SPE • AAPG • SEG
CCUS
CARBON CAPTURE, UTILIZATION, AND STORAGE
THE INDUSTRY'S LEADING EVENT
FOR CCUS MANAGEMENT
AND DEVELOPMENT
3-5 MARCH 2025
HOUSTON, TEXAS

Business Models for Carbon Capture and Utilization: A Case Study in Finland

Adebayo Agbejule and Maarit Mäkelä

Vaasa University of Applied Sciences (VAMK)
Department of Energy and Environmental Engineering
Wolffintie 30, Vaasa, Finland

Introduction

- Carbon capture, utilization, and storage (CCUS) refers to a group of technologies aimed to separate CO_2 from large-scale emission sources for transporting the captured CO_2 to specific sites but followed by CO_2 recycling in such case, both for utilization or geological storage purposes *(Li et al., 2016)*.
- The role of CO_2 capture, utilization, and storage is recognized as a key option in reducing greenhouse gas emission *(Ku et al., 2020)*.
- Research on CCU has focused on capturing and utilization technologies, with little research on business models and development *(Saarinen et al., 2024)*.
- Muslemani et al.(2020) identified that one of the most fundamental reasons why CCUS is not an established technology in industrial sectors, is that there is yet to be defined concrete business models for the operation of CCU utilization.

Objectives of the Paper

- A knowledge gap exists in identifying the most important elements driving success in industrial CCUS business models.
- Review the main components of existing business models.
- Present a case study of carbon capture utilization in Finnish energy and process industry with emphasis on value propositions.

Definition of a Business Model

- Business model is "***how a firm does business***", in other words, ***"a company's logic of earning money***".
- The core idea of a business model is to define how a company delivers value to customers, attracts customers to pay for value, and converts those payments to profit.
- A primary component of a business model is its value proposition, explicitly stating the value and attractiveness of the product or service offered to the customer.

Business Models from Literature

Richardson, 2008

- Value Proposition
- Value Creation & Delivery
- Value Capture

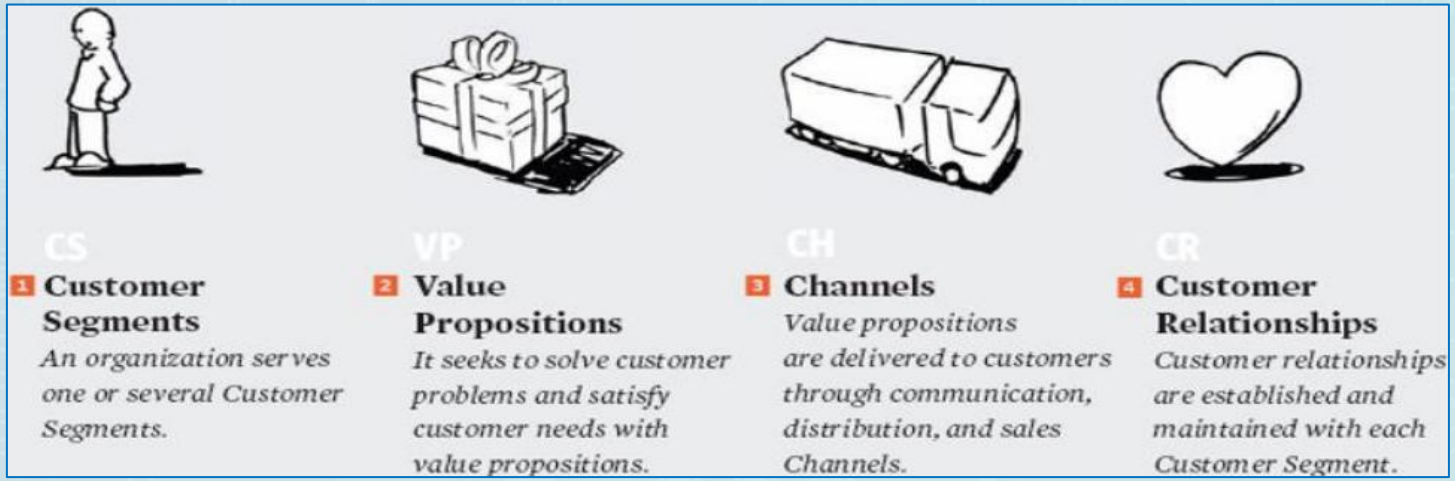
Johnson et al., 2008

- Customer Value Proposition (CVP)
- Key Resources
  Key Processes
- Profit Formula

Osterwalder et al., 2011

- Value Proposition
  Customer Segments
  Customer Relationships
- Key Resources
  Key Activities
  Channels
  Key Partnerships
- Revenue Stream
  Cost Structure

Business Model Canvas



Source: *Business Model Canvas (Alexander Osterwalder et al., 2010)*

Value Propositions for CCUS

RR Resource Recovery	GG Green Growth	LCG Low-Carbon Grid
Value proposition for CCUS • *Manage CO_2 emissions while improving O&G production*	**Value proposition for CCUS** • *Affordably reduce emissions from economic activity*	**Value proposition for CCUS** • *Enable high renewables penetration onto the grid*
Key drivers • *Project return* • *Economic growth*	**Key drivers** • *Climate action goals* • *CO_2 price or emissions cap*	**Key driver** • *Cost-competitive dispatchable low-carbon power*
Technical imperatives • *Operational performance* • *Site-to-site variability* • *Process standardization* • *EOR yield vs CO_2 storage*	**Technical imperatives** • *Cost reduction (capex & opex)* • *Low-carbon H_2 production* • *CO_2 conversion to value-added products*	**Technical imperatives** • *Flexibility* • *Innovative uses of CCS as an enabler for electrification-based decarbonization*
Policy requirements • *Carbon pricing certainty for project financing* • *Path to deep decarbonization*	**Policy requirements** • *Clarity in policy over time and across sectors* • *Consistency across borders*	**Policy requirements** • *Adequate electricity and carbon market signals for CCUS design and integration*
Moving forward (near-term) • *Scale up infrastructure and gain operational experience balancing recovery vs storage*	**Moving forward (near-term)** • *Launch industrial hubs and derisk large-scale investment in CCUS*	**Moving forward (near-term)** • *Pilot use of CCS for grid stability and validate business models around indirect value.*

Source: *Ku et al. (2020)*

Resource recovery focuses on the management of carbon in the production of hydrocarbon resources, primarily the removal of CO_2 from natural gas extraction and the use of CO_2 in enhanced oil recovery operations: (*key driver is revenues and costs*)

Green growth emphasizes CO_2 reductions in support of climate action, using CCUS to reduce the carbon footprint of economic activity (key driver policy and regulation)

Low carbon grid development focuses on the value of CCUS in supporting grid scale energy storage

Establishing the value of CCUS is vital establishing a functional business model

Key Elements of a CCUS Business Model

Where is the value proposition?

Project type	Ownership	Economic rationale	Challenges	Stakeholders
Full chain	Public	Public sources	High capital and operating costs	Government
Part chain	Private	Grants, tax credits, loan support	Long project lead times	Policy makers
Self-capture with third-party CO_2 offtake	Public-private partnership	State-owned enterprises	Project complexity	Regulators (including permitting)
CO_2 transport and storage as-a-service		Carbon pricing	Innovation gaps	Private sector
Capture-as-a-service		Public procurement of low-emissions products	Co-ordination among various steps and/or players	Project investors and owners
		Public procurement of carbon dioxide removal services	Cross-border transport	Developers and operators
		Private sources	Policy uncertainty	Supply chain contributors
		Direct use of CO_2	Public awareness and acceptance	Civil society and the public
		Low-emissions products	Availability of finance	
		Voluntary carbon markets	Risk management and insurance	

Source: *International Energy Agency. (2023). CCUS policies and business models: Building a commercial market. International Energy Agency. https://www.iea.org/*

Key Roles of Business Model

- The term ‘’business model’’ refers to a company’s plan for making a profit. It identifies the products or services the company plans to sell, its target market, the gap in the market it is trying to fill, any anticipated expenses and a financial model to operate in a profitable manner.
- Social and environmental sustainability have recently become a major driver for innovation in companies’ business models.
- Divergent value propositions across these models lead to different drivers, technical imperatives, and policy requirements *(Ku et al. 2020)*.
- Business models are not only used to provide revenue certainty but can also tackle specific risks and allocate them in a fair and balanced manner (for instance, between governments and private sector actors for CCUS).

Value Propositions of CCU Projects in Finland

ACTORS	VALUE PROPOSITION	APPLICATION	DEPLOYMENT STAGE
Westenergy	Green Growth	CCU for Power-to-fuels (P2X) to produce carbon neutral transportation fuels	Advanced Stage
Fortum	Green Growth	Research on plastics CCU using CO_2 from WtE plants	Early Development
Keravan Energia Oy	Low Carbon Grid	Piloting and feasibility of power-to-gas in a biomass-fired power plant	Advanced Stage
Turun Seudun Energiantuotanto Oy	Green Growth	Feasibility of a hydrogen and power-to-X plant to produce fuel for heavy road and marine transport	Construction
Neste – SHARC Project	Green Growth	CCS and hydrogen production at the Porvoo oil energy	Advanced Stage

Case Study - Westenergy

Case Company	*Westenergy in Vaasa, Finland*
Business	*Waste to Energy power plant - 200,000 tonnes of waste is refined into electricity, heat & renewable materials, 180,000 tonnes of CO2 is emitted*
Methodology	*Case Study*
Data Collection	*Interview*

Design of the Powerplant

The Westenergy plant is located next to Stormossen in Koivulahti, 9 km from Vaasa

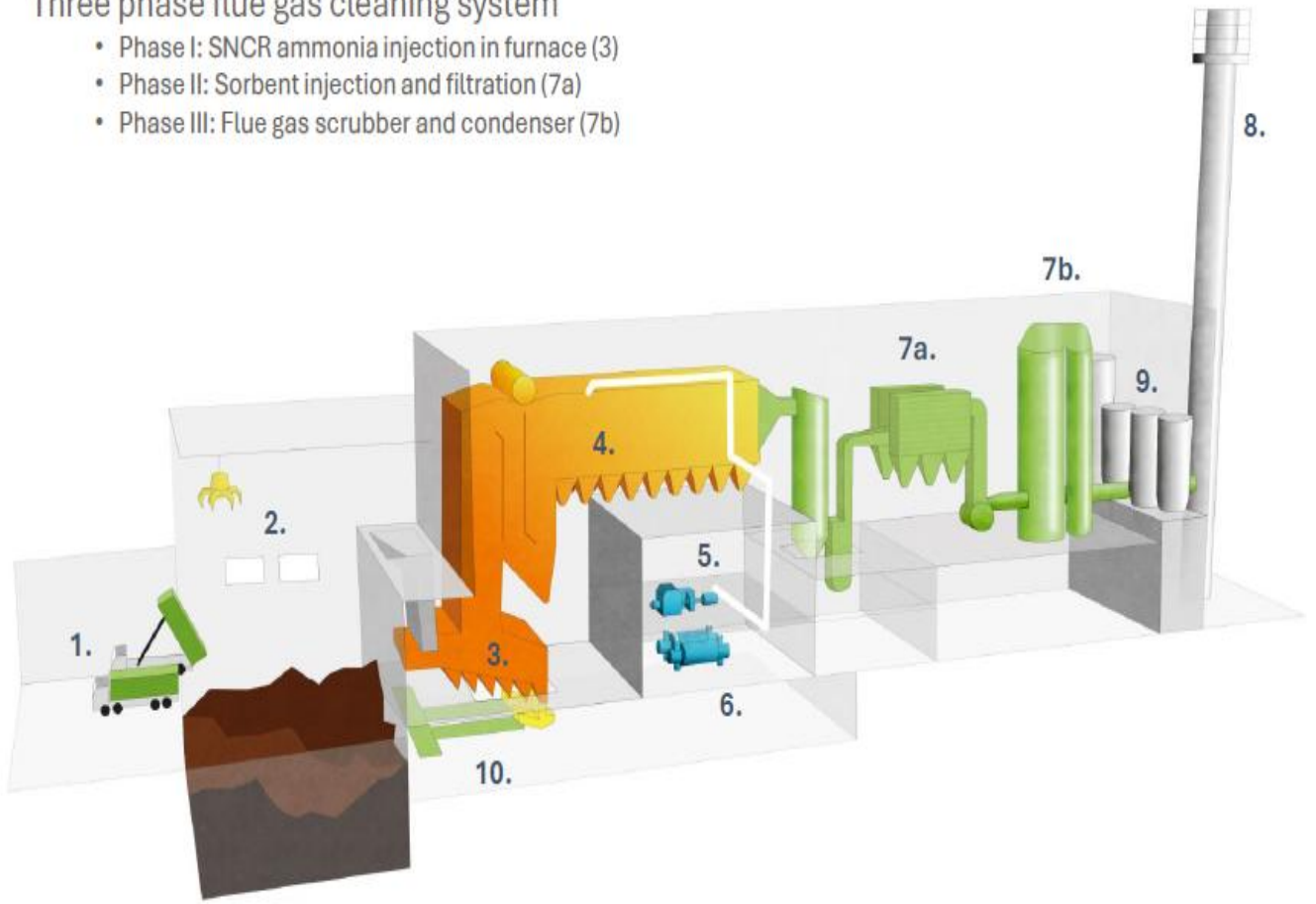
Main consultant:	Ramboll
Boiler manufacturer:	HZI
Steam turbine:	MAN Energy Solutions
FGC system:	LAB and B&W Vølund

Total efficiency:	105 % with fgc
Steam pressure:	40 bar
Steam temperature:	400 ° C
Thermal power:	67 MW
Electric capacity:	15 MW
Heating capacity:	55 MW
Annual operating hours:	~ 8400 h
Processing capacity:	200 kt/a

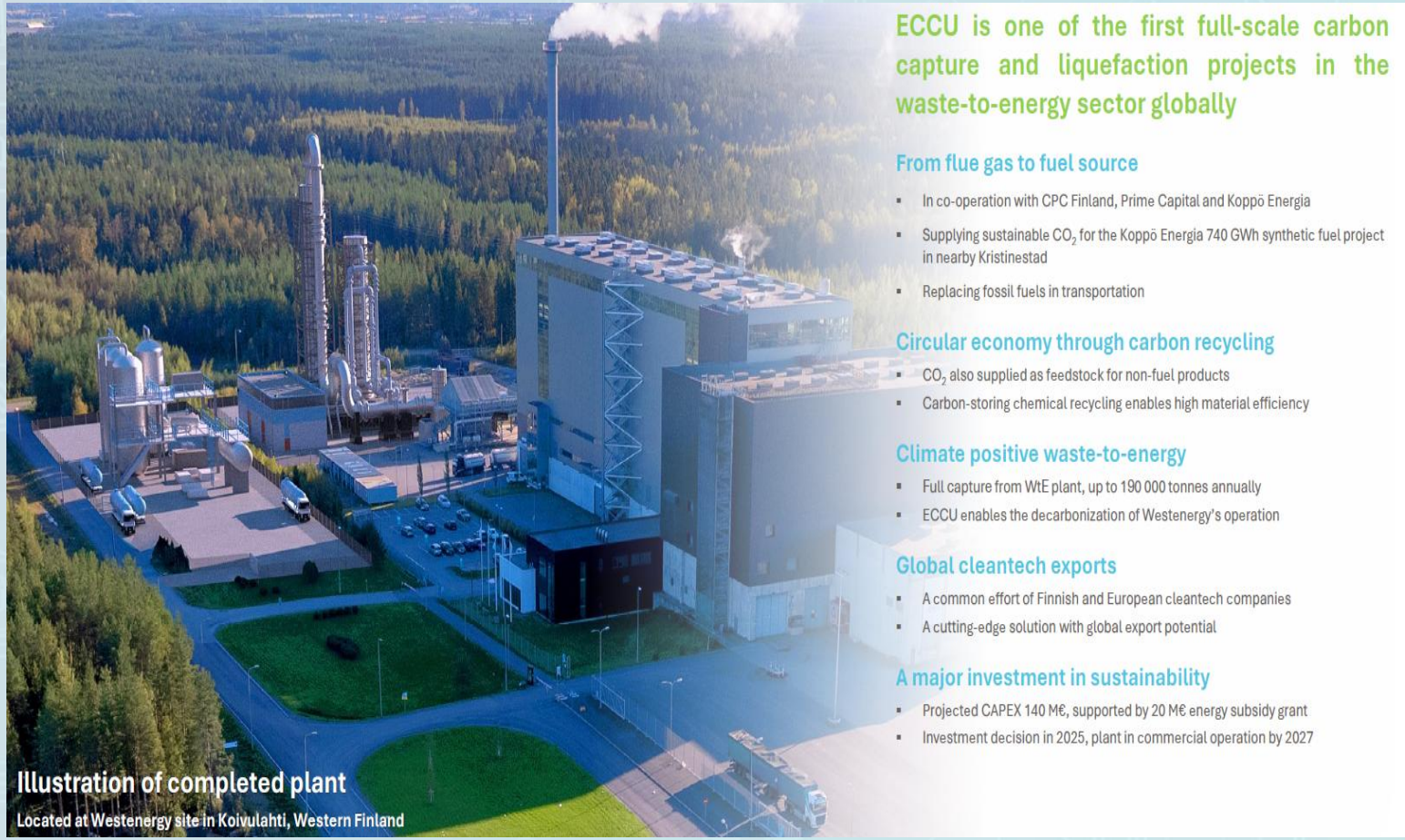
1. Tipping hall
2. Waste bunker
3. Grate
4. Boiler
5. Turbine and generator
6. District heat exchangers
7. Flue gas cleaning
8. Stack
9. Sorbent & residue silos
10. Slag handling

Three phase flue gas cleaning system

- Phase I: SNCR ammonia injection in furnace (3)
- Phase II: Sorbent injection and filtration (7a)
- Phase III: Flue gas scrubber and condenser (7b)



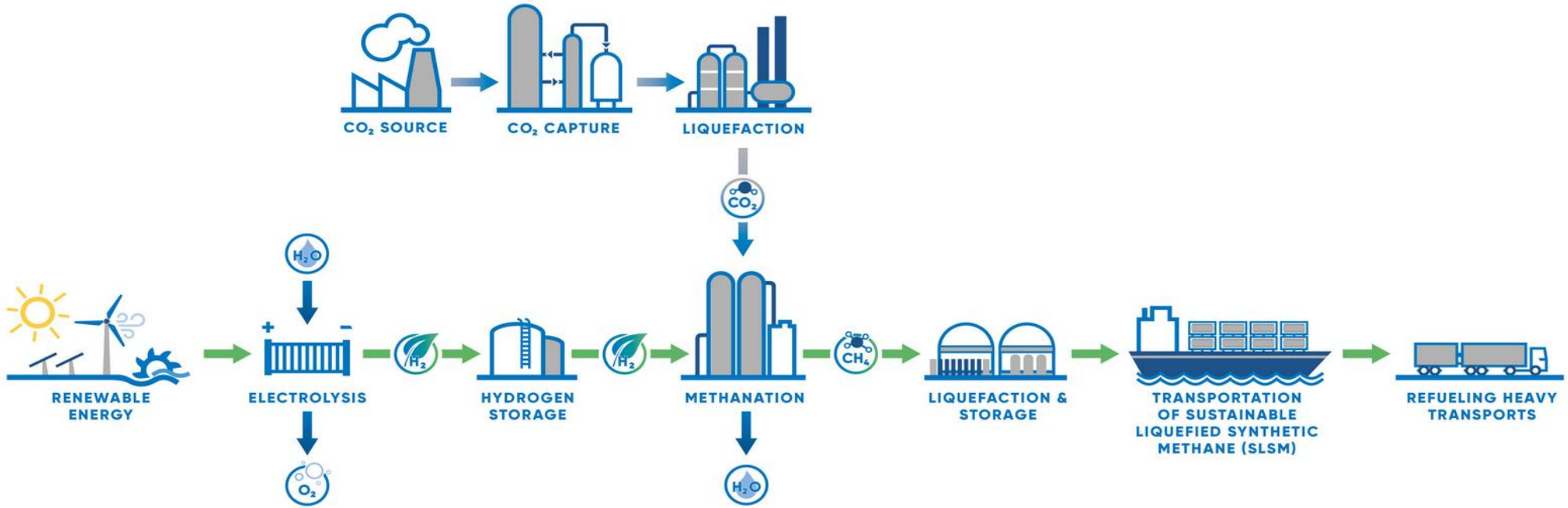
Value Proposition for Westenergy



e-fuel, permanent carbon products (green growth), & **recycling** and **storage** for value added product (green growth).

This requires the development of a business model for supply of CO_2 to develop e-fuel, and for carbon recycling and storage for high material efficiency.

From renewables to liquefied methane:



Interview Analysis

"In terms of the business models, the intersection between the green growth model and legislation is rather interesting (or underdeveloped) as value creation from a low energy state molecule like CO_2 is most often dependent on external factors, i.e.. policy driven".

"At least in WtE, the demand for carbon dioxide created by regulation and emission targets in other sectors can and does still clash with the specific decarbonization requirements imposed on the CO_2 supplier. When discussing this issue with European colleagues in the WtE sector, most often the expressed primary driver in the EU is an expected emission cost, the direct avoidance or indirect mitigation of this cost being the main benefit of either CCU or CCS operations".

"In this way, CCUS can be seen as a pre-emptive cost mitigation strategy, being hindered by regulatory unclarity on how the carbon removals and emission reductions are actually allocated. Quite often, this has the tendency to lead to discussions on either double counting of emission reductions or imbalances in the benefit sharing from CCU value chains. On the other hand, given that this cost mitigation may be the prerequisite for future existence or growth, this phenomenon still exists under the green growth umbrella, albeit in a more existential manner. For those with purely biogenic carbon dioxide, the issue is moot".

- Development Manager, Westenergy

Conclusion

- A primary component of a business model is its value proposition, explicitly stating the value and attractiveness of the product or service offered to the customer.
- The value proposition of CCU can change depending on the key drivers behind CCU business models.
- A company can have two value propositions for CCU.
- Each company should assess the role of CCU technologies within its long term targets of growth and climate change mitigation, in order to clearly establish a CCU value proposition, and act accordingly.

The authors appreciate the grant support by the Pohjanmaan Liitto MAP UP 2PX project (Finland).

Email: ade@vamk.fi

Thank you for listening!
Any Questions?