COMMERCIALIZATION OF EMERGING ENVIRONMENTAL SUSTAINABILITY TECHNOLOGIES: CASE STUDY BASED ON CCU&S

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Challenges & Issues for the Commercialization of CCU&S Technologies

Since 1980s, global interest in CCU&S as an important technological solution in a portfolio of power-generation options (e.g., renewables, nuclear, …) to mitigate GHG emissions has increased. The safe and cost-effective implementation of CCU&S technologies offer countries significant benefits such as the maintenance of diversified portfolio of electricity-generation options, critically reducing financial and security risks, improving technology reliability and environmental performance, minimizing energy price volatility, and at the same time address CO_2 emissions from large industrial sources (Tomski et. al., 2012). In particularly for the United States, CCU&S appears to be an attractive option to mitigate GHGs emissions and address the issues associated with climate change. However, the CCS task force commissioned by the Obama Administration as well as numerous studies have identified significant policy, institutional, economical and societal obstacles to the successful commercialization of such technologies. Figure 1 illustrates early data highlighting some of these key obstacles in the commercialization pathway of CCU&S technologies.

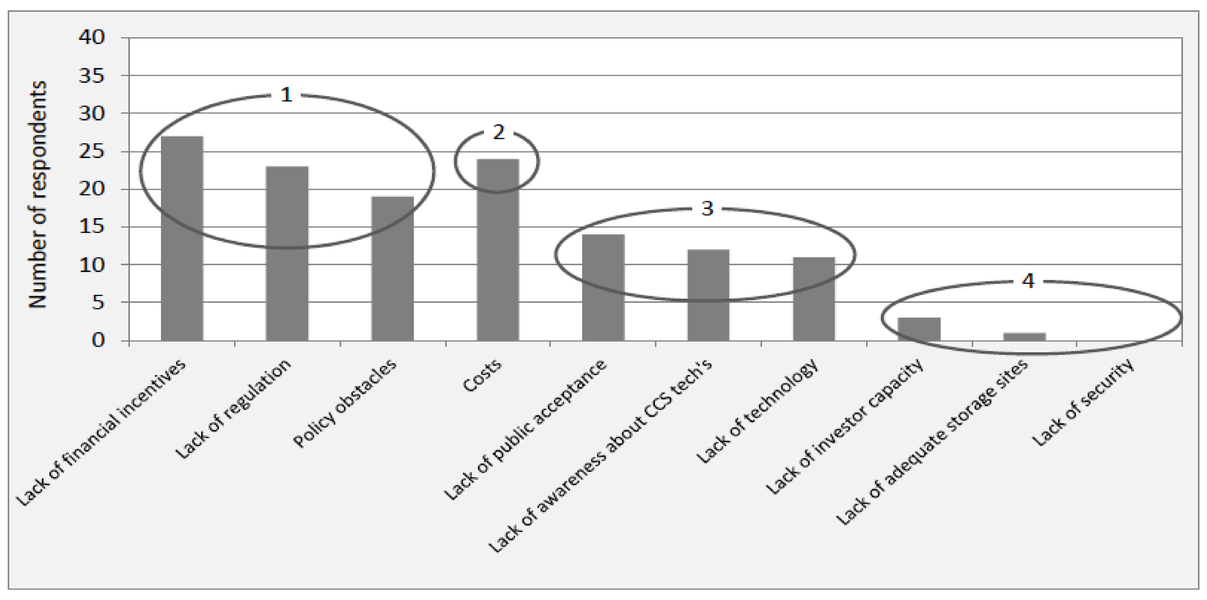

Fig.1: Biggest obstacles to commercial success (STRACO2, 2009)

Emerging Technology Life-Cycle

CCU&S are emerging technologies whereby principal activities have to be managed at different times in the technology lifecycle to increase the chance of market entry and success. Figure 2 illustrates the life-cycle of such emerging technologies and key stages along their development and commercialization pathway. The integration of stakeholders at each stage is integral to the successful market penetration of emerging technologies.

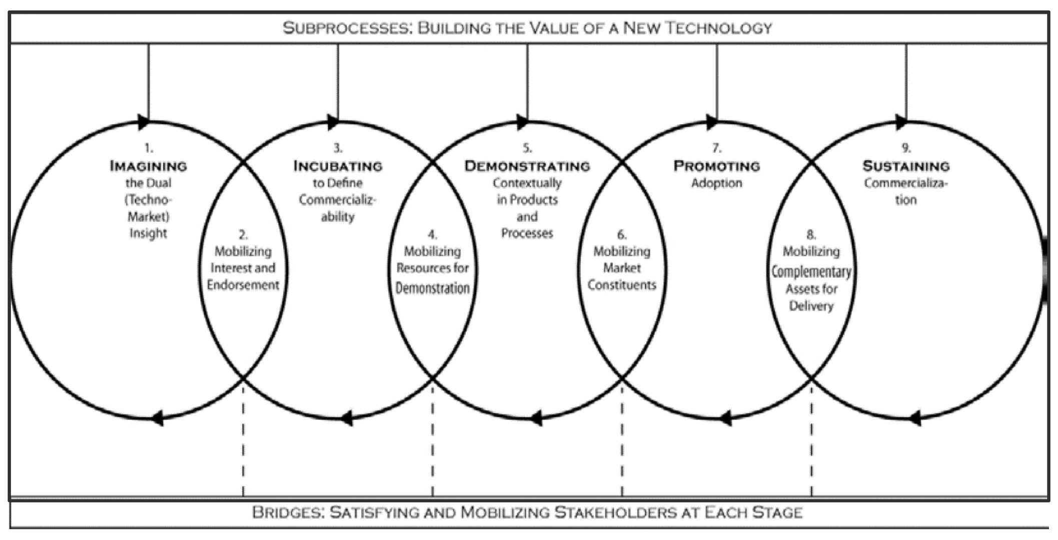

Fig.2: Process of emerging technology commercialization & stakeholder engagement (Jolly, 1997)

From a business perspective, with a predominant focus on return-on-investment (ROI), technology development and commercialization strategies focus on finding a way to enable early, rapid and complete market penetration. Commercialization risk diminishes as the technology development process continues. The research and marketplace lines in Figure 3 depict the points where stakeholder focus changes. The intersection point with the development pathway illustrates the amount of risk associated with the emerging technology development and the time to get to the marketplace.

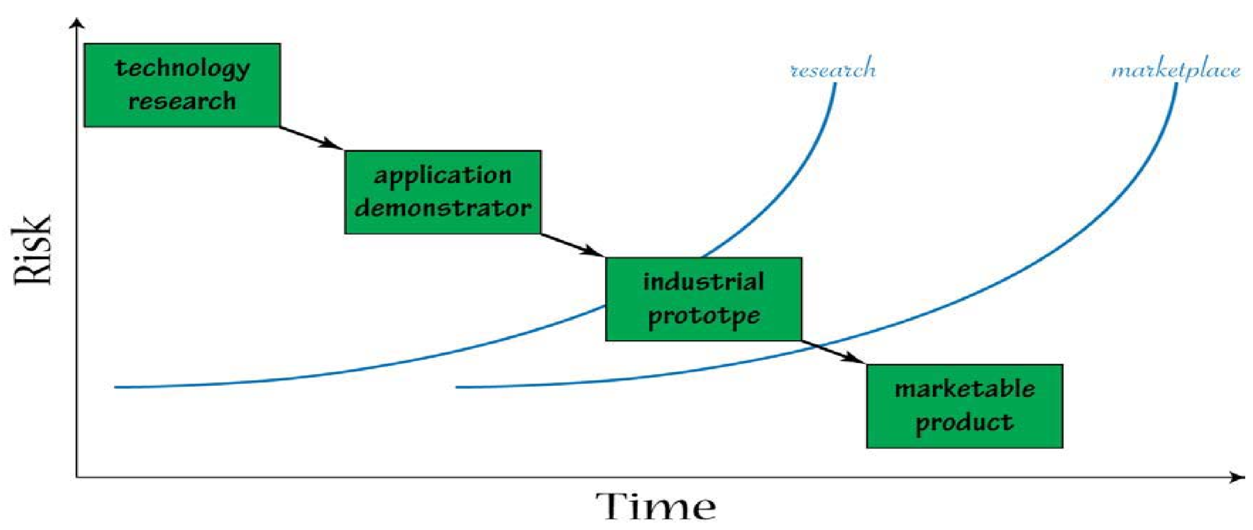

Fig.3: Technology development cycle (Wilson, 2001)

Figure 4 illustrates a life-cycle model from loss/profitability perspective, being concerned with R&D sunk costs, timeline to recovering these costs, modes (e.g. types of licenses) of making the technology yield a profit proportionate to the costs and risks involved. Currently, CCU&S as a commercial technology would be identifiable in the R&D phase below the business breakeven point. In contrast, technologies such as enhanced-oil-recovery (EOR) would be identifiable in the mature phase of the curve. In general, the use of advanced economic analyses techniques such as "discounted cash flow" and "compound real options valuation" have been shown to be an effective support for decision-making, risk assessment, infusion planning, probabilistic cost estimation, schedule uncertainties, and program-level decision tree analysis (Tralli, 2004).

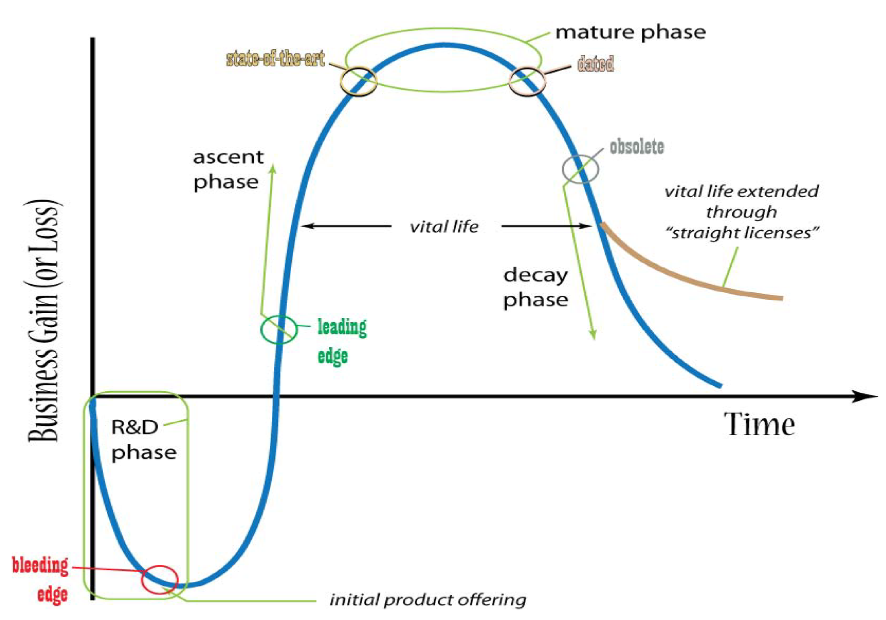

Fig.4: Management view of a technology life-cycle (UNIDO, 1996)

Strategic Master Planning for CCU&S

As depicted in Figure 5, strategic planning is fundamentally about exploiting strengths and the competitors' weaknesses, and neutralizing weaknesses and competitor's strengths (Brauer & Cesarone 1991). The competitor may be another company or another technology that is filling the energy production sector. Ultimately, this leads to implementing tactical strategies with accompanying performance metrics that drive the decisions leading to sustainable advantages (Brauer & Cesarone, 1991). More and more governments have opted to develop a strategic "National Master Plan" to provide a roadmap for a well-coordinated approach for CCUS activities (Brauer & Brauer, 2018). Countries such as Australia, UK and the Netherlands have led the way in developing CCS master plans (Global CCS, 2017). The purpose of a CCUS master plan is to outline a detailed long-term strategy on which countries and companies in the CCS value chain can build their business models. It is essential that a CCS master plan takes a long-term view (at least 30-40 years), and that governmental CCUS policy be developed as transparently, robustly, and predictably as possible (Global CCS Institute 2017) and in line with the national CO2 emission reduction strategy.

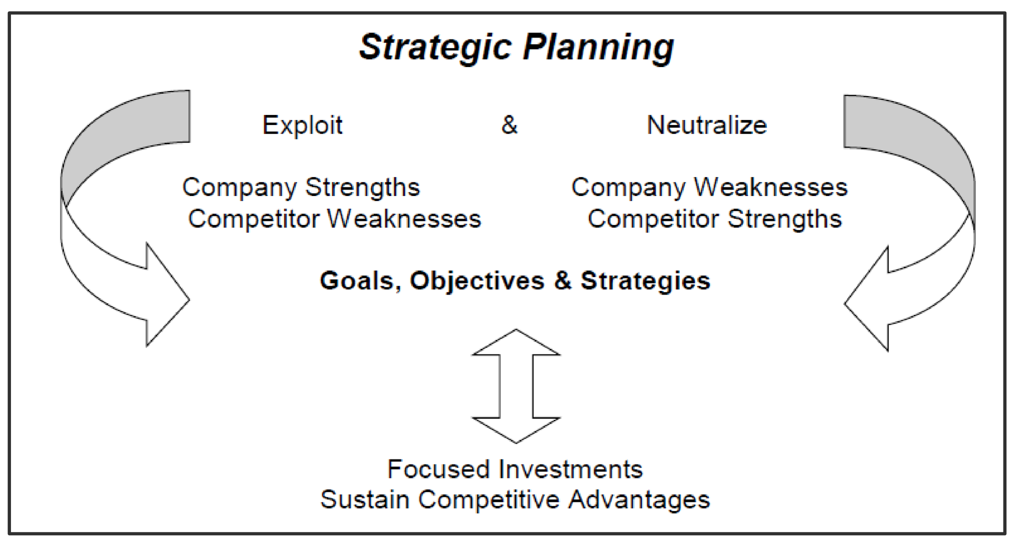

Fig. 5: Strategic Planning (Brauer & Cesarone, 1991)

Stakeholder Education & Engagement

Stakeholder support is a key building block for a successful market implementation and societal uptake of emerging technologies. However, misconceptions and biases in people's energy perception could influence their support of proposed energy developments integral to the success of restructuring a nation's energy system. Education has been identified as one of the key factors shaping how people view energy-related issues (Figure 6). In equipping young adults with the cognitive skills and knowledge necessary to navigate in the confusing energy environment, science outreach and education could play a key role in addressing such misconceptions and biases and pave the way for informed decision-making (Lee, 2016).

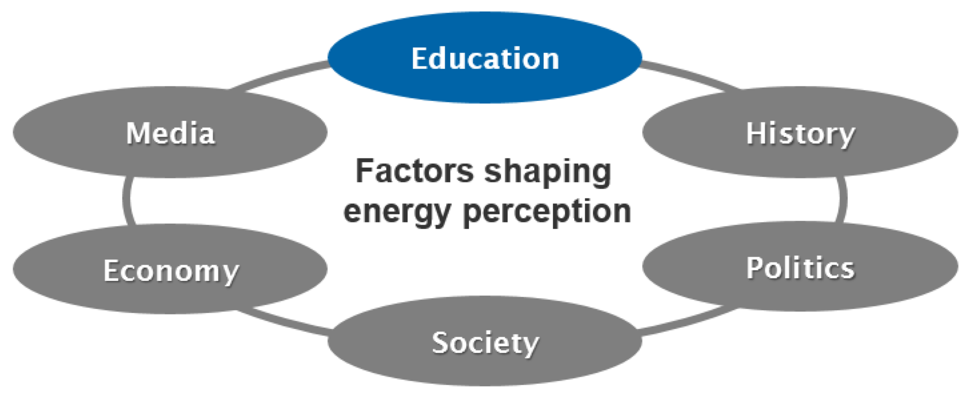

Fig.6: Factors shaping perception of energy sources and related issues (Lee & Gloaguen, 2015)

An example of an effective CCU&S education and outreach project was that conducted by Richland Community College as part of the US Department of Energy – National Energy Technology Laboratory Project "Illinois-Industry Carbon Capture and Storage" (IL-ICCS) (Brauer 2014a & 2014b). The outreach project is developed in line with best practices developed by the National Energy Technology Laboratory (U.S. DOE, 2013) namely (1) Integrate Public Outreach with Project Management; (2) Establish a Strong Outreach Team; (3) Identify Key Stakeholders; (4) Conduct and apply Social Characterization; (5) Develop an Outreach Strategy and Communication Plan; (6) Develop Key Messages; (7) Develop Outreach Materials tailored to the Audiences; (8) Actively Oversee and Manage the Outreach Program throughout the Life of the CO2 Storage Project; (9) Monitor the Performance of the Outreach Program and Changes in Public Perceptions and Concerns; (10) Be Flexible – refine the Outreach Program as Warranted.