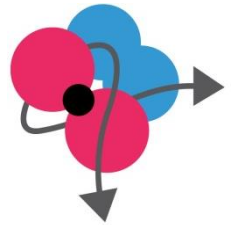
Enabling a Low-Carbon Economy via Hydrogen and CCS

Webinar 4
23rd June 2020

Business case development and hydrogen-CCS chain tool

	• **Part 1: Business case development for H_2-CCS integrated chains**
10:00	• *Welcome*
10:05	• *Introduction and Objectives* Ward Goldthorpe (Sustainable Decisions Limited)
10:20	• *Business Context Assessment* Ward Goldthorpe (SDL), Jonathan Schwieger (First Climate) & Catherine Banet (UiO)
10:40	• *Business Risk Identification and Mitigation* Ward Goldthorpe (SDL)
10:50	• *Q&A*
10:55	• *Business Models Development* • *Business Case Development and Assessment* Lionel Avignon (SDL)
11:25	• *Conclusions and Q&A*
11:30	• **Break**

	• **Part 2: H_2-CCS chain tool and evaluation methodologies for integrated chains**
12:30	• *Overview and rationale of the work package; modelling framework* Nilay Shah (Imperial College London)
12:45	• *Model reduction approach and rationale* Julian Straus (SINTEF)
13:15	• *Integrated design optimisation and LCA – method development and application study* Nixon Sunny (ICL) & Karin Treyer (PSI)
13:45	• *Overview of operational modelling, including local thermodynamic models* Edward Graham (ICL)
14:00	• **End of webinar**



Business case development for H_2-CCS integrated chains

Work Package 3 Webinar
23rd June 2020

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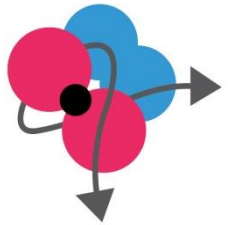
ELEGANCY WP3

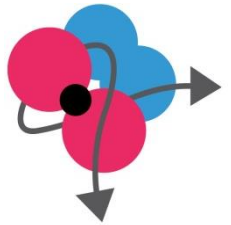


Introduction & Objectives

Webinar Objective

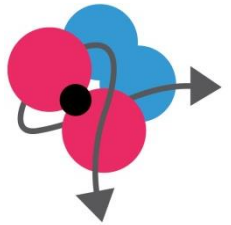
- Summarise outcome of Work Package 3 on H_2-CCS business model and business case development
- Describe the methodology including principles, processes and tools developed to facilitate future H_2-CCS integrated chain development
- Illustrate with examples from UK H21 North of England case study
- Encourage participants to read and use materials (reports and tools)

CCUS Context in Europe



- No success in developing CCUS infrastructure in Europe despite many attempts and significant innovation funding across Europe
- The major investment barriers to initial deployment of H_2-CCS are not technological, but political and commercial.
- Risks - whether perceived or real - determine the attractiveness of investment opportunities, the level of return investors need, and the value for money governments expect.
- Need to develop business models and business cases which allocate, share and mitigate risks between the public and private sectors and gain support from the public

UK H21 Case Study: Conceptual Business Case Definition



The business case concept definition for the UK H21 case study is directed at the objective to achieve:

A commitment to phased investment in H_2-CCS infrastructure to cost effectively decarbonise residential heating in the north of England and to support UK energy system decarbonisation to meet a net zero emissions target by 2050.

A. PROJECT PRESENTATION

H2-CCS Sectors	Full H_2-CCS chain, H2 for gas network conversion and other sectors
Project Status	Concept
Project Type	First of a Kind Large Scale Infrastructure Deployment
Project Scale (financial)	CAPEX: £22.78 billion OPEX: £955 million per annum post 2035
Project Scale (emissions)	CO_2 emissions reduction 12.5 Mtpa

Geographical Extent	North of England
Implementation Timeline	2023-2035
Market Maturity	Market creation
Main Public Sector partners/stakeholders	General government - to be defined later
Main Private Sector partners/stakeholders	Gas distribution companies (Northern Gas Networks, Cadent), H2 production companies (BOC, Air Liquide), oil and gas companies (BP, Shell, Total, Equinor, ENI, National Grid, Power generation companies

WP3: Introduction

Objective

To develop a business case framework comprising optional elements for application to the WP5 case studies (exemplifying different European integrated H_2-CCS chains) and elsewhere

Principal Activities

1. Assessing the business context, including the macro-economic, legal/regulatory, market and fiscal background to a H_2-CCS development proposition
2. Assessing the policy issues, business risks and incentive mechanisms impacting investment for the various actors in a H_2-CCS value chain
3. Creating processes and tools to develop business models and commercial structures including risk mitigation strategies
4. Designing a business case assessment methodology, framework and templates

Business Model Development Methodology

PROCESS

WP3 INPUT

Definition of Case Study Scope

- Geographical extent
- Market sectors
- H2-CCS Chain

Case Study Parameters

Focused Background Review and Gap Analysis

- Early identification of key business issues
- Guided review based on experience

Review and Gap Analysis Guidance and Tools

Legal and Regulatory	Policy and Incentives	Market
•International •EU •National	•Key policies required •Gap analysis tool	•Background assessment tool •Market failure analysis tool •Macroeconomic & fiscal indicators

Business Risks Identification & Mitigation

- Identify and address major investment barriers
- Identify and prioritise business risks
- Investigate risk mitigation measures

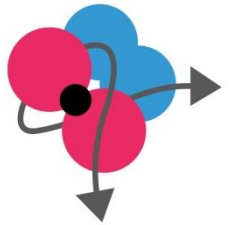
Business Risk Assessment Tool

Business Models Development

- Business structures and integration
- Risk allocation between public and private sectors
- Risk impact on cost of capital and de-risking instruments

Business Model Guidance

KEY INTERACTIONS



WP4

- Chain model structure
- WP3 output impact model functionality and cases
- WP4 output impact business models and business cases

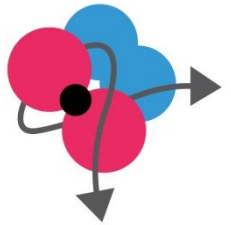
External parties

- Real life investors (public and private, debt and equity)
- Market representatives
- ZEP Working Group

WP5

- Case study owner
- Knowledge expert
- End user

Key Principles



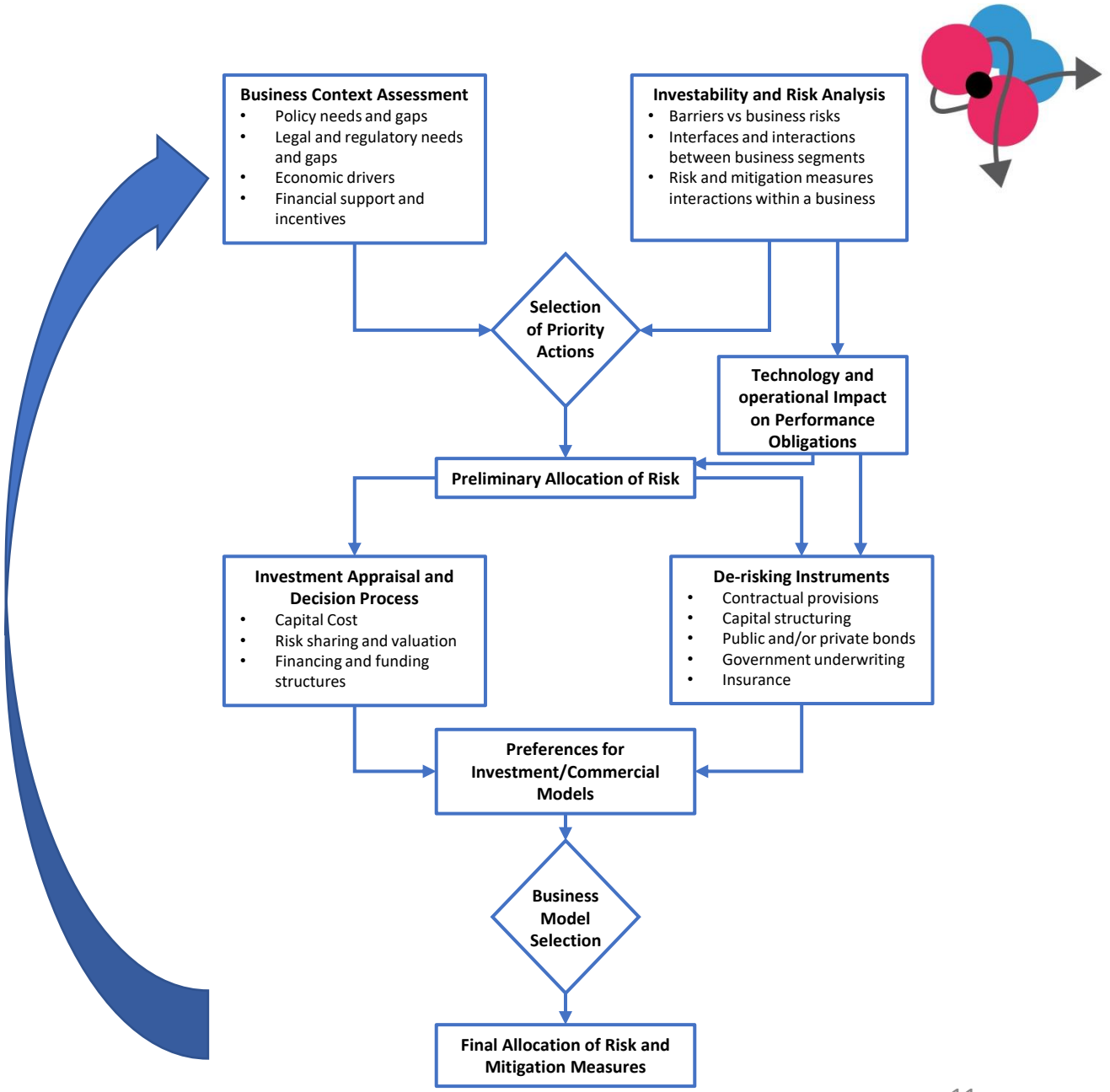
- Dealing with a Complex Business and Policy Environment
  - Simplification and Prioritisation
    - Design for simple and impactful visualisation of critical investment issues for decision support.
  - Knowledge and Guidance
    - Provide structured assistance on process and use of tools.
  - Engagement & Collaboration
    - Design for comparison of options and preferences and to facilitate the engagement and conversations between private sector and public sector on key issues early in project lifecycle.

- Risk Management, Mitigation and Allocation throughout the Lifecycle
  - Process/Tools should be designed to be flexible for various levels of project maturity – allow for increased levels of detail as a project advances.

- Each case study/project is specific
  - Process/Tool should be flexible for the users to adapt to their own project conditions.
  - Applicability anywhere in Europe and beyond
  - Adaptable to other CCS/CCUS/BECCS/DACS chains, networks and systems

Outcome

- Overall methodology which can be implemented with minimal expert facilitation
- Step by step workflows
- Structured guidance
  - Based on actual CCS implementation experience
  - Contained in detailed reports
  - Key principles and knowledge summarised in the tools
- Excel Analytical and Visualisation Tools
  - Designed to be easily modified to suit specific case study or project



WP3 Deliverables

Relevant Public Reports:

1. D3.2.1 - Report detailing the regulatory, fiscal and macro-economic background for each case study
2. D3.3.2 - Report detailing policy issues, business risks, de-risking instruments, and incentive mechanisms relevant for case study countries
3. D3.3.3 - Report detailing the development of business models and commercial structures
4. D3.3.4 - Report detailing the guidelines for the assessment and application of the business case templates in WP5
5. D3.4.1 - Synthesis report providing a structured overview of the content of the four detailed public documents

Tools:

1. Business Context Assessment: Market Background Assessment#, Market Failures Analysis*, Policy and Financial Support Analysis* and Policy Needs Heat Map*
2. Risk Assessment* and Risk Mitigation Heat Map*
3. Business Model Selection*
4. Business Case Definition and Assessment*

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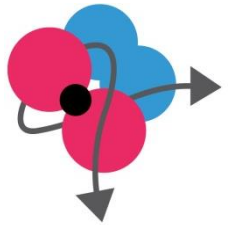
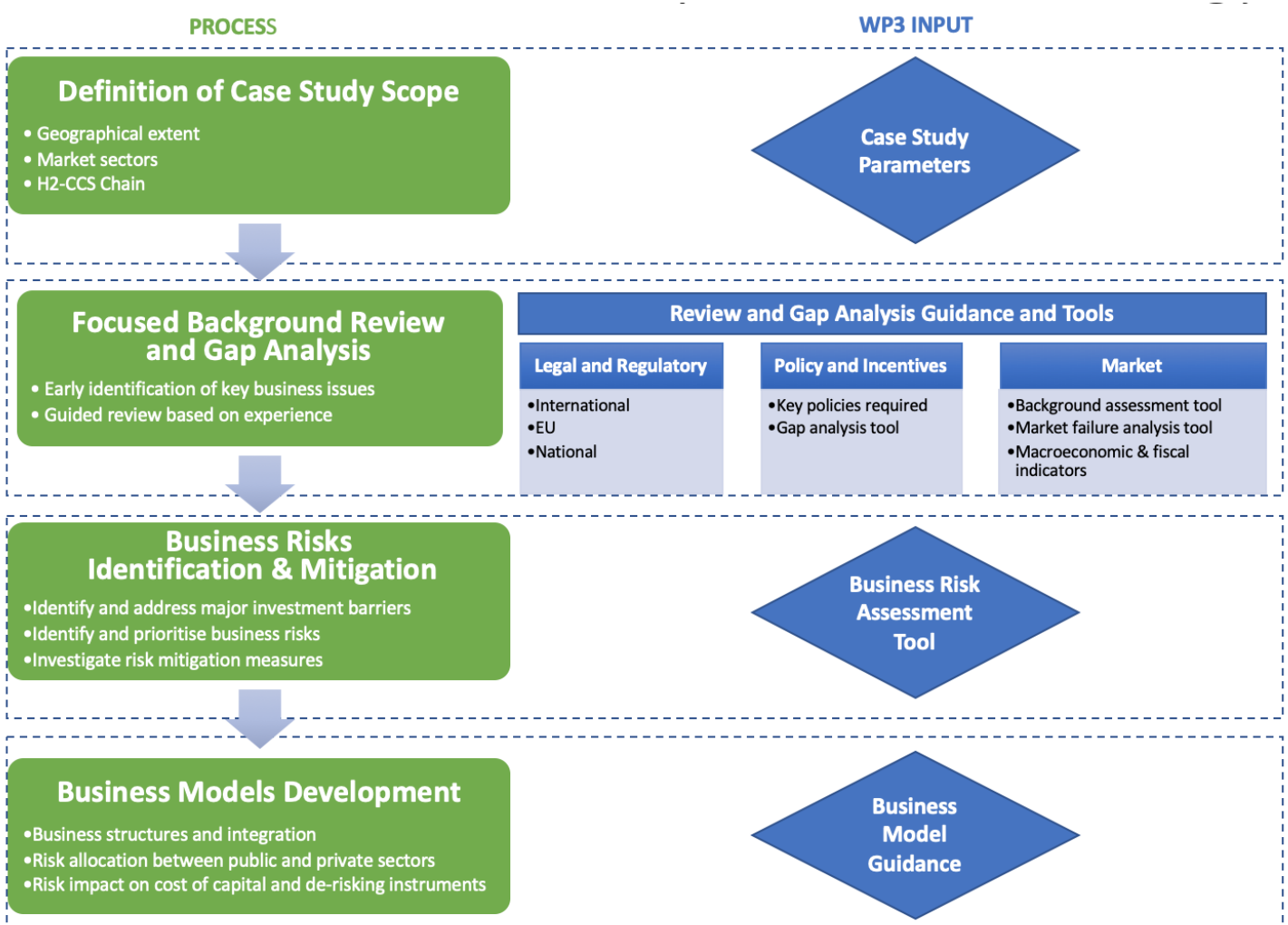
DELIVERABLES AVAILABLE ONLINE AT:
https://www.sintef.no/projectweb/elegancy/publications/

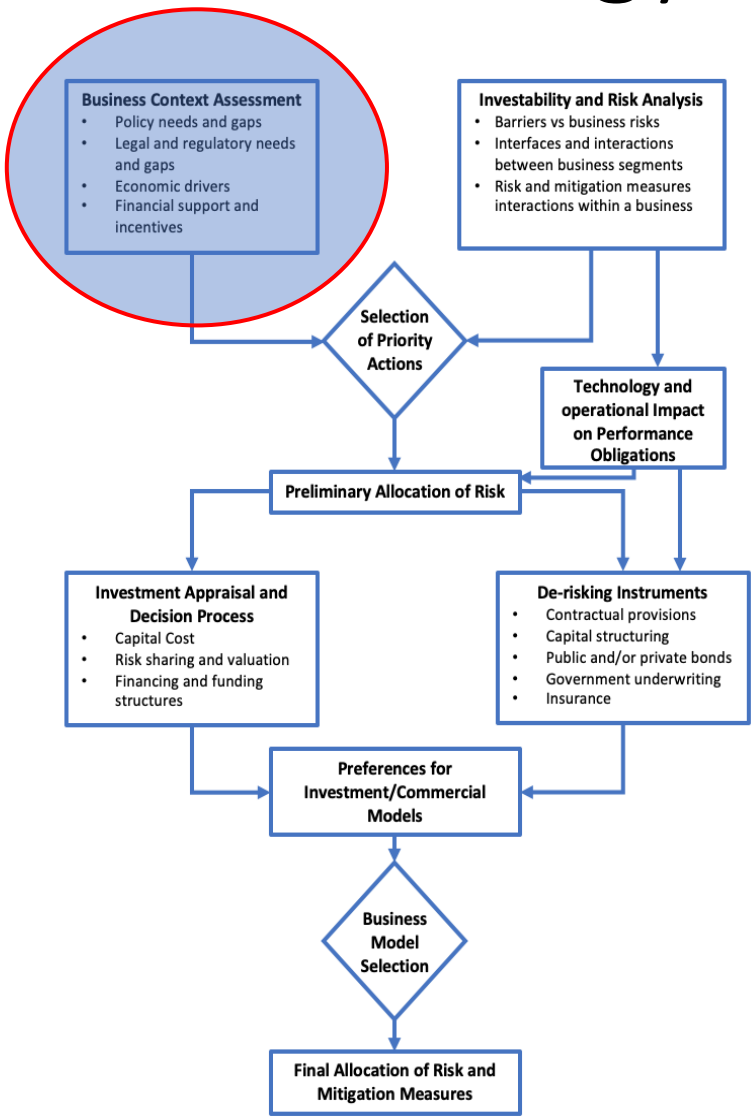
ELEGANCY WP3



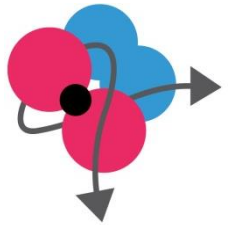
Business Context Assessment

Business Model Development Methodology





Guidance



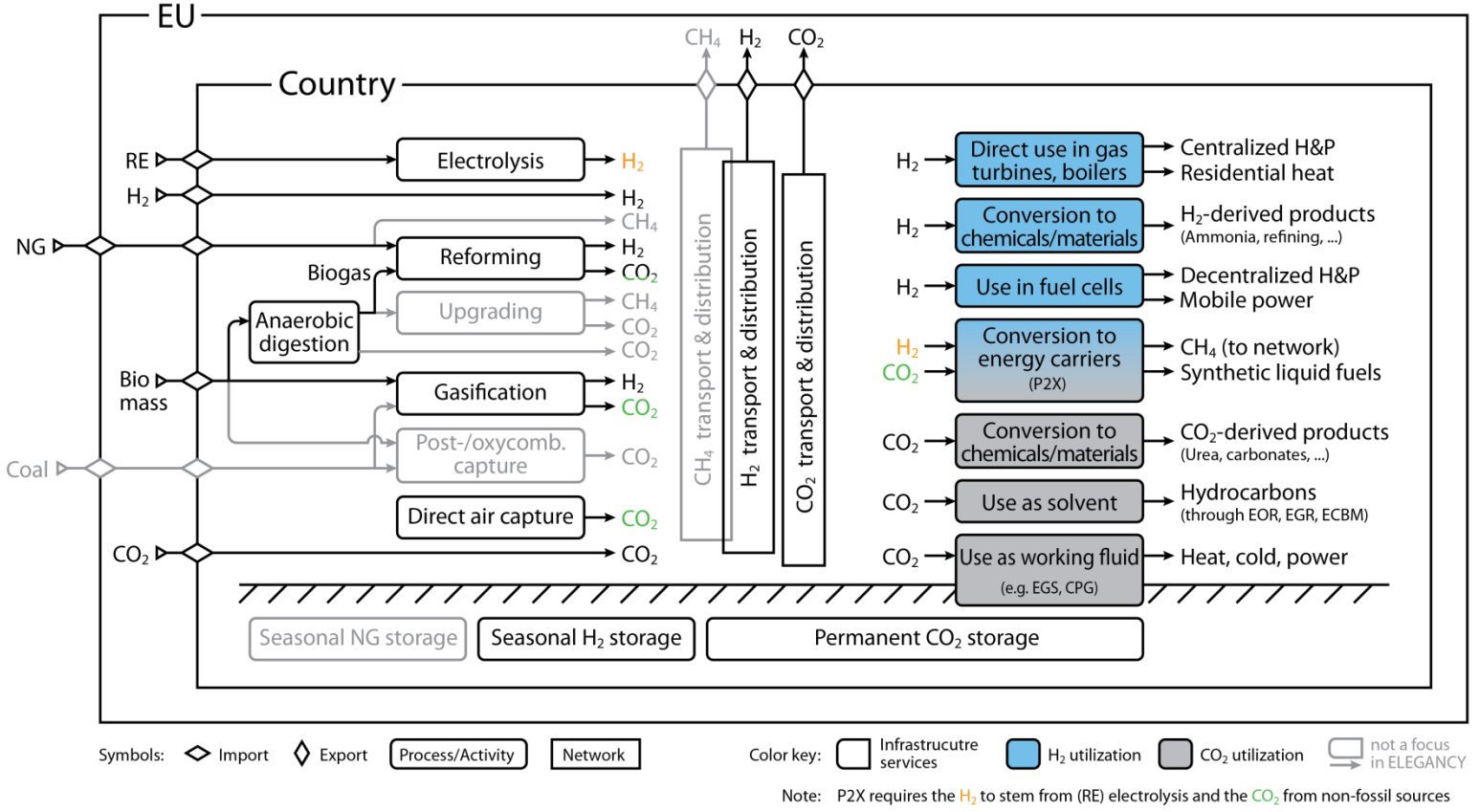
- Objective: identification of main business drivers and stakeholder needs from focused and guided review of existing business and investment background

  - Key macroeconomic drivers
  - Legal and regulatory environment
  - Market fundamentals and applicable market failures
  - H_2-CCS business options
  - Policy status and financial support mechanisms.

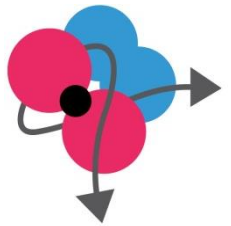
- An important aspect of this assessment method is the requirement to include systems thinking and to review the interactions between different market players reflected in the H_2-CCS chain business segments.

H_2-CCS Business Options

- Framework for visualizing fields of activity within the elements of integrated H_2-CCS chains
- Identify markets and structure business opportunities (supply-side, demand-side, logistic networks)



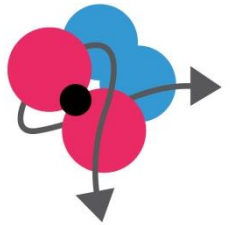
Market Background



- Focus on understanding the business, market, and macro-economic context for H_2 and CCS in the project country

- Who are the market players?
- What interactions or synergies exist?
- What are the drivers for the H_2-CCS business opportunities?

Legal & Regulatory Background



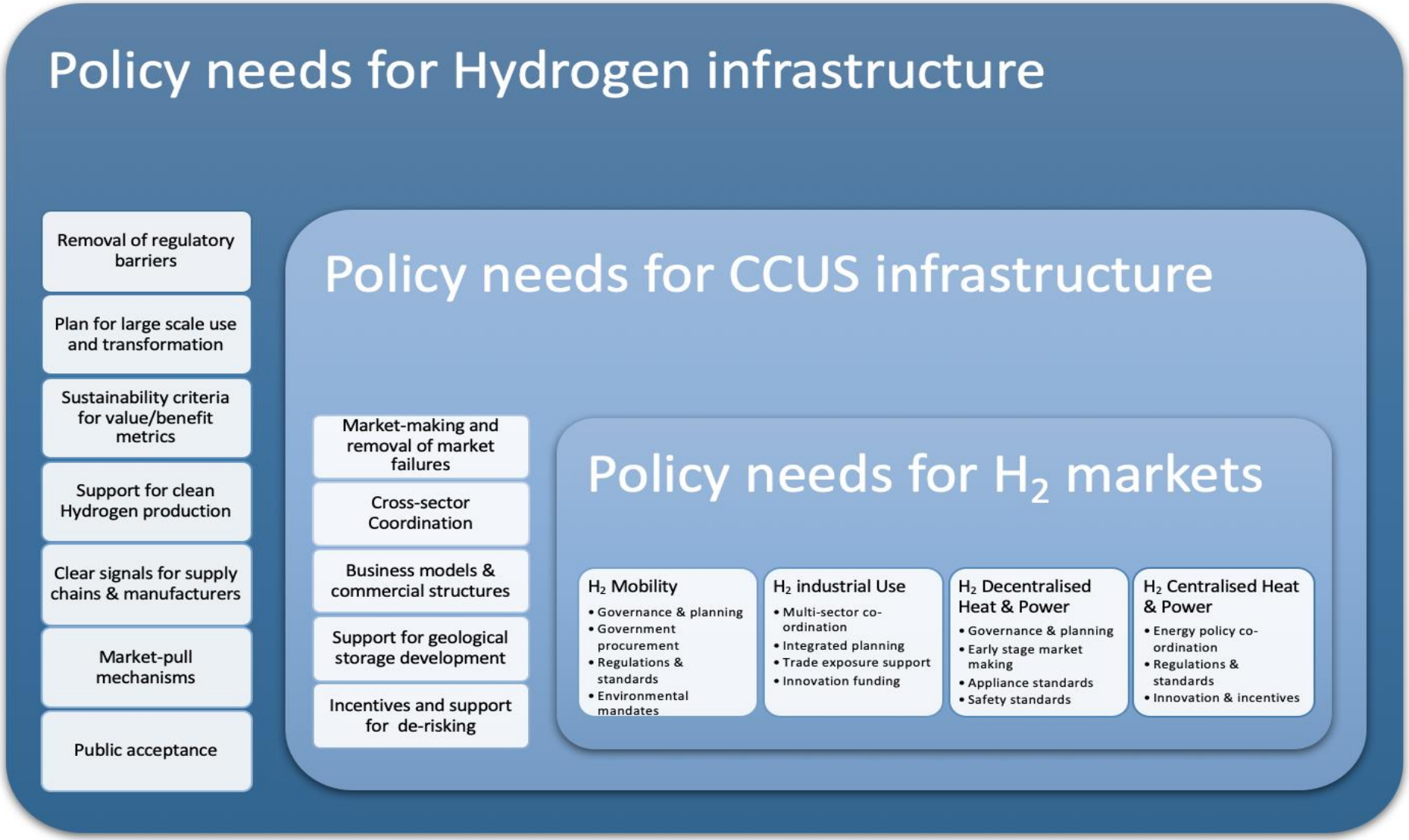
- Focus on assessing the key legal and regulatory parameters relevant to integrated H_2-CCS chains (legal mapping).
  - Used as an input to risk assessment matrix and de-risking strategy.

- Three levels of regulation: international, EU/EEA and national.

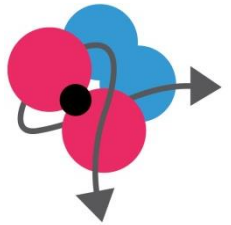
- Identified needs:
  - Clarification
  - Adaptation or new rules needed

- Ultimate objectives: legal certainty, incentives (throughout the chain), sustainability.

A Systems Approach to H_2-CCS Policy Needs

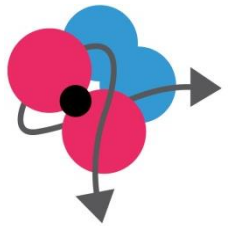


Business Context Analysis Tools



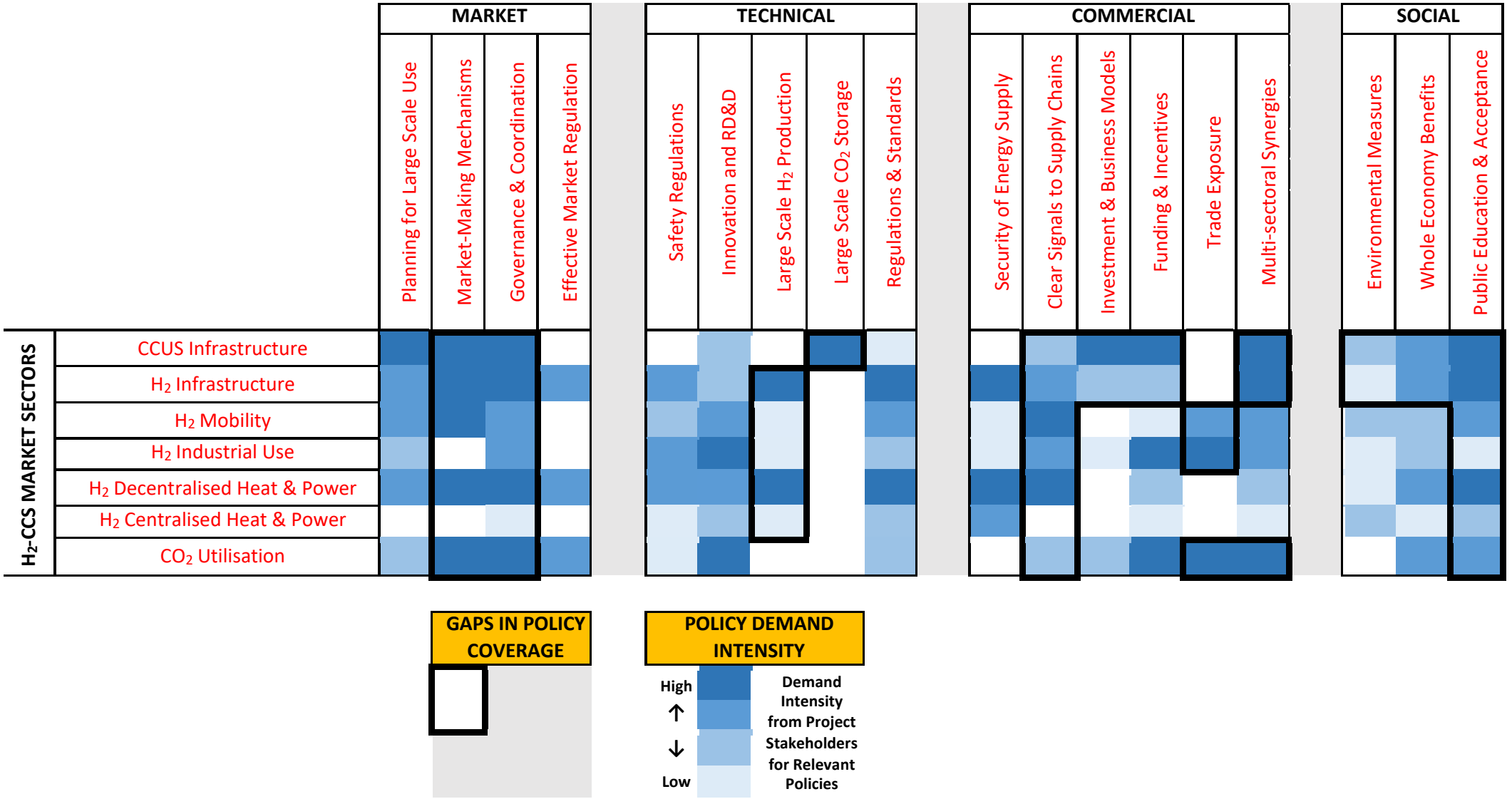
- Objective: Facilitate and focus relevant assessments and stakeholder dialogue
- Excel based, flexible for user to adapt to suit specific case study
- Structured guidance provided: specific categories, questions, tool guidance
- List of business context tools:
  - Market Background Assessment
  - Market Failures Analysis
  - Policy and Financial Support Analysis
  - Policy Needs Heatmap

UK H21 Case Study Market Failures Heatmap

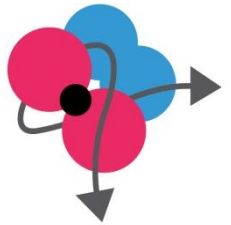


Market Opportunities/Market Failures	Missing Market	Coordination Failure	Negative Externality Low Priced CO2 Emissions	Positive Externality Improved Air Quality	Natural Monopoly	Merit Goods Hydrogen	Merit Goods CO2 Utilisation	Merit Goods Appliances & Equipment	Location Immobility	Social Inequality Fuel 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

UK H21 Case Study Policy Needs Heatmap

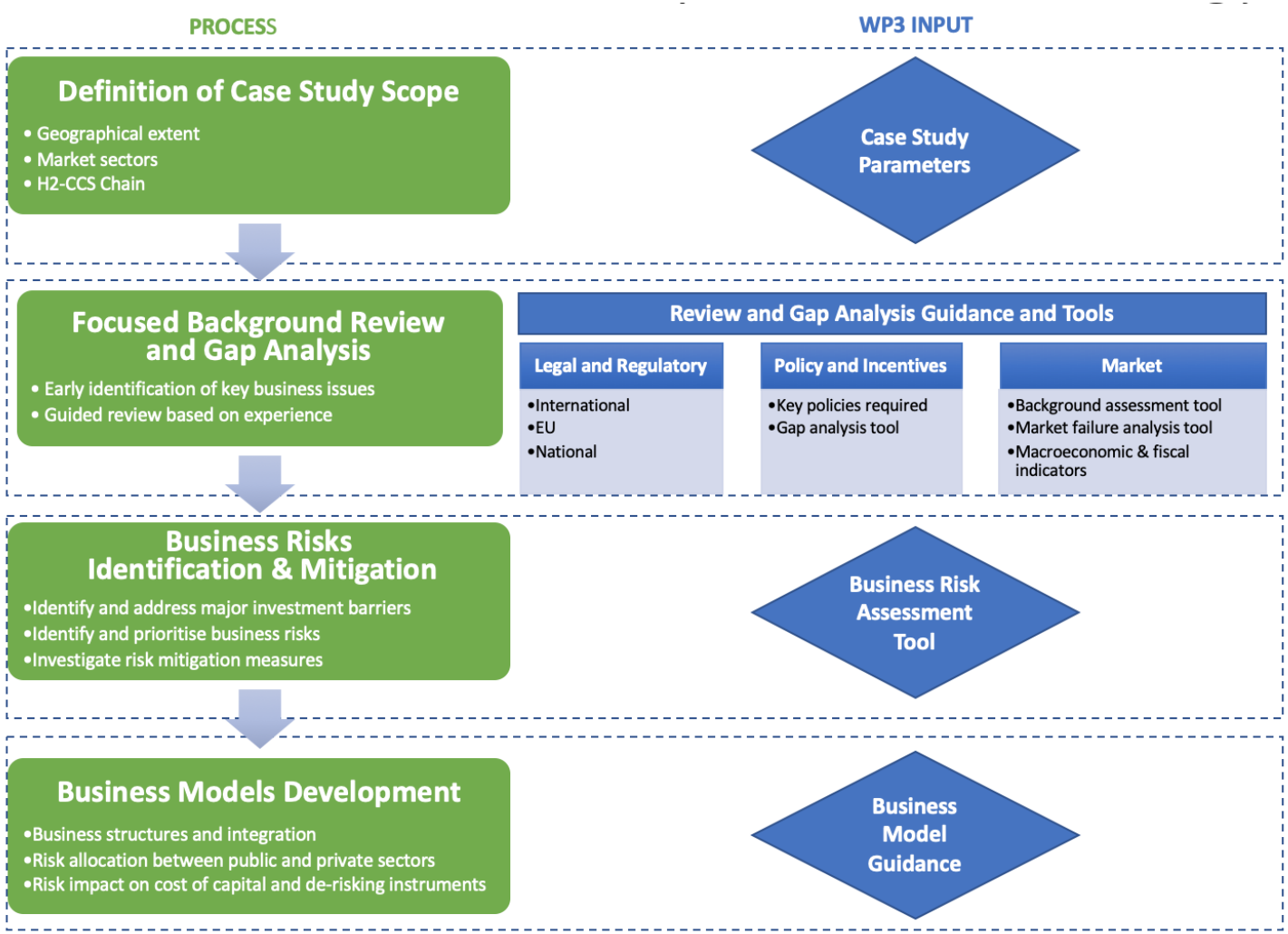


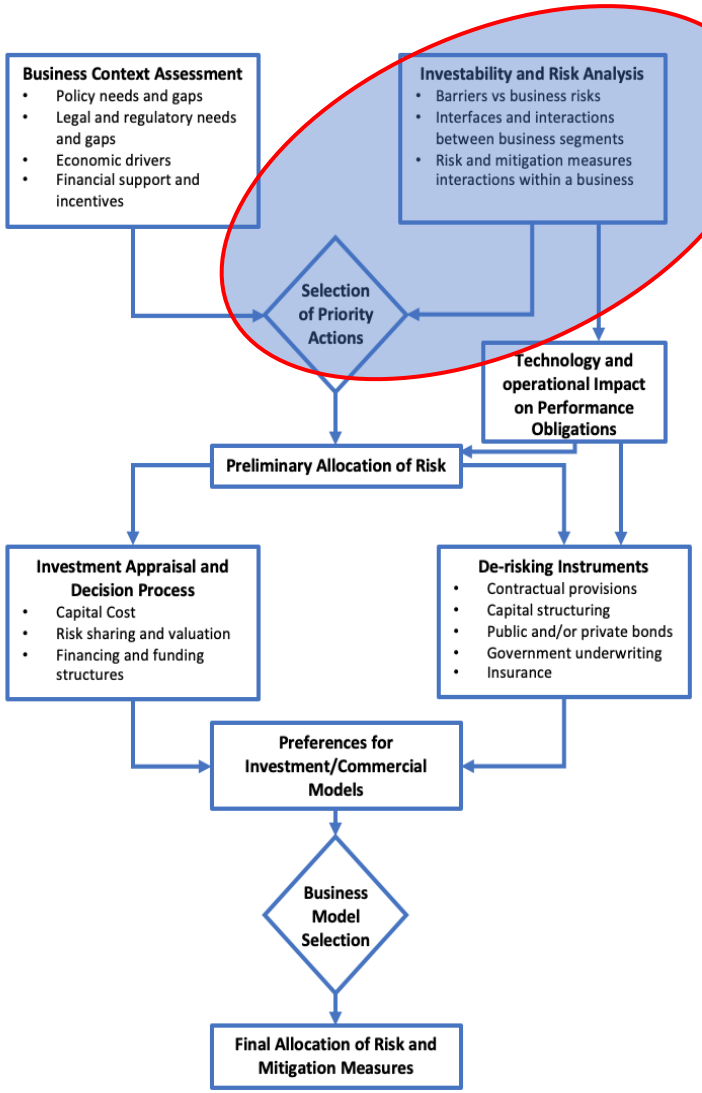
ELEGANCY WP3



Business Risks Identification & Mitigation

Business Model Development Methodology





Guidance

- **Risk Classification**
  - Classification used by the Climate Policy Initiative ("CPI") and based on OECD, 2008 report (Public-Private Partnerships: In Pursuit Of Risk Sharing And Value For Money)
- **Principles**
  - Risk allocated to parties best placed to manage them
- **Risk Types**
  - Exogenous Risks (from outside the project)
  - Endogenous (from inside the project)
- **Risk Mitigation**
  - Instruments categorised and divided between public sector/private sector
- **Investment barriers**
  - Specific circumstances/facts which make risks excessive (for which there are no satisfactory mitigation measures) and prevent investment

POLITICAL, POLICY, SOCIAL RISKS

Sources:
- Actions of governments and citizens

Enhanced by:
- Reliance on public financial and institutional support
- Investment horizon longer than policy cycle
- Environmental impact of some technologies creating social resistance

TECHNICAL, PHYSICAL RISKS

Sources:
- Technology characteristics
- Environment/sites impacts

Enhanced by:
- Not yet proven green technologies
- Lack of accurate technology performance data
- Uncertainty over measurements of the natural resources availability

MARKET, COMMERCIAL RISKS

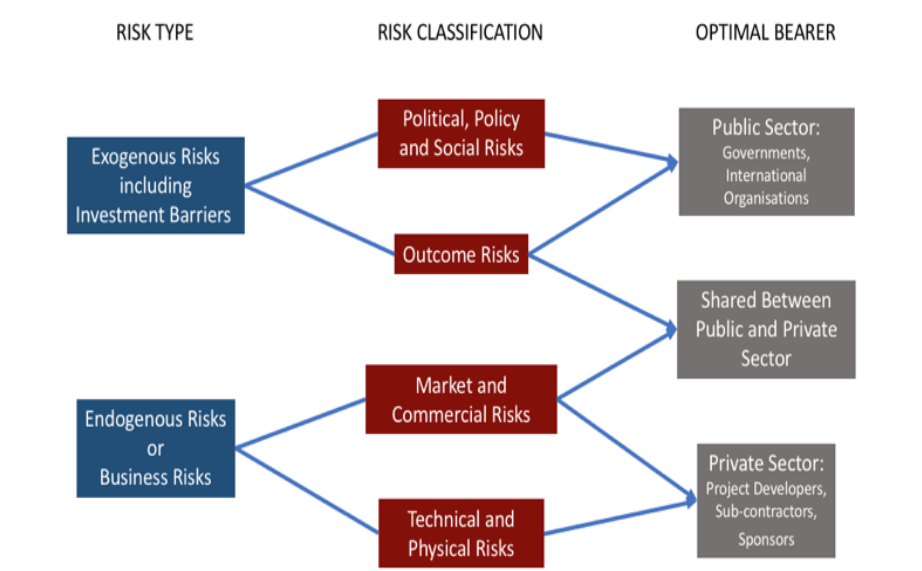
Sources:
- Valuation of input and output
- Cost and availability of financial resources

Enhanced by:
- High upfront costs
- Long investment horizon and payback periods
- Financiers' unfamiliarity with green investments
- Complexity of infrastructure investments

OUTCOME RISKS

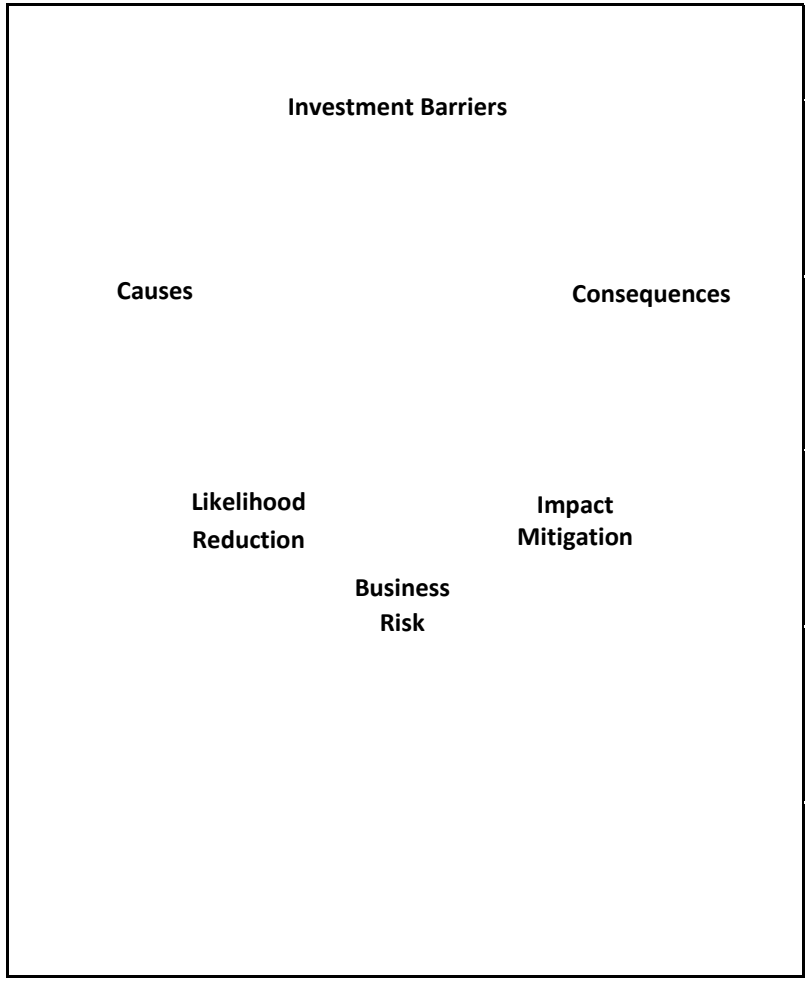
Sources:
- Commitment of limited public resources
- Uncertainty of delivering public interest goals objectives

Enhanced by:
- Amount of public support required
- Current budget constraints



Risk Assessment Tool: Investment Barriers

ASSESSMENT METHODOLOGY



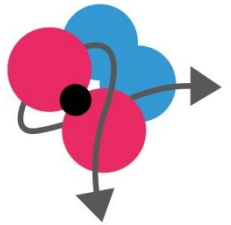
PRIVATE SECTOR INVESTABILITY RATING GUIDANCE

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 Assessment Tool: Business Risks



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

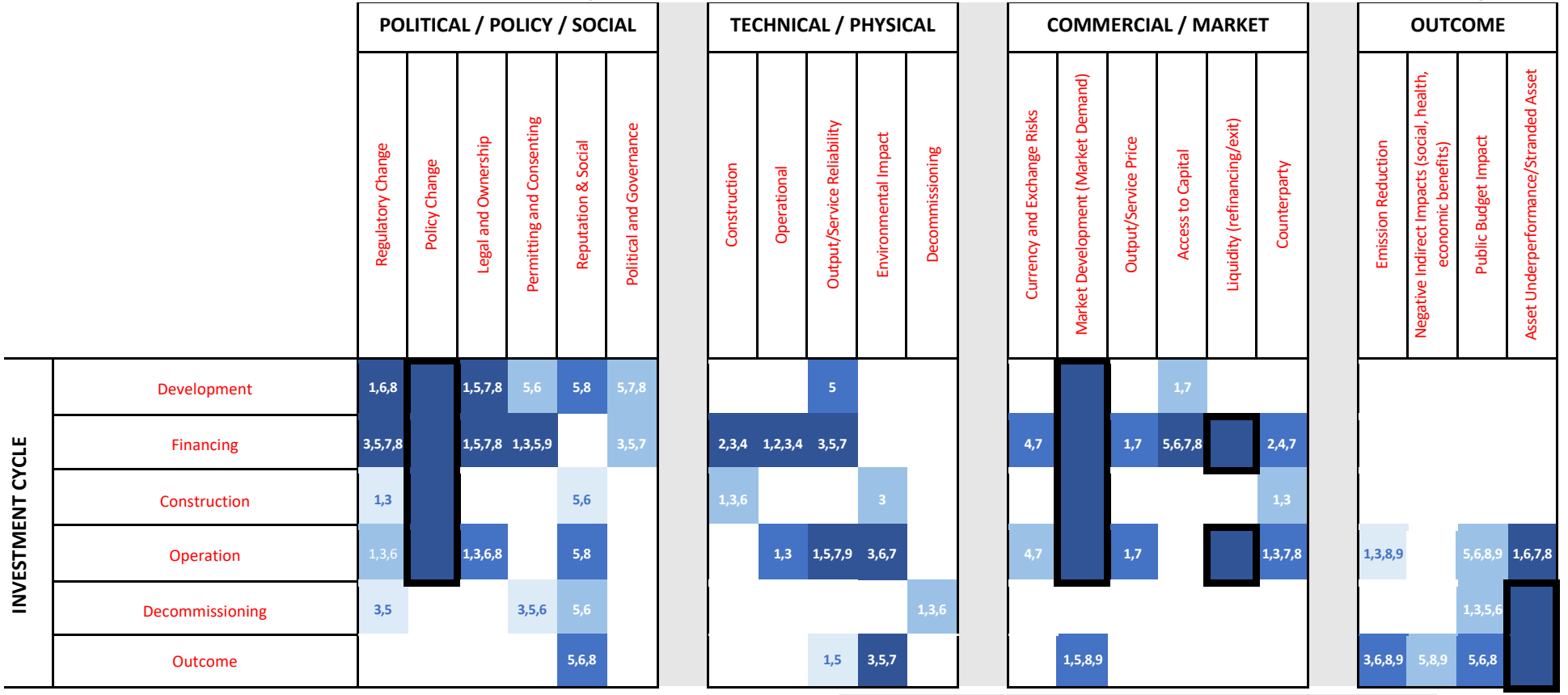
RISK IMPACT RATING GUIDANCE

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

UK H21 Risk Matrix Example

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
LEGAL AND OWNERSHIP RIGHTS	Outstanding legal issues in 2023 prevent integration of the collective investment decisions for the first H21 full chain system components and city conversions using results of the NoE FEED study	✗	✓	✓	✓	✗	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	Control of Cause: Likelihood Reduction	Regulations, Legal and Influence	Non-Existing	yes	2

UK H21 Case Study Investment Risk Heatmap

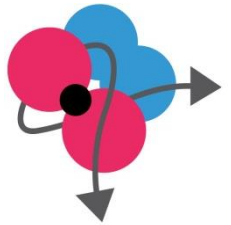


Methodology:

- Outcome from risk assessment or populate directly – depends on project stage/detail available.
- Gaps in risk mitigation coverage show critical areas to address for investability.

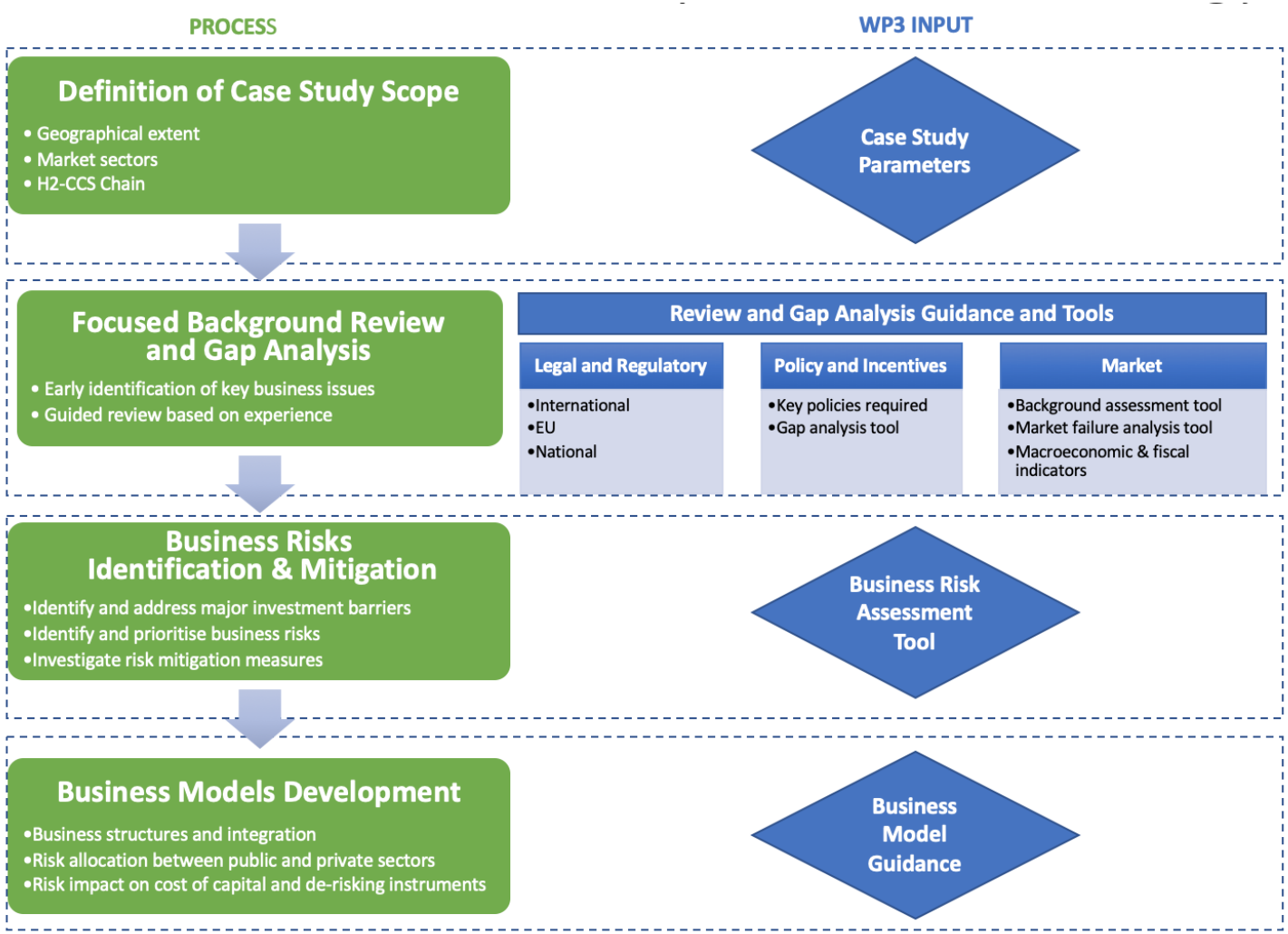
Adapted from: Climate Policy Initiative, 2013, *Risk Gaps: A Map of Risk Mitigation Instruments for Clean Investments*

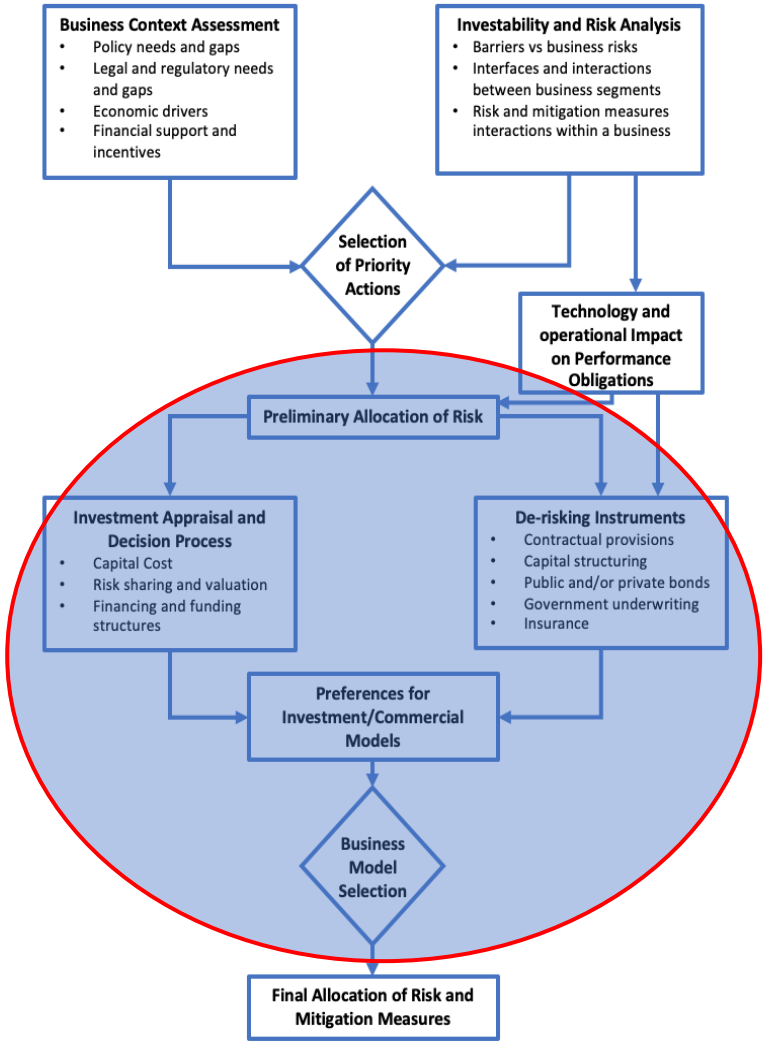
ELEGANCY WP3



Business Models Development

Business Model Development Methodology



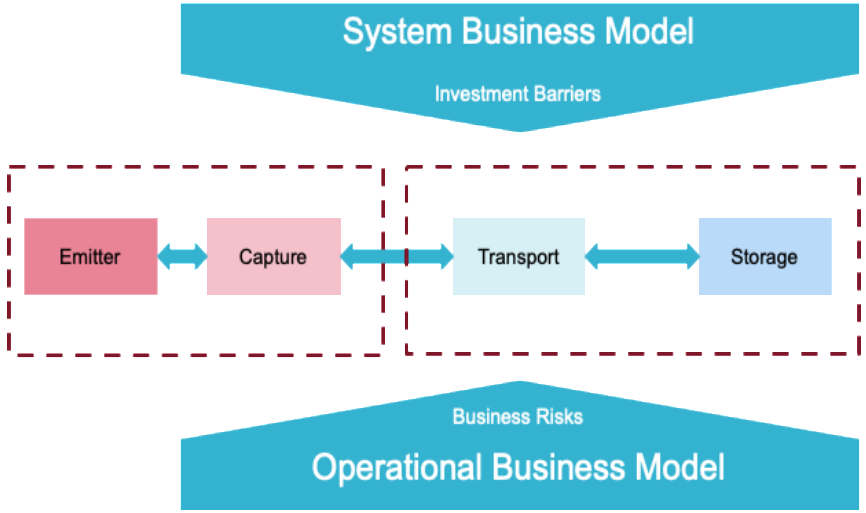


Guidance – Theory (1)

The framework facilitates the choice of business model to create an investable business proposition for public and private sector parties

What is Business Model?

- A way to organise and structure all the material elements of investment, market development, asset operation that will deliver the combined objectives of the public and private sector parties.
- The ELEGANCY framework differentiates between system scale business models and sector operational business models

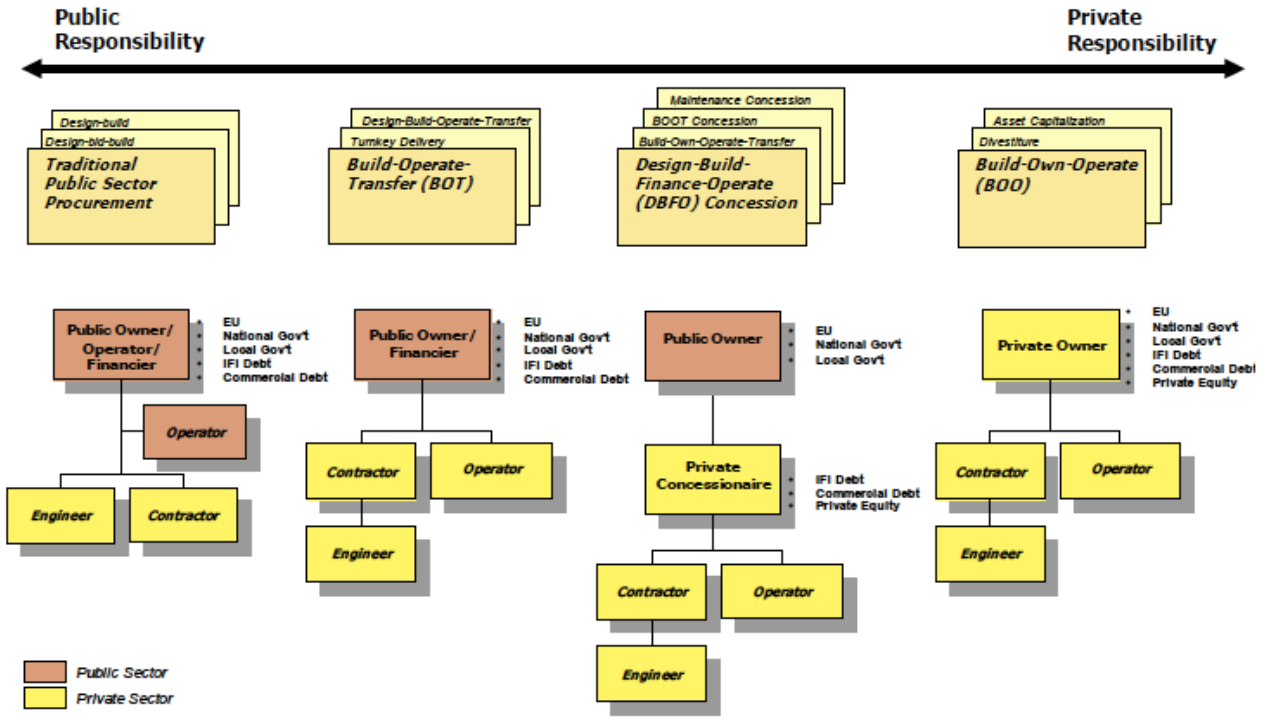


Investment Structures – Key Components

- Structures are classified by the degree of transfer of responsibility and risks from the public sector to the private sector.
- 4 Key Components
  - Asset and Rights Ownership
  - Capital Sourcing
  - Market Development (and Remuneration)
  - Physical Delivery

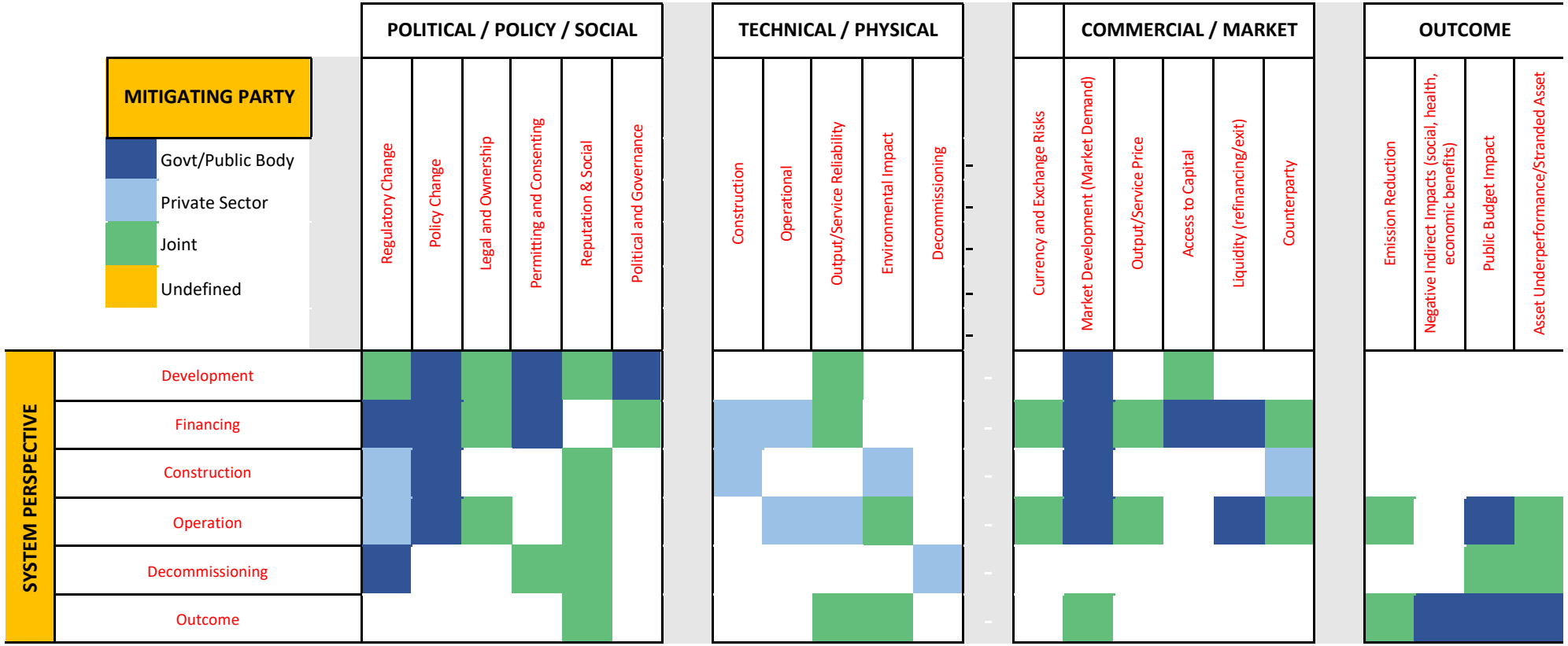
Guidance – Theory (2) - No One Size Fits All

- Established historical models
- Regional/National preferences influenced by a number of factors
- Allowing for innovation whilst appreciating complexity (and therefore risks) to set up and then manage and deliver
- Need for collaboration and engagement between public and private sectors
- Guidance is provided in Business Model Selection Tool with references to key principles

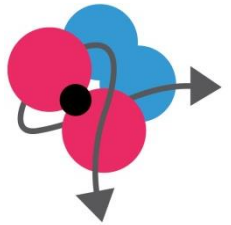


Source: European Commission, 2003, *Guidelines for successful Public Private Partnerships*

UK H21 Case Study Risk Sharing & Collaboration



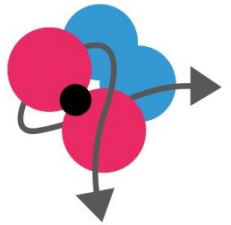
UK H21 Case Study System Business Model



E. BUSINESS MODEL PREFERENCE

Business Model	Ownership	Capital Sourcing	Market Development		Physical Delivery	
			Responsibility	Revenue Model	Responsibility	Business Structure
H2 Production	PRIVATE	PRIVATE	PUBLIC	Targeted Revenue Support	PRIVATE	Free Market Enterprise
H2 Transmission	PRIVATE	PRIVATE	PUBLIC	Price Regulated Revenue + Construction Support	PRIVATE	Regulated Asset Base (New)
H2 Distribution	PRIVATE	PRIVATE	PUBLIC	Price Regulated Revenue	PRIVATE	Regulated Asset Base (Existing)
H2 Storage	PUBLIC	PRIVATE	PUBLIC	Price Regulated Revenue	PRIVATE	Public Concession (Design-Build-Finance-Operate)
CO2 Capture						
CO2 Gathering						
CO2 Transmission	JOINT	JOINT	PUBLIC	Price Regulated Revenue	PRIVATE	Joint Venture
CO2 Storage	JOINT	JOINT	PUBLIC	Price Regulated Revenue	PRIVATE	Joint Venture
Mobility						
Industry	PRIVATE	PRIVATE	PUBLIC	Targeted Revenue Support	PRIVATE	Free Market Enterprise
Decentralised Heat & Power						
Centralised Heat & Power	PRIVATE	PRIVATE	PUBLIC	Targeted Revenue Support	PRIVATE	Free Market Enterprise

ELEGANCY WP3



Business Case Development and Assessment

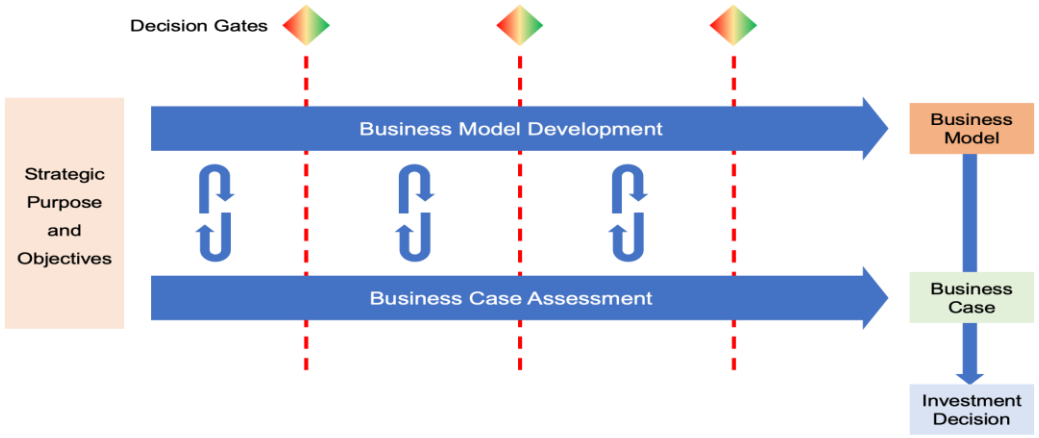
Guidance - Business Case

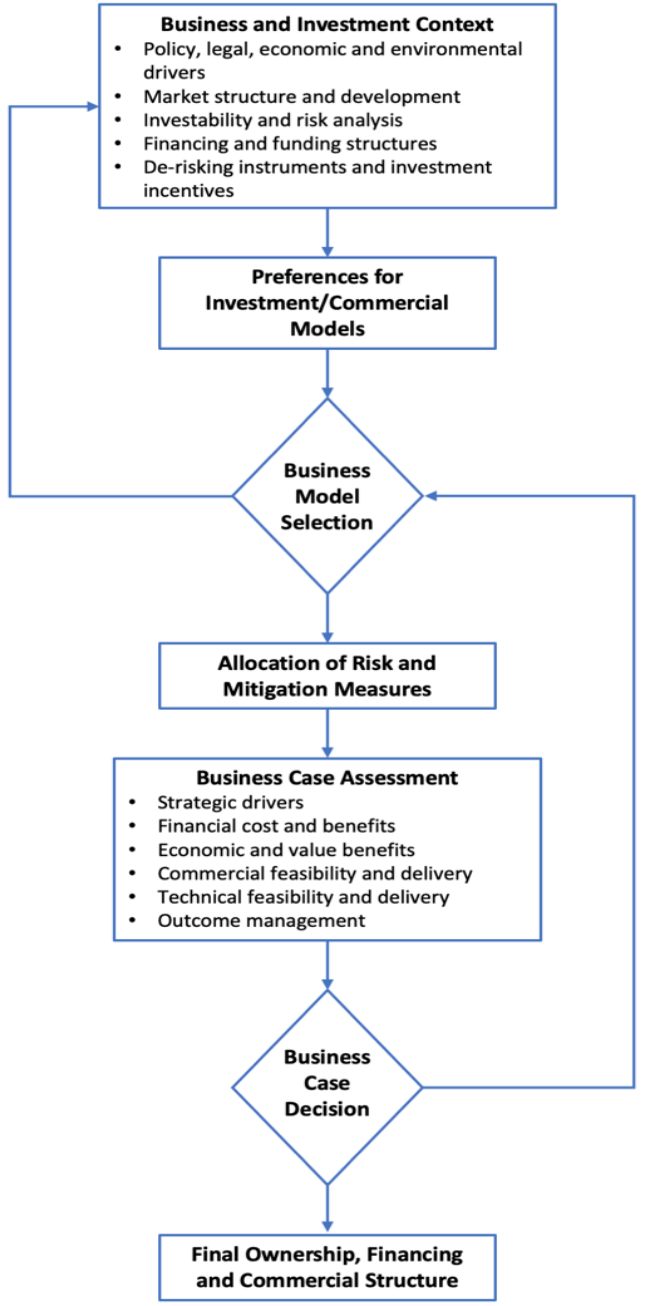
➢ What is a business case?

- Structured rationale to why the project is necessary now, how and why it delivers the strategic objectives of the stakeholders, why it is a sound investment, why it should be preferred to alternatives, how outcome risks are managed.

➢ Business Case Development

- An iterative process with the business model selection
- Driven by key factors from background assessment
- Multiple dimensions for assessment
- Tested against counterfactual scenarios





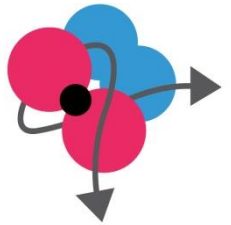
Guidance - Structure & Dimensions

- Business Case Definition
  - Project type, geography, market status, key actors…
  - Objectives and Key Metrics : Social, economic, financial, environmental, technical

- Justification and Assessment structured over 6 Main 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

Tool: Business Case Definition & Assessment



- Flexible Excel spreadsheet with structured guidance
- Consolidates outcomes of WP3 workflow and assessments:
  - Business and investment context
  - Business model selection
  - Allocation of risks and mitigation measures
- Enables structured analysis of each business case dimension appropriate to project maturity
- Incorporates results of other tools and methods:
  - ELEGANCY WP4 Techno-economic tool
  - Traditional Tools: Cash flow NPV, Monte-Carlo, Real Options, etc.)
  - Cost Benefit Analysis (Social, environmental, economic), Social Cost Effectiveness Analysis

UK H21 Business Case Definition Example

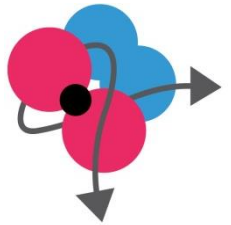
Illustrative Sub-set of Business Sector Strategic Drivers

CATEGORY	ASPECT TO BE RATED								
	MARKET SECTOR	H_2 INFRASTRUCTURE				CCS INFRASTRUCTURE		H_2 END USE MARKETS	
		H_2 Production	H_2 Transmission	H_2 Distribution	H_2 Storage	CO_2 T&D	CO_2 Storage	Industry	Centralised Heat & Power
MARKET DEVELOPMENT	Government willingness to intervene in creation of new low carbon markets	Medium	Medium	Low	Low	Medium	Medium	Low	Medium
	Opportunity to adapt and reuse existing market development mechanisms	medium	high	high	Medium	low	low	low	Medium
	Government willingness to socialise costs of developing new markets and infrastructure	Medium	high	high	Medium	Medium	Medium	low	High
	Government willingness to become an active market actor to facilitate market development	Low	low	low	low	medium	medium	low	low
	Private sector interest in investing early into sector	Medium	high	high	Low	high	high	medium	medium
	Private sector ability to undertake market development without government support	low	low	low	low	low	low	low	low
PHYSICAL DELIVERY	Existing physical assets and opportunities for re-use	Medium	high	high	low	low	low	Medium	high
	Clustering of potential customers, demand and/or assets	High	high	high	high	high	high	high	high
	Technology maturity (incl. CO2 capture)	Medium	Medium	Medium	Low	High	medium	high	medium
	Capacity of private sector to manage physical assets and manage unforeseen construction or operation activities	High	high	high	medium	high	high	high	high
SOCIETAL	Extent of positive public support for contribution of each sector to system decarbonisation		Medium	Medium		Medium	Medium	Medium	Medium

UK H21 Business Case Example: Strategic Rationale

KEY STRATEGIC ISSUES	QUESTIONS	ALIGNMENT RATING	RESPONSE
Demonstrate how proposal fits with the government's strategic objectives	Environmental	High	* supports UK policy of heat decarbonisation and obligations of Climate Change Act. Hydrogen has the potential to facilitate decarbonisation with minimum cost and disruption to customers while using established gas infrastructure to manage supply. H21 North of England presented a vision for decarbonisation of 70% of meter points by 2050 using a regional roll out strategy (the first phase would achieve 14% of UK heat and 12.5Mtpa of CO2 avoided by 2034). * facilitates the use of hydrogen across all business sectors as an alternative 'clean' fuel and supports decarbonisation through use and further expansion of oversized CO2 T&S infrastructure.
	Economic	High	* facilitates development of a new H2 supply chain; * sustains the existing gas distribution/transmission businesses for the long term; * protects the economic interests of industrial clusters by creating cost effective optionality for decarbonisation * Sustains economic value from oil and gas in country through energy transition.
	Financial	Medium	* Initial infrastructure is created at scale in line with recommendations to achieve cost effectiveness. * Technical risks are minimised through use of proven technology, initial use of H2 in sectors with operational/fuel flexibility. * Government funding is minimised through private sector ownership and delivery in most business sectors and use of regulated returns.
	Political	Medium	* Low regrets proposition with phased system deployment. * Significant optionality is built-in and there is minimum risk of under-utilisation. Anchoring the CCS infrastructure on hydrogen allows optionality for end users to either use a clean fuel (hydrogen) or use carbon capture (dependent on specifics of industry).
Sources of Value (Public Sector)	* How does the project support other ongoing decarbonisation activities ? * What are the additional sources of value created by the project for the public sector? * Does the project support the acceleration/execution of other H2-CCS projects? How? What are the potential synergies?	High	* industrial: the project would create the ability for industrials to decarbonise partially at minimum cost, commitment and complexity through fuel switching. This could create a competitive advantage for UK manufacturing. * power generation: the project would both facilitate the decarbonisation of the existing conventional power sector without large and complex investments in stand-alone carbon capture facilities for plants with limited life span. It would support further renewable electricity penetration by acting as a backbone for new clean flexible back-up generation and energy storage. * it creates opportunities for the UK to import CO2 from other countries by building on the competitive advantage of owning large scale CO2 storage sites.
Demonstrate how proposal fits with private sector participants' strategic objectives	Financial	Low	
	Market and Product Development	High	
	Environmental	Medium	
	Reputation/Brand	High	
	Other strategic objectives	High	
Sources of Value (Private Sector)	* Does the project support other ongoing activities in the company(ies)? How? * What are the additional sources of value created by the project for the company(ies)? * Does the project support the acceleration/execution of other projects for the company? How? What are the potential synergies?	High	* Supports preservation of existing business and offers new business opportunities for gas distribution and transmission companies. * Supports continuation of existing power generation facilities and new business opportunities at scale for power generators

Conclusions



- Systems thinking and a structured approach to dealing with complexity are essential to understanding H_2-CCS investability.
- De-risking the first large scale H_2-CCS chains in Europe requires investment decisions based on the principles of low regrets, collaboration and flexible options that do not lock-in fossil fuels.
- Market development and coordinated delivery of Hydrogen and CCUS need to be facilitated by governments
- ELEGANCY WP3 has created an 'expert-driven' adaptable methodology and toolkit for public and private sector stakeholders to develop business models and business cases that satisfy these criteria.

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