Creating Effective Low-Carbon Innovation Policy by Getting the Institutions Right

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Ontario is leading in many climate policy areas such as renewable energy, smart grids, and the recent announcement that it intends to join the Western Climate Initiative cap-and-trade system. As part of its climate policy framework, Ontario has committed to reinvest the proceeds from its proposed cap-and-trade system, in a transparent way, back into projects that will further reduce GHG emissions and improve business competitiveness. To meet this commitment, and create momentum in its transition towards a green economy, the province will need to encourage the deployment of a variety of new low-carbon technologies to change the way society supplies and uses energy. The reinvestment of carbon revenue proceeds presents an opportunity to build Ontario based firms with capabilities to compete in the growing global market for clean technologies.[a] It is perhaps **an ideal time for Ontario to lead the way by implementing a strategic and comprehensive low-carbon innovation policy**. A critical first step involves creating the right innovation institutions.[b] This policy brief discusses critical public sector institutional design factors for policymakers to consider.

Carbon Pricing Revenue → Innovation Policy → Institutions

In April 2015, Ontario announced it will implement a cap-and-trade system and that it will invest funds raised through the auction of emission permits in projects to reduce greenhouse gas (GHG) pollution and improve business competitiveness. Some of these revenues could be invested in low-carbon innovation initiatives to further GHG reductions and help develop Ontario clean technology industries.

Innovation is a process of putting new ideas into practice.[1] Improving innovation performance is critical to ensuring future economic prosperity and achieving meaningful GHG reductions.[2] However, Canada is stuck in what Peter Nicholson has called a "low-innovation equilibrium".[3] We have strong scientific capabilities, an educated workforce, and our governments invest a lot of money in research and development (R&D). Yet, Canada falls behind when it comes to using its knowledge to build new firms and industries, and applying new technologies to increase economic performance.[4] A transition to a low-carbon economy offers a window of opportunity to improve Canada's innovation underperformance – if the right policy actions are taken. Innovation policy supports are needed to push against market failures and structural barriers that impede green technologies. Ontario also has an interest in aligning the deployment of clean technologies with the creation of domestic economic opportunities. Thus far, while provinces such as Ontario have installed renewable energy and energy efficient technologies[5], Canada has nevertheless lost 71% of its 2005 share in the global market for manufactured goods in the renewable energy and energy efficiency sectors.[6]

[a] Analytica Advisors 2015 Canadian Clean Technology Industry Report registers the global market for environmental goods at close to $1 trillion in 2014.

[b] The reference to institutions is not meant to solely refer to an organization, but rather the wider notion of the rule sets that describe how the public sector is organized, how it operates, and interacts with the rest of society.

There is growing recognition of the need for innovation policy to become more comprehensive and strategic[7] - capable of identifying domestic innovation strengths, analyzing the multiple barriers that confront new innovations, and tailoring policy actions to remove these barriers. This requires an approach that is principally concerned with adapting policy to the evolving needs of different sectors, technological areas, and regions.[8] New approaches to technology development emphasize creating frameworks to encourage policy learning and adaptation over "picking" certain areas for investment. In this policy arena **creating the right organizational structures and operating principles within the public sector is a critical element to achieving success**.

This policy brief provides a list of key success factors in the design of institutions to accelerate low-carbon innovation. The list of success factors is based on a review of the innovation policy literature and case studies of four low-carbon energy innovation policy initiatives: The Advanced Research Projects Agency-Energy (ARPA-E) in the United States, the United Kingdom Carbon Trust, the Netherlands Energy Transitions Project, and Sustainable Development Technology Canada (SDTC).

Institutional Design Principles for Innovation Policy

What follows is a list of institutional design principles for policymakers to consider – a comprehensive outlook and flexible policy approach; creating an island for experimentation with a bridge to government; being mission oriented; being embedded in industry, yet autonomous; and undertaking systemic evaluations. Relevant lessons from our case studies are mentioned throughout.

A Brief Introduction to Low-Carbon Innovation Case Studies

Advanced Research Projects Agency – Energy (ARPA-E)
ARPA-E is an agency within the Department of Energy in the United States with a focus on promoting high-potential, high-impact energy innovations. It is modelled after the Defense Advanced Research Projects Agency (DARPA). The agency was created in 2007, and funded in 2009 as part of the stimulus policies to fight the recession.

United Kingdom Carbon Trust
The UK Carbon Trust was created in 2001 as a not-for-dividend private company. It was originally intended to help businesses react to the introduction of a climate levy by improving energy efficiency and developing new low-carbon technologies. In 2011 The Trust's core funding was eliminated and it must now access funds through private sources or by bidding for government contracts.

The Netherlands Energy Transitions Project
In 2011 the fourth National Environmental Policy Plan adopted a "transitions management" approach to low-carbon innovation policy. Under this policy framework the Ministry of Economic Affairs worked with stakeholders to develop future scenarios and "transition paths" to a low-carbon future. A series of experiments - or pilot project – were launched to promote technological and social innovations consistent with the low-carbon pathways envisioned. By 2009, 409 transition experiments were conducted to support seven different transition pathways in areas such as sustainable mobility, the built environment, and realizing supply chain efficiencies.

Sustainable Development Technology Canada (SDTC)
The federal government created SDTC in 2001 as a foundation - an arms length, not-for-profit organization governed by a Board of Directors. SDTC operates three funds: the Tech Fund, which support projects related to climate change, and clean air, water, and soil; the NextGen Biofuels Fund to support large demonstration-scale production facilities for 2nd generation biofuels; and the Natural Gas Fund to support downstream natural gas technology.

1. A Comprehensive Outlook and Flexible Policy Approach

Many different factors need to come together for an innovation to be successful, and as technologies and economies evolve different policy strategies are often required. Innovation studies emphasize that policy needs to consider the *entire system* that influences technological development.[9] Monitoring an innovation system involves understanding the roles of different innovation players such as universities, firms, associations, and users; considering the entire lifecycle of a technology; analyzing multiple innovation activities such as mobilizing financial and human resources, developing sectoral and regional innovation strategies, and building new networks to exchange knowledge; and examining how existing economic structures block or enable new technological developments.[10] Gaps such as missing players (e.g. lead users), weak innovation activities (e.g. missing networks), or a lack of support during a critical moment in a technology's evolution can contribute to innovation failures. **The danger is that policies based on using only one instrument (e.g. tax credits) or focusing on one stage of technological development (e.g. basic research) will leave such gaps and may result in innovation failure if they go unfilled**. An innovation policy approach needs to be comprehensive. It also needs to be flexible because problems will differ across a technology's lifecycles and across different regional, sectoral, and technological contexts.

The cases explored demonstrated how organizations took a comprehensive outlook and flexible policy approaches. Both the UK Carbon Trust and SDTC were originally created to help companies cross the "valley of death" when firms must demonstrate technologies before they can attract private venture capital, yet both organizations broadened their suite of programs. SDTC now helps companies with market entry by making connections with private investors, customers, and export markets. The UK Carbon Trust undertook a very wide range of activities such as direct investment in technology companies, business incubation, labeling and standard setting, and sector analysis. The broad suite of activities allowed the Trust to demonstrate both short-term successes while also undertaking long-term projects with transformative potential. ARPA-E works across the different stages of innovation lifecycles.[11] Its program directors push basic science to solve well-defined demands for sustainable energy solutions and its tech-to-market advisors consider all aspects of commercialization. The Netherlands Transition Project also took a broad perspective - recognizing the need for both technological and social innovations.

The need for comprehensiveness and flexibility does not necessarily require administrative centralization. Innovation systems in countries such as the US and Ireland are described as "networked" in nature, with multiple public sector organizations playing different roles.[12] Breznitz and Ornston highlight the benefit of carving out niche spaces within the public sector.[13] Their case studies of Isreal and Finland found that agencies with limited power and resources, yet a high degree of freedom and flexibility, produced novel policy approaches that were picked up by other sections of government. There insights suggest different agencies and sections of government can specialize in different innovation functions. For instance, an organization like ARPA-E analyzes the entire innovation system

and plays the critical function of promoting experimentation and creating new technological options. Other public institutions, such as investment banks, will help the most promising technologies and companies expand their impact.[14] A network of innovation institutions might enable both flexibility and experimentation as well as comprehensiveness. Each organization must have a comprehensive understanding of the innovation system and the role they play within it. In such a structure, coordination across the public sector will be needed to ensure adequate hand-off of projects and initiatives. The next section discusses how such coordination might be achieved.

2. Create Islands for Experimentation with a Bridge to Government

Low-carbon innovation involves long-term processes, such as technological evolution, that are characterized by significant uncertainty.[15] An agency working on the frontiers of low-carbon innovation needs to be accepting of failures - recognizing them as normal occurrences that can contribute to learning.[16] If low-carbon innovation policy is caught in what public administration scholar Donald Savoie[17] calls "blame games", decision making will lose focus on fostering long-term transformations. The Solyndra example in the US demonstrates that expending political capital on specific projects can create liabilities for politicians, and that political necessities can cause administrators to continue supporting a project when it should be cut off. Excessive politicization can direct public attention away from the overall success of broader policy initiatives.[c]

The creation of an independent innovation agency is a key feature of many innovation policy success stories,[d] and of the low-carbon innovation examples explored. Independent status can promote policy innovation and experimentation, a strong mission orientation, administrative flexibility, protection from short-term political imperatives, and it can prevent political leaders from being caught in blame games. The main drawback of administrative independence is that it restricts the ability of the agency to wield certain policy tools that require more direct government ties, such as: public procurement, the creation of initial markets, or standard setting. Consideration of this tension has led to models of institutional design that create institutional "islands" to increase administrative independence in areas such as innovation project selections, while maintaining specific, well defined links to government by a direct "bridge" to broaden the suite of available policy tools.

ARPA-E follows an "island-bridge" model that aims to capture the benefits of both independence and cross-government coordination. The agency is islanded to promote experimentation and focus on the

[c] In the US, solar cell manufacturer Solyndra received loan guarantees from the US government and went bankrupt in 2011. President Obama used Solyndra as a poster child for his economic recovery policies and received substantial criticism after the company's bankruptcy. Despite the political controversy, the loan guarantee program was an overall success and supported technological winners such as the Tesla electric car.

[d] Relevant examples outside of the sustainable energy sector include DARPA in the US, VINNOVA in Sweden, the Office of the Chief Scientist in Israel, the Enterprise Development Program in Ireland, and Sitra in Finland.

mission, but it has a bridge to the Secretary of Energy who acts as a high-level political champion. The bridge supports democratic accountability between the government and agency, and lets the agency coordinate with government departments with access to policy tools needed to support the continued development of technologies. This model will be most effective when the innovation agency is connected to a political leader with authority to work the machinery of government, and who understands and supports the mandate of the innovation agency.[18] In the Ontario context this could be a senior Minister, the Premier, or a senior advisor to the Premier.

It is important to note that real autonomy is only partially achieved through administrative independence. Independence is also supported by providing stable funding from a non-political source; establishing a clear mission and appropriate evaluation frameworks; and developing a high-level of expertise, professionalism, and integrity within the organization. These topics are addressed below.

3. Mission Oriented

An organization tasked with accelerating low-carbon innovation should have a clear, mobilizing mission. In the cases explored, the UK Carbon Trust's original mission was to "accelerate the UK's move to a low-carbon economy", SDTC's was to "act as the primary catalyst in building a sustainable development technology infrastructure in Canada", while ARPA-E's slogan is "Changing What's Possible". An inspiring mission acts as a forceful magnet for attracting talented individuals.[19] It promotes integrity, as employees are intrinsically motivated to deliver on the mission. It also supports the organization's independence by signalling a clear public good objective rather than service to a particular clientele or political group.

It is useful to contrast a mission-oriented initiative with stakeholder-based institutions. As will be discussed in the next section, innovation institutions must have an interactive and hands on relationship with the private sector and non-governmental organizations, yet **a mission rather than stakeholder interests should ultimately guide the organization**. Stakeholders must understand that they can engage with the organization to fulfil its mission, but they cannot control it. The organization should aim to create a "transformative alliance"[20] between different groups in society working towards the common mission to transition towards a low-carbon economy - it should not be weighted down by the need to appease competing interests.

4. Embedded in Industry yet Autonomous

A public sector innovation organization must develop a strong understanding of the economic sectors and technologies it supports. There is a continuous need to interact with market players (firms, users, industry associations, etc.) to gather relevant information and to coordinate innovation efforts.[21] Becoming truly "embedded" requires the build-up of trust between a public purpose organization and entrepreneurs outside of government.[22] Bygone theories of public administration called for the public

sector to be insulated from private firms, to guard against political capture.[23] Such insulation is unrealistic in low-carbon innovation policy. Insulation would cut off information flow needed to create effective policies and would significantly decrease the public sector's capacity to shape innovation trajectories through activities such as network building.

Institutional design can guard against capture by vested interests by promoting the *autonomy* of the organization and its personnel.[24] Public servants must engage with private sector partners on their own terms, which requires them to have a high level of expertise and independent visions of technology futures. ARPA-E provides an example. The agency hires program directors at the frontier of technological innovation, often with experience in academia. The first stage of the program creation strategy is to "envision" the energy landscape. The idea is to "define success early before others define it for you".[25]

Another way to avoid capture by narrow interests is for the organization to promote "embedded" interactions with multiple innovation players, including civil society and technology users.[26] Civil society groups can help identify and manage social barriers to technology adoption (e.g. how to promote low-income inclusion in sustainable energy).[27] Engaging users is also critical to improve products and ensure low-carbon performance (consider home energy management systems). While innovation literatures emphasize the importance of civil society engagement, the cases explored did not show that these theoretical ambitions were achieved. For instance, critics of the Netherlands Energy Transitions Project argued that the strong influence of incumbent energy interests resulted in missed opportunities for social innovation.[28] Political legitimacy and the engagement of technology users are especially important in the low-carbon innovation field. Engaging civil society must not be an afterthought.

5. Leadership and Expertise

A low-carbon innovation organization must have a leader that commands authority and respect in both the private sector and government administration. Leaders should have managerial as well as scientific/technical expertise and aim to create an entrepreneurial culture within the organization.[29] In the clean innovation realm, leaders should also understand environmental objectives.

To promote policy effectiveness and the requisite autonomy from the private sector the organization must attract or develop a **small cadre of individuals with deep domain-specific knowledge**. Where to find these people is a context-specific question. ARPA-E relies heavily on academics with expertise developed through their research. They serve 3-5 year terms. The UK Carbon Trust principally recruited personnel from the business community. SDTC recruited a team with a wide spectrum of backgrounds and the right motivation and developed knowledge of clean technology sectors over time.

Two models can be implemented separately or in combination. The ARPA-E staffing model pulls expertise from outside and creates temporary project teams. Another model would build capabilities in-

house, by creating groups with specialized knowledge in technological areas or sectors developed over longer timeframes.[30] In either case, attracting talented individuals when they are available can require the ability to quickly hire and sign contracts. ARPA-E operates outside of standard government procurement and hiring systems,[31] demonstrating that organizational independence can facilitate talent attraction.

6. Funding Stability

Funding instability can significantly reduce an organization's functional independence and damage its credibility with private sector partners. A lack of stable funding was a weakness in all the cases of low-carbon innovation institutions explored here. Relevant examples can be found outside of the climate policy area. The Defence Advanced Research Projects Agency (DARPA) shows what can be achieved with meaningful and stable levels of funding – the agency played a role in developing now ubiquitous technologies such as the Internet, voice recognition software, and geographic positioning systems.

Allowing an agency to take an equity stake in the companies it supports is an option that can promote independent funding streams, however it might only be appropriate at latter stages of a company's growth. This ensures the public earns some return on its investment and will promote the legitimacy of government financing initiatives.[32] However, a degree of committed, stable public funding is critical to maintain independence from the private sector and accountability to government. The UK Carbon Trust presents a cautionary tale. In 2011, the government cut The Trust's core funding and announced it would need to bid for future government work - effectively transitioning The Trust into a private consultancy rather than an arms-length public purpose organization. This situation arguably reduces its independence from government since it must now navigate political arenas to receive funding. It also reduces credibility with the private sector because companies fear that the Trust will be a potential competitor.

The proposed introduction of a cap-and-trade climate policy presents the opportunity to create a dedicated and secure revenue source for low-carbon innovation that would reinforce many of the institutional design principles discussed. There is a natural linkage with a clear mission to reduce GHG emissions and dedicated and secure funding for a low-carbon innovation agency will promote its autonomy from short-term political pressures while maintaining its accountability for the use of public funds.

7. Systemic Evaluation

Making investments in low-carbon innovation, such as new clean technologies with transformative potential, requires an acceptance that some projects will fail while others will pay off. An institutional structure should ensure that technology successes are able to offset the inevitable losses, and therefore **institutional evaluation should be based on the entire portfolio of "winning" and "losing" projects**

over a sufficiently long period of time. In addition, project success should be judged based on social or systemic objectives such as the creation of spillovers across the economy, which can occur in projects that both succeed and fail to reach commercialization stages.[33] Low-carbon innovation policy is successful if the government is truly doing something different from the private sector and removing the bottlenecks that confront new innovations, thus a public institution cannot be judged on the same basis as a private sector investor.

Restricting the evaluation of innovation to one or even a limited number of indicators (e.g. patents, or financial return from investment) will reveal only limited aspects of the innovation picture and could misdirect policymakers towards supporting only one aspect of the innovation system. A multitude of indicators can be used to monitor innovation systems such as the number of new products and firms, quality improvements, and price performance. To maintain focus on a clean innovation mission, environmental indicators should be tracked and given significant weight in the evaluation of projects.

In addition to monitoring output indicators, policymaker should also track innovation activities or processes such as network building, market formation, entrepreneurial experimentation, and initiatives to increase human capital.[34] The most effective policy actions might involve using soft instruments such as making new connections, or alerting entrepreneurs to new opportunities, or structural interventions such as changing standards. These types of policy actions might not be easily quantified or framed in terms of inputs and outputs.[35]

The case studies show that organizations can build credibility by closely tracking multiple indicators such as actual and estimated GHG reductions, and dollars leveraged from the private sector. These indicators can be used to demonstrate early success and competence. Truly transformative policy actions might span longer time frames and require evaluation frameworks that seek to support iterative learning and signal the need for course corrections.[36] Policy objectives and challenges with evaluating the public sector's unique role in promoting low-carbon innovation should be discussed upfront to avoid misunderstandings that lead to unnecessary controversies.

An ill-conceived evaluation framework can misdirect policy efforts, impede flexibility, create unnecessary overhead costs, and trigger political conflicts.[37] A review of the literature suggests there is a clear need for policymakers to think broadly about how to monitor and evaluate policy agendas aimed at triggering long-term transformations. This is an area that deserves careful consideration and more policy research.

Conclusion

The availability of carbon revenues from a cap-and-trade system presents an opportunity to deliver stable funding for a low-carbon innovation agenda.[38] **Stable funding is a key innovation success factor that few jurisdictions have been able to provide**. While carbon revenues will likely be allocated based

on multiple policy priorities, one option is to allocate some of the revenues towards building low-carbon innovation systems in Ontario. Finding the right institutional design and operating principles is critical for effective policy implementation. This policy brief highlights the following institutional design principles for consideration by policymakers:

- Encouraging a comprehensive outlook and flexible policy approaches
- Creating islands for experimentation with a bridge to a high-level political champion
- A focus on mission rather than stakeholder interests
- Having close ("embedded") interactions with industry, yet creating the requisite amount of autonomy to avoid capture and undue influence
- Selecting the right leadership. Attracting and building expertise within the organization
- Providing stable and predictable funding
- Taking a systemic perspective to evaluation

These lessons have been drawn from a literature review and case studies of leading low-carbon innovation institutions. They provide useful examples of how Ontario could meet its commitment to reinvest proceeds of the proposed cap-and-trade system to further reduce GHG emissions and improve economic competitiveness.

Endnotes

[1] see Jan Fagerberg, "Innovation: A Guide to the Literature," ed. Jan Fagerberg, David C. Mowery, and Richard R. Nelson, The Oxford Handbook on Innovation (Oxford: Oxford University Press, 2005), 1–27.

The definition from the OECD's Oslo Manual on "The Measurement of Scientific and Technological Activities" is "an innovation is the implementation of a new or significantly improved product (good or service), a new marketing method, or a new organisational method in business practices, workplace organisation or external relations."

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[3] Peter J. Nicholson, "Disrupting Canada's Low-Innovation Equilibrium" (Presentation to Research Money Conference, Ottawa, May 17, 2012).

[4] see Conference Board of Canada, "How Canada Performs: Innovation," 2015, http://www.conferenceboard.ca/hcp/provincial/innovation.aspx; Conference Board of Canada, "How Canada Performs: Environment," 2015, http://www.conferenceboard.ca/hcp/details/environment.aspx.

[5] Ontario's renewable energy policies helped give Canada the second fastest clean energy investment growth amongst G-20 countries in the Pew Centre's 2013 tracking of "Who's Winning the Clean Energy Race".

[6] Analytica Advisors, "2015 Canadian Clean Technology Industry Report (Synopsis)" (Ottawa, 2015).

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