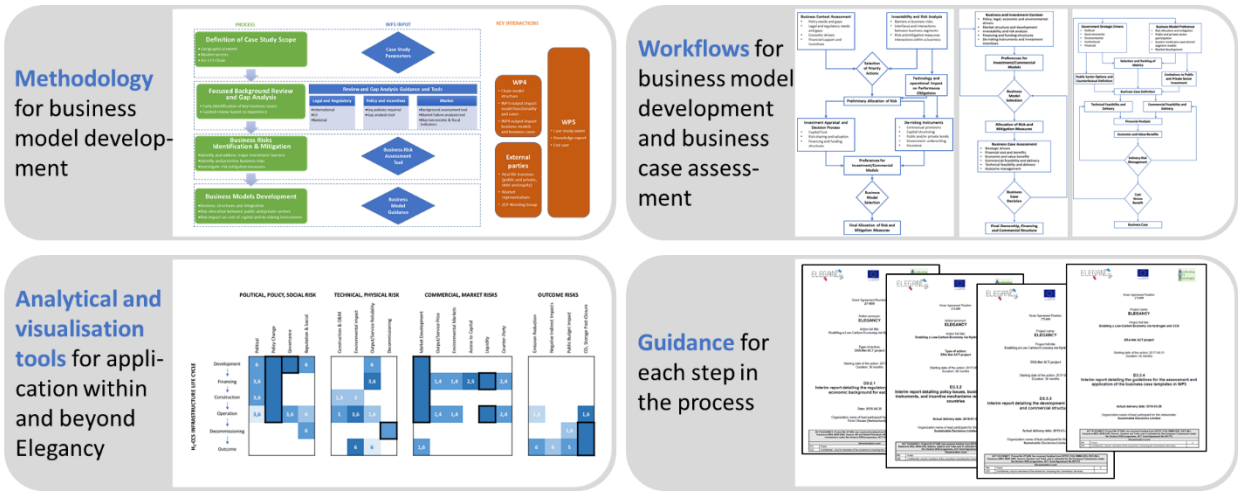
Date	Location	Formal milestone	Purpose and stakeholders
March 9, 2018	University of Oslo, Faculty of Law, Oslo	Yes (M3.1, M3.2)	Invitation-only workshop for ELEGANCY and select external H_2-CCS stakeholders to peer review the background assessment tools and the risk matrix
September 18, 2018	European Commission's DG Research and Innovation's building in Brussels	Yes (M3.3)	Invitation-only workshop for ELEGANCY and select external H_2-CCS and CCUS stakeholders to facilitate expert discussion and solicit feedback on mitigating investment barriers and business risks

Date	Location	Formal milestone	Purpose and stakeholders
February 6, 2019	Imperial College London, London	No	Workshop with ELEGANCY project partners from the Netherlands to introduce and test the business case framework on the Dutch case study in WP5
February 11, 2019	University of Oslo, Faculty of Law, Oslo	No	Invitation-only workshop for ELEGANCY, ALIGN and select external H_2-CCS stakeholders on legal issues surrounding CCS, including regulatory and legal de-risking measures as well as transfer of liability
March 14, 2019	Offices of Weber Shandwick, Avenue de Cortenbergh, 1000, Brussels	Yes (M3.4)	Invitation-only workshop for ELEGANCY and select external H_2-CCS and CCUS stakeholders to discuss and debate a series of topics related to risk sharing, business models and business cases for CCS
May 8, 2019	Online webinar	No	Internal ELEGANCY webinar to present the full business case framework and provide guidance on applying suite of tools
November 29, 2019	Imperial College London, London	No	Workshop with ELEGANCY project partners from Germany to introduce and test the business case framework on the German case study in WP5
June 23, 2020	Online webinar	Yes (M3.5)	Public webinar to present the full business case framework and accompanying suite of tools

2.4 Outputs

WP3 outputs collectively constitute the business case framework (see Table 2-3). This publicly available assessment framework is applicable to H_2-CCS projects at all development stages. Methodologies and workflows for business model development and business case assessment guide the process, which is conducted in practice by applying a suite of standardized analytical and visualization Excel-based tools. Structured guidance describing the approach and providing exemplar assessments is available in the interim reports (D3.2.1 to D3.3.4), detailed instructions in the tools, and recorded webinars. See Section 8 of this report for information on accessing all these materials.

Table 2-3 Constituents of the business case framework



2.5 Business Model Development Methodology

The high level flowchart in Figure 2-1 presents the overall methodology developed and applied by WP3 to select business models for H_2-CCS opportunities (see ELEGANCY reports D3.2.1, D3.3.2 and D3.3.3). A business case can be defined and assessed once a business model is selected. The ELEGANCY business case assessment methodology (presented in report D3.3.4) is therefore applied to business models chosen through the process described herein. As business model preferences can change with changing business contexts as well as with the maturity of a project, the combined selection and assessment process is iterative, but follows the same steps and analysis at fit-for-purpose levels of detail.

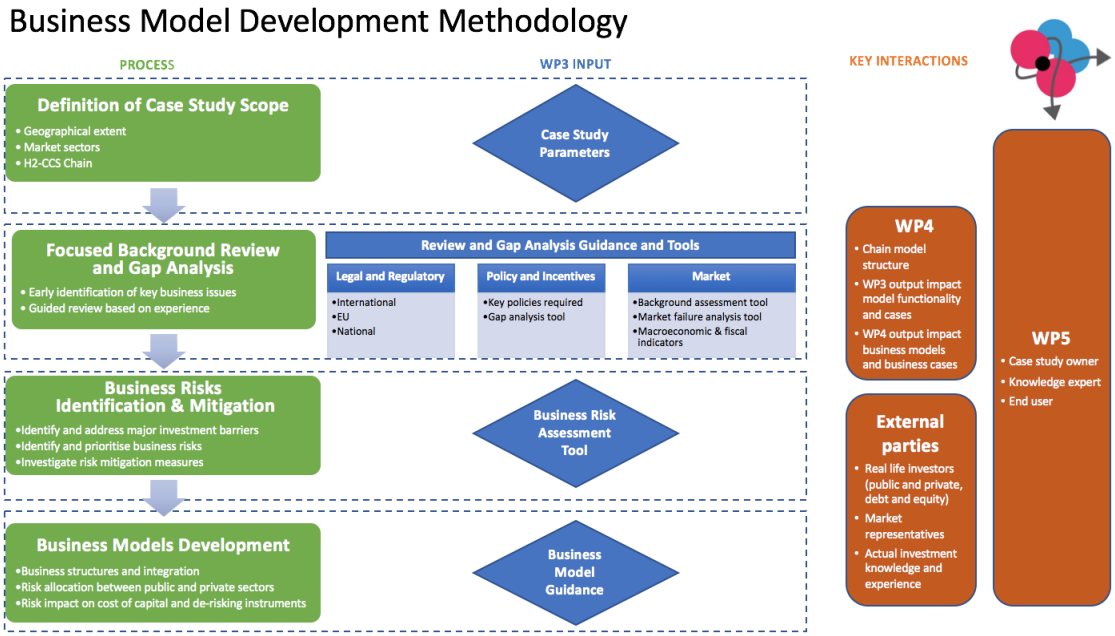


Figure 2-1 Business Model Development Methodology

The Business Model Development process is divided into four distinct steps:

Step 1: *Definition of the scope of the particular H_2-CCS chain for the relevant case study*

The process commences with an initial focus on the specific H_2-CCS chain technical sub-components, business segments, and associated market sectors of main interest, the geographical extent (including industrial hubs, production facilities, storage areas, end-users, cross-border interactions, etc.), and market potential.

First Climate and Sustainable Decisions Limited have created a standardised framework for any case study lead organisation to use in this first step that matches the needs of the scope definition exercise described above. This framework comprises the technology elements and market sectors, a H_2-CCS chain business tree, and an extensive set of potentially relevant case study parameters (described in report D3.2.1). This framework and analysis were used side-by-side with the scenarios and quantitative estimates of market potentials undertaken in WP5 *Task 5.1 Interfaces* and reported in D5.1.1.

Step 2: *Focussed market background review and gap analysis*

The purpose of this second step is to guide an overall assessment of the market background for any case study in preparation for the third step of understanding the investability and handling of major business risks. The major barriers and business risks that are faced by potential developers and financiers in the H_2-CCS business chain have been identified by stakeholders to be non-technical, and robust economic scrutiny is essential for any large-scale infrastructure investment. Technology components within the H_2-CCS infrastructure chain and end markets exist and have proven functionality. Hence, investing in, and delivering, low-carbon hydrogen using CCS at scale requires an understanding of the risks associated with government policy, market development, and regulatory frameworks. Full chain operability issues are another area of risk that is dealt with in Step 3 below.

A set of Excel spreadsheet tools (Report D3.2.1 and Report D3.3.2 Appendix A.1) has been designed and produced, based on the project development experience gained over a number of years in countries such as Netherlands, Norway and UK, to facilitate a simple high-level analysis of the major drivers for each of the H_2-CCS chain market sectors and business segments. The market background includes the legal and regulatory environment, the market fundamentals and applicable market failures, key macroeconomic drivers, the policy status and financial support mechanisms. An important aspect of this assessment method is the requirement to include systems thinking and review of the interactions between different market players reflected in the chain business segments.

Step 3: *Business and investment risk identification and mitigation*

Based on the information gathered during step 2, the third step is to identify and quantify the major business risks that impact the level of investment potential for each of the market sectors and business opportunities from both a public and a private sector perspective. A bespoke risk assessment spreadsheet tool has been designed (Report D3.3.2 Appendix A.2) that can be applied to any individual or bundled business opportunities along the H_2-CCS chain selected from the standardised business tree.

Section 2.4 of report D3.3.2 describes the risk assessment methodology in more detail. In summary, assessable risks are divided into:

1. Investment Barriers: these are circumstances or facts that raise the risk of detrimental investment outcomes to an unacceptable level for any type of investor. Generally, these barriers will affect multiple segments along the chain, or the whole chain, and require a ‘system view’ and multi-party (often in collaboration with government) approach to mitigation measures. These barriers need to be addressed in priority for any investment to be possible; and
2. Major Business Risks: these are risks that impact cost, revenue, liabilities, financing, schedule and therefore the risk/return equation for a final investment decision (FID). Individual businesses will generally be capable of mitigating these through familiar technical, commercial, insurance and other standard measures.

This step facilitates an early identification and prioritisation of investment barriers and risks to be addressed by a case study lead organisation and guide the subsequent communication and conversations with potential private investors and public/government organisations.

Step 4: *Business model development*

The fourth step in the method focuses on how to remove the investment barriers and mitigate business risks, and to select appropriate business models for any given case study. Chapters 4-7 of Report D3.3.2 deal with the principles and elements used in the methodology. Report D3.3.3 completes the methodology with a description of the business model selection process, its relationship with preparing and assessing a business case, and a business model selection tool. When applied to case studies, the outcome will be the development of a number of viable commercial structures and business models, investigation of the potential investor mix and the allocation of risks between those investors for each of the market opportunities, the de-risking mechanisms required from the financial and carbon markets and from the EU and national governments.

2.6 System and Operational Business Models

In order to create further clarity about business models the ELEGANCY WP3 methodology differentiates between system or macroeconomic business models and business segment or micro-economic business models (Figure 2-2). System business models are the principal means for the mitigation of exogenous risks (including political, policy, social and outcome risks) that cannot in general be managed by the private sector alone and provide a macroeconomic solution that can overcome barriers to investment by both the public and private sectors into the various operational segments of a full chain H_2-CCS infrastructure. Operational business models focus on the risks and delivery of the outputs and services for a particular business segment within the H_2-CCS chain. The red dashed boxes show possible bundling of business segments.

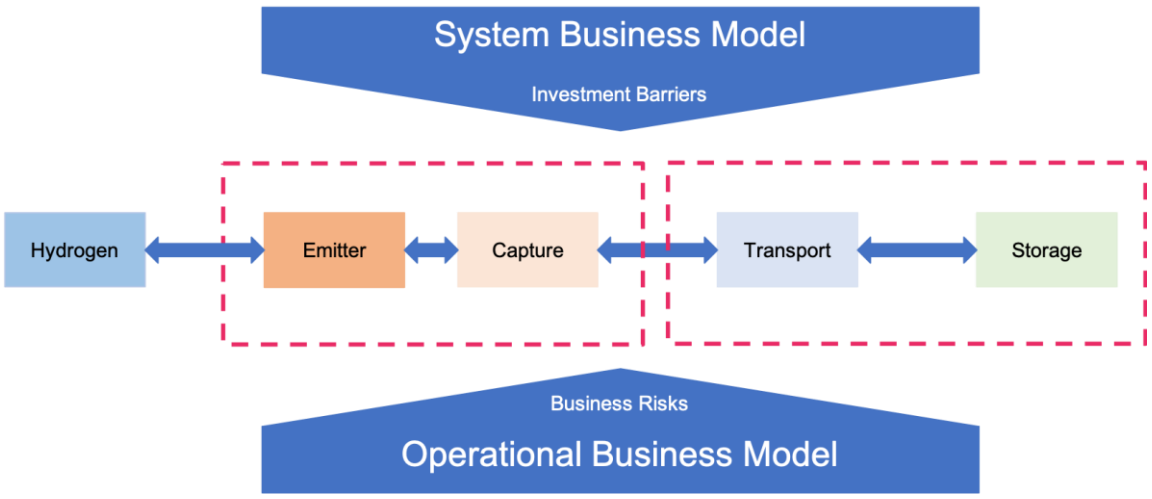


Figure 2-2 Business Model Characterisation

Unlike renewable energy entering mature electricity networks, CCS infrastructure and its applications have not in general been supported by fit-for-purpose holistic 'programmatic' government interventions. In large part this has been because of an inertia to commit to CCS as a climate mitigation technology. This in turn has created barriers to investment which extend beyond the business risks that an individual project may experience, even with government financial or fiscal incentives.

The combination of ELEGANCY WP3 and WP5 case study research has led us to the conclusion that a viable system business case is a pre-requisite for achieving an investable project business case. The development and selection of sector- or project-specific business models is dependent on an over-arching system business model that, at a minimum, must address the following:

a. System-level strategic rationale and objectives;
b. Cross-sectoral synergies and sector coupling;
c. Development of 'low carbon' end use markets;
d. Enduring system governance and oversight until markets are self-sustaining;
e. Public-private risk sharing reflecting system characteristics/properties;
f. Public-private collaboration and capacity/capability building;
g. Societal and social acceptance with removal of moral hazard; and
h. Development of real options for low regrets transition pathways.

2.7 Business case assessment methodology

The ELEGANCY business case assessment framework and methodology is based on the principle of front-end loading (or planning)[1] used extensively by the private sector for stage gate decision making in project development and Final Investment Decisions (FID). This approach is also core to the UK HM Treasury business case development process[2] and other public sector organisations. Front-end loading simply refers to the fact that a strong emphasis is placed at an early stage of the business case on strategic rationale and objectives, business context, characterisation of the opportunities and benefits, understanding threats and risks, delivery options, and indicative costs. Essentially this approach addresses the 'what?' and 'why?' of the business proposition as the first assessment stage where the potential impact of decisions is highest, but the data and information available is at its lowest. It also begins the process of answering 'how?' by establishing the principal key performance indicators, or metrics, and 'who?' by allocating and sharing risks associated with delivering the various elements of the business proposition.

A complete business case at either H_2-CCS chain system level or for an individual business segment within the chain is characterised in the ELEGANCY framework by the six dimensions described in Section 7.2.3. The data required and outputs of the assessment in each of these dimensions evolve with increasing levels of project maturity. An iterative development of the business case associated with a selected business model progresses through decision gates and increasing levels of expenditure. This process is discussed in ELEGANCY report D3.3.3 as described above in Step 4 of the business model development.

Actual investment in, and delivery of, the projects comprising the ELEGANCY case studies will be reliant on cooperation between private sector sponsors and host governments. At the level of investigation that can be undertaken in the ELEGANCY project, it will only be possible to explore a sub-set of dimensions of a full system-level business case. Furthermore, without private sector sponsors in specific business segments, the business cases for investment in these assets and operations cannot be developed.

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[1] See for example: Samset, K. and Williams, T. (2010) Issues in Front-End Decision Making on Projects. *Project Management Journal* (PMJ), 41, 38-49

[2] HM Treasury (2018) Assessing Business Cases: A Short Plain English Guide, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/190609/Green_Book_guidance_short_plain_English_guide_to_assessing_business_cases.pdf, accessed 11th August 2020

Ultimately the system business case in each case study (and jurisdiction) requires some understanding of how collaboration between public and private sector stakeholders will influence the business model selection and the elements of the strategic dimension. This can be facilitated by the WP3 suite of tools but will require stakeholder workshops to produce a realistic set of inputs rather than a theoretical set.

Table 2-4 Overview of ELEGANCY business case dimensions

Business Case Dimension	Description
Strategic Drivers and Rationale	• Business case definition • Objectives of project, investment and/or intervention • Key strategic issues to be addressed • Business Model Preference • Key performance indicators and metrics
Financial Cost and Benefits	• Standard evaluation of cost and revenues • Standard metrics of Return on Investment (RoI), IRR, NPV • Assessment of additional sources of value created by the project
Economic and Value Benefits	• Quantification of direct economic impacts, economic rate of return (ERR) and economic net present value (ENPV) • Identification, and quantification where possible, of indirect economic, social and environmental benefits, distributional impact
Commercial Feasibility & Delivery	• Business model selection • Commercial structuring and capital sourcing • Contracting, procurement
Technical Feasibility & Delivery	• Assessment of technical design and construction, operating and decommissioning arrangements for physical delivery • Technology assessment and comparison
Outcome Management	• Standard risk identification, quantification and mitigation • Monte Carlo, scenarios, real options, optimism bias • Monitoring metrics for delivery and governance

3 REPORT D3.2.1 - REGULATORY, FISCAL, AND MACRO-ECONOMIC BACKGROUND FOR EACH CASE STUDY

3.1 Summary

Prior to commencing the ELEGANCY project a common conclusion from a large body of studies[3,4,5,6] and project feasibility work[7,8,9,10] is that under current regulatory and policy frameworks across Europe, significant market barriers and market failures exist that discourage and prevent investment in the constituent CO_2 capture, transport and storage projects that make up the CCS infrastructure chain.

The ELEGANCY project is dedicated to the novel concept of using H_2-CCS integrated chains as a means of increasing the business value proposition for CCS infrastructure deployment. For optimal chain integration, there is a need for combined work on regulatory, commercial and technology issues. New risks and issues will come into play when the CCS chain is interfaced with a demand driven H_2 network. Within ELEGANCY, WP3 investigates the regulatory, commercial, financial and business innovation needs to make H_2-CCS chains investible ahead of sufficiently high carbon prices that would drive investment choices. More specifically, WP3 investigates the macro-economic level, i.e. the current market and regulatory situation, as well as the elements that will eventually make up viable business models, i.e. suitable commercial structures, responsibilities and allocation of risk, risk mitigation strategies as well as incentive mechanisms.

To guide this assessment process, WP3 of ELEGANCY has developed an overall methodology structured around a number of steps (see Section 2.5): 1) define the scope of the particular H_2-CCS chain for the relevant case study, 2) perform a focussed market background review and gap analysis, 3) identify business and investment risk and corresponding risk mitigation strategies, and 4) develop business models. This report sets the basis of this methodology – which is then further elaborated on throughout subsequent reports (D3.3.2, D.3.3.3, and D3.3.4) – and focuses on the two initial steps.

Conceptual frameworks and tools are presented in this Report which have served as basis for further work in WP3 to develop a business risk matrix as well business model selection and business case assessment tools (chapters 4 to 7). This includes a business options framework, generic case study parameters, and purpose-built spreadsheet tools for market background and

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[3] Goldthorpe, W., Ahmad, S., Eldering, L., Sannes, O., Baker, A., Grosvenor, D., .Dean, T. (2016). *A need unsatisfied - Blueprint for enabling investment in CO_2 storage.* London, UK: Deloitte/The Crown Estate.

[4] Hare, P., Davies, G., & Murray, S. (2013). *Options to incentivise UK CO_2 transport and storage.* Oxford, UK: Pöyry/The Crown Estate.

[5] ZEP (2014). *Business models for commercial CO_2 transport and storage.* Bruxelles, Luxembourg: Zero Emissions Platform.

[6] Heap, R. (2016). *Potential Role of H_2 in the UK Energy System.* London, UK: Energy Research Partnership.

[7] See for example: Dixon, P. and Mitchell, T. (2016) *Lessons and evidence derived from UK CCS programmes, 2008 – 2015*, http://www.ccsassociation.org/press-centre/reports-and-publications/, Carbon Capture and Storage Association, accessed 11th August 2020

[8] MPE. (2016). *Feasibility study for full-scale CCS in Norway.* Ministry of Petroleum and Energy.

[9] Sadler, D., Cargill, A., Crowther, M., Rennie, A., Watt, J., Burton, S., & Haines, M. (2016). *H21 Leeds City Gate Report.* Leeds, UK.

[10] van Engelenburg, B., & Noothou, P. (2013). The 'Six Commandments' for regional CCS developers. *Greenhouse Gas Science & Technology, 3*, 427-30.

market failures assessments. In parallel to these macro-economic, market and fiscal background evaluation elements, consideration is also given to the legal and regulatory background.

Using this suite of elements developed in WP3, the market and regulatory background is provided for each of the five case study countries.

Report D3.2.1 is structured as follows.

Chapter 2 introduces the methodological approach for the mapping of business options and parameters, as well as for the assessment of the regulatory and market background and market failures – including the data gathering tools that were designed for the purpose of these assessments.

Chapter 3 provides the system overview for H_2-CCS chains and a compilation of business options within the chains

Chapter 4 presents a set of generic *parameters* relevant for the H_2-CCS chain and its interface with the larger energy system, as well as the assessment of the legal, regulatory and market background from a general, pan-European perspective.

Chapters 5 through 10 present case study parameters as well as the regulatory and market background at the time of assessment for each of the five case study countries.

3.2 Chapter 2: Methodology

3.2.1 Methodological approach

This chapter elaborates on the methodological approach defined in WP3. See Section 2.5 for the overview provided of the business model development methodology and the applicable process steps for applying it to case studies or projects.

3.2.2 Market Background Assessment

To accompany Step 2 (*Focussed market background review and gap analysis*) of the business model development methodology, First Climate designed an Excel-based tool to facilitate the qualitative and quantitative assessment of the prevailing market background for the H_2-CCS integrated value chain of a given country and/or case study.

The user first proceeds to identify the business options of relevance to the case study along the H_2-CSS chain (structured as H_2 infrastructure, CCS infrastructure, H_2 utilization, CO_2 utilization – see Section 3.3). The tool then contains modules with questions about the market players, market structure, the existence and strength of business drivers, and about the market-relevant country context. In each of these modules, the user is asked to research/compile information and to provide an expert opinion according to the list of questions and for the business options that are relevant to the business or case study. The tool does not ask for estimates about market potential or any hypothetical situation but requires the user to simply describe the present situation and to provide ratings correspondingly.

The assessment of business drivers provides valuable insights into prevailing market dynamics (or lack thereof) for a specific H_2-CCS chain segment – basis upon which further background assessment tools in the toolkit can build to identify market failures and policy gaps.

3.2.3 Market Failures Assessment

While this section in Report D3.2.1 covers the Market Failures Assessment developed by Sustainable Decisions Limited, the tool is covered in greater detail under Report D3.3.1. See Section 4.2 (Report D3.3.1) for a description of the aims and outcomes of the Market Failures Assessment tool.

3.3 Chapter 3: H_2-CCS Business Options

3.3.1 H_2-CCS Flow Sheet and Business Tree

This chapter provides an overview of what can be characterised as the "markets" for hydrogen and CCS infrastructure services as well as the key end-use markets for hydrogen and CO_2. While hydrogen is highly flexible as an energy carrier, clean at point of use and can supply a range of markets (e.g. transport sector, heat and power for residential, commercial and industrial purposes, portable power, electricity production at medium and large scale), CO_2 has more limited applications and global emissions far exceed current utilization markets[11] (e.g. solvents such as for enhance oil recovery (EOR), chemical feedstocks, working fluids). Reduction of industrial emissions is an imperative if climate targets are to be met, and CCUS infrastructure will eventually be essential for the task. Hence, conceptually, there is "market" potential for the provision of CCS infrastructure services to industry.

The flow sheets presented in Figure 3-1 and Figure 3-2 enable the users of WP3's business development framework to orient and position the field(s) of activity or interest of a case study quickly within the H_2-CCS integrated chain. Figure 3-1 highlights the activities (processes, services), commodity flows, and end-user markets that are included in one or in several of the five ELEGANCY case studies. Activities on the left-hand side of the flow sheet represent the supply side, while the use-cases on the right-hand side represent the demand side. The two sides are connected by the logistics network for natural gas, hydrogen, and CO_2. The network services include gathering, transmission, storage (intra-day, seasonal, permanent), and distribution. All elements are within the national borders of a case study and commodity flows can either stem from or end in other European countries, or countries outside Europe.

Figure 3-2 shows a second flow sheet using the same logic as in Figure 3-1, but highlighting alternative, competing, or complementary elements that affect the H_2-CCS value chain. This provides additional guidance for (future) considerations about market potential, failures and risks as part of the data gathering process for business development.

The categorization of business options is refined further in the business tree representation of the chain elements included in the ELEGANCY flow sheet, presented in Table 3-1. A terminology for business categories is introduced in the left-most column, which in the centre and right-most column further "branch" into individual business options (hence "business tree"). From top to bottom, the table is split into four modules, representing the supply side (H_2/CCS infrastructure services) and the demand side (H_2/CO_2 utilization). In this way, similarly to the flow sheets, this business tree serves to provide orientation before starting to use or during the use of WP3 data gathering tools.

[11] ZEP (2017) *CCS and Europe's Contribution to the Paris Agreement - Modelling least-cost CO2 reduction pathways.* Bruxelles, Belgium: Zero Emissions Platform.

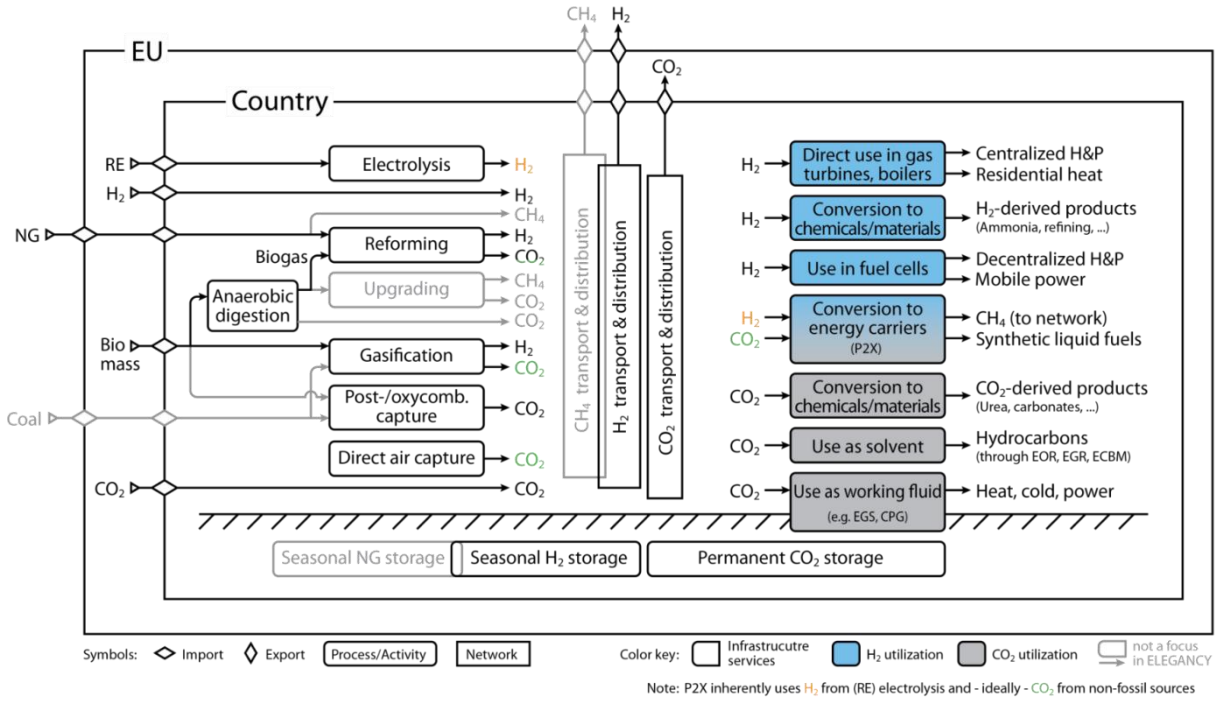


Figure 3-1 Flow sheet of the H_2-CCS value chain.

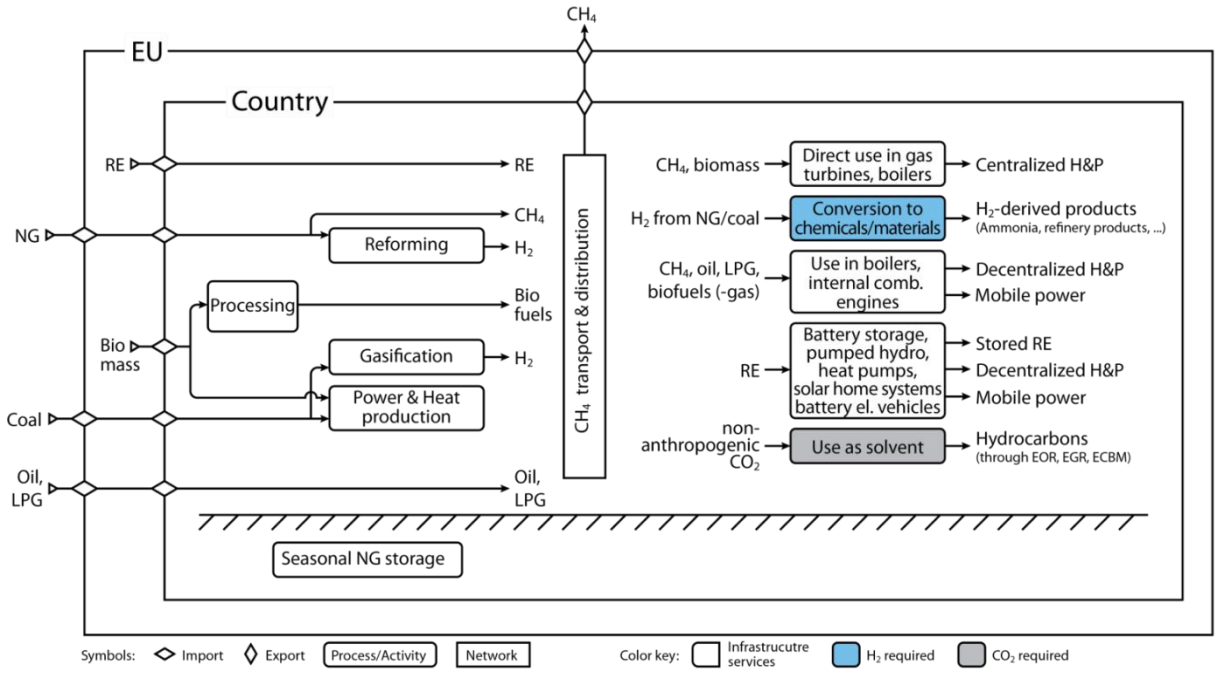


Figure 3-2 Alternative/competing/complementary elements affecting the H_2-CCS value chain.

Table 3-1 Business tree of the H_2-CCS value chain

Business categories	Underlying activities	Further specifications
H_2 supply chain: H_2 production and infrastructure service options		
Production	Reforming (incl. water-gas shift (WGS) reaction and H_2/CO_2 separation)	… of natural gas (NG)
		… of biogas
	Gasification (incl. WGS, H_2/CO_2 separation)	… of biomass
		… of coal
	Electrolysis	… using grid electricity (gridE)
		… using renewable electricity (RE)
Import/export	Import	… from other European countries
	Export	… to other European countries
Transmission & distribution	Transmission by pipeline	… of pure H_2
		… blended into NG network
	Transmission by cargo tanks	… using ships
		… by rail
		… by trucks
	Distribution to end users by pipeline	… pure H_2 residential/C&I distribution network
		… blended into NG distribution network
	Distribution to end users by cargo tanks	… by trucks
	Distribution to end users from stationary sources	… through hydrogen refuelling station (HRS) network
Storage	Intermediate (short-term) storage	… in pressurized containers
		… in salt caverns
	Seasonal/strategic storage in geological reservoirs	… in salt caverns
		… in saline aquifers
		… in depleted oil/gas fields
CCS value chain: CO_2 capture and infrastructure service options		
Capture (production)	Reforming (incl. WGS, H_2/CO_2 separation)	… of NG
		… of Biogas
	Gasification (incl. WGS, H_2/CO_2 separation)	… of biomass
		… of coal
	Biogas upgrading	
	Ethanol production	
	Post-/oxycombustion capture	… from biomass
		… from coal
		… from industrial processes (NG processing, cement, iron & steel, pulp & paper, etc.)
	Direct air capture	
Import/export	Import	… from other European countries
	Export	… to other European countries
Gathering, transmission & distribution	Gathering/transmission by pipeline	
	Transmission by cargo tanks	… by ships
		… by rail
	Distribution to end users by pipeline	… e.g. to greenhouses
	Distribution to end users by cargo tanks	… by trucks
Storage	Permanent geological storage of fossil/geogenic CO_2 for power/industry decarbonization or of biogenic/direct air captured (DAC) CO_2 for negative emissions	… in saline aquifers
		… in depleted oil/gas fields
		… in-situ (enhanced) mineralization

(Business tree of the H_2/CCS value chain, continued)

Business categories	Underlying activities	Further specifications
H_2 demand side: Utilization options		
Direct use (combustion)	Use in gas turbines	… for centralized power (& heat)
	Use in boilers	… distributed for residential and C&I heat (& power)
		… centralized for district heating
Use as feedstock: Conversion to chemicals/materials	Chemical industry applications	… yielding ammonia
		… yielding methanol
		… yielding petrochemical products (nylon, polyurethanes,…)
		… yielding other chemicals
	Refining in petroleum industry	… yielding refinery products
	Use as reducing agent in metal industry	… for iron reduction, or for special metals
Use in fuel cells	Stationary fuel cells	… distributed for residential and C&I power (& heat)
		… centralized (stacked fuel cells) for power (& heat)
	Mobile fuel cells	… to power FCEVs (passenger cars)
		… to power FCEBs (buses)
		… to power FC trucks
		… to power FC aircrafts
		… to power FC ships
CO_2 demand side: Utilization options		
Conversion to energy carriers (P2X)	Power-to-gas for RE storage (incl. reverse WGS & Sabatier reaction)	… yielding renewable CH_4 to be fed to NG network
	Power-to-liquids for RE storage (incl. reverse WGS & FischerTropsch reaction)	… yielding renewable synthetic liquid fuels (e.g. for aviation)
Use as feedstock: Conversion to chemicals/materials (some also energy carriers)	Chemicals without permanent storage potential	… yielding urea
		… yielding formic acid/carboxylic acids
		… yielding methanol
		… yielding organic carbonates/polycarbonates
		… yielding carbamates/polycarbamates
		… yielding other chemicals
	Inorganic carbonates with permanent storage potential	… yielding precipitated calcium carbonate (PCC)
		… for concrete curing
		… for ex-situ mineralization of alkaline wastes (bauxite residues, fly ashes, slags, waste concrete)
		… for ex-situ mineralization of natural minerals (Mg/Ca-silicates, enhanced weathering)
Use as solvent	Supercritical extraction without storage potential	… yielding e.g. decaffeinated coffee
	Enhanced hydrocarbon recovery with permanent storage potential	… for enhanced oil & gas recovery (EOR/EOR+/EGR)
		… for enhanced coal bed methane recovery (ECBM)
Use as working fluid	Working fluid applications without storage potential	… for supercritical CO_2 power cycles
	Geoenergy application with storage potential	… for enhanced geothermal systems using CO_2
		… for CO_2 plume geothermal (CPG)
Other uses without conversion	Food processing	… for preservation
		… for beverage carbonation
	Water treatment	… for re-mineralization and pH-control
	Horticulture (greenhouses)	… yielding food plants, flowers
	Aquaculture	… yielding algae (mostly for biofuel)
	Other niche applications	… e.g. fire extinguishers, refrigerant gas, etc.

3.3.2 Overview of H_2 and CCS Infrastructure and Utilization Markets

This section of Report D3.2.1 presents a comprehensive review of existing markets and opportunities for CCS and H_2 infrastructure, as well as their corresponding end-use applications. Expectations for future development of these sectors are also covered.

3.4 Chapter 4: Background at International and EU Level

3.4.1 Generic Case Study Parameters

A large number of factors – ranging from the political and market environments through to the technological and operational influences on investment choices – have to be considered in order to develop and select business models. Assessing a business case for a particular business model also requires an understanding of the costs and benefits of the various mitigation options for a particular risk profile created by these factors.

The various characteristics, or parameters, of H_2-CCS chains are compiled and classified in this Chapter, starting with a number of different classes for generic use. These Generic Parameters form the foundational basis for work in WP3 to develop a universally applicable H_2-CCS business risk matrix (see D3.3.1), enabling alternative business models and a business case framework to be developed. In a second step, specific instances of these generic parameters have been identified for each of the five case studies. Indeed, case studies in ELEGANCY provide examples of a variety of market and infrastructure development situations. These Case-Study Specific Parameters are reported in the national background chapters of D3.2.1 (see Section 3.5).

The compilation of generic H_2-CCS chain parameters was undertaken as a desktop study based on expert knowledge of the physical and commercial development and operation of value chain systems and infrastructure. This knowledge was applied to a number of public and private sector reports related to hydrogen technologies and market development, and to CCS project and infrastructure delivery in the case study countries. As a result, the generic H_2-CCS chain parameters were divided into eight sets of interrelated qualitative and quantitative characteristics and metrics, as presented in Table 3-2.

Table 3-2 Generic Case Study Parameters

1. CO_2 Abatement and Supply Potential	**2. Markets: Supply & Demand**	**3. Market Structure: Gas, Electricity, Fuels**	**4. H_2-CCS Infra-structure Chain Design, Deployment and Operability**
CO_2 capture potential	*Hydrogen market potential – primary / secondary*	*Market Functionality*	*CO_2 Processing and Hydrogen Production*
Location and industry cluster synergies	*Hydrogen production potential*	*Market Regulation*	*Hydrogen and CO_2: Transportation options*
	CO_2 utilisation potential		*Hydrogen and CO_2: Storage options*
			Oil and Gas (O&G) Infrastructure: lifetime extension and utilisation of existing O&G assets (Cf. Storage potential)
			Nat. gas networks con-version / transformation
			Scalability impact

			Timing, roadmap and development schedule
			Supply chain synergies and metrics
5. H_2-CCS Infrastructure Chain Operability	**6. Commercial and Financial**	**7. Regulation and Policy**	**8. Social and Environmental**
Natural Gas Operational Constraints: feedstock supply management	*Macro-economic metrics*	*Impact of regulations and permitting*	*Social acceptance and impact*
H_2 Operational Constraints: production, storage and demand management	*Project and cluster metrics*	*Impact of EU energy directives*	*Decarbonisation and emissions metrics including embodied CO_2 and Lifecycle analysis (LCA)*
CO_2 Operational Constraints: CCS operational and interface management	*Commercial and financial risk profiling - risk sharing, liability allocation*	*Government value for money metrics*	
	Ownership/Collaboration /cooperation/Public-Private Partnership metrics	*Integrated assessment*	
	Capital expenditure (Capex) and Operating expenditure (Opex) optimisation	*Political acceptance*	
	Cost of capital and financing metrics		
	Financial support mechanisms		
	Tax		
	Commercial/financial metrics		
	Commodity price impact		
	Cost/benefit metrics for different stakeholder groups		

3.4.2 Legal Background at International and European Level

In parallel to the background work on compilation of generic case study parameters, WP3 conducted an assessment of the legal background relevant to the different components of the H_2-CCS chain applicable to the case study countries. A key objective of this assessment was to identify both legal bottlenecks and legal incentives in the development of a H_2-CCS chain. The analysis also contains considerations related to the general regulatory approach followed. To this end, the scope of the research is on international and European law on the one hand, and national law on another hand. For legal and regulatory background at national level, see Section 3.5.

An important preliminary remark concerning the scope of the research is the rapidly changing legal environment. Different changes in the legislation entered into force within the three-year lifetime of the ELEGANCY project or are expected to enter into force shortly after its termination. Immediate regulatory changes related primarily to the adoption at EU level of the Clean Energy Package for All Europeans legislative package. Expected relevant changes which still are pending are the revision of the Gas Directive and the negotiations around Brexit. One should also expect, as part of the European Green Deal, new legislative changes related to the newly revised

Renewable Energy Directive, the EU Emissions Trading Scheme and the Energy Taxation Directive, among others. At the international level, one should expect the final adoption of detailed rules for the implementation of the Paris Agreement and the different carbon mechanisms defined in it (Article 6). Those upcoming legal and regulatory changes form part of the regulatory uncertainty of any new technology and business activities under development and need to be addressed as a separate risk factor.

A large number of factors will influence the choice of the business models for integrated H_2-CCS chain projects. Those factors also influence the nature of the legal challenges and the type of legal incentives. The legal screening exercise undertaken focused on the definition of the operations within the H_2-CCS chain in the light of the specificities of the five national case studies. Therefore, the assessment covered legislation applicable to the following sectors: electricity and gas, heating, transport and industry.

The assessment focused on the interaction between CCS and hydrogen, and not solely on CCS and hydrogen as separate activities. In that connection, it is important to note that not all activities in the H_2-CCS chain will be of equal commercial value: some relate to pure legal obligations without - still - being commercially attractive (e.g. CO_2 storage) and could possibly qualify as public service obligations; while others are by nature commercial. There must be a balance of those different interests when building a chain approach to H_2-CCS. Clarifying the status for the transfer of CO_2 and H_2 ownership through the supply chain and the different industrial processes, and the attached obligations, is equally important to stimulate operations.

The legal background analysis has identified two types of need related to: (i) the *clarification* of the currently applicable legal framework, where legislation is in place but needs interpretation in the 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.

(i) Need for clarification of the currently applicable legal framework in relation to:

1. Market design: 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). A first example is unclear coverage of the temporary storage of CO_2 and hydrogen. A second example is the applicability of unbundling rules. A third example is the unclear coverage of mobile CO_2 transport under the EU Emissions Trading Scheme.
2. Financial support measures, state aid regime and public procurement;
3. Access to the grid for hydrogen, pure or blended;
4. Transport infrastructure regulation for CO_2 and hydrogen;
5. Fuel quality requirements;
6. Use of biomass and regulation of negative emissions.

(ii) Need for adaptation of current framework or need for new rules in relation to:

1. Cross-boundary movement of CO_2 for permanent storage;[12]
2. Alignment with the Clean Energy Package for All Europeans;
3. CCS Directive and focus on permanent storage of carbon dioxide;
4. Balance of responsibilities along the chain (commercial operations vs. non-commercial operations like storage of CO_2);
5. Standardisation efforts for technical requirements (transport, blending, infrastructures);
6. Market valorisation: regime for guarantees of origin for hydrogen (including as part of the implementation of the Renewable Energy Directive), criteria for sustainable finance under the Taxonomy Regulation.

By identifying those legal bottlenecks, the research permitted identifying legal mitigation strategies.[13]

3.5 Chapters 5 through 10: National Backgrounds

In these final chapters, the conceptual elements, spreadsheet tools and background assessments elaborated thus far in the Report – i.e. market background assessment tool, market failures assessment tool, generic case study parameters, EU/international legal background – are applied and/or extended to the national context of all five case studies. The inputs for this macro-economic, market, fiscal and regulatory background review of each country builds on communications with ELEGANCY partners and external stakeholders, as well as publicly available literature such as journal articles, reports, governmental bulletins and statistics, and legislation

3.5.1 Case-Study Specific Parameters

Specific instances of the generic parameters that provide an additional level of detail for the ELEGANCY case studies in each of the national contexts were compiled. These specific parameters reflect answers to the questions why?, what? and how? for H_2-CCS chain investment and deployment. The responses and their priorities are grouped for each of the five countries into three corresponding sets:

1. The *Climate Business Context* sections focus on the energy, environmental and policy context for each of the regions/countries that will influence their priorities and objectives with regard to the definition, investment and deployment of a commercially viable H_2-CCS infrastructure.
2. The *Markets* section focusses on those markets, sectors and technologies of particular interest for each of the case studies and highlights important interfaces between them.

[12] A major development in 2019 has been the agreement reached in relation to the London Protocol's export amendment (2009 amendment to Article 6 of the London Protocol to the 1972 London Convention on the Prevention of Marine Pollution by Dumping of Wastes and Other Matter) concerning the transboundary transport of CO_2 for the purpose of permanent storage. The Parties to the Protocol agreed on 11 October 2019 to enable a provisional application of the amendment between countries who decide to do so, in accordance with Article 25 of the Vienna Convention on the Law of the Treaties. The initiative was developed by the governments of Norway and The Netherlands.

[13] O'Brien Alice and Banet Catherine, 'De-risking the hydrogen-CCS supply chain through law, journal article (under peer-review).

3. The *Delivery* section summarises the parameters of particular relevance for the viable deployment of a H_2-CCS chain that meets the case study objectives, and which could create a clean energy pathway attractive to investors with sufficient optionality to address both the specific current climate business context and the uncertainty of the future.

3.5.2 Regulatory Background at National Level

All five national case studies raise some general common questions concerning:

- the consequences of the distinction between common law vs. civil law;
- the consequences of the distinction between public law requirements vs contractual law requirements, and how the two interact;
- the reliance on standardisation vs harmonisation of requirements in law;
- the relationship between energy, climate and spatial planning tools, and the – generally - limited level of integration;
- The potential increased interaction between the different case studies.

Specific legal barriers in national legislation have been identified and consist notably in the following:

- The relevant EU legislation may have been transposed fully and correctly, some implementation measures are still needed to make the legislation fully operative;
- The regime for hydrogen production, transport, supply and consumption is unclear, also as a result of the lack of clarity of EU legislation (see Section 3.4.2 above);
- Safety rules do not cover all envisaged uses of hydrogen, particular at small scale level;
- The permitting system for the different activities remains complex, particularly when activities are combined. This also reflects a lack of integrated approach in the permitting regime for, again, combined activities and across energy carriers;
- There is a lack of clear governance framework and repartition of competences between entities in relation to H_2 infrastructures (ownership, operation, supervision);
- Uncertainty remains or regulatory incentives are absent to ensure the transfer of liability between actors along the chain;
- There are no sufficient regulatory incentives for the re-use of existing energy infrastructures.

Good national regulatory practices consist in:

- The adoption of a clear legislation framework;
- The standardisation of private practices, including standardisation of contractual provisions;
- The development of regulatory sandboxes by regulators;
- Official request for clarification sent by national authorities to the European Commission for the purpose of providing legal certainty in the application of European legislation;
- Streamlining of permitting procedures as part of an industrial cluster approach;
- Streamlining of environmental permits.

3.5.3 Market Background

Market backgrounds for the case study scopes were assessed using the spreadsheet tools to collect inputs from ELEGANCY partners and external stakeholders on existing businesses, major R&D

activities, key players, on the strength of a selection of business drivers in promoting the existing markets, as well as on the prevalence of market failures in a given country context. The multiple inputs received to the spreadsheet tools for the various countries were merged into 'consolidated expert opinion' versions and key trends/takeaways were extracted. The results are presented in the Report by drawing cross-sector and cross-country comparisons. Where sufficient information was available, business driver and market failures heatmaps were developed. Presented in Table 3-3 is an example business driver heat map for the UK case study. For market failure heatmaps, see Section 4.2.

Across the case study countries, a number of similarities were noted at the time this assessment was conducted with regards to the strength/weakness of current business drivers:

- On the **H_2 infrastructure** side stakeholder actions are the strongest drivers of activity in supply chain segments, namely through commitments made or strategic positioning in anticipation of future markets. Market dynamics, in the form of commodity price fluctuations, affect these segments to a certain extent as well. On the other hand, regulations such as carbon pricing are found to be of limited impact in promoting the hydrogen supply/service options listed.
- No strong overarching driving force can be identified across all case study countries for **CCS infrastructure**. In contrast to H_2 infrastructure, CCS infrastructure is only mildly driven (if at all in certain cases) by stakeholder actions such as commitments, social preferences or anticipation of future markets. Similarly, commodity price fluctuations, both with respect to fuel use in capture processes and overall supply chain costs, are also rather moderate drivers. With regards to regulations, these are in fact more often identified as barriers to CCS deployment than drivers, although carbon pricing is in certain cases identified as a promoter.
- Drivers for activity in **end-use markets for H_2** are mostly reported for mobility and industrial applications. For these, environmental consciousness of consumers and social preferences are key drivers. Other notable drivers of H_2 utilization in certain cases are stakeholder commitments, carbon pricing and regulation.
- Given the limited data collected on drivers of end-use markets for CO_2, direct conclusions across countries could not be drawn.

With respect to market failures, significant market failures were identified overall in all case studies (with the exception of the Netherlands, where no data was reported for this specific assessment) demonstrating the complexity of the challenges faced by early stage H_2-CCS sectors. At a high level, all countries pointed to missing markets, coordination failure and unpriced negative externality as inhibitors of investment and business activity. However, upon closer inspection, the results revealed certain specificities of each country, which highlighted aspects to be considered for the development of the business case frameworks. These can be summarised as follows:

- **Netherlands**: No data
- **Switzerland**: On the infrastructure and the end-use side, the country is clearly facing broad and considerable market failures for early-stage H_2-CCS chain development.
- **UK**: Most end-use market and infrastructure services are rated with high market failures, with hydrogen infrastructure facing the broadest scope of challenges.

- **Germany**: CO_2 infrastructure (i.e. production, transmission/distribution, storage) faces more intense market failures than hydrogen infrastructure. Of note as well is the high disincentive for early-mover risk-taking due to knowledge creation spillover effects.
- **Norway**: The market failure landscape is generally identified as less severe in Norway than in other countries. Nevertheless, market failures in H_2 infrastructure remain high.

Table 3-3 Business drivers heat map for the UK case study.

H2 Infrastructure		Supply chain segment:	Production			Transmission, distribution		Storage	
		Supply/service options: (cf. Tab 'Business tree')	Reforming	Gasification	RE electrolysis	By pipeline, by vessel	Through hydrogen refuelling stations (HRS) network	Intermediate (short-term) storage	Seasonal/strategic, long-term geological storage
N°	Indicator								
I.1 Market players and interactions									
I.1.1	In the given country context and with focus on the scope of your case study: Which H2 supply/infrastructure service options are currently being offered domestically?		present	not present	not present	present	present	not present	not present
I.2 Business drivers									
For the country under investigation and the H2 supply and infrastructure service options that are present (as selected in I.1.1), rate and describe the strength of the following indicators as drivers for H2 infrastructure services. In infrastructure sectors already dealing with grey/carbon-intensive H2, rate and describe the strength of the indicator as driver to switch to green/low-carbon H2. For									
I.2.1	**Cost of production/services**:	Provide rating:	weak	choose from list	strong	strong	strong	strong	choose from list
I.2.2	**Commodity prices**:	Provide rating:	medium	choose from list	not a driver	weak	weak	not a driver	choose from list
I.2.3	**Fiscal advantages**:	Provide rating:	not a driver	choose from list	strong	strong	strong	strong	choose from list
I.2.4	**Carbon pricing mechanisms:**	Provide rating:	not a driver	choose from list	not a driver	not a driver	not a driver	not a driver	choose from list
I.2.5	**Other regulations (apart from those in I.2.3-4):**	Provide rating:	choose from list	choose from list	choose from list	medium	medium	choose from list	choose from list
I.2.6	**Stakeholder commitments:**	Provide rating:	strong	choose from list	strong	strong	strong	strong	choose from list
I.2.7	**Clustering:**	Provide rating:	medium	choose from list	not a driver	medium	not a driver	not a driver	choose from list
I.2.8	**Technological advances:**	Provide rating:	strong	choose from list	strong	weak	medium	strong	choose from list
I.2.9	**Anticipation of future markets**:	Provide rating:	strong	choose from list	strong	strong	strong	strong	choose from list

CCS Infrastructure		CCS value chain segment:	Capture					Gathering, transmission, distribution		Storage
		Capture/service options: (cf. Tab 'Business tree')	Reforming	Gasification	Biogas upgrading, ethanol production	Post-/oxycombustion capture*	Direct air capture	By pipeline	By vessel	Permanent geological storage
N°	Indicator					* from power&heat and from industrial point sources (incl. NG processing in the gas industry)				
II.1 Market players and interactions										
II.1.1	In the given country context and with focus on the scope of your case study: Which CO2 capture/infrastructure service options are currently being offered domestically?		not present	not present	not present	not present	not present	not present	not present	not present
II.2 Business drivers										
For the country under investigation and the CCS infrastructure service options that are present (as selected in II.1.1), rate and describe the strength of the following indicators as drivers for CCS infrastructure services.										
II.2.1	**Cost of production/services**:	Provide rating:	strong	choose from list	choose from list	strong	choose from list	medium	choose from list	medium
II.2.2	**Commodity prices**:	Provide rating:	strong	choose from list	choose from list	strong	choose from list	medium	choose from list	medium
II.2.3	**Fiscal advantages**:	Provide rating:	not a driver	choose from list	choose from list	weak	choose from list	not a driver	choose from list	not a driver
II.2.4	**Carbon pricing mechanisms:**	Provide rating:	strong	choose from list	choose from list	strong	choose from list	strong	choose from list	negative driver
II.2.5	**Other regulations (apart from those in II.2.3-4):**	Provide rating:	not a driver	choose from list	choose from list	weak	choose from list	not a driver	choose from list	negative driver
II.2.6	**Stakeholder commitments:**	Provide rating:	not a driver	choose from list	choose from list	not a driver	choose from list	not a driver	choose from list	not a driver
II.2.7	**Clustering:**	Provide rating:	not a driver	choose from list	choose from list	weak	choose from list	medium	choose from list	weak
II.2.8	**Technological advances:**	Provide rating:	medium	choose from list	choose from list	strong	choose from list	weak	choose from list	medium
II.2.9	**Anticipation of future markets**:	Provide rating:	not a driver	choose from list	choose from list	not a driver	choose from list	medium	choose from list	strong
II.2.10	**Social preferences or rejection:**	Provide rating:	not a driver	choose from list	choose from list	not a driver	choose from list	not a driver	choose from list	not a driver

(Business driver heat maps for the UK case study - continued)

H2 Utilization		Market sector:	Mobility*	Industry		Decentralized heat & power*		Centralized heat & power*	
		Utilization options: (cf. Tab 'Business tree')	Use in mobile fuel cells	Conversion to chemicals/materials	Direct use via combustion for process heat only*	Direct use via combustion in boilers for heat (& power)	Decentralized stationary FCs for power (& heat)	Direct use via combustion in gas turbines	Large stationary FC stacks
N°	Indicator		*primary subsector considered is road transport (passenger cars, buses, lorries).	*space heating and power (via combustion, gas turbine, stationary FC) is not considered part of the sector, but in the heat&power sectors.		*the focus lies on decentralized heat via direct combustion in boilers; decentralized FC option is added as a niche option		*the focus lies on large power, whereas the co-harvesting of heat is always an option for large power applications.	
III.1 Market players and interactions									
III.1.1	In the given country context and with focus on the scope of your case study: What are the currently prevailing H2 utilization options?		present	present	not present	not present	not present	not present	not present
III.2 Business drivers									
For the country under investigation and the utilization options that are present (as selected in III.1.1), rate and describe the strength of the following indicators as drivers for H2 utilization. In sectors where H2 is already being used, rate and describe the strength of the indicator as driver for green/low-carbon H2 utilization.									
III.2.1	**Price for H2 products or services**:	Provide rating:	strong	weak	choose from list	choose from list	strong	choose from list	choose from list
III.2.2	**Fiscal advantages**:	Provide rating:	strong	not a driver	choose from list	choose from list	strong	choose from list	choose from list
III.2.3	**Carbon pricing mechanisms:**	Provide rating:	not a driver	not a driver	choose from list	choose from list	not a driver	choose from list	choose from list
III.2.4	**Other regulations (apart from those in III.2.2-3):**	Provide rating:	weak	not a driver	choose from list	choose from list	not a driver	choose from list	choose from list
III.2.5	**Stakeholder commitments:**	Provide rating:	strong	strong	choose from list	choose from list	strong	choose from list	choose from list
III.2.6	**Environmental consciousness of consumers:**	Provide rating:	strong	weak	choose from list	choose from list	weak	choose from list	choose from list
III.2.7	**Social preferences or rejection:**	Provide rating:	strong	not a driver	choose from list	choose from list	not a driver	choose from list	choose from list

CO2 Utilization		Market sector:	Mobility	Industry*			Decentralized heat & power	Centralized heat & power
		Utilization options: (cf. Tab 'Business tree')	Conversion to liquid synthetic fuel*	Conversion to chemicals/materials	Use as solvent	Other uses without conversion	Conversion to CH4 to be fed into NG network*	Use as working fluid*
N°	Indicator		*Additional note at bottom of this tab.	*space heating and power (via combustion, gas turbine, stationary FC) is considered in the sectors to the right (columns H and I).			*Additional note at bottom of this tab.	*considering supercritical CO2 power cycles and geoenergy applications.
IV.1 Market players and interactions								
IV.1.1	In the given country context and with focus on the scope of your case study: What are the currently prevailing CO2 utilization options?		not present	not present	not present	not present	not present	not present
IV.2 Business drivers								
For the country under investigation and the utilization options that are present (as selected in IV.1.1), rate and describe the strength of the following indicators as drivers for CO2 utilization.								
IV.2.1	**Price for CO2 products or services**:	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list
IV.2.2	**Fiscal advantages**:	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list
IV.2.3	**Carbon pricing mechanisms:**	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list
IV.2.4	**Other regulations (apart from those in IV.2.2-3):**	Provide rating:	choose from list	choose from list	choose from list	don't know	choose from list	choose from list
IV.2.5	**Stakeholder commitments:**	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list
IV.2.6	**Environmental consciousness of consumers:**	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list
IV.2.7	**Social preferences or rejection:**	Provide rating:	choose from list	choose from list	choose from list	choose from list	choose from list	choose from list

4 REPORT D3.3.1 - A BUSINESS RISK MATRIX FOR APPLICATION IN TASK 3.3

4.1 Summary

Report D3.3.1 is a summary cover document for the risk assessment Excel tool suite comprising a number of background assessment tools and the business risk matrix. The tool suite is designed for application to the business model and business case development in ELEGANCY WP3, to the WP5 case studies, and for general use in other settings and jurisdictions. A brief description of the functionality of each of the background assessment tools is provided, followed by a detailed explanation of the risk assessment methodology.

4.2 Market Failure Assessment

This tool is designed to facilitate the qualitative and quantitative assessment of market failures for the market sectors of relevance for the H_2-CCS integrated chain of a case study. Market failures are not necessarily barriers to investment. They are situations, mechanisms or activities that change or affect the dynamics of a properly functioning market and distort the ability of the market to achieve equilibrium between supply and demand without external intervention.

The spreadsheet table in the tool lists the market sectors in the first column in multiple rows and lists all the types of market failures in the first row in multiple column headings. The user can decide to add additional rows in order to break down the markets sectors into multiple business segments as per suggested categories taken from the standardised business tree from deliverable D3.2.1 (for example, dividing centralised heat and power into direct combustion and fuel cell combined heat and power (CHP)).

For each market sector the types of market failure (if any) are selected and given a rating according to the extent of each failure. The ‘extent’ of the failure is defined as the severity of its effect, impact or consequence on the market or business segment in the H_2-CCS chain. Relevant options are chosen from a drop-down menu. If any of the market sectors are not relevant to a case study, there is a not applicable 'n/a' option.

The following table is an example of a market failure assessment taken from the UK WP5 case study dealing with the use of hydrogen, produced from autothermal reforming (ATR) with CCS, for decarbonising heat and other activities in the north of England.

Table 4-1 UK Case study market failures assessment

Market Opportunities/Market Failures	Missing Market	Coordination Failure	Negative Externality Low Priced CO2 Emissions	Positive Externality Improved Air Quality	Natural Monopoly	Merit Goods Hydrogen	Merit Goods CO2 Utilisation	Merit Goods Appliances & Equipment	Location Immobility	Social Inequality Fuel Poverty	Information Failure and Asymmetry	Knowledge Creation Spillovers
H_2/CO_2 End Use Markets												
Large Stationary Power	High	High	Low	Low	Low	Medium			High			
Small Stationary Power	High	High	High			Medium		Medium	Low	Medium	Low	Medium
Mobility - Vehicles	High	High	High	Medium	Medium	Medium	Medium		Low	Low	Low	Medium
Mobility - Other												
Heat	High	Medium	High	Medium	Low	Medium		High	Medium	High	Low	Medium
Chemicals and Industry	Low	Low	High	Medium		Medium	High		Medium		Low	High
Power to X (Storage)	Medium	High	High		Medium	High			Medium		Low	High
H_2-CCS Chain												
H_2 Retail	High	High	High	High	Low	High		High		High	Low	Low
H_2 Distribution	High	High	High	High	Medium	High			Medium			Low
H_2 Storage	High	High	High	High	High	High			High		High	Medium
H_2 Transmission	High	High	High	High	High	High			High			Low
Low Carbon H_2 Production	Medium	High	High	High	Medium	High			Medium		Low	Low
CO_2 Capture	Medium	High	High	Medium	Low		High		Low		Low	Medium
CO_2 Gathering	High	High	High		High		High		Medium		Low	Medium
CO_2 Transmission	High	High	High		High				High		Medium	Medium
CO_2 Storage	High	High	High		High				Medium		High	Medium

4.3 Policy and Financial Support Assessment

This tool is designed to facilitate the qualitative and quantitative assessment of the existing regulatory policies and financial support mechanisms against expected requirements.

Firstly, the market sectors of relevance for the H_2-CCS integrated chain of the case study are selected. The market sectors are made up of a number of business segments that provide products or services, which are again taken from the business tree of deliverable D3.2.1. These can be considered in greater detail during the course of the policy assessment and additional policy needs added to the spreadsheets as deemed appropriate.

For each of the relevant market sectors, the policies in place are reviewed against the identified 'market needs'. Three assessments are carried out.

1. First the importance of the policy need is rated using a simple scale of low/medium/high.
2. The second rating is an estimated time period over which the policy needs to be developed and implemented for maximum benefit to the evolution of the market sector and its associated technologies.
3. The third assessment is aimed at determining the level of compliance of existing policies for the case study under review. The level of compliance is rated from 1 to 10 (1=Not compliant; 10=fully compliant) and the user is asked to provide evidence. Cells automatically change colour in relation to the rating.

The final aspect of this rating tool is a review of the level of financial support available for the implementation of the relevant policies and activities to determine whether this is currently sufficient. Multiple options are provided: very low and low (i.e. insufficient), sufficient, and high (which has a positive impact on the timeline for implementation). The user is again asked to provide evidence to allow for comparison with other case studies or market sectors and facilitate future revisions of the assessment.

The data collected in the tool can be further processed to generate a policy needs heat map, which is introduced in Report D3.3.3 (see Section 5.2.2 below).

4.4 Risk Assessment

Sustainable Decisions Limited created a "Risk Assessment Tool" presented in Report D3.3.2 Appendix A.2. This tool is designed to carry out a preliminary assessment of the investability barriers and major business risks in each of the market sectors/business opportunities of a specific case study in order to steer the development of the appropriate business model, and to define and prioritise the actions to be taken in order to mitigate and manage those risks. The risk assessment methodology is described in more detail below.

4.4.1 Risk Assessment methodology

Step 1: *Identification of business opportunities*

The market sectors/business opportunities of relevance for the H_2-CCS integrated chain of the case study are selected to understand how many risk assessments need to be completed and to frame the analysis of each one depending on its level of integration. Business opportunities may be grouped together to represent vertical integration of the value chain components in one entity, those which are/will be managed by the same entity (public/private) or where the investment risks

are fully integrated within the same entity. These business opportunities should be consistent with the H_2-CCS chain business segments of the business tree defined in deliverable D3.2.1).

Step 2: *Detailed risk assessment*

The risk assessment methodology for the H_2-CCS chain uses a modified bow-tie assessment technique. The analysis is undertaken at two levels followed by a consistency check between the two:

1. At the first level, major investability barriers are identified. These barriers are "fact" or in risk parlance have 100% likelihood. These barriers affect investment in substantial parts or all of the H_2-CCS chain. A number of these barriers have been experienced by CCS projects and commercialisation programmes, and many have been well documented. Mitigation measures need to be identified to enable public and/or private sector entities to invest and operate. A market failure such as a missing market is an example of an investment barrier. A regulation or statute resulting in an uncapped liability for a business is another.

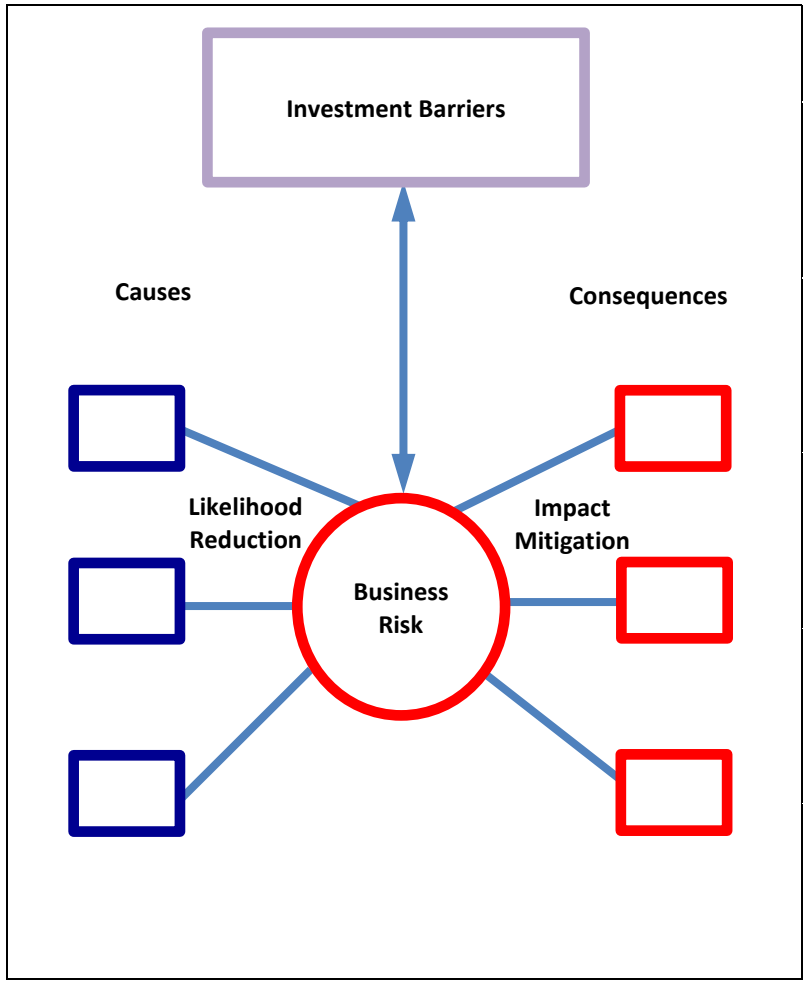
2. At the second level, specific business risks affecting each of the business opportunities are reviewed and their likelihood and impact on the feasibility or value of the business opportunity are assessed using a traditional risk matrix methodology. The consequences on investability are also rated using a scale from 1 to 5 where 1 is low risk and 5 is prohibitive risk. Guidance tables with qualitative description of the rating values for risk likelihood, risk impact and investability are provided in the instructions sheet to help the user. A degree of flexibility in interpretation is allowable for the severity of the impact depending on the nature of the proposed investment or operational entity. Mitigation measures for cause and consequence are then analysed using a bow tie approach, which addresses control and recovery actions for cause and consequence respectively. Those measures are categorised from a pre-defined list (contractual, legal, etc.) and assessed to understand their level of market development and whether government intervention is required.

Step 3: *Consistency check*

The impact of the business risks at the second level on investability in the business opportunity is also assessed from a chain perspective to determine if investability barriers and mitigations need to be reviewed and revised or the nature of the business entity needs to be modified. A consistency check between the investability barriers at level 1 and the business risks at level 2 is undertaken to ensure any level 2 risks that result in a chain investability impact of rating 5 are escalated to barriers and dealt with accordingly. Consistency between mitigation measures is also cross-checked.

4.4.2 Risk Matrix Guidance and Legend

ASSESSMENT METHODOLOGY



PRIVATE SECTOR INVESTABILITY RATING GUIDANCE

Investability Rating	Guidance
1	Established business opportunity with standard business risks. Investment open to standard market players with standard financing and insurance available
2	Medium risk investment with debt financing available at short tenor and high interest, higher than standard IRR required, risk profile acceptable to more than 50% of market players
3	High risk investment with low debt ratio bank financing available, proven technology and acceptable regulatory and legal environment
4	Investment requires high risk appetite - First mover investor - No debt financing available, strategic investment, company with large balance sheet
5	No Investment possible - uncapped or unmanageable liabilities, high uncertainty of revenue and cost, unacceptable performance guarantees and warranties

PUBLIC SECTOR INVESTABILITY RATING GUIDANCE

Investability Rating	Guidance
1	Established public sector investment activity and/or risk profile
2	Medium risk to Government, small number of previous public sector investments with similar risk profile, general community support for the activity, infrastructure, or service
3	High risk investment with potential for stranded or under-performing assets left in public sector hands
4	Investment requires high risk appetite from Government with Treasury buy-in, very strong or new policy support, likely a need for new legislative mechanisms, possible need for bi-partisan agreement in parliament
5	No public investment possible - political or financial exposure too high

RISK MITIGATION MEASURE CATEGORY GUIDANCE

Mitigation Measure Category	Guidance
Contractual Terms	Examples include take or pay, bank guarantees, pricing structure, change of control and change of law provisions, risk allocation, liability limits for specific events, consequential damages
Financial Market and Debt Instruments	Minimum repayment levels, debt service cover ratio, step in rights, swaps, derivative instruments, new technology guarantees/requirements
Insurance	Insurance cover to protect against specific risks and cap liabilities
Technology	Improvements in technology to improve reliability, improve efficiency, reduce capex/opex, reduce uncertainty of unplanned operational events
Policy and Market Signals	Policy commitments, targets and carbon budgets, Principles for evaluating investment – (social economic benefits), decision-making structure
Regulations, Legal and Influence	Legislative changes to define, allocate and reduce liabilities, legal requirements for permitting and planning consent including financial guarantees and liability for decommissioning, pollution…
Financial Support	Financial support mechanisms (grants, tax allowances, FITs, subsidies, CfDs, etc.), public sector underwriting, Third Party Access policy, Regulated/Unregulated business
Market Design, Supervision, Market Provider	Intervention for competition, tradeable permits, competitive tendering, direct service or goods provision,
Ownership Structure / Investor Type	Joint ventures, strategic partnerships and vertical integration of value chain, impact of government participation, public-private ownership/operating model

RISK LIKELIHOOD RATING GUIDANCE

Risk Likelihood	Guidance
1	Very unlikely
2	Unlikely
3	Possible
4	Likely
5	Very Likely

RISK IMPACT RATING GUIDANCE

Risk Impact	Guidance
1	Insignificant
2	Minor
3	Moderate
4	Major
5	Severe

4.4.3 Example of Section of a Business Risk Matrix from the UK Case Study

Risk Category	Business Risks	Nature of Impact					Scope of Chain Impact	Risk Quantification			Investability Rating	Mitigation Measures	Target of Mitigation Measure: Cause or Consequence?	Category	Current Status of Mitigation Measure	Government Intervention Required (y/n)	Investability Rating (Post Mitigation)
		Cost	Revenue	Financing	Schedule	Liabilities		Likelihood	Impact	Rating							
REGULATORY	A functional regulatory framework agreed between government and the private sector to govern the business model and investments in the H21 system is not in place in time for FID by 2023	✗	✗	✔	✔	✗	H2-CCS Chain	4	5	20	4	Utilise an Executive Steering Committee to drive the process with engagement of all key parties (grouped in regulatory, regional and functional expert working groups)	Control of Cause: Likelihood Reduction	Market Design, Supervision, Market Provider	Early stage of development	yes	3
	Inconsistent laws and regulations between end use markets and those governing CCS permitting and operations affect construction and/or service delivery	✔	✗	✔	✔	✔	H2-CCS Chain	3	4	12	3	Establish an oversight council including Ofgem, IPA, HSE, OGA and others to ensure laws and regulations are consistent, compatible and fit-for-purpose in liaison with the executive steering committee	Control of Cause: Likelihood Reduction	Market Design, Supervision, Market Provider	Non-Existing	yes	2
	Mandatory third-party access to infrastructure leads to operational and commercial problems such as controlling H2 and CO2 quality specs and inability to meet regulations and performance guarantees	✗	✔	✗	✗	✔	H2-CCS Chain	3	4	12	3	Regulator/Competent Authority implements evidence-based pragmatic and flexible compliance regime and penalty response	Recovery from Consequence: Impact Reduction	Regulations, Legal and Influence	Early stage of development	yes	2
												Contractual gas quality specifications with performance guarantees and contractual liabilities from counterparty operators	Control of Cause: Likelihood Reduction	Contractual	Existing	no	2
POLICY CHANGE	Government policy of supporting critical and strategic evidence gathering for H2 in general and H21 in particular does not extend to the H21 FEED and live trials before 2023	✔	✗	✗	✔	✗	H2 Chain	3	5	15	4	Minimise value at risk from project development activities and seek necessary guarantees from government	Recovery from Consequence: Impact Reduction	Contractual	Existing	yes	2
												Create H2-CCS business case optionality with flexibility to adjust if city conversion is not progressed: flexibility in sizing of hydrogen plant and storage, other hydrogen users (power plant, industry)	Recovery from Consequence: Impact Reduction	Policy and Market Signals	Early stage of development	yes	3
	Government de-prioritises H2-CCS in Clean Growth and Industrial Strategies in the period to 2023	✗	✗	✔	✔	✗	CCS Chain	3	5	15	4	Minimise value at risk from project development/FEED activities, ensure shared government contribution to fund FEED, and seek necessary guarantees from government	Recovery from Consequence: Impact Reduction	Contractual	Existing	yes	3
	The functional regulatory framework agreed between government and the private sector to govern the investments in the H21 system is unilaterally changed by government before the second phase of H21 investment	✔	✔	✔	✔	✔	H2-CCS Chain	2	5	10	3	Remuneration structure is sufficient for stand-alone investment in 1st phase infrastructure investment. Return on investment in oversizing of infrastructure is covered by an appropriate contractual mechanism and guaranteed/protected by the government.	Recovery from Consequence: Impact Reduction	Financial Support	Non-Existing	yes	2
												Business Case for H2-CCS chain is not linear and includes flexibility and optionality in terms of sizing and hydrogen users for future development - so that long term commitment of city conversion is not critical for investment decision - for example modular and expandable hydrogen plant, key future users identified (industry, hydrogen power plants, etc.), staged development of CO2 storage reservoirs	Recovery from Consequence: Impact Reduction	Market Design, Supervision, Market Provider	Non-Existing	yes	2

5 REPORT D3.3.2 - POLICY-ISSUES, BUSINESS RISKS, DE-RISKING INSTRUMENTS, AND INCENTIVE MECHANISMS RELEVANT FOR CASE STUDY COUNTRIES

5.1 Summary

The major barrier to deployment of CCS is no longer technological, but political, regulatory and commercial. There remain many technical challenges associated with the successful development and operation of CCS systems, but the general agreement is CCS at industrial scale is technically feasible.

However, the successful realisation of such large-scale low carbon infrastructure investment requires the mobilisation of vast amounts of domestic and international private capital (equity and debt) to supplement limited government resources and facilitate a more efficient use of those resources by sharing the risks with private sector. Large scale infrastructure investment due to its nature requires government involvement – direct or indirect to address fundamental investment barriers. Policies are critical in determining the attractiveness of investment opportunities and their risk profile. In addition, these opportunities face traditionally many other challenges such as cost overruns, delays, availability of private finance, demand/volume uncertainty and therefore risk of oversizing, counterparty credit risk, etc.

Risks - whether perceived or real - determine the attractiveness of the investment opportunities and the level of return investors expect, and it is therefore critical to understand, mitigate and allocate risks which private sector lenders and investors perceive as excessive or beyond their control and are not willing to accept. Good management of risks also determines the overall value realised by the execution of the project. In a review of infrastructure projects, McKinsey[14] concluded that "large infrastructure projects suffer from significant undermanagement of risk in practically all stages of the value chain" and highlighted the need for good risk-informed project management made up of a risk management framework which identifies the most critical issues and choices to be made, a set of practical tools to help public and private investors make those choices, and an implementation framework to ensure disciplined execution throughout the life cycle of the project.

With regard to H_2-CCS infrastructure investment, ClimateWise[15], a global insurance industry leadership group highlighted in 2012 that "the absence of viable risk management solutions presents a material barrier to the development of Carbon Capture and Storage (CCS) at scale in Europe". In Europe, the combination of high capital costs, low and unpredictable carbon prices, dependency on public policy and financial support at time of tight national budgets, immature regulatory framework, credit risk across the infrastructure chain represents a major investment challenge which, without a clear risk management and allocation model, increases the risk

[14] Beckers, F. and Stegemann, U. (2013), *A risk-management approach to a successful infrastructure project*, McKinsey, https://www.mckinsey.com/industries/capital-projects-and-infrastructure/our-insights/a-risk-management-approach-to-a-successful-infrastructure-project, accessed 11th August 2020

[15] ClimateWise (2012) *Managing Liabilities of European Carbon Capture and Storage*, https://www.cisl.cam.ac.uk/publications/sustainable-finance-publications/remove-obstacle-carbon-capture-and-storage, accessed 11th August 2020

perceptions and profiles significantly for the potential investors especially in a global financial market competing with more mature infrastructure investment opportunities.

The successful realisation of large H_2-CCS network investment will need good decision making and risk management frameworks to identify and track critical investment barriers and major business risks and find risk management solutions applicable to the relevant H_2-CCS chain throughout the life cycle of the project.

ELEGANCY WP3 developed a risk-centred framework applicable to any case studies to facilitate the development of suitable business models, i.e. those which allow a feasible risk allocation and delivery of profitability and value in order to facilitate the necessary private and public investment in an effective manner. WP3 is focused on providing the methodology, tools and guidance necessary to allow private and public entities to discuss and determine the appropriate business model which works in the specific context of the country and case study, rather than providing a recommendation on the ideal business model. The main objectives of WP3 have been to develop a business case framework comprising:

- a number of guided assessment tools for the legal, market, macro-economic, fiscal and policy background relevant to integrated H_2-CCS chains; and
- a suite of optional elements for constructing business models, which can be applied:
  within ELEGANCY in the WP5 case studies; and
  beyond ELEGANCY in any other country wishing to explore opportunities for H_2-CCS chains or other large scale CCUS applications.

Report D3.3.2 is structured as follows.

Chapter 2 recaps the methodological approach introduced in report D3.2.1 for the characterization of the business context of a case study and completes the suite of assessment tools to include policy gap and risk analyses.

Chapter 3 provides a detailed summary of government policy requirements to facilitate the technology innovation, market creation and infrastructure investability for the delivery of large scale H_2-CCS chains. It is complemented in Appendices B-G with a review of current European and ELEGANCY Case Study country policies that are relevant to the development, deployment and operation of H_2-CCS chains.

Chapter 4 presents the concepts of investment and business risk, investment barriers and principles of risk allocation.

Chapter 5 presents a portfolio of options to address investment barriers present in the five case study countries.

Chapter 6 discusses the issues and needs facing the different types of major stakeholders in H_2-CCS chains when considering business risks, and the mechanisms for sharing and allocating those risks. The chapter also presents a portfolio of standard options to address business risks in commercial and finance contracts.

Chapter 7 presents an example summary outcome of a policy and risk assessment following the WP3 methodology.

5.2 Chapter 3: Hydrogen-CCS Policies

5.2.1 Summary and objective

The climate, economic and social contexts against which policies for H_2-CCS market and infrastructure development are assessed are presented first. These are followed by a summary of the policy requirements for H_2 and CCS which have been distilled from recent expert reviews. The reviews include the hydrogen and fuel cell (HFC) sector and its potential markets within a low carbon transition, as well as the CCS sector comprising the current understanding of the delivery requirements for infrastructure, industrial emissions reduction and CO_2 utilisation. These reviews take account of the lessons learned over the last decade from European and national CCS demonstration programmes.

Appendices in Report D3.3.2 provide a summary of current European and ELEGANCY Case Study country policies that are relevant to the development, deployment and operation of H_2-CCS chains. The policy environment in Brussels and nationally is very dynamic and this summary attempts to take account of the policy announcements as of July 2018. While not exhaustive, it provided a useful snapshot of the contemporary thinking of governments in case study countries.

This chapter, and the complementary Chapter 3 *H_2-CCS Business Options* in Report D3.2.1, form the basis for assessing policy gaps, and market barriers and failures that work to discourage rather than facilitate investment in H_2 and CCS - both separately and in combination. These inputs are used in business risk assessment, risk allocation and sharing, and the development and selection of business for application in the case studies in WP5.

5.2.2 Policy Requirements

5.2.2.1 Overview

The need for government policy intervention to deliver large-scale infrastructure investment for the public good is a well-recognised principle[16]. Amongst the risk characteristics of infrastructure development, particularly in the face of new or evolving markets, are:

- long lead times for development and deployment;
- high up-front capital cost;
- long term returns dependent on long duration contracts attempting to deal with uncertainty;
- the risk of stranded assets and/or sub-optimal capacity sizing;
- orchestrated market making/market signals for new infrastructure leading to lack-of-demand risk; and
- financial and structural complexity with multiple public and private sector interfaces.

In the case of CCS infrastructure, the IEA[17] has highlighted that where successful delivery has occurred, the government role has included:

- "strong and sustained government support including policy incentives that adequately address additional capital and operating costs";

[16] See for example: London School of Economics Growth Commission (2013) *Investing for Prosperity*, http://www.lse.ac.uk/researchAndExpertise/units/growthCommission/documents/pdf/LSEGC-Report.pdf, accessed 11th August 2020

[17] IEA (2017) *Five keys to unlock CCS investment*, https://webstore.iea.org/five-keys-to-unlock-ccs-investment, accessed 11th August 2020

- "a requirement or incentive to reduce emissions through emissions performance standards, the imposition of a sector-specific carbon tax or regulatory measure – often in combination with a grant or subsidy"; and
- "A low-risk political, social and regulatory environment for CO_2 storage, including regulatory frameworks to facilitate access to pore space and to manage long-term liability for the stored CO_2".

The policy gap analysis carried out as part of the ELEGANCY WP3 methodology allows for the complexity of policy interactions between different market and business segments and between the needs of the public and private sectors. Figure 5-1 is an example of a policy needs 'heat map' based upon the requirements described in Report D3.3.2 for the UK H21 Roadmap case study. This figure can be used to summarise the output that arises from application of the policy gap analysis method and tool to any particular case study.

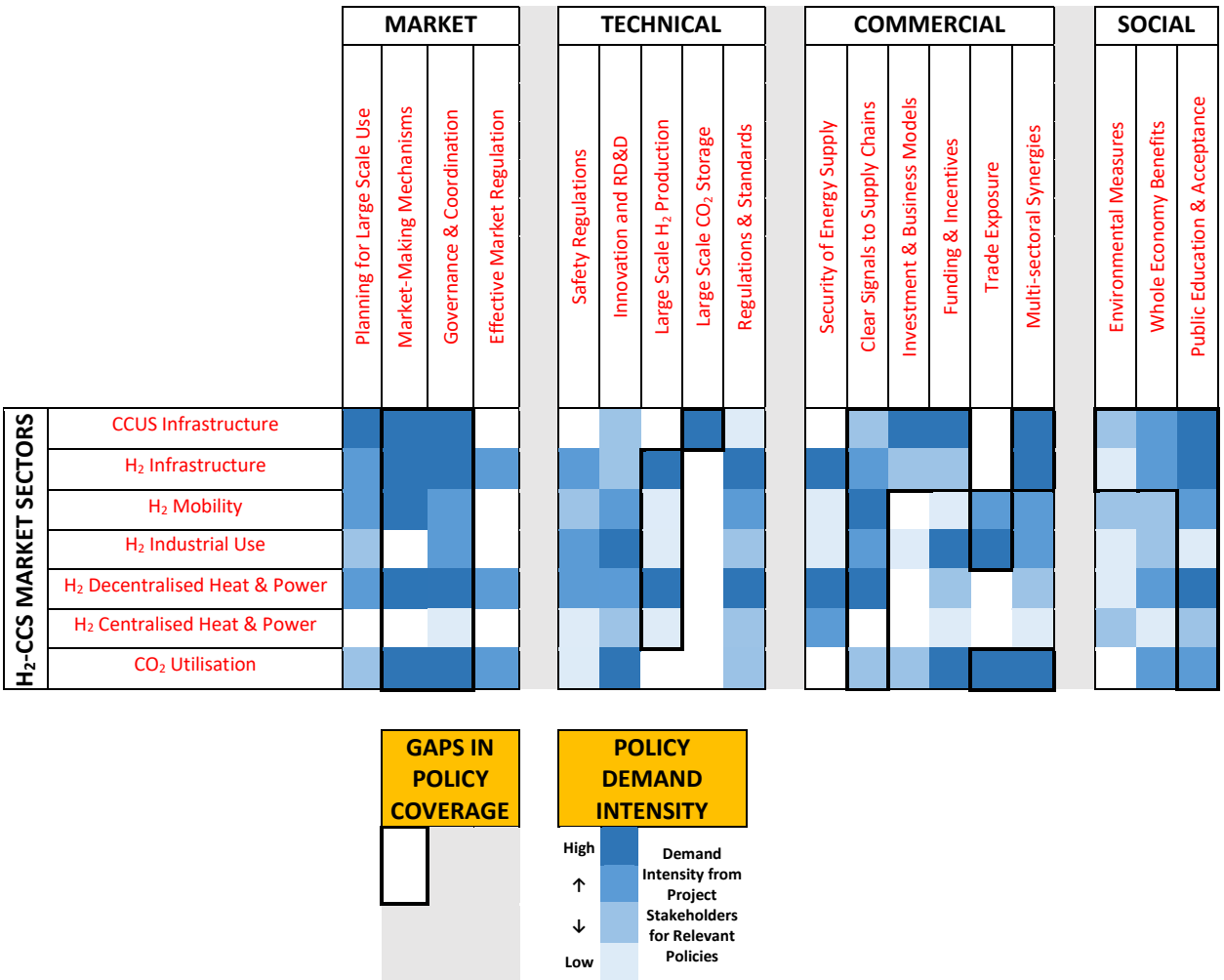


Figure 5-1 Example assessment of policy needs for delivering H_2-CCS business segments from the UK case study (concept adapted from CPI[18])

[18] Climate Policy Initiative (2013) *Risk Gaps: A Map of Risk Mitigation Instruments for Clean Investments*, https://climatepolicyinitiative.org/wp-content/uploads/2013/01/Risk-Gaps-A-Map-of-Risk-Mitigation-Instruments-for-Clean-Investments.pdf, accessed 11th August 2020

5.2.2.2 Sector Requirements

Detailed policy requirements are provided in Chapter 3 of the report for each of the H_2-CCS chain segments and end-use markets:

1. Hydrogen infrastructure;
2. CCUS infrastructure;
3. Hydrogen markets:
    - Low/no emissions heat;
    - Low/no emissions mobility;
    - Power generation;
    - Industry

5.2.2.3 European Union and Country Policies

European Union and case study country policies relevant to the funding of innovation and support for development of hydrogen-CCS markets and infrastructure as of July 2018 are summarised in the report Appendices.

5.3 Chapter 4: Defining Investment Barriers and Investment Risks

5.3.1 Summary

The first steps of the business model selection and development methodology focused on the relevant business background assessment (legal and regulatory, macro-economic and fiscal, market and public policy). This initial exercise allows the gathering of critical factors predominantly outside the control of the private developers/investors which traditionally exert a significant influence on their real and perceived investment risks. The remainder of Report D3.3.2 focuses on step 3 of the methodology, i.e. the identification and mitigation of the major business and investment risks and investment barriers that impact the investment attractiveness and expected rate of return for each of the market sectors and business opportunities from both a public and a private sector perspective. This chapter presents and discusses the concepts and differences between business risks and investment barriers, catalogues and categorises typical and relevant investment risks and barriers for H_2-CCS infrastructure investment.

5.3.2 What are Investment Risks and Barriers?

Investment risks can be defined as the potential of an event having negative impact on the investment outcome (as a combination of likelihood and severity of the event), which can be described in terms of investment/business profitability, reputation, etc., from a private investor perspective or poor social/economic/environmental benefits from a public investor perspective. Investors, whether private or public, analyse their risks to achieve specific outcomes in order to make decisions on their investment choices. The level of risk whether real or perceived by the potential investors determines whether large infrastructure projects can attract sufficient private capital at an acceptable rate of return for both the private and public parties. In addition, undermanagement of risks and risk allocation throughout the life cycle of the project is the main cause of poor outcome of private/public partnership infrastructure investment.

Investment barriers are actual circumstances/external conditions that have a major influence on the quantification of specific investment risks by the potential investors and for which there are no risk mitigation measures available in the market and therefore require a tailored intervention by the government in order to attract private investment. The investment barriers result in those risks being considered excessive or beyond their control by the potential investors and therefore prevent investment in the project/business sector.

Risk allocation in green infrastructure investments between the private and public parties determines the level of risk carried by each based on the ability of the parties to mitigate the risks and control the outcomes. Good risk allocation should allocate the risks to the parties best suited to take them. The ELEGANCY WP3 methodology uses the risk allocation framework of the Climate Policy Initiative[19] based on the OECD risk sharing model for public private partnerships[20] in which risks are defined as being either endogenous or exogenous with the following definitions:

- "Endogenous risks are risks which the project developer or sponsor has a certain extent of control over and can directly manage in order to influence the actual outcome (e.g. technology, management of financial resources);
- Exogenous risks are risks which the project developer has neither control over, nor ability to mitigate (e.g. political risks, adverse changes in national policies, currency devaluation) and are better managed by the public actor."

5.3.3 Investment Risks

Investment Risks can be classified subjectively in many different ways. The WP3 methodology uses the classification of risks presented in Figure 5-2.

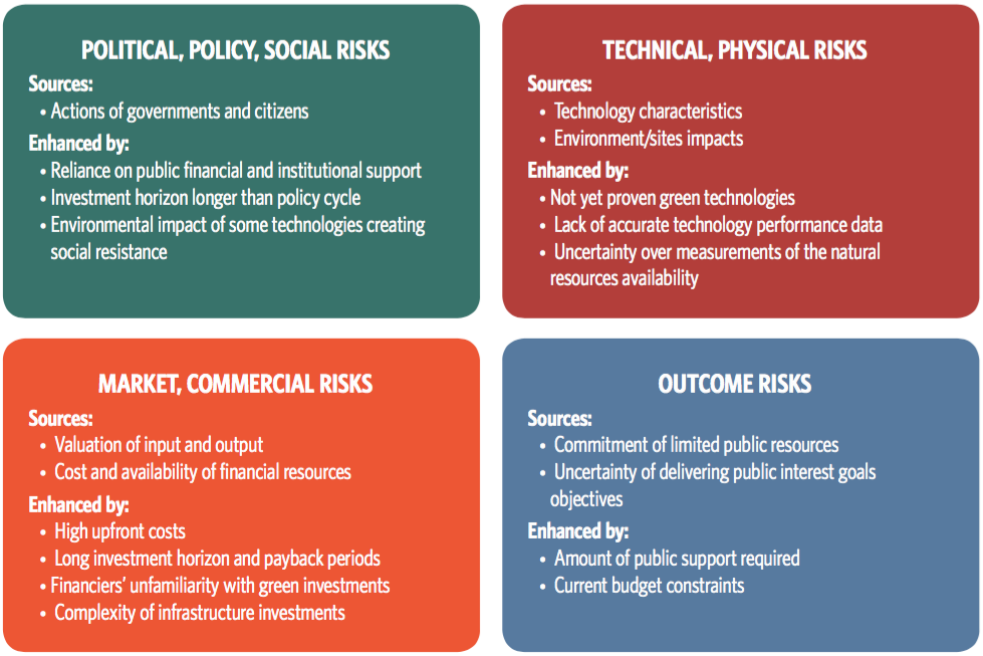


Figure 5-2 Risk Classification (after CPI[21])

Detailed examples of these risks are provided in the report.

[19] CPI (2013) op. cit.
[20] OECD (2008) *Public-Private Partnerships: In Pursuit Of Risk Sharing And Value For Money*, http://www.oecd.org/gov/budgeting/public-privatepartnershipsinpursuitofrisksharingandvalueformoney.htm, accessed 11th August 2020
[21] CPI (2013) op. cit.

5.3.4 Risk Allocation – Essential Principles and Main Actors[22,23]

Risk allocation is at the centre of every infrastructure development involving private and public finances. The appropriate application of risk allocation principles determines not only the attractiveness for equity, debt and government investors of a given project (acceptable rate of return, financeability) by ensuring the risks are allocated to the parties best placed to bear them, but also whether it will able to remain viable though to the end of a long-term contract.

The central tenants are:

- risks should be allocated to the parties best suited to manage them and at the lowest cost;
- risk allocation should consider not only who is the best party to management the occurrence of the risk but also the outcome of the risk (and its ultimate cost);
- risk allocation should be informed by market conditions

The risk allocation framework depicted in Figure 5-3 was developed by the Climate Policy Initiative and builds upon the OECD risk sharing model for public-private partnerships[24]. Exogenous risks such as political, policy, social risks and outcome risks are generally difficult to manage for private parties who have limited control over their occurrence and their impact and better allocated to the public sector. Endogenous risks such as market and commercial risks and technical and physical risks are general better to be borne by the private sector. However, these principles are flexible and need to adapt to the project circumstances.

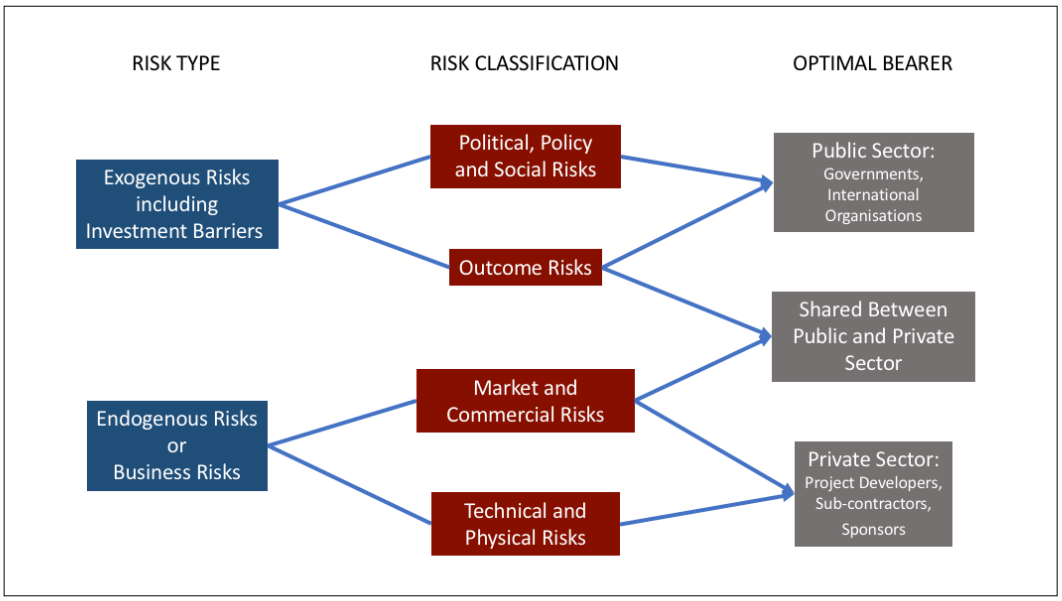


Figure 5-3 Risk allocation framework (after CPI[25])

[22] See also: Hovy, P. (2015) *Allocation in Public-Private Partnerships: Maximizing value for money*, International Institute for Sustainable Development, https://www.iisd.org/sites/default/files/publications/risk-allocation-ppp-maximizing-value-for-money-discussion-paper.pdf, accessed 11th August 2020

[23] See also: Climate Policy Initiative, CPI (2013) op.cit.

[24] OECD (2008) op. cit.

[25] CPI (2013) op. cit.

5.4 Chapter 5: Addressing Investment Barriers

5.4.1 Role of government

Investment in new H_2-CCS infrastructure and creation of new low carbon energy markets are high risk, long term, capital intensive type of investments. They create long life cycle assets with high sunk costs where there is a significant gap between average and marginal costs resulting in high inherent revenue uncertainty risks especially with the possibility of technical obsolescence from technological improvement. In addition, there are specific investment barriers for H_2-CCS chains. Tailored government intervention is needed to address generic and specific investment barriers for the relevant local conditions and mitigate/re-allocate the associated exogeneous investment risks that cannot be underwritten by insurance, or commercial arrangements between private equity and/or debt investors.

5.4.1.1 Instrument Types for Government Intervention

The government has access to a wide range of types of instruments to achieve desired policy outcomes. These instruments do not only serve to remove investment barriers but also to deliver value for money for the public by influencing the actual and perceived risk profiles of the investment and therefore the rates of return earned on private investment and by helping markets function effectively[26].

5.4.1.2 Tailoring interventions for market maturity – from macro-economic intervention to micro-economic intervention

Government intervention also needs to be tailored and evolve with the advancement of the markets and infrastructure development. Policies and incentives to create and facilitate the initial investment in new infrastructure and new markets will be different from those required to maintain a viable business on an ongoing basis into the future. In the early stages of new infrastructure build and market creation, there is a strong need for engagement between private and public stakeholders to develop a suitable package of intervention at the macro-economic level that is coherent and forward looking. This is needed in order to attract private investment and create a long-term shift in energy landscape at a suitable cost to the public. Governments need to create the investment framework with a clear policy direction (and stability), basic structure, rules and regulations and appropriate tailored interventions to address the market failures and investment barriers

As the sector matures, the objectives of the government shift from attracting the first investors to encouraging further build out of infrastructure, accelerating market growth, multiplying market investments and the entrance of market players to introduce greater market competition. The public intervention needs to transition to more private market mechanisms: government mandates and agreements with private investors are replaced by commercial agreements between private entities, the level of subsidies or other financial support and market regulation is adjusted, ownership of assets by the government is reviewed and reduced as relevant.

5.4.1.3 Tailoring interventions for each business sector

The package of government intervention needs to be tailored for each business sector of the H_2-CCS chain, for the investor types, the investment risk profiles and specific investment barriers

[26] Office of Fair Trading (2009) Governments in markets – why competition matters – a guide for policy makers, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/284451/OFT1113.pdf, accessed 11th August 2020

considering the history of similar markets in-country or internationally, and the existing regulations and constraints.

5.4.2 Government Measures to Remove Investment Barriers

This section presents a list of government measures for illustrative purposes to support the case study teams in their case study development and discussions with private and public entities. It is not intended to be an exhaustive list of measures and it is expected that applying the methodology will lead to selecting and creating the right package of measures for a given project in the specific country environment.

5.4.3 Assessed Principal Investment Barriers for Case Study Countries

This section presents a peer-reviewed list of principal investment barriers applicable to ELEGANCY case study countries together with examples of possible measures to remove or mitigate the barriers within those jurisdictions.

5.4.4 Carbon Markets and Finance Mechanisms

Putting a price on carbon has become one of the priorities of policymakers around the world when it comes to bringing down greenhouse gas emissions and driving investment in cleaner technologies. The World Bank[27] lists several characteristics and advantages of carbon pricing over the more classic "command and control" instruments such as mandatory emission limits. Indeed, carbon pricing:

- captures the external costs of carbon emissions and ties them to their sources through a price on carbon;
- shifts the burden for the damage back to those who are responsible for it and can reduce it;
- provides an economic signal;
- gives polluters a choice between halting or reducing their polluting activity, and continuing to pollute and pay for it; and
- ensures overall environmental goals are achieved in the most flexible and least-expensive way to society.

There are two principal types of carbon pricing: carbon taxes and cap and trade systems. A third mechanism is carbon offsetting, which can be used in combination with the two aforementioned types of carbon pricing. A fourth type, voluntary approaches that put a price on carbon, is less common. These policy options are described in detail in the report. Possible carbon finance mechanisms are also discussed.

5.5 Chapter 6: Addressing Business Risks

5.5.1 Overview

The report provides an example of how different types of de-risking measures can be applied to the principal business risks in a CCS chain for, and between, developers/operators, public authorities and financiers. The sections of Chapter 6 explore in more detail mitigation of some of these principal business risks from the perspectives of the different stakeholders involved; namely owners/operators, financiers, and public authorities/governments. Note that some of these risks

[27] The World Bank, http://www.worldbank.org/en/programs/pricing-carbon, accessed 11th August 2020

are related directly to investment barriers identified and discussed earlier in the report chapters 4 and 5. For example the possibility of long term leakage from a storage site creates both an initial investment barrier (due to regulatory and financial requirements) as well as an ongoing operational business risk (due to penalty exposure and remediation costs). This narrative is followed by reviews of the standard contract-based de-risking mechanisms for construction financing and operating service agreements. Making use of contractual arrangements, or agreements, between parties allows for bespoke solutions to risk and liability sharing. However, all are built up from some standard mechanisms that become tailored to the specific project situation.

5.5.2 Owners and Operators: Equity

5.5.2.1 Role, Risks/Issues and Needs of Owners and Operators

Operators within the H_2-CCS chain will service multiple industries such as power generation, industrial CCUS, combined heat and power networks, hydrogen networks and transport fuel, leaving them exposed to the different dynamics of these markets for their revenues. Furthermore, financeable infrastructure projects and geological storage sites are required before emitters and other market and service customers can take FID on their own investments. Hence the infrastructure providers require investment de-risking (which is very substantial in the case of storage) ahead of market demand, because without any certainty of a market for their services any investment is purely speculative. It is therefore difficult for infrastructure developers to make an investment case with uncertainty in demand requirements, while also being exposed to significant upfront financial and long-term liability risks (such as the case for CO_2 storage).

Joint public and private sector partnerships (PPP) are a tried and tested way of dealing with the conundrum of infrastructure investment ahead of market demand, and H_2-CCS is no different. Public authorities will need to share in CCUS risks that cannot be allocated along the chain via contracts, and a special commitment from Government will be required to provide a backstop for uninsurable elements or CCS specific business risk items which are unable to be borne by the private sector.

5.5.2.2 Options to Mitigate Risk and Ensure Commercial Benefit

An infrastructure developer that wants to implement a new project while protecting its corporate balance sheet against the risks associated with the project would typically establish a special purpose project company (SPV). Under a PPP structure that SPV could have contractual arrangements with a public authority to implement the project and raise the funding. The SPV is a company with no previous business and no projects aside from the infrastructure project on its balance sheet. As a result of high upfront costs and delayed revenue streams, infrastructure projects are normally structured via project finance. The ability of the private party to accept liabilities is therefore limited by its structure. The project company is legally independent from its shareholders. This provides a safeguard for the project in the event of failing shareholders dragging an otherwise healthy project into distress or vice versa.

Experience in the Netherlands, Norway and United Kingdom[28] shows that investors and project developers will require commitments from Government to underwrite extraordinary risks if private sector capital is to be attracted for CCUS infrastructure investment. These include market

[28] See for example: Dixon, P. and Mitchell, T. (2016) *Lessons and evidence derived from UK CCS programmes, 2008 – 2015*, http://www.ccsassociation.org/press-centre/reports-and-publications/, Carbon Capture and Storage Association, accessed 11th August 2020

size, development and capacity utilisation, and the uninsurable elements or CCS specific business risk items that the private sector is unwilling to accept. In particular, insurers, financiers or operators will be unable to bear unlimited liabilities, so where liabilities are not limited in size, risk sharing with Government will be essential, for example to develop and operate CO_2 storage facilities.

5.5.3 Financiers and Investment Funds: Debt

5.5.3.1 Role, Risks/Issues and Needs of Financiers

To entice investors any H_2-CCS business segment needs to be a competitively attractive investment with other opportunities. The uncertainty in revenue for CCS transport and storage businesses expose investors to too many risks and these are therefore not currently suitable for debt financing, particularly for investment funds.

Commercial banks, investment banks or other institutional investors provide the debt portion of project financing. Project financing is a specialised funding structure that relies on the future cash flow of a project as primary source of repayment, and holds the project's assets, rights and interests as collateral security. It is also referred to as non- or limited recourse finance, i.e. lenders have no- or limited recourse to the sponsors or shareholders of the project company for repayment of the loan. Lenders are, of course, very interested in the creditworthiness of counterparties to the various project contracts, and the efficacy of guarantees and warranties of suppliers.

Financiers are typically risk-averse, which means that they are not willing to accept much risk in a normal non-recourse project finance structure. In allocating risks between a public authority and private SPV, it is therefore important to understand how the SPV is organised - including its legal structure and its contractual arrangements with the subcontractors - and to what extent risks are accepted in the regular markets of subcontractors, insurers and financiers.

Hence, the predictability of the future cash flows and suitable risk profile are the most prominent requirements to enable project financing. This combination is required to facilitate higher gearing and attract debt finance, reduce the cost of capital and increase affordability for users, and to spread the capital costs over as much of the working life of the infrastructure as possible.

5.5.3.2 Options to Mitigate Risk and Prevent Commercial Loss

The report presents the details of a number of mitigation measures for dealing with the risks and needs of commercial lenders and investors, including:

1. Regulatory arrangements and legal environment;
2. Enduring policy frameworks and change of policy underwriting;
3. Insurance cover;
4. Insurance for carbon allowance reimbursement (CARI); and
5. Public sector underwriting for CO_2 Storage risks where no insurance is available.

5.5.4 Public Authorities

5.5.4.1 Role, Risks/Issues and Needs of Public Authorities

Governments do not have unlimited financial resources for delivering infrastructure and the PPP approach gives a public sector entity the ability to tackle its infrastructure investment in partnership with the private sector while limiting requirements from its own resources. As risk allocation within PPP delivery models is about risk sharing between parties, it allows certain

project risks to be transferred to the private party, but some risks will still be retained by the public authority under a PPP contract.

The risks for which the public authority is responsible are often referred to as "compensation events." Compensation events consist of special circumstances that are under the control of the public authority or are most efficiently managed by the public authority. Compensation events can also be those that present a risk that still represents value for money when assumed by the public authority, even if the circumstances are not under the control or manageable by the public sector.

Typically, a PPP contract specifies that as a result of the compensation event the private party must be left in a no-better or no-worse position than if the compensation event had not occurred. In other words, the private party will receive financial compensation for costs related to the occurrence of the event. Hence, public authorities can take on roles such as commercial underwriter and guarantor of last resort in order to remove business risks that cannot be borne by project developers.

Governments can make use of State agreements, or umbrella and implementation agreements, that do not fall strictly into the PPP category, but which bind multiple public and private sector parties together with risks, liabilities and remedies allocated formally between them. Such agreements are common with trans-national pipelines and LNG projects.

5.5.4.2 Options to Mitigate Risk and Reduce Financial Exposure

Governments also have legislation, regulation and other statutory instruments at their disposal to implement risk sharing through a combination of mandates, consents and permits, both at the start and throughout the life of a project, along with contractual remedies, fiscal instruments and securities that can be imposed on developers/operators. Many of the CCS-specific legal and regulatory models developed to-date offer de-facto examples of risk-sharing between operators and one or more public authorities. Regulatory frameworks apportion the risks associated with CCS activities throughout the infrastructure lifecycle, as well as offering clearly defined parameters to a public authority's role and responsibilities.

Public authorities are able to assess the technical competence and experience of project developers in executing projects of a comparative nature, handling technologies and equipment of a similar size. The project structure and track record of the engineering, procurement, and construction contractor or equipment suppliers will all contribute to minimising the likelihood of an adverse risk materialising and increase a project's likelihood of success. A public sector authority is able to minimise and manage financial risk exposures through carrying out appropriate due diligence and financial appraisal of developers. In the context of EC rules, financial appraisal is a selection criterion and is designed to identify the financial risks to be assessed alongside other relevant qualitative and quantitative factors that can be grounds for selecting a candidate to tender or negotiate when bidding for significant public sector contracts[29].

[29] See for example: European Commission (2015) *Public Procurement Guidance for Practitioners*, http://ec.europa.eu/regional_policy/sources/docgener/informat/2014/guidance_public_proc_en.pdf, accessed 11th August 2020

5.5.5 Mitigation Measures for Project Finance: Construction Phase

This section of Chapter 6 provides a summary of important risk mitigation methods for project financing, including:

1. Conditions precedent;
2. Liquidated damages;
3. Performance bond;
4. Warranties;
5. Contingency funds; and
6. Insurance.

5.5.6 Mitigation Measures for Project Finance: Operational Phase

Previous sections and chapters of the report show the myriad risks that an infrastructure operator can be exposed to, and which can strongly influence the ability to re-pay debt as well as to make returns above an investment hurdle rate. This section of Chapter 6 is a summary of the key contractual instruments used between service contract counterparties described by Ruster[30], and which will inform a financier's view of the viability of debt servicing, including:

1. Use-or-pay, supply-or-pay;
2. Pass-through;
3. Contingency reserves;
4. Cash traps;
5. Insurance; and
6. Risk compensation.

[30] Ruster, J. (1996) *Mitigating Commercial Risks in Project Finance*, *Public Policy for the Private Sector*, Note 69, The World Bank, http://documents1.worldbank.org/curated/en/138481468765577520/pdf/16928-Replacement-file-069RUSTE.pdf, accessed 11th August 2020

5.6 Chapter 7: The Project/Infrastructure Risk Profile

5.6.1 Putting it all together

The WP3 methodology leads to "maps" that can provide useful summaries of the key hurdles to investment and risks to business operations. These maps are then used for dialogue between stakeholders to determine preferences for risk sharing and the types of instruments available to be used between them. If possible, combinations of public and private solutions can be structured and re-structured over the lifecycle of infrastructure or an individual project for transitioning between public intervention to solely private sector commercial mechanisms as a market materialises and matures.

Figure 5-4 demonstrates the high-level risk profile and mitigation preferences for a full lifecycle H_2-CCS infrastructure from the UK case study. Such maps demonstrate where gaps in risk mitigation instruments exist (usually creating investment barriers for the private sector) and can be used at increasing levels of detail in different business segments. They will be used in the next steps of the methodology to guide business model selection and recommendations for policy support. Taking a top-down holistic approach to business models is a more efficient way with a higher likelihood of success for solving investability issues related to H_2-CCS infrastructure then has been the typical approach in Europe to date[31].

[31] See for example: UK CCUS Cost Challenge Taskforce (2018) *Delivering Clean Growth*, https://www.gov.uk/government/publications/delivering-clean-growth-ccus-cost-challenge-taskforce-report , accessed 11th August 2020

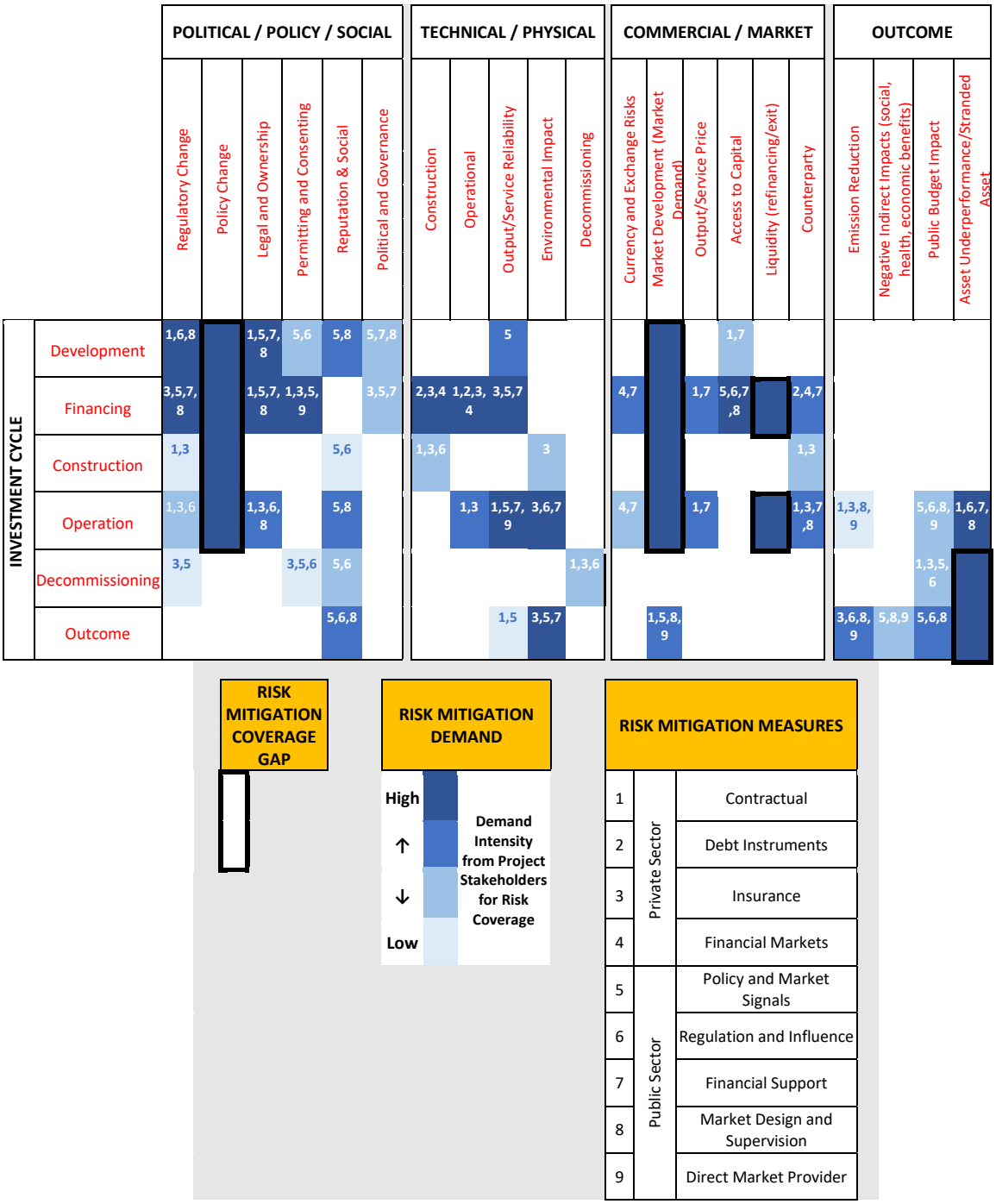


Figure 5-4 Example H_2-CCS chain demand for risk mitigation instruments from the UK case study (modified from CPI[32])

[32] CPI, (2013), op. cit.

6 REPORT D3.3.3 - DEVELOPMENT OF BUSINESS MODELS AND COMMERCIAL STRUCTURES

6.1 Summary

This report continued the previous work undertaken by Sustainable Decisions Limited in ELEGANCY WP3 and focused on developing a framework to support the selection of suitable business models at both system level and business level for H_2-CCS chains by both private and public sector entities.

The previous report D3.3.2 highlighted that the major barrier to deployment of CCS is no longer technological, but political and commercial. In this context, and taking into account the multiple attempts at CCS in Europe over the past 15 years, the WP3 methodology has been structured to facilitate engagement between public and private sector parties as early as possible for the joint definition of suitable business models and business cases which could be approved by their respective stakeholders (shareholders and the public).

There are numerous definitions of business models in the literature but in simple terms, business models describe how a business or organisational entity creates, delivers and captures value. A business model can also be defined in terms of 'how a business or other organisational form characterises its activities in order to achieve its goals of profit-making or other objectives[33,34,35]. In another version, Alexander Osterwalder created the Business Model Canvas[36] where a business model is made of 9 elements: key resources, key activities, partners, costs, value proposition, customer relationships, customer channels, customers, and remuneration/revenue.

In the case of European first-of-a-kind (FOAK) or early stage H_2-CCS chain infrastructure such as investigated in the ELEGANCY case studies, we need to consider the business model to be a way to organise and structure all the relevant and material elements of investment, market development and asset operation that can deliver the combined objectives of the public and private sector sponsoring parties.

The choice of a business model will depend on a number of factors; the technological and organisational capabilities of the entities and their competitors, the stage of maturity of the relevant markets, the wider social, economic and institutional context including policies and incentives. There is a vast array of traditional forms of business models for infrastructure investment, each host country having their own cultural and historical preferences. In addition, these models are

[33] Bryson, J., Pike, A., Walsh, C., Foxon, T., Bouch, C., Dawson R. (2014) *Infrastructure Business Models (IBM) Working Paper*, iBUILD programme, Newcastle University, University of Leeds, University of Birmingham, https://research.ncl.ac.uk/media/sites/researchwebsites/ibuild/BP2%20-%20Infrastructure%20business%20model%20definition_DRAFT.pdf, accessed 11th August 2020

[34] Teece, D., J. (2010) *Business Models, Business Strategy and Innovation*, Long Range Planning 43, 172-194, Elsevier, http://www.businessmodelcommunity.com/fs/root/8jig8-businessmodelsbusinessstrategy.pdf, accessed 11th August 2020

[35] Zott C., Amit R., Massa M. (2011) *The Business Model: Recent Developments and Future Research*, J Management 37:4, 1019–1042, http://www.cse.tkk.fi/fi/opinnot/T-109.4300/2013/luennot-files/Zott%20et%20al.%20-%202011%20-%20The%20Business%20Model%20Recent%20Developments%20and%20Future%20Research.pdf, accessed 11th August 2020

[36] Osterwalder A., Pigneur Y. (2010) *Business Model Generation: A Handbook for Visionaries, Game Changers, and Challengers*, (Wiley Desktop Editions), Wiley, Hoboken, New Jersey

also ever-changing to adapt to the challenges of the external environment at any given time. Infrastructure investment is quite unique and requires business models that can address its specific characteristics: requirement for major upfront capital investment, long term revenue streams, public involvement, natural monopolies, and complex value delivery (economic, social, environmental value in addition to financial returns).

Technical, policy and commercial innovation is essential in the case of first-of-a-kind project with the creation of new markets. Therefore, the framework developed in the report aims to offer the user the flexibility to define the most appropriate business models for his or her investment opportunity or case study. The framework includes a number of fundamental building blocks combined with the information gathered on business context and risk from the earlier stages of the ELEGANCY process. At the same time the business model selection is guided by existing traditional business models but without being constrained by them.

The first steps of the ELEGANCY business model selection and development methodology concentrated on the relevant business background assessment (legal and regulatory, macro-economic and fiscal, market and public policy), and on the identification and mitigation of major business risks and investment barriers. The chapters in the report focus on step 4 of the methodology, i.e. the selection of appropriate business models (at system and business level) to create an investable business proposition from both a public and private perspective. Report D3.3.3 is a companion report to the ELEGANCY report D3.3.4, which details the business case development and assessment process for any given business model.

Finding a suitable business model requires a complex and tailor-made interaction between the public and private sector to define the right ownership, funding (capital and operating) structure and allocation of risks and responsibility. Specific guidance will be provided (along with an Excel based business model selection tool) with reference to the main drivers for business model selection, the risk allocation and transfer of responsibility between public and private sector, main types of public/private business structures available, key types of contractual relationships and agreements to support the user.

The report presents:

- the overall methodology (and supporting business model selection tool) to guide the selection of potential business models from the information collected and analysed from the business context assessment and risk assessment;
- guidance on the main types of financial structures classified by their types of ownership, financing and revenue streams;
- guidance on the main types of commercial agreements and terms; and
- the main operability parameters and risks that impact the commercial agreements.

The report is structured as follows.

Chapter 2 recaps the methodological approach introduced in reports D3.2.1 and D3.3.2 and extends the overview to the business model selection process presented in this report. It is complemented in Appendix A with a compilation of business risks and mitigation measures provided through consultation with CCS experts and practitioners.

Chapter 3 provides a detailed review of private/public business structures that can be considered for the selection of a H_2-CCS business model in different jurisdictions and case studies.

Chapter 4 summarises some of the principal operability conditions that can influence business risk handling in H_2-CCS service contracts, and which have an impact on business models. It is complemented in Appendix C with a greater level of detail of the terms handled in typical commercial contracts.

Chapter 5 presents the business model selection process in detail with guidance on each one of the process steps.

A complementary Excel spreadsheet tool for business model selection is included in the ELEGANCY WP3 toolkit.

6.2 Chapter 2: Methodology

6.2.1 Defining Business Models

Substantial confusion and ambiguity have arisen around the term 'business model' in the CCS community and in the preferences of different CCS stakeholders for the deployment of CCS infrastructure. Some exponents use the term to mean revenue and revenue support structures. Some use it to mean the split of ownership between the public and private sector. Some focus on market creation and development models. Others combine all the necessary ownership structures and policy and fiscal/financial support mechanisms required to facilitate delivery of FOAK or early stage projects. Still others distinguish between sectors such as 'industrial CCS', 'electricity generation with CCS', or 'CO_2 transport and storage'.

Different perspectives between the public and private sectors have influenced CCS dialogue and policy development with respect to business models. The public sector (Government) is looking to cost effective and 'affordable' solutions for dealing with emissions targets and therefore necessarily focusses on macro-economic and fiscal impacts of intervening or investing in infrastructure development. Private sector organisations must ensure shareholder funds are deployed in ways that provide appropriate returns either in the short term or over a longer-term strategic horizon. Hence each looks to a business model that delivers the business case which justifies their involvement. Finding alignment between these has been difficult for FOAK and early stage CCS infrastructure projects.

In order to create some clarity within the ELEGANCY WP3 methodology we differentiate between system or macro-economic business models and business segment or micro-economic business models (Figure 6-1). System business models are the combined elements, structures and mechanisms that can overcome barriers to investment by both the public and private sectors for the development and utilisation (through market creation) of a full chain H_2-CCS infrastructure. Operational business models are the organisational forms and combined elements, structures and mechanisms that deliver the outputs and services for a particular business segment within the H_2-CCS chain while both mitigating the risks that the business activity faces and providing a return on funds deployed.

Section 4.5 of ELEGANCY report D3.3.2 discussed the principles of risk allocation and in particular introduced the CPI framework[37] of endogenous and exogenous risks as an approach to

[37] CPI (2013) op. cit.

risk sharing in public-private partnerships. Building on report D3.3.2, the system business model is identified as the principal means for the mitigation of exogenous risks (including political, policy, social and outcome risks) that cannot in general be managed by the private sector alone. The operational business model is identified with mitigating endogenous business risks (market, commercial, technical and physical risks) that the private sector can manage. There is an interaction between the two when outcome, market and commercial risks must be shared between public and private sectors. How this is done, and with what preferences, is the interface between the two scales of business model. In other words, the system business model provides a macroeconomic solution that enables investment and activities to take place at the operational business segment level. What can't be resolved at the operational business level will need to be supported at the system level because the whole infrastructure chain is affected.

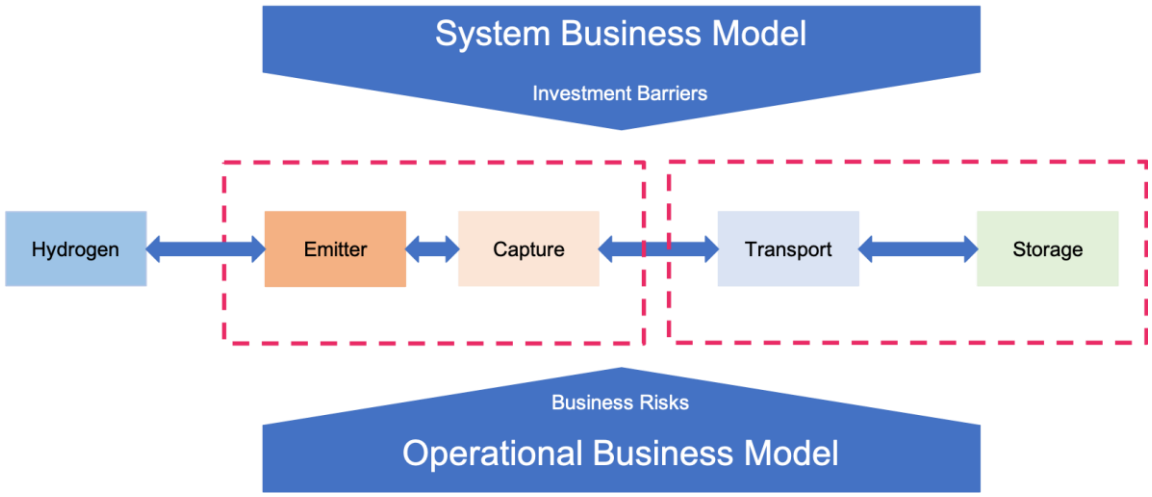


Figure 6-1 Business Model Characterisation

Each scale of business model in Figure 6-1 has an associated business case, the metrics for which are tailored to the drivers and outcomes required of the case study or project. The red dashed boxes show possible bundling of business segments.

6.2.2 Drivers for Business Model Selection

The following steps have been codified in the selection process and included in the ELEGANCY business model selection spreadsheet tool:

- Background Review and Gap Analysis key issues. Comparison between public and private sector assessments – identify overlaps and differences
    - Principal market/macro-economic drivers
    - Investment barriers
    - Risk heat map
    - Policy Needs heat map
    - Intervention measures - Public vs private sector preferences
    - Mitigation measures - Public vs private sector preferences
    - Outstanding regulatory concerns;
- From the analysis identify major or material differences between the public and private sector views– these become priorities to address in the business model solutions;

- Understanding the above at system level and individual chain components/business sectors provides guidance on boundaries between 'conventional' business investment solutions/decisions (BAU) and those presented by the H_2-CCS chain in a case study;
- From the above analysis, a number of key business model drivers can be extracted and tested against what would be required to deliver the various dimensions of a business case. These are most relevant to prioritise actions for developing the risk sharing and allocation solution;
- The previous step is conducted at system level first and then at business segment level – this can be iterated to ensure consistency.

Tables of business model drivers are provided in the report.

6.2.3 Infrastructure Investment Structures: Role of the Public and Private Sectors

In the same way as risk categories were classified in report D3.3.2 in four main categories to facilitate the risk assessment exercise, guidance is provided in this section to classify infrastructure investment structures according to a number of key principles. This presentation and classification are designed as guidance for the user to select a suitable structure which addresses the business risks and investment barriers. A number of key traditional investment structures and their strengths and weaknesses are detailed in Chapter 3 of the report.

The main axis to classify those structures is the degree of transfer of responsibility and risks from the public sector to the private sector. On one end of the spectrum, the public sector retains all responsibility for the ownership, financing, and all the physical activities. On the other end, all these responsibilities are transferred to the private sector without any public sector intervention. In between, there are many types of arrangements where those responsibilities are split between the public and private sector.

The structures can be classified according to four main components of the transfer of responsibility (Figure 6-2).

Figure 6-2 Main components for investment structures in the transfer of risk and responsibility from the public sector to the private sector

These components are defined as:

- *Assets and Rights Ownership*: 100% public, 100% private, Joint Ventures, mixed shareholding, split asset ownership and usage rights;
- *Capital Sourcing*: public sector, private sector (debt, equity), international funds, export credit agencies, and any combination;
- *Market Development*: market maturity, and who is responsible for market development where the market is immature or does not exist, dictates the capacity of the economic system to remunerate or create value for the participants. Remuneration ranges from direct and/or indirect support from fully government-based revenue to fully market-based revenue (no support). Mechanisms include service-based payments, performance-based (availability, capacity) payments, regulated returns on capital and operating costs, regulated tariffs, demand-based payments, market-based revenue with government support (such as contract for differences, feed in tariffs, renewable obligation certificates); and
- *Physical Delivery*: the extent of the activities transferred to the private sector (design, build, operate, maintain, or any specific services).

There is a vast range of variations based on multiple combinations of the components above to allocate the risks and responsibilities appropriately.

6.2.4 Commercial Agreements

For completeness the methodology includes summaries of operability issues and key commercial terms that may help with understanding how contract structures can address business level risks and use commercial arrangements:

- for the transfer of responsibility between the public and private sector;
- for the provision of the main industrial services through the H_2-CCS chain.

6.2.5 Business Model Selection and Business Case Assessment

At the heart of the ELEGANCY methodology for business model selection and its associated business case assessment is an iterative development process analogous to the typical investment/development stage gate and decision-making progression for a major infrastructure project. The business model selection process is described in the report in detail in Chapter 6.5. The summary above highlights how this selection process takes account of all inputs derived from WP3 tools and assessments of the business, investment and risk context along with relevant drivers for a case study. A flow chart of the process is shown in Figure 6-4.

The business case development and assessment processes are the subject of report D3.3.4 '*Detailing the guidelines for the assessment and application of the business case templates in WP5*' which is described in Chapter 7 below.

6.2.6 The Relationship Between Business Models and Business Cases

Section 6.2.1 introduced the principle that to make a business case for an investment proposition, or strategic macroeconomic objective, there needs to be a business model that describes how the outcome will be achieved and what mechanisms will mitigate risks and support delivery actions. The business model selection process therefore has a link to the metrics that will define its corresponding business case.

The iterative process previously discussed, and used in the ELEGANCY methodology, is summarised in Figure 6-3 below. Decision gates refer to points at which decisions are made to undertake increasingly more detailed work and increasing expenditure on project and policy design and development. For the ELEGANCY case studies, there will only be one initial pass through the process in order to advance the proposals to a point where there is useful input to government and industry stakeholders as per the ERA-NET ACT objectives.

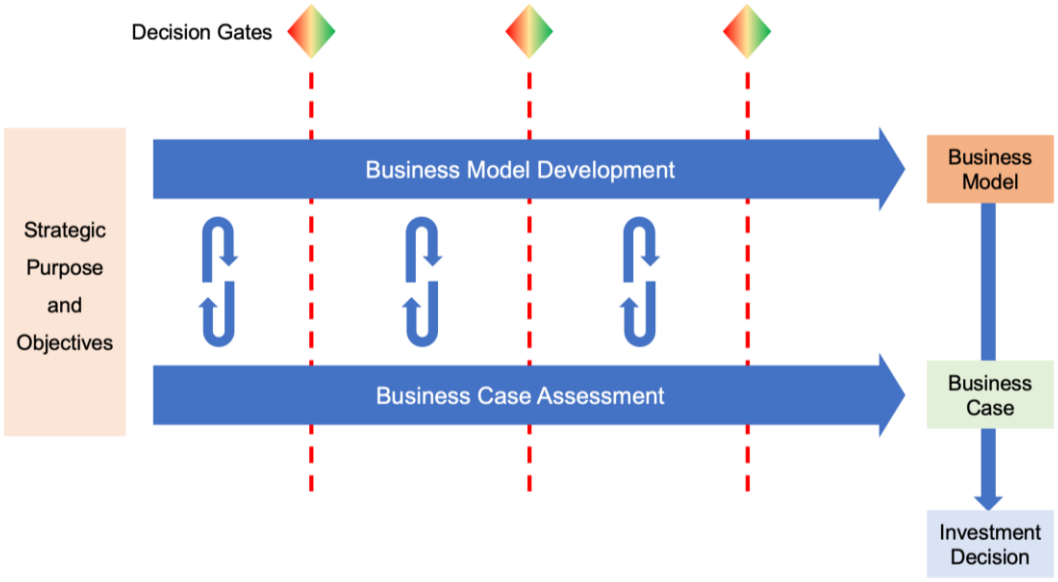


Figure 6-3 Iterative Development of Business Investment Decision

Business model development and selection is based upon the drivers that have been tailored to the strategic purpose and objectives of a case study or infrastructure project. The information on business context resulting from the detailed risk and policy assessments undertaken in previous steps of the method is used to determines stakeholder preferences for the investment and commercial models that form the basic structure of both the system business model (for removing investment barriers) and the operational business model for high priority business segments that interact with, or have an impact on, those barriers.

Once an allocation of risks and mitigation measures has been made between relevant stakeholder entities, a business case assessment can be undertaken. Depending on the outcomes of this assessment it may be necessary to review the business model and modify its structure and mechanisms. In some cases, it may also be necessary to revisit the business context analysis to alter or vary the associated stakeholder preferences. This can lead to a different business model being selected. The business case is then again assessed. The process can repeat until stakeholders converge on an agreed outcome.

Figure 6-4 below represents the main steps of the iterative process between business model selection and business case assessment.

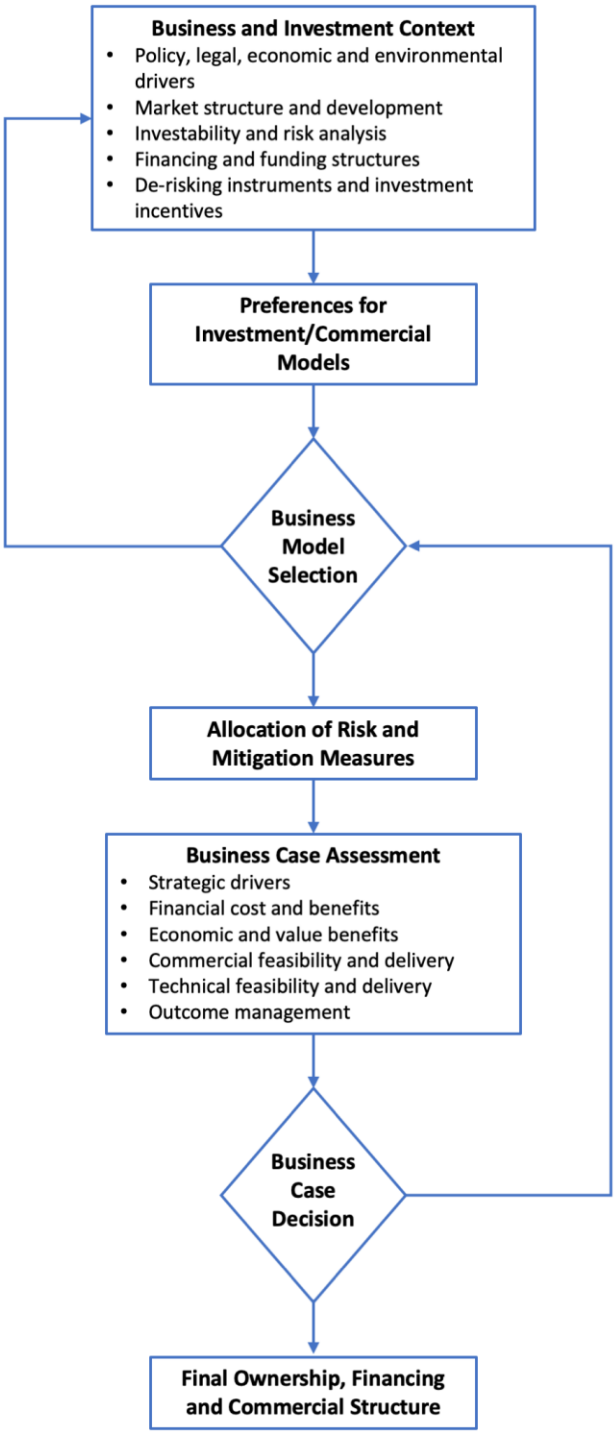


Figure 6-4 Business Case Development Process

6.3 Chapter 3: Private/Public Business Structures for the Selection of a Business Model

6.3.1 Overview

This chapter introduces and presents the main types of existing business structures in the context of infrastructure investment in order to provide a useful reference point for the selection of business models in the projects/case studies. Such structures represent major building blocks of any business models both for the overall system and for the individual business sector and are critical in the allocation of responsibility and risk between the public and private sector, to secure the necessary investment and stakeholder approvals. They will be presented briefly with their key characteristics, advantages and disadvantages and categorised according to four main components: ownership, financing, market development (including revenue structure), and responsibility for operational activities. Examples (based on UK experience) are provided to illustrate the use of these structures.

There is a large number of variations in the detail of these structures, and complex structuring can be used to fine tune them. In addition, these structures are also the subject of continuous innovation to adapt to the external investment environment, jurisdiction, and macro-economic conditions. However, this chapter only focuses on the main structures to facilitate the high-level business model definition and engagement between public and private sector entities rather than the numerous detailed variants discussed at later stages of project development.

The objective is to provide general guidance and a list of high-level options for the business structures to be used when applying the business model selection methodology. The chapter also provides an overview of the process of debt financing along with characteristics/drivers to be aware of. This aspect of business model selection is important because private sector finance will always look at how the participants in a project are sharing the risks, and any loan decision making process must be harmonised with, and complementary to, the project sponsors' decision processes.

6.3.2 Private/Public Business Structures

The main classes of business structures are presented with their key characteristics and advantages and disadvantages. These classes illustrate various levels of transfer of responsibility and risk between the public sector and private sector, and therefore offer a range of options for the allocation of risk between the parties. Figure 6-5 provides a summary of the main structures discussed in the report. Though commonly and widely used in practice, there is no firm and agreed definition of the term public-private partnership (PPP) in the literature. The following definition is from the International Transport Forum at the OECD[38]:

"*One can define a public-private partnership as an agreement between the government and one of more private partners… according to which the private partners deliver the service in such a manner that the service delivery objectives of the government are aligned with the profit objectives of the private partners and where the effectiveness of the alignment depends on a sufficient transfer of risk to the private partners*."

[38] Meaney, A., and Hope, P. (2012) *Alternative Ways of Financing Infrastructure Investment: Potential for 'Novel' Financing Models*, OECD/ITF, https://www.econstor.eu/obitstream/10419/68826/1/726714259.pdf, accessed 11th August 2020.

Higher Risk Transfer

Business Model Structures	Characteristics	UK Examples
Free Market Private ownership, finance and delivery Market Risk – No Revenue Support	• Competitive markets • Full exposure to market/volume risk • Higher risk/return expected from investors	• Cable and mobile phone networks • Petrol stations
Public Concession (Design-Build-Finance-Operate) Public ownership / Private finance and delivery Demand based Revenue	• Procured by public sector • End user paid revenue stream with full exposure to final demand/utilisation	• M6 Toll
Free Market Enterprise Targeted Government Support Private ownership, finance and delivery Targeted revenue support – Price stabilisation (Cfd, FIT, ROCs), Capacity payments, Grants	• Competitive markets • Government-led market framework to influence desired market outcome	• Electricity Generation
Build Own Operate Private ownership, finance and delivery with performance based returns agreed contractually with government	• Individual assets rather than network • Non-recourse commercial debt financing, equity financing, multilateral bank financing • Integrated private sector delivery (construction and operation) for lower overall cost	
Public Concession (Design-Build-Finance-Operate) Public ownership, Private finance and delivery with performance based Revenue (Design-Build-Finance-Operate)	• Procured by public sector • Public sector revenue stream - limited market risks • Social infrastructure services deemed not appropriate for full privatisation	• Public Finance Initiative (Schools, hopsitals…)
Build Operate Transfer Public ownership and finance, private delivery with performance based returns agreed contractually with government	• Individual assets rather than network • Integrated private sector delivery (construction and operation) for lower overall cost • Financing from regional, national and international funds and commercial debt and government bonds	
Regulated Asset Base (Operating Assets) Private ownership, finance and delivery Price regulated revenue	• Monopoly infrastructure businesses • Independent regulation of returns on capital and operating costs providing stability for investors- under regulatory licence • Revenue paid by end users • Lower cost for public and • Potential risks in regulatory structure to adapt to needs of changing environment to incentivise necessary infrastructure upgrades	• Electricity, gas and water transmission and distribution networks
Regulated Asset Base (New Assets) Private ownership, finance and delivery Price regulated revenue and government support for construction	• Same as above • Regulatory licence awarded pre construction and additional government support for construction risks	• Thames Tideway Tunnel
Joint Venture Joint public/private ownership Price regulated revenue	• Resulting from part privatisation with government retaining shareholding and control (often golden shares) • Independent regulation of returns guaranteeing returns on capital and operating costs and providing stability for investors	• National Air Traffic Service
Government Owned Contractor Operated (GOCO) Public Ownership and finance, Private delivery Tender based, contractual agreements	• Government Owned Contractor Operated (GOCO) • Access operating efficiencies • Government retains full ownership for strategic assets / services	• National Nuclear Laboratory
Capital Procurement – Design & Build Public Ownership, finance and control Limited scope delivery	• Public Sector procurement • Financing from regional, national and international funds, multilateral bank financing, commercial debt and government bonds	• Crossrail

Lower Risk Transfer

Figure 6-5 - List of Main Business Structures

6.3.3 Market Development – New models to manage uncertainty in immature markets

The realisation of first-of-a-kind investments in large-scale infrastructure requires overcoming significant uncertainty over the future demand prospects. Such investments have to compete with other technologies or options to replace infrastructure already in place. In addition, given the large-scale nature of these infrastructure investments (and therefore costs), even a small saving in the cost of capital can result in a large absolute overall saving for the public so new models are worth investigating. As a consequence, new models have emerged to replaced PPPs. The Regulated Asset Base (RAB) model, which has been used historically in the regulated utility sector (gas and electricity distribution networks) is one of the candidates being considered by governments who want to use PPP structures rather than government owned/controlled entities.

6.4 Chapter 4: Chain Operability, Risks and Service Contracts

6.4.1 Operability and Commercial Contracts

The key constraints on how different segments of the H_2-CCS chain can be made to function together from an individual business perspective (operational business model) within the market/full chain system business model relate to the technical and technology risks, limitations, operating conditions, and maintenance requirements that find their way into commercial contracts for service or product delivery at the interfaces between the different business segments. We call these various constraints the operability conditions for a business.

Chapter 4 of the report summarises some of the principal operability conditions that can influence business risk handling in H_2-CCS service contracts and have an impact on business models. Appendix C of the report contains a more detailed summary of the typical commercial terms and conditions that can be found in such agreements.

6.4.2 Typical Conditions Precedent

In any commercial agreement 'conditions precedent' (CPs) define the conditions that must be satisfied in order for the contract, or parts of the contract, to come into force. A common example is that loan funds will not be released from a lender until a number of conditions are met by the borrower/developer. For very large and complex projects with multiple business segments and/or multiple participants CPs are often subject to some form of multi-party 'umbrella agreement', which might be in the form of a State agreement with a government or government organisation, an inter-governmental agreement or treaty (if international), or a commercial 'co-ordination' or 'implementation' agreement. The purpose of the umbrella agreement is to ensure a co-ordination and governance structure that enables mitigation of a variety of risks that ultimately are related to CPs.

Examples of conditions precedent include:

1. Statutory and regulatory approvals/permits;
2. Any linkages between parties in an umbrella agreement or implementation agreement - Entire chain investment can be jeopardised:
   - Commissioning/turn-down;
   - Window for start of services, deliveries, delays;
   - Allocation of specified risks;
3. Financing and other project structuring requirements; and
4. Actions if the CPs are not met – penalties, remedies, security package etc (for finance see report D3.3.2).

6.4.3 Commercial Contracts

The operability conditions and key performance obligations of the following operations are presented:

1. Hydrogen production and integrated capture;
2. Long term Hydrogen Sale and Purchase Agreement (SPA)
3. CO_2 Pipeline;
4. H_2 pipeline;
5. CO_2 Storage; and
6. Inter-seasonal H_2 Storage.

6.5 Chapter 5: Business Model Selection

6.5.1 Selection Process

The Business Model Selection Process is illustrated in Figure 6-6 below. Additional guidance (including recommended activities and supporting tools and guidance) is provided for each of the process steps.

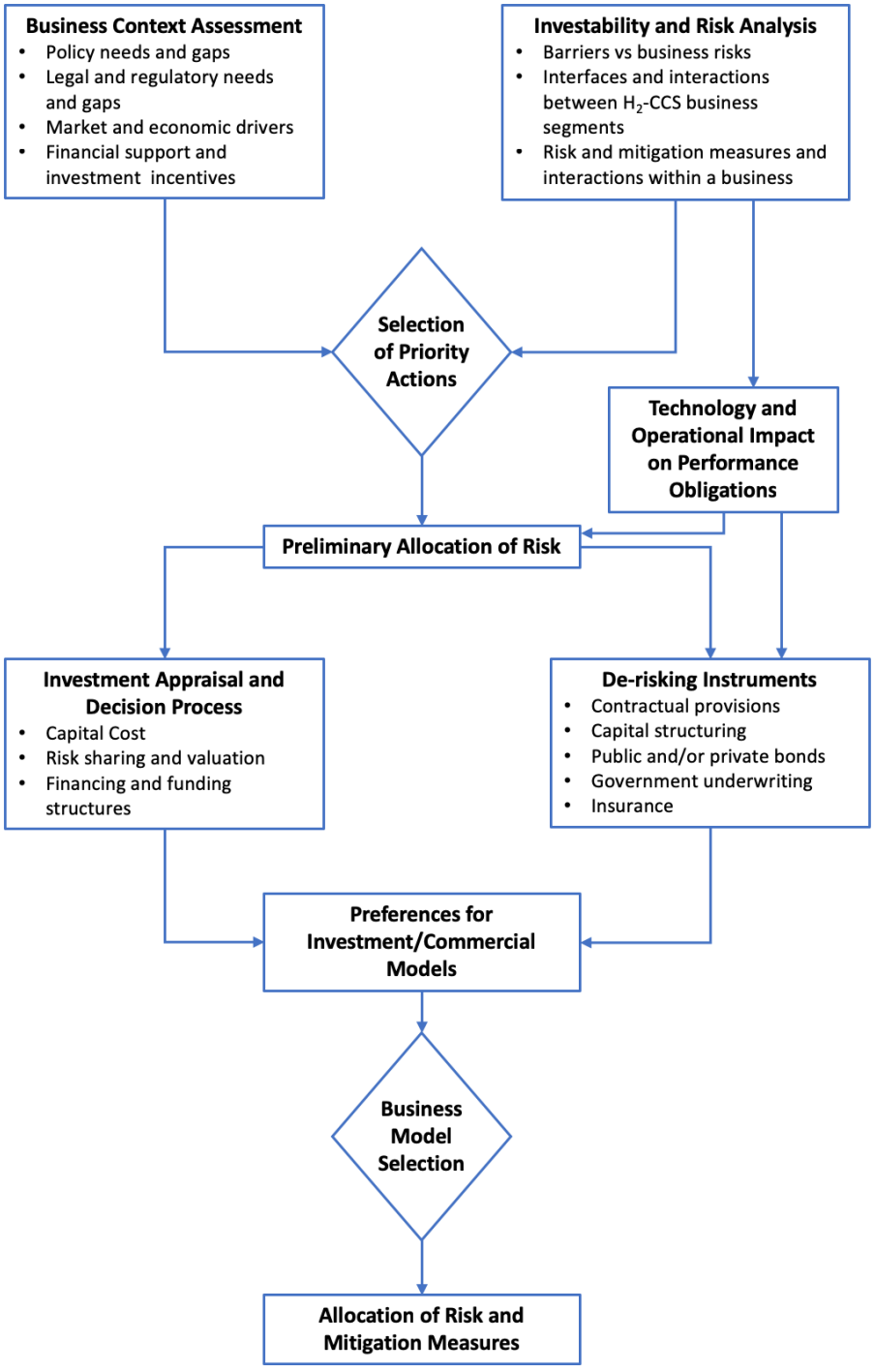


Figure 6-6 Business Model Selection Process

7 REPORT D3.3.4 - GUIDELINES FOR THE ASSESSMENT AND APPLICATION OF THE BUSINESS CASE TEMPLATES IN WP5

7.1 Summary

The report is the last of the interim methodological reports in ELEGANCY WP3 and continued the previous work undertaken by Sustainable Decisions Limited in reports D3.3.2 and D3.3.3. The report concentrates on the business case assessment framework, templates and application guidelines that are complementary to the method for selecting suitable business models at both system level and business level for H_2-CCS chains described in the companion report D3.3.3.

The report completes the overall methodology for the development and assessment of business cases within an iterative framework repeated at various stages of a case study or project lifecycle.

The report is structured as follows.

Chapter 2 recaps the methodological approach introduced in reports D3.2.1, D3.3.2 and D3.3.3 and extends the overview to the business case development and assessment process presented in this report.

Chapter 3 presents the business cases development and assessment process in detail with guidance on the business case dimensions and templates contained in an ELEGANCY WP3 Excel spreadsheet tool. The templates from the spreadsheet tool are presented in Appendix A of the report. This chapter also describes a number of public sector business case protocols and discusses methods for use in the extension of cost-benefit analysis to wider macro-economic value assessment.

Chapter 4 summarises the ELEGANCY WP3 toolkit and how to make effective use of the ELEGANCY WP4 H_2-CCS Chain Modelling toolkit within the business case development and assessment process.

7.2 Chapter 2: Methodology

7.2.1 Summary

This chapter defines what a business case is, and the characteristic elements that are included. A brief recap is presented of the business model selection process contained in report D3.3.3. along with an overview of the generic business case templates and assessment process presented in this report. The business case assessment methodology also includes a complementary business case development and assessment tool. A short introduction to the application and uses of the ELEGANCY WP4 modelling toolkit in business case assessments is included.

The overall business model and business case methodology, and the principal elements, were tested with government, industry and NGO stakeholders in two workshops conducted jointly with the European Technology and Innovation Platform ZEP[39]. Ideas and recommendations from a

[39] European Technology and Innovation Platform ZEP (2019) http://www.zeroemissionsplatform.eu, accessed 11th August 2020

ZEP temporary working group on 'Collaboration across the CCS Chain' were also included in the methodology.

7.2.2 What is a Business Case?

HM Treasury in the UK provides a neat and concise definition of a business case[40]:

"*The business case is a management tool and is developed over time as a living document as the proposal develops. The Business Case keeps together and summarises the results of all the necessary research and analysis needed to support decision making in a transparent way. In its final form it becomes the key document of record for the proposal, also summarising objectives, the key features of implementation management and arrangements for post implementation evaluation.*"

As a decision support exercise, a business case will be strongly influenced by the perspective and purpose of the entity or audience for whom it is developed. Thus, in complex infrastructure and new market investments as exemplified by the ELEGANCY case studies, public sector objectives (macroeconomic, social and environmental) and private sector business imperatives (shareholder returns commensurate with risk and opportunity cost) have to be blended together in such a way to deliver a combined business case that works for all stakeholders. To facilitate this, the ELEGANCY WP3 framework has differentiated between two contexts and scales; one for system business models and one for operational business models (see report D3.3.3). This methodology enables a targeted analysis for the system business case as well as the subordinate, but interlinked, business cases for component businesses.

For a given project, investment, or case study objective a complete business case will comprise:

1. Characterisation of the business and investment context;
2. Selection of a business model from a suite of preferences;
3. An allocation of risk and mitigation measures to stakeholders;
4. A qualitative and quantitative assessment against metrics that measure the value and delivery of the project against the objective;
5. A comparison with counterfactual alternatives if the project is not executed; and
6. Recommended ownership, financing and commercial structure.

In the ELEGANCY methodology a business case is prepared for a selected business model because of the strong relationship linking risk and liability sharing with financing and ownership. Consequently, an iterative process is used for business case definition and analysis that commences with a range of preferences of stakeholders (Section 3.1 of Report D3.3.4), and changes or updates the selected business model where appropriate as the process progresses. For the process to deliver an outcome satisfactory to all stakeholders there is a need for initial selection and ranking of appropriate metrics that will effectively parametrise and quantify the infrastructure proposition for comparison with counterfactuals as well as alternative business investment opportunities.

[40] HM Treasury (2018) Assessing Business Cases: A Short Plain English Guide, https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/190609/Green_Book_guidance_short_plain_English_guide_to_assessing_business_cases.pdf, accessed 11th August 2020

To achieve the 'consensus' business case described above, the ELEGANCY development and assessment process has been devised as a synthesis of best practice from standard private sector procedures and a number of public sector protocols.

7.2.3 ELEGANCY Business Case Development and Assessment Process

Chapter 3 of D3.3.4 contains a detailed explanation of the ELEGANCY WP3 business case development and assessment process, with flowcharts summarising the process shown in Figure 3-2 and Figure 3-3 of that chapter. The framework implemented via this process comprises guidance (see Section 7.3.2 below), templates (Appendix A of Report D3.3.4) and a spreadsheet tool that aids in the addition of content to these templates. The templates are designed to fully characterise a business case and some key foundation principles of this framework are introduced in the following sub-sections.

7.2.3.1 Business Case Dimensions

A complete business case at either H_2-CCS chain system level or for an individual business segment within the chain is characterised in the ELEGANCY framework by the six dimensions illustrated in Figure 7-1, and described in more detail in Table 7-1. The data required and outputs of the assessment in each of these dimensions evolve with the iterative development of the business case through decision gates and increasing levels of expenditure. This process was discussed in ELEGANCY report D3.3.3.

Figure 7-1 ELEGANCY Business Case Dimensions

Table 7-1 Overview of ELEGANCY business case dimensions

Business Case Dimension	Description
Strategic Drivers and Rationale	• Business case definition • Objectives of project, investment and/or intervention • Key strategic issues to be addressed • Business Model Preference • Key performance indicators and metrics
Financial Cost and Benefits	• Standard evaluation of cost and revenues • Standard metrics of Return on Investment (RoI), IRR, NPV • Assessment of additional sources of value created by the project
Economic and Value Benefits	• Quantification of direct economic impacts, economic rate of return (ERR) and economic net present value (ENPV) • Identification, and quantification where possible, of indirect economic, social and environmental benefits, distributional impact
Commercial Feasibility & Delivery	• Business model selection • Commercial structuring and capital sourcing • Contracting, procurement
Technical Feasibility & Delivery	• Assessment of technical design and construction, operating and decommissioning arrangements for physical delivery • Technology assessment and comparison
Outcome Management	• Standard risk identification, quantification and mitigation • Monte Carlo, scenarios, real options, optimism bias • Monitoring metrics for delivery and governance

7.3 Chapter 3: Business Case Development and Assessment

7.3.1 ELEGANCY Business Case Assessment

A flowchart of the ELEGANCY business case assessment process is provided in Figure 7-2 below and further guidance on the assessment for each of the dimensions is provided in the subsequent sections.

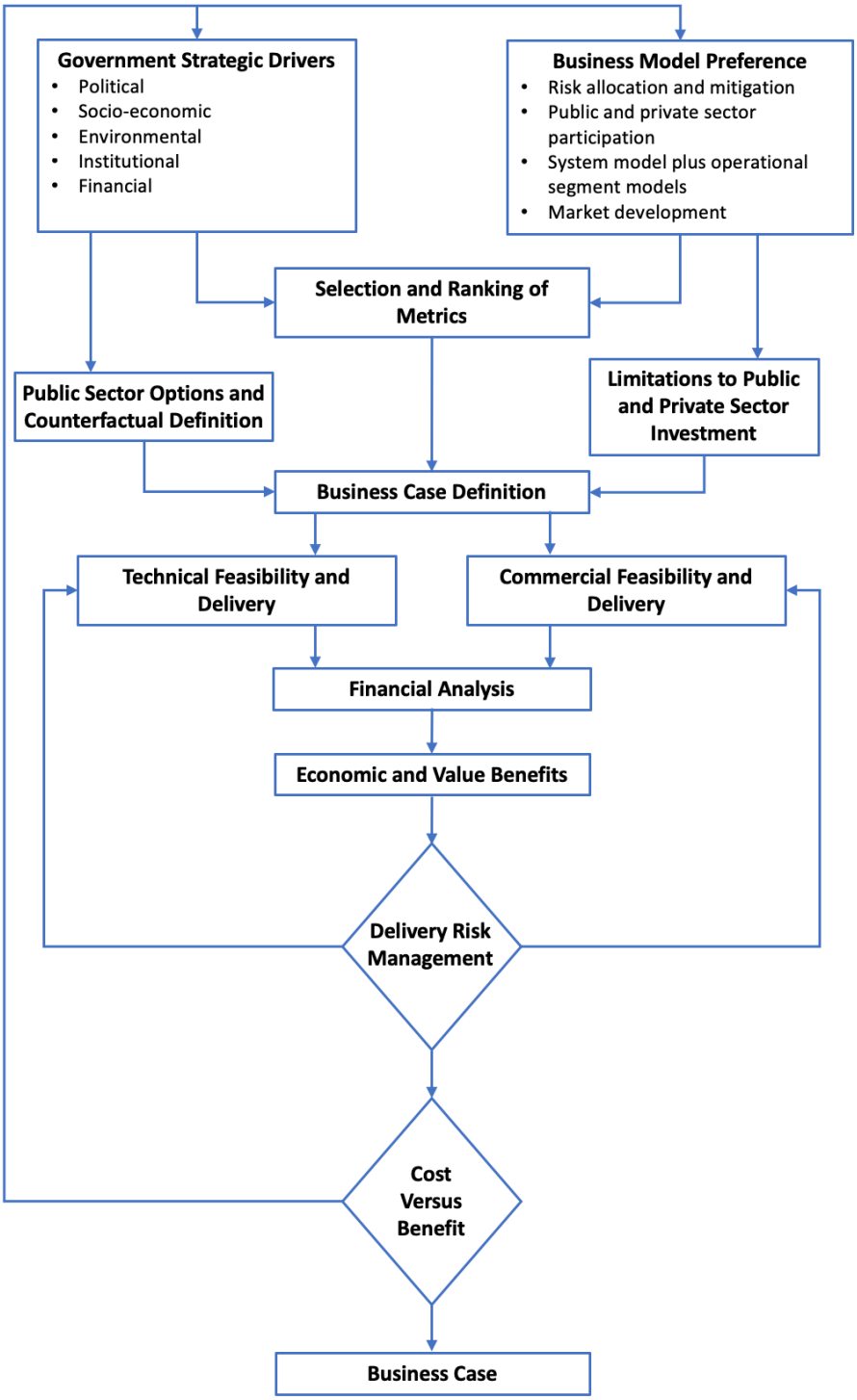


Figure 7-2 Business Case Assessment Process

7.3.2 Business Case Assessment Structure

This section presents high level guidance which has been prepared for the definition and assessment of each of the business case dimensions (Figure 7-1) and included in the Business Case Definition and Assessment Tool - in accordance with the flowchart in Figure 7-2.

Detailed spreadsheet templates have been developed for each of these dimensions and included in the Business Case Definition and Assessment Tool (see report Appendix A).

7.3.3 Examples of Public Business Case Assessment Protocols

This section of the chapter reviews some best practice public sector business case assessment protocols. These protocols provide valuable insights into how a collaborative business case can be developed between the public and private sectors. They also demonstrate just how similar the public sector decision-making is to that of the private sector. Closing the business case gaps between the two relies on merging the financial and economic cases (and the drivers of a cost-benefit analysis[41]) to find a value-for-money proposition that works for both public and private perspectives. Joint determination of the business model based on agreed risk and liability sharing is essential to achieve this outcome. Hence, the need for the iterative process within the ELEGANCY methodology described previously. Each of the public sector protocols described in the report is a subset of, and compatible with, the ELEGANCY business case structure and templates. Protocols include:

1. United Kingdom HM Treasury
2. European Commission
3. European Investment Bank
4. World Bank

7.4 Chapter 4: Complementary Tools

This chapter summarises the ELEGANCY WP3 toolkit and how to make effective use of the ELEGANCY WP4 H_2-CCS Chain Modelling toolkit within the business case development and assessment process. Chapter 8 below provides a detailed look at the toolkit

7.4.1 Using the Chain Modelling Toolkit in Business Case Assessment

This section provides guidance on how to make use of the H_2-CCS chain modelling tool developed in ELEGANCY WP4 in each one of the business case dimensions.

[41] Cost benefit analysis (CBA) is a quantitative technique that assesses costs and benefits in monetary terms for a project, investment or intervention over a forecast period and discounts each to arrive at present values that can be adjusted for risk and uncertainty. The difference between the present value benefits and costs is the net present value (NPV). CBA is conducted as a comparative calculation against the case when the intervention is not performed, or against an alternative case.

8 BUSINESS CASE DEVELOPMENT TOOLKIT

8.1 Summary

The ELEGANCY Business case development toolkit is a collection of spreadsheets released under the Creative Commons Attribution NoDerivs (CC BY-ND) license. It can be found on the ELEGANCY website at:
https://www.sintef.no/projectweb/elegancy/programme/wp3/business-case-development-toolbox/

Supporting Tools	Source
• Market Background Assessment • Market Failures	Report D3.2.1
• Risk Assessment and Matrix • Policy and Financial Support Analysis	Report D3.3.2
• Risk Mitigation Heat Map • Policy Needs Heat Map • Business Model Selection Tool	Report D3.3.3
• Business Case Definition and Assessment Tool	Report D3.3.4

The following sections provide descriptions and guidance for each of the tools.

8.2 Market Background Assessment

This tool is designed to facilitate the qualitative and quantitative assessment of the market background and business drivers for the H_2/CCS value chain segments and market sectors of relevance for a particular case study.
The tool consists of three tabs providing guidance (Tab **Instructions**, Tab **H_2-CCS flow sheet**, and Tab **Business tree**), and of five Tabs I.-V. containing modules with mostly qualitative questions about the market background and business drivers for the H2/CCS value chain:

Tab:	Description:
H2-CCS flow sheet	This tab contains a flow sheet of the integrated H2/CCS value chain as covered within the ELEGANCY project, as well as an additional flow sheet showing the alternative/competing/complementary elements affecting the H2/CCS value chain. This serves to position the case study within the overall project scope.
Business tree	This tab contains an overview of the business opportunities, categorized into I.) H2 production and infrastructure service options, II.) CO2 capture and infrastructure service options, III.) H2 utilization options, IV.) CO2 utilization options. Also, this tab serves for the orientation of the user within the H2/CCS integrated value chain.
I. H2 Infrastructure	This tab covers the supply side of the H2 part of the H2/CCS chain, split into the three segments **Production**, **Transmission/distribution**, and **Storage**. A first module of questions asks the user to select the business options of relevance to him or to his case study: "present", "niche application", and "not present". For those options that are marked present (and voluntarily also for those identified as "niche applications"), the user is asked to provide qualitative information about the corresponding market players and their interactions. A second module of questions asks the user to evaluate the strength of certain business drivers in promoting the business options selected in the first module: "strong driver", "medium driver", "weak driver", "not a driver", and "negative driver". A 'negative driver'-rating is appropriate should the listed business driver in fact hamper H2 supply and infrastructure services rather than drive them.
II. CCS Infrastructure	This tab covers the supply side of the CCS part of the H2/CCS chain. It has the same structure as described above for the Tab I. H2 infrastructure.
III. H2 Utilization	This tab covers the demand side of the H2 part of the H2/CCS chain, split into the four market sectors **Mobility**, **Industry**, **Decentralized heat & power**, **Centralized heat & power**. A first module of questions asks the user to select the business options of relevance to him or to his case study, and to provide qualitative information about the corresponding market players and their interactions. A second module of questions asks the user to provide and explain a rating of the strength of certain business drivers in promoting the business options selected in the first module.
IV. CO2 Utilization	This tab covers the demand side of the CCS part of the H2/CCS chain. It has the same structure as described above for the Tab III. H2 utilization. Note that CO2 utilization is not a primary focus of the ELEGANCY project. It is included in this Market Assessment tool for the sake of completeness, i.e. to cover the entire H2/CCS value chain from supply to demand.
V. Context	This is Tab covers qualitative and quantitative questions in three modules addressing the **Macroeconomic and fiscal context**, the **Climate policy context**, and the **Market context** for some key markets that are in relation to the H2/CCS value chain, namely the **Electricity market**, the **Natural gas market**, and the **Biogas market**.

- In each Module, the user is asked to research/compile information and to provide an expert opinion according to the list of questions (rows) and for the business options that are relevant to his business or case study (columns).
- Some questions are accompanied by additional guidance notes in the rightmost column of Tabs I.-IV.

8.3 Market Failures Assessment

This tool is designed to facilitate the qualitative and quantitative assessment of market failures for the market sectors of relevance for the H2-CCS integrated chain of the case study.

The table lists the market sectors in the first column in multiple rows and lists all the types of market failures in the first row in multiple column headings. The user can decide to add additional rows in order to break down the markets sectors into multiple business segments as per the categories suggested in the comments box (for example, dividing centralised heat and power into direct combustion and fuel cell CHP)

- Definitions for each type of market failure are provided in the section below. Market failures are not necessarily barriers to investment. They are situations, mechanisms or activities that change or affect the dynamics of a properly functioning market and distort the ability of the market to achieve equilibrium between supply and demand without intervention.
- Assessment: For each of those market sectors, determine which type of market failure (if any) is applicable and the extent of the failure. The "extent" of the failure is defined as the severity of its effect, impact or consequence on the market or business segment in the H2-CCS chain. Choose the relevant option from the drop-down menu. If any of the market sectors are not relevant to the case study, you can choose 'n/a' from the drop-down menu.
- The cells are automatically formatted based on the selection made from the drop-down list with the colours below:

Quantitative Rating

Low

Medium

High

Definitions of Market Failure Type	
Missing Market	No demand/market exists for the goods or services, thus creating a lack of price signals and preventing investment or even business interest in the activity.
Coordination Failure	Investment and business activities are dependent on synchronised or coordinated planning, design, financial investment decisions and construction in other related activities in order to mitigate counterparty or stranded asset risk. No coordination results in no market activity.
Negative Externality Low Priced CO_2 Emissions	Insufficient carbon price signal exists to effectively value the environmental impact of emissions and as a consequence impacts negatively investment interest in low carbon technologies or market-making activities.
Positive Externality Environmental and Social Value of Hydrogen Utilisation	The positive environmental and social value of the activity is not taken into account in individual consumer decisions nor priced into alternative goods and services based on traditional technologies. For example, HFCEVs improve city air quality but the social cost of pollution is not included in the price of conventional vehicles. A level of government support and/or socialisation of costs is required to create a properly functioning competitive market.
Positive Externality Environmental and Social Value of CO_2 Utilisation	Paradoxically, captured CO_2 that is available for certain types of utilisation has an underestimated positive environmental and social value in a circular economy: e.g. for the production and use of alternative fuels such as methanol, DME and OME. An appropriate quantitative lifecycle assessment should be undertaken for definitive evaluation of the positive externality.
Natural Monopoly	The activity is naturally non-competitive or creates a high barrier to entry thus providing the first mover or operator with a dominant position, allowing market control and the ability to set higher prices.

Definitions of Market Failure Type	
Location Immobility	H_2-CCS infrastructure is highly location dependent (e.g. geological storage of H_2 and CO_2, pipeline corridors, industrial clusters) - this is a significant cost constraint for broader deployment. The free market won't deliver beyond locational preferences without government intervention.
Social Inequality Fuel Poverty	Financial constraints are limiting the development of markets and infrastructure build-out in areas of high fuel poverty. There needs to be a level of government support.
Information Failure and Asymmetry	Market participants do not have access to information of equal amount or quality, or do not have equal capability to utilise information. Commercial transactions and decisions can be distorted leading to sub-optimal outcomes.
Knowledge Creation Spillover	There is a significant risk that third parties and competitors can benefit from the investment made by first movers and innovators in both end-user markets and across the H_2-CCS chain, thus creating disincentives for taking risks in the early investment and market-making activities

8.4 Risk Assessment and Matrix

B. IMPORTANT GUIDANCE	
Objective	1. To carry out a Preliminary assessment of the investment barriers and business risks for each of the business opportunities of any case study. 2. To steer the development of the appropriate business model, and to define and prioritise the actions to be taken in order to mitigate and manage those risks.
Structure	* 3 x Guidance sheets (orange): "Instructions" (objectives, general structure and overall methodology), "Detailed Instructions" (detailed instructions to fill in operating sheets) and "Risk Categories" (specific table describing risk categories and sub-categories). * 1 x General Input Sheet (brown): "Overview Information" (sheet to enter user and project/case study info). * 4 x Operating Sheets (red): "Political, Policy and Social", "Technical and Physical", "Market and Commercial", and "Outcome" Risk (sheets to complete the assessment of major business risks and identification of investment barriers).
Methodology	* Firstly, general information on the case study/project is input into the general input sheet '**Overview Information**' (brown). This is designed to facilitate the recording and tracking of each of the risk assessments - different versions by different respondents, and at different stages of the project * Secondly, the risk assessment is completed in the 4 assessment sheets (red). The risk assessments for the H2-CCS chain is undertaken at two levels in no particular order and with a consistency check between the two. Investment barriers can be extracted from the analysis of the major business risks or investment barriers can be identified immediately using existing knowledge of the industry and later cross-checked when the business risks have been analysed. **1. BUSINESS RISKS: IDENTIFICATION AND ASSESSMENT WITH INVESTABILITY IMPACT** in the bottom table (light blue) of the assessment sheets, specific business risks affecting each of the business opportunities are identified and assessed along with their impact on the investability of the opportunity. Mitigation measures are identified/proposed and their impact on investability is quantified. The key risks are identified using four main categories: Political/Policy and Social, Technical and Physical, Market and Commercial, Outcome. These categories and additional subcategories are defined and explained in the guidance tab '**Risk Categories**'. The likelihood and impact of those risks on the feasibility or value of the business opportunity are assessed using a traditional risk matrix methodology. The likelihood and impact risk rating values and descriptions are provided in the guidance tables in tab '**Detailed Instructions**', and a degree of flexibility in interpretation is allowable for the severity of the impact depending on the nature of the proposed investment or operational entity. These risks impact the investability from an investor's point of view. This impact is quantified using a scale from 1 to 5 where 1 is low risk and 5 is prohibitive risk (i.e. no investment is possible). Mitigation measures for cause and consequence are identified using a bow tie approach, which addresses control and recovery actions for cause and consequence respectively. **2. INVESTMENT BARRIERS** In the top table (dark blue) of the assessment sheets, major investment barriers are identified. These barriers are circumstances or "facts" that raise the risk of detrimental investment outcomes to an unacceptable level for any type of investor (investability rating of 5). Generally, these barriers will affect investment in multiple segments along the chain, or the whole chain, and require a "system view" and multi-party (often in collaboration with government) approach to mitigation measures. These barriers need to be addressed in priority for any investment to be possible. These barriers can either be extracted from the business risk table (i.e. from the risks with a 5 rating) or from existing knowledge given a number of these barriers have been experienced by CCS projects and commercialisation programmes, and many have been well documented. Mitigation measures need to be identified to enable public and/or private sector entities to invest and operate. This is designed to help understanding and communication of the key issues preventing investment and facilitate the engagement with the government on the actions to be taken to remove such barriers. A market failure such as a missing market is an example of an investment barrier. A regulation or statute resulting in an uncapped liability for a business is another.

B. IMPORTANT GUIDANCE	
	3. CONSISTENCY STEP The impact of the business risks on investability in the business opportunity is also assessed from a chain perspective to determine if investment barriers and mitigations need to be reviewed and revised or the nature of the business entity needs to be modified. A consistency check between the investment barriers in the top table and the business risks in the bottom table is undertaken to ensure any business risks that result in a chain investability impact of rating 5 are escalated to an investment barrier and dealt with accordingly. Consistency between mitigation measures is also cross-checked.

8.5 Policy and Financial Support Analysis

This tool is designed to facilitate the qualitative and quantitative assessment of the existing regulatory policies and financial support mechanisms against expected requirements.

C. IMPORTANT GUIDANCE

* Firstly, determine the market sectors of relevance for the H2-CCS integrated chain of the case study and fill in the table above. The market sectors are made up of a number of business segments that provide products or services. These can be considered in greater detail during the course of the policy assessment and additional policy needs added to the spreadsheets as deemed appropriate. The following table summarises the business segments consistent with the ELEGANCY Market Background Assessment Tool.

APPLICABLE MARKETS	BUSINESS SEGMENTS				
H2 Infrastructure	Production	Transmission	Distribution	Short-term Storage	Seasonal Storage
CCS Infrastructure	Capture	Gathering	Transmission	Distribution	Storage
H2 Mobility	Vehicles	Rail/Marine/Air			
H2 Industrial Use	Chemicals/Materials	Process Heat			
H2 Decentralised Heat & Power	Direct Combustion	CHP Stationary Fuel Cells			
H2 Centralised Heat & Power	Direct Combustion	Stationary Fuel Cell Stacks			
CO2 Utilisation	Synthetic Fuels	Chemicals/Materials	Solvent	Conversion to Methane	Working Fluid

* For each of the relevant market sectors, review the policies in place against the identified 'market needs'. Three assessments are carried out.
1. First rate the importance of the policy need using a simple scale of low/medium/high.
2. The second rating is the estimated time period over which the policy needs to be developed and implemented for maximum benefit to the evolution of the market sector and its associated technologies.
3. The third assessment is aimed at determining the level of compliance of existing policies for the case study under review. Rate the level of compliance from 1 to 10 (1=Not compliant; 10=fully compliant) and provide evidence in the adjacent column. Cells will automatically change colour in relation to the rating.

* Then, review the level of financial support available for the implementation of those policies and activities to determine whether this is sufficient. Multiple options are provided: very low and low (i.e. insufficient), sufficient, and high (which has a positive impact on the timeline for implementation). Provide evidence in the adjacent column.

* Please be thorough with the provision of evidence - this is useful to benchmark multiple case studies and for future re-assessment when policies and/or financial support are amended.

* General help is provided for each column in the notes for the top-level row.

8.6 Risk Mitigation Heat Map

B. IMPORTANT GUIDANCE	
Objective	The Risk Mitigation Heat Map is an assessment and visualisation tool with the following objectives: - assess and communicate the criticality of each of the (pre-defined) risk categories with regard to their impact on investment in relevant business sector of the H2-CCS Chain; - assess and communicate the mitigations measures for each risk category (using a pre-defined classification); - highlight those risk categories which represent investment barriers, i.e. those with high criticality and without appropriate mitigation measures.
Structure	* 3 x Guidance sheets (orange): "Instructions" (objectives, general structure and overall methodology), "Risk Categories" (specific table describing risk categories and sub-categories), "Risk Mitigation Measures" (table of detailed risk mitigation measures and options to consider when completing the heat map). * 1 x General Input Sheet (brown): "Overview Information" (sheet to enter user and project/case study info). * 1 x Operating Sheet (red): "Heat Map" (sheet to complete the assessment and representation of major business risks, potential mitigation measures and highlight investment barriers). * 1 x Example Sheet (green): "Heat Map Example" (sheet to demonstrate what a completed assessment looks like).
Methodology	* Firstly, general information on the case study/project is input in to the general input sheet 'Overview Information' (brown). This is designed to facilitate the recording and tracking of each of the heat map assessments - different versions by different respondents, and at different stages of the project. * Secondly, the heat map is completed in the "heat map" sheet (red). This can be completed directly or using the risk assessments which may have been completed prior to this this exercise. The Heat Map is made up horizontally of a number of pre-defined risk categories and vertically of the business development stages (see Risk Categories sheet for guidance on pre-defined risk categories). The Heat Map requires two inputs from the user: Investment risk criticality (measured in terms of the need for mitigation measures to reduce the risk with regard to investment) and the proposed risk mitigation measures (using a number of pre-defined categories). An example has been completed for CCS infrastructure in the UK (for illustrative purposes only) in the Heat Map Example sheet (green). 1. Investment Risk Criticality/Risk Mitigation Demand - In each cell of the heat map (corresponding to a risk category for a stage of development of the business sector), assess the demand for risk mitigation (i.e. risk criticality) and colour the cell with the relevant colour. Guidance on the risk categories can be found in the Risk Categories guidance sheet. - Copy the relevant reference cells (which can be found between cells P16 and P19) and paste it in the appropriate space in the heat map. 2. Risk Mitigation Measures - For each cell of the map, identify the existing risk mitigation measures which could be used to mitigate the relevant investment risks. These measures are selected from pre-defined categories. which are listed and numbered in the mini table in the sheet (U15:AA24). Additional information (and examples) is provided in the Risk Mitigation Measures Guidance sheet. - Type into the cell the numbers of the selected risk mitigation measures. Multiple measures may be selected and entered into the cell, separated by a coma. In the mini-table, only top-level risk mitigation measures are presented. Sub-level measures are also available, explained and numbered in the guidance sheet. The user is welcome to use this additional sub-level and enter the appropriate numbering into the cells. 3. Investment Barriers/Risk Mitigation Coverage Gap - When both steps 1 and 2 have been completed, the risks mitigation coverage gaps can be identified, i.e. any cells with highest criticality/risk mitigation demand but without existing and sufficient risk mitigation measures available. - Change the border type for these cells to BOLD by changing the cell formatting.

8.7 Policy Needs Heat Map

B. IMPORTANT GUIDANCE

Objective

* This tool is designed to be a visualisation aid for facilitating identification and discussion of priority policy requirements to facilitate delivery of an H2-CCS chain and the business segments of which it is comprised. The tool can be used in conjunction with the ELEGANCY Policy Gap Analysis tool or independently.

Methodology

* Firstly, determine the market sectors of relevance for the H2-CCS integrated chain of the case study and fill in the table in the **Overview Information** brown tab. The applicable market sectors are made up of a number of business segments that provide products or services. These can be considered in greater detail during the course of a policy assessment and added to the spreadsheets with additional policy needs as deemed appropriate. The following table summarises the business segments consistent with ELEGANCY Work Package 3 Business Models and Cases, and the Market Background Assessment Tool. The table is repeated for convenience in the **Overview Information tab**.

APPLICABLE MARKETS	BUSINESS SEGMENTS				
H2 Infrastructure	Production	Transmission	Distribution	Short-term Storage	Seasonal Storage
CCS Infrastructure	Capture	Gathering	Transmission	Distribution	Storage
H2 Mobility	Vehicles	Rail/Marine/Air			
H2 Industrial Use	Chemicals/Materials	Process Heat			
H2 Decentralised Heat & Power	Direct Combustion	CHP Stationary Fuel Cells			
H2 Centralised Heat & Power	Direct Combustion	Stationary Fuel Cell Stacks			
CO2 Utilisation	Synthetic Fuels	Chemicals/ Materials	Solvent	Conversion to Methane	Working Fluid

* For each of the relevant market sectors, review the policies in place against the policy categories and identified sector policy needs provided in the **Example Sector Policy Needs** orange tab of the spreadsheet. There are 18 policy categories comprising the Heat Map. Further categories can be created if felt necessary, but it is advisable to try and work within those already defined. The policy needs can be modified, added to, or deleted for the specific case study under investigation. If the ELEGANCY Policy Gap Analysis Tool is also being used in conjunction with this Heat Map, then any changes made in one should be copied to the other.

* The heat map (red tab) is filled out as follows:

1. For each applicable market sector and each policy category in the matrix determine the level of demand ("demand intensity") for that policy category from stakeholders in order to progress the case study project this will be performed separately for public sector and private sector stakeholders to obtain their different perspectives.
2. Fill the cell at the intersection in the matrix of the market sector and policy category with the appropriate colour shade
3. Outline in bold any cells in the resulting heat map where it is considered there is a complete absence of policy addressing that category for the case study. The bold outlines can be aggregated for a group of cells for neater visualisation.

8.8 Business Model Selection

A. IMPORTANT GUIDANCE	
Objective	The Business Model Selection Tool is an assessment and visualisation tool with the following objectives: - Summarise the key findings on investment barriers and major investment risks, the preferred risk mitigation and allocation from previous exercises, understand their impact on the key components of business models, both at system and sector level; - Facilitate the definition of A number of potential business models at system and individual sector level from both a public and private sector perspective; - Facilitate engagement and collaboration between public sector and private sector partners/stakeholders to define common priorities and resolve investment barriers jointly
Structure	The tool consists of: * 1 x General Input Sheet (brown): "Overview Information" (sheet to enter user and project/case study info). * 3 x Guidance Sheets (orange): "Instructions" (objectives, general structure and overall methodology), "Guidance" and "Risk Categories" (specific table describing risk categories and sub-categories). The guidance sheets provide the generic and specific guidance on how to use the tool and supporting information on the definition of the risk categories. * 6 x Operating Sheets (red): - "System Drivers" and "Sector Drivers" - these sheets are focused on the assessment of relevant business model drivers at system and sector level - "System Summary" and "System Priority Risks" - these sheets are focused on the main investment risks and risk allocation at system level and their impact on the definition of a business model at system level - "Sector Summary" and "Sector Assessment". Additional sheets can be created for additional sectors
Methodology	* **Overview:** Firstly, general information on the case study/project is input in to the general input sheet 'Overview Information' (brown). This is designed to facilitate the recording and tracking of the business model reviews and assessments - different versions by different respondents, and at different stages of the project. One of the key information is the table "Case Study: Applicable Business Segments" where the user chooses the applicable business sectors for the relevant project/case study by simply selecting Yes or No from the drop-down menu. This table is linked into the "Sector Drivers" and "System Summary" sheets in order to automatically grey out those sectors which are not applicable. * **System Drivers and Sector Drivers**: these two sheets are a compilation of key external elements which are considered to have a significant impact on the business model selection. The user is invited to rank the strength of these drivers using qualitative measures by choosing Low, Medium or High from the drop-down menu based on his knowledge or the information gathered from the Business Context Assessment (see Guidance tab). Sectors which are not applicable to case study/project are automatically greyed out based on the selections made in the Overview sheet (See above). * **System Summary and System Priority Risks**: The "System Priority Risks" is a heat map where the major investment risk categories (those with greatest impact on the investment decision) are highlighted. A colour coding is used to represent the party (private/public) responsible for their mitigation (from the user's perspective). Mitigation options include Private, Public, Joint and Undefined. The user simply copies and pastes one of the cells from C3:C6 in the relevant place. Three identical tables are created in this sheet to allow for input from representatives from the private sector, from the public sector, and also a subsequent comparison of these perspectives and finally, if possible, the development of a joint view. In the System Summary, the user can define preferences for the business model based on the key components of the business model (See Guidance for further information on those components). The "System Priority Risks" heat map, and the other sheets are tools to support the user in the selection of each of the business model components. Additional tables can be added for the user to develop multiple business model options - simply copy and paste one of the existing table below the others.

A. IMPORTANT GUIDANCE	
Methodology	**<u>* Sector Summary and Sector Assessment:</u>** The Sector Assessment sheet is a detailed review of the major investment risks, the preferred/likely party responsible for their mitigation and the resulting impact on any of the business model components (See Guidance for further information on those components). This sheet is divided in two identical sections. The tables on the left are designed to be completed from the private sector's perspective and the tables on the right from the public sector's perspective. The tables represent the main risk categories and their subcategories and are consistent with the risk classification used in the risk assessment tools. The sector Summary is designed for the user to develop sector business models based on the key business model components. For each of these, the user selects the level of responsibility allocation between private/public by either entering a value in the relevant cells (yellow cells with red font) or by moving the slider. Commentary boxes are also available to enter further details and comments. Similarly, to the "Sector Assessment", the sheet is divided vertically into two identical sections - left for private sector perspective and right for public sector perspective. All the other sheets are tools to support users in their selection. Additional sheets can be created for any of the business sectors of the H2-CCS chain and new sheets can be added by duplicating the existing ones.

8.9 Business Case Definition and Assessment

A. IMPORTANT GUIDANCE	
Objective	The Business Case Definition and Assessment Tool is a tool to facilitate the definition and assessment of a business case for an H2-CCS chain and/or any relevant sectors of that chain: - Facilitate the definition of a business case at system and individual sector level from both a public and private sector perspective; - Facilitate the assessment of the business case; - Facilitate engagement and collaboration between public sector and private sector partners/stakeholders .
Structure	The tool consists of: * 1 x General Input Sheet (brown): "Overview Information" (sheet to enter user and project/case study info). * 2 x Guidance Sheets (orange): . The guidance sheets provide the generic guidance and background methodology e on how to use the tool and supporting information on the definition of the dimensions * 11 x Operating Sheets subdivided into: 3 x Operating Sheets (Purple): Business Case Definition and supporting tabs 8 x Operating Sheets (Red): Business Case Assessment - one for each of the six dimensions and two supporting tabs for the last dimension (Outcome Management)
Methodology	* **Overview:** Firstly, general information on the case study/project is input into the general input sheet 'Overview Information' (brown). This is designed to facilitate the recording and tracking of the business case reviews and assessments - different versions by different respondents, and at different stages of the project. One of the key information summaries is the table "Case Study: Applicable Business Segments" where the user chooses the applicable business sectors for the relevant project/case study by simply selecting Yes or No from the drop-down menu. This table is linked into the "Sector Drivers" and "System Summary" sheets in order to automatically grey out those sectors which are not applicable. * **Business Case Definition:** This sheet summarises the business case under a number of headings. The user is invited to fill in tables, and guidance is provided in each of the sections. - *Drivers:* this sheet is a compilation of key external elements which are considered to have a significant impact on the business case development. The user is invited to rank the strength of these drivers using qualitative measures by choosing Low, Medium or High from the drop-down menu based on his/her knowledge or the information gathered from the Business Context Assessment. Sectors which are not applicable to case study/project are automatically greyed out based on the selections made in the Overview sheet (See above). - *Counterfactual:* This sheet allows the user to summarise the key characteristics of the counterfactual scenarios selected for a comparative assessment with the main business case scenario. * **Business Case Assessment - 6 Dimensions:** **Strategic Rationale:** This sheet is divided into two sections: Objective, Strategic Issues. In the Strategic Issues, a number of key strategic issues are defined based on experience. For each of these issues, the user is invited to answer a number of questions and assess the alignment of the project proposition with the Business Case Definition. **Financial Cost and Benefits and Economic Value and Benefits: :** These sheets are divided into three sections: Objective, Financial /Economic Analysis/Cost Benefit and Cost Effectiveness and Assurance. In the main section (respectively Financial Analysis and Cost Benefit and Cost Effectiveness), the user is invited to fill in quantitative information for a number of pre-defined dimensions - separate dimensions defined specifically for the public sector and the private sector. In the Assurance section, the user is invited to describe the assurance process which was followed during the quantitative analysis and preparation of the business case document.

A. IMPORTANT GUIDANCE	
Methodology	**Commercial Delivery and Technical Delivery sheets:** These sheets are also divided into three sections: Objective, Commercial Structures/Technical Design and Assurance. In the main section (respectively Commercial Structures and Technical Design), the user is invited to fill in qualitative information for a number of pre-defined dimensions - separate dimensions defined specifically for the public sector and the private sector. In the Assurance section, the user is invited to describe the assurance process which was followed during the preparation of the business case document. **Outcome Management:** This sheet is supported by two additional sheets (Risks and Planning). This sheet is divided into four sections: Objective, Risk Assessment and Mitigation, Overall Delivery Planning and Collaboration & Engagement. In the Risk assessment and Mitigation section, the user is invited to summarise in a table the major risks and their mitigation measures as highlighted in the supporting sheet 'Risks'. In the Collaboration and Engagement section, the user is invited to describe the engagement plan with public and private sectors and list in a table the planned activities, their timing and the lead party. - *Risks*: This sheet is divided into four sections: Objective, Standard Risk Assessment, Other Risk Assessment Methodologies, Assurance . The "Standard Risk Assessment" section includes a risk mitigation heat map and a table summarising the main risks and their mitigation measures. The user is invited to fill in both tables based on the outcome of the risk assessment exercise carried out at an earlier stage of the business case development process. Additional guidance is provided at the beginning of that section. The "Other Risk Assessment Methodologies" includes a simple table where the user can summarise any other methodologies used and the outcome of the assessment (including the links to the quantitative results and impacts in the financial and economic business case dimensions). In the Assurance section, the user is invited to describe the assurance process which was followed during any quantitative analysis and the preparation of the business case document. - *Planning:* This sheet is divided into three sections: Objective, Commercial Delivery Plan and Technical Delivery Plan. In each of the main sections, the user is invited to fill in two tables, a table summarising the key planned activities with their timeline, responsible party and amount of funding required, and a table summarising the key milestones and their timeline.
Supporting Tools	The full ELEGANCY business case development and assessment process is described in Reports D3.2.1, D3.3.2 and D3.3.3. A toolbox containing a full suite of complementary business tools for assisting with the collection and analysis of the information required is available for use under a Creative Commons licence CC BY-ND. The reports and Toolbox are available at: https://www.sintef.no/projectweb/elegancy/publications/ Insights and supporting analysis into the business case dimensions can also be obtained through use of the ELEGANCY Work Package 4 H2-CCS chain modelling toolkit. This is open-source software. Models built with this toolkit can provide some potentially useful inputs to: • the selection of business models in the iterative ELEGANCY process ; • the selection of value and delivery metrics; • development of counterfactual scenarios and baselines; • economic cost effectiveness analysis; • understanding distributional impact and optimism bias; and • delivery and operability risk assessment and mitigation plans. On completion of the ELEGANCY project the relevant reports, user documentation and toolkit are available at: https://www.sintef.no/projectweb/elegancy/publications/