

Accelerating Clean Innovation: *Policy Drivers and Research Needs*

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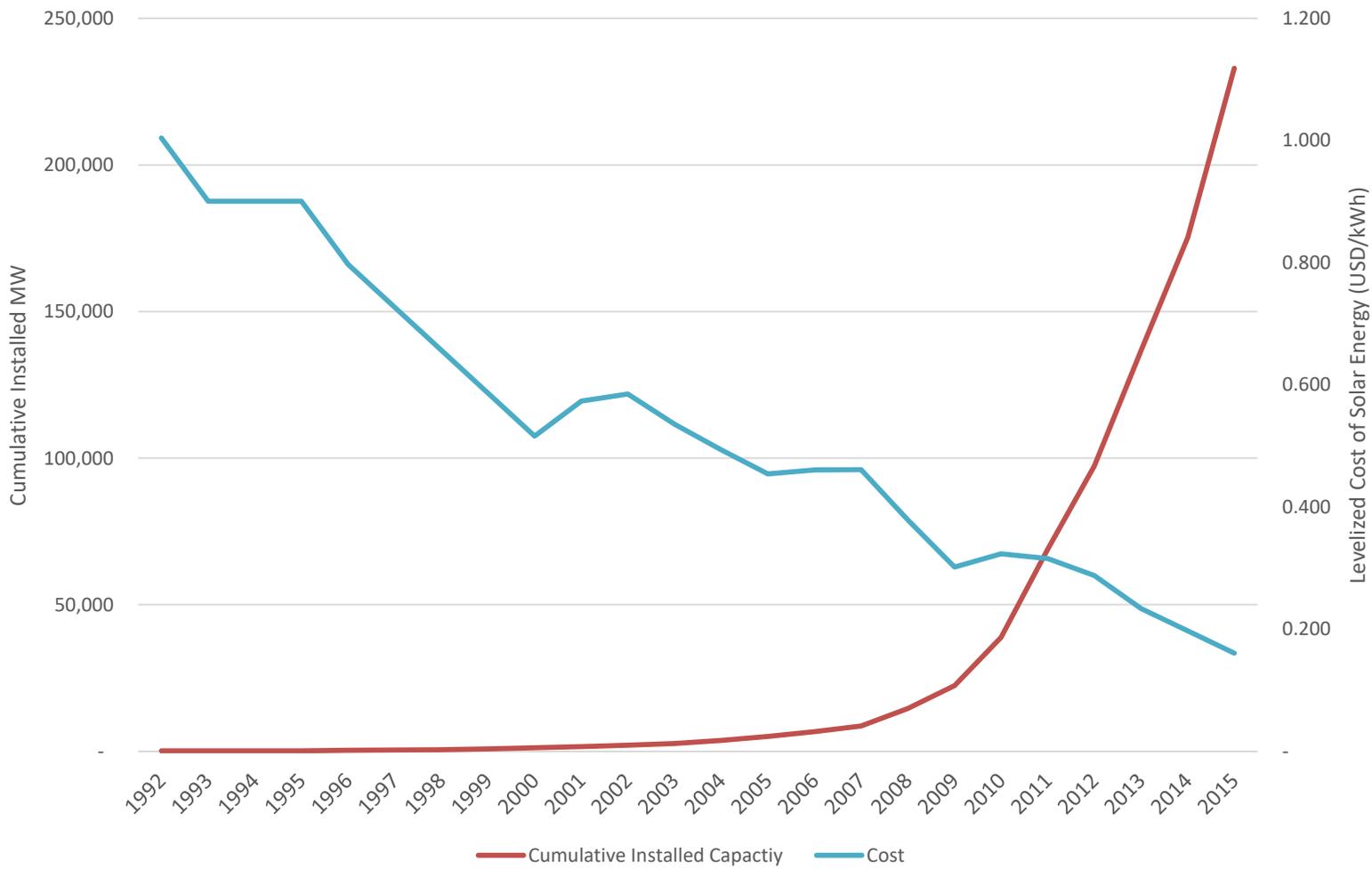
Why Clean Innovation Matters

- Environment
 - Reduce cost and time to meet climate targets (and other green goals)
- Economy
 - Emerging global economy rewards clean performance and innovation
 - Reduce costs, produce greener products / processes for growing markets
 - Opportunity for *all parts* of the economy
 - Clean tech: Fast growing (\$2.5T by 2020) – jobs, research, exports
 - Resources, manufacturing: Clean performance = market *access, opportunities*
 - Bio-chemicals = \$83B by 2019 (agric., forestry)
 - Rare Earth minerals (clean tech) = \$75-100B by 2025 (mining)
 - Resource innovation / efficiency gains > \$3T by 2030 (McKinsey)
 - Infrastructure (low carbon economy) ~ \$90T by 2030 (NCE 2016)



Innovation = Falling Costs, Growing Markets

Solar Power Installation and Costs



How Canada is Doing at Clean innovation?

- **General story: Doing fairly well at early stages of innovation (R&D), and less well as move to market.**
 - Limited data, metrics impede full analysis
- Global clean tech market share = 1.4%, down 12% since 2008 [Analytica]
- Canada's performance and outlook improving
 - Moved to 4th (from 7th) on 2017 Cleantech Innovation index
 - Strong in emerging cleantech; weaker in commercializing and converting
- 3.4% of env patents registered, but 1.6% of clean techs developed here [OECD]
- Big barrier: scale-up for capital-intensive firms
 - E.g. Canadian VC funding size 50% lower than US for later stage [Cycle 2016]
- Some evidence that Canadian firms slow in clean tech adoption
 - 9% adopted clean technologies, vs 29-43% for other types [StatsCan 2014]



Conceptual Frameworks: Innovation System & Govt's Role

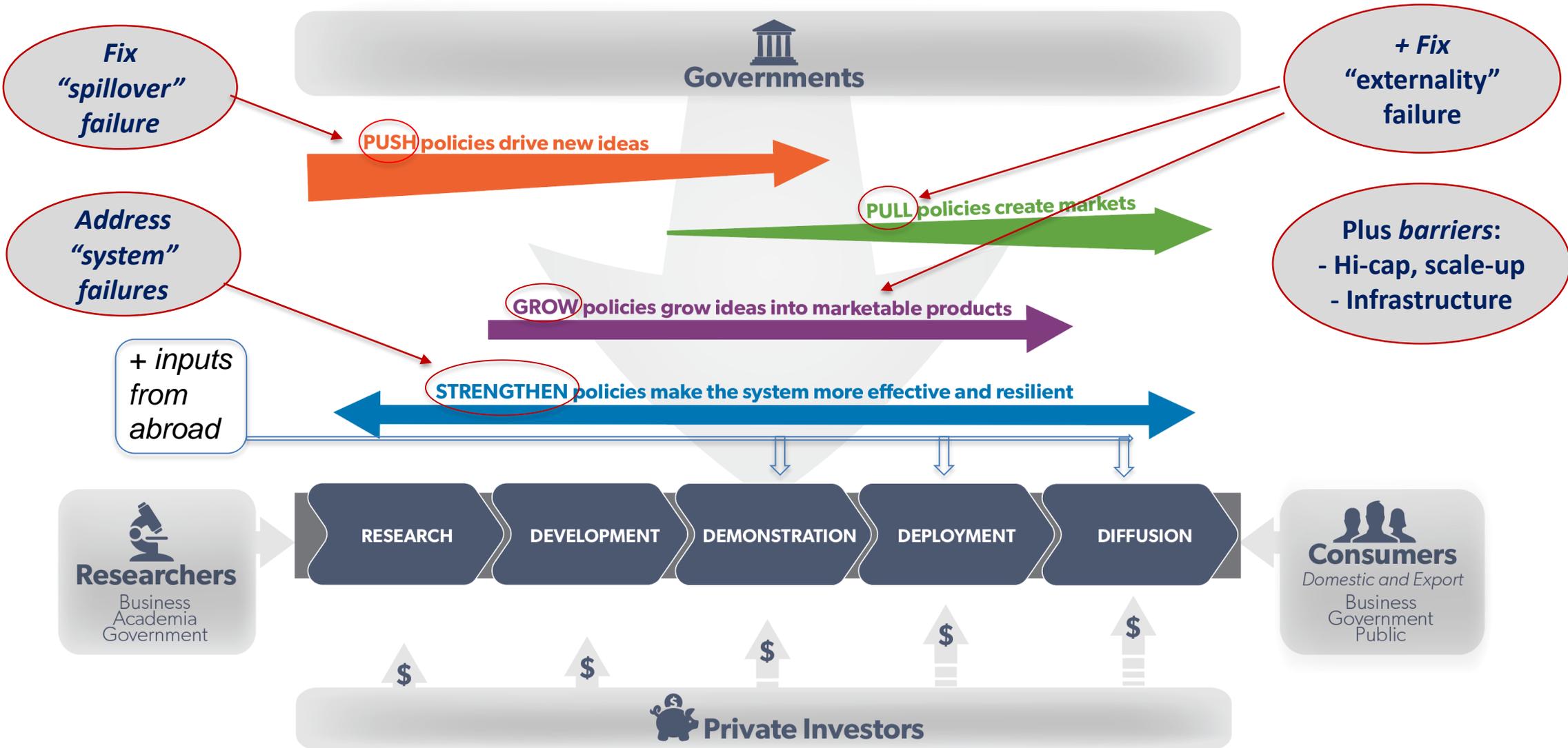
Innovation Perspective	Sustainability Problem	Type of Analysis	Policy Implications
Innovation Stages (pipeline)	Market Failures & Barriers	Trade-off / optimal policy mix between demand-pull and supply-push	<p>Promote R&D (push)</p> <p>Boost demand via smart regs, carbon pricing, procurement</p>
Systems of Innovation	Systems Failures	<p>Evolution / transition</p> <p>Technology and sector specific studies of innovation processes and structural barriers</p>	<p>Create spaces for new tech, building connections</p> <p>Promote diversity and experimentation</p> <p>Long-term visions</p>
Evolutionary Economic Geography	Regional / Lock-in	<p>Analyze regional assets</p> <p>Explore interactions within and between sectors</p>	<p>Promote strategic coupling b/w local/global economies</p> <p>Promote "green linkages" with traditional sectors</p>

Haley & Elgie, 2016



Clean innovation needs extra public support – *how?*

(* simplified map of clean innovation system)



Clean innovation needs extra public support – why?

General innovation:

- Market failure #1 – knowledge spill-overs (R&D)
 - spill-overs often *greater* in clean tech (Dechezleprêtre, 2014)

Clean innovation has extra barriers / needs:

- Market failure #2 – **environmental externalities**
 - fundamental: undercuts demand, finance
- Plus extra market barriers
 - Infrastructure dependence (e.g. energy, transport)
 - Capital intensive, long scale up, commodity pricing
 - Policy risk: low carbon demand driven heavily by gov't policies
 - Emerging technology risk: investors lack information, expertise



Clean innovation needs extra public support – why?

Driving clean innovation requires more than just fixing market failures

- Must also address *system* failures and barriers
 - Overcome *incumbent technology lock-in* that impedes innovation uptake
 - Understand specific systems, target barriers, foster innovation
- Emerging research says governments don't just fix markets; *co-create and shape* them to achieve important *public missions* (e.g. low carbon)
 - Must 'tilt' the playing field (i.e. provide direction) towards 'clean'
 - *But where and how to tilt in smart ways?*



Overall lessons: government policy & programs

- Policy mix is critical (a *system*):
 - *Comprehensive*: How broadly policies apply across system
 - *Credible*: The reliability / predictability of policies
 - *Coherent / Consistent*: Policies are reinforcing, not contradictory
 - Evaluate mix: align, fill gaps, or “patch” (*How?*)
- Systems transition: overcoming lock-in of incumbent techs is critical
 - Esp. hard for highly regulated markets (energy) and commodities.
 - Programs must:
 - Create safe market ‘niche’ for entrants (often disruptive innovators),
 - Incumbents: Reduce institutional supports, encourage disruptive innovation
- Not just fix market failures; must ‘tilt’ entire system towards clean innovation
 - Need mix of *top-down* (set direction) and *bottom-up* (experiment) approaches
 - Different approaches to spur *downstream* tech deployment / diffusion (usu. incremental) vs upstream invention / development (often more disruptive)



NRC, Councils
- Need to target clean innov.

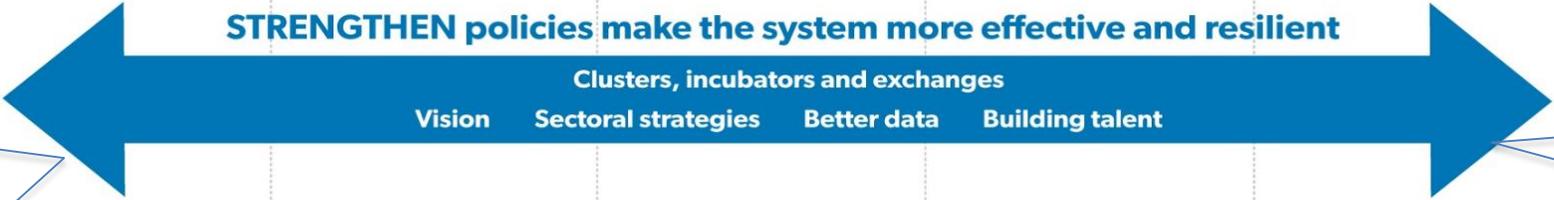
Research credit
- target clean innov. (SRED)?

Infrastructure
- \$22B for green infra

Procurement
- Test bed for clean tech

Carbon pricing

Smart regs
- Clean fuel std
- Cars (ZEV)
- Building code
* Predictable and flexible!



Investment
- >\$2B for clean tech (BDC, EDC, SDTC)
* Leverage private \$s!

Strategy
- Vital to all decisions!
- Budget funds 6 sector strats

Incentives
- ACCA for clean tech?

Reduce barriers
- e.g. Front-runner desk

Clusters
- \$950M



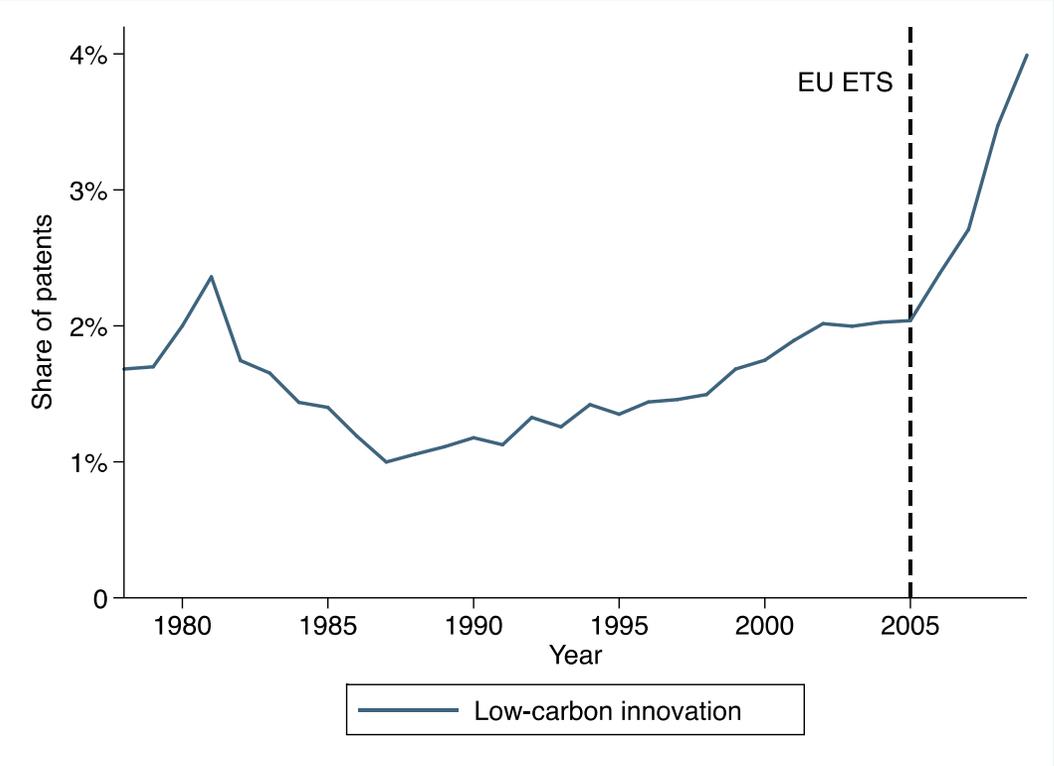
1: “Pull” – Stimulating Demand

- ***Market demand for clean innovation is driven mainly by government action (policy, pricing, procurement)**
 - Without this ‘pull’, ‘push’ and ‘grow’ programs (spending) are less effective
- Policy implications:
 - Design climate policies for both mitigation *and innovation*
 - **Stringent, flexible, predictable** env’t policies drive innovation (OECD)
 - *Flexible* = Pricing, and flexible regulations (not prescriptive)
 - *Stringent* standards are good for innovation
 - but politically / economically hard in near term (need adjustment period)
 - ***Predictable**: Critical to drive longer-term investment (hard for governments)
 - ‘Stickyness’: e.g. targets, policy trajectory, external bodies, revenue recycle



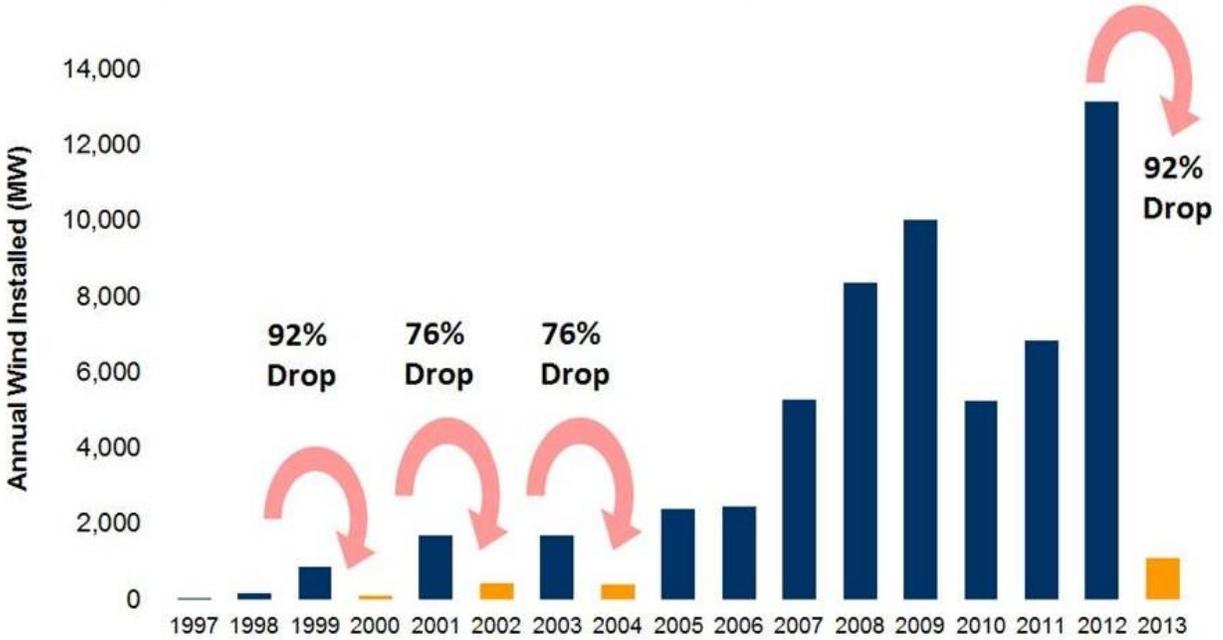
Stringent, predictable policy drives Innovation

Share of low-carbon patents in Europe



Calel & Dechezleprêtre 2014

Historic Impact of Production Tax Credit (PTC) Expiration on Annual Wind Capacity Installation



American Wind Association, 2015

1: “Pull” – Stimulating Demand (cont’d)

- Need ‘sticks’ and ‘carrots’ (transition, competitiveness, political econ)
 - Pair stringent standards with targeted cost-savings
 - e.g. ACCA for clean tech
 - Reduce regulatory barriers to innovators
 - e.g. ‘sandbox’, front-runner desk

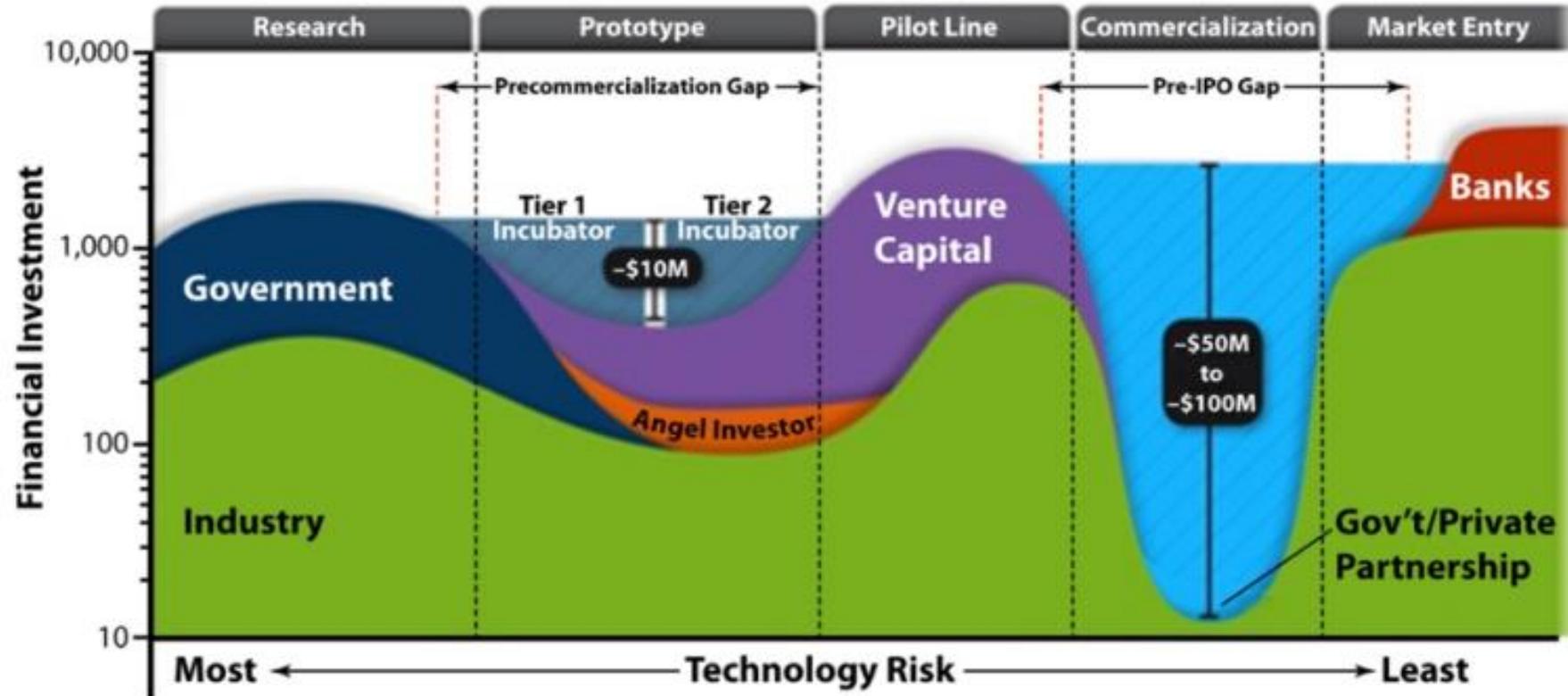


2: “Grow” – Financing Support (market)

- **Moving clean tech from R&D to market faces extra barriers. Private sector underinvesting. Need public funds to de-risk.**
 - Barriers: High policy risk, infrastructure dependence, new area
 - Key finance gap is high-capex: long scale-up time, commodity pricing



The Cleantech Valley(s) of Death



1st Valley of Death

2nd Valley of Death

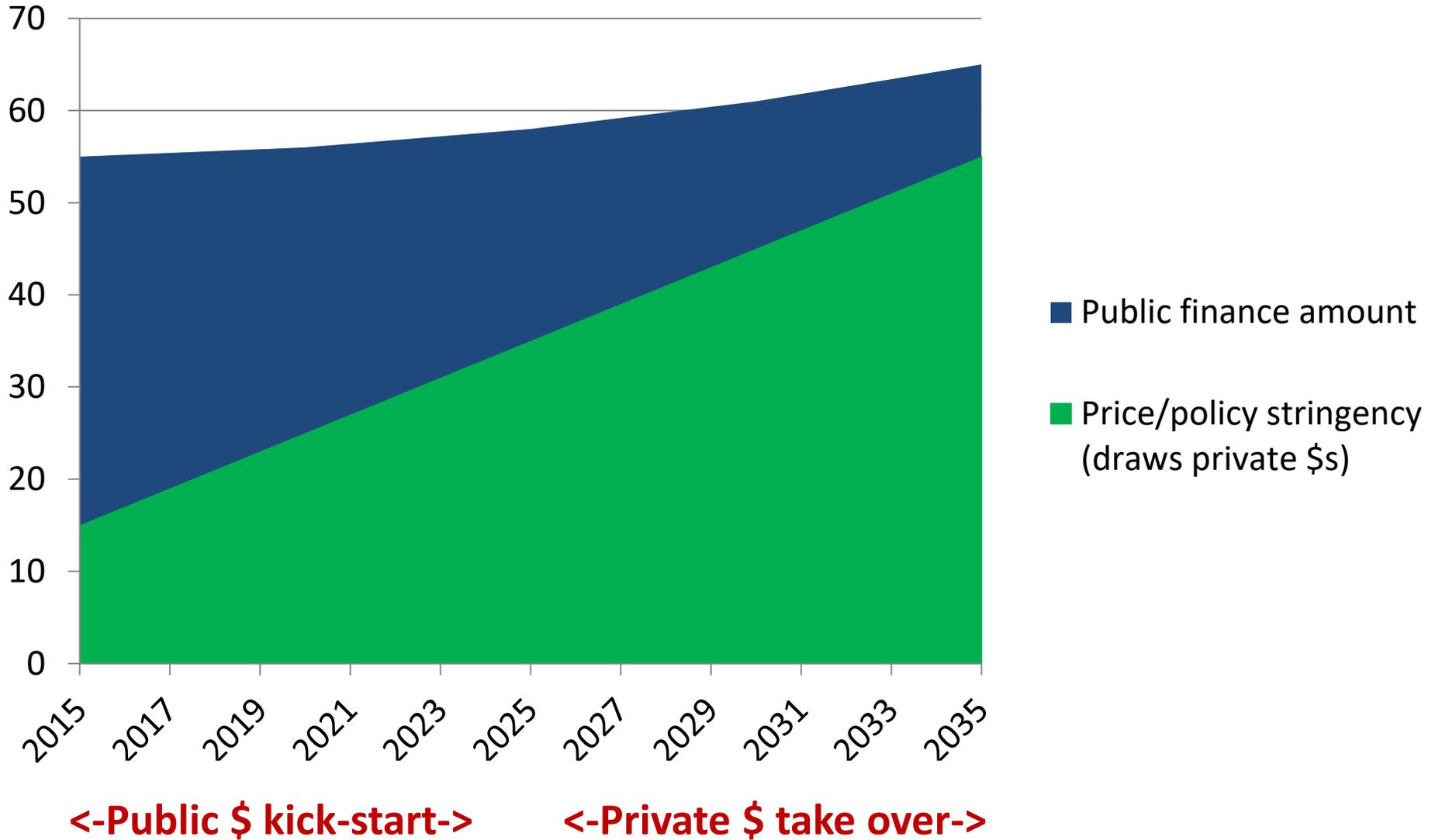


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 - Key finance gap is high-capex: long scale-up time, commodity pricing
- Design of government programs is critical.
 - **De-risk** to draw in private investors (Tools: grants, loans, equity, other?)
 - Best done by **arm’s length bodies** (nimble, risk tolerant, expert, apolitical)
 - Build new **public risk-return models** (financial + environmental)
 - **Transitional** – reduce public \$s as policy stringency rises, markets take over



Government Finance vs Policy Stringency



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- Deep skepticism of gov’t as investor (“*can’t pick winners*”)



Frame: *Mission-Orientated* Innovation, Investment

- Mission-Orientated Innovation (e.g. low carbon)
 - States don't just fix markets; co-create and shape them for key public goals
 - requires setting sustained direction, but not easy:
 - Highly uncertain & long lead times,
 - Requires cumulative & collective action across stages
- Public Investment needs to:
 - Influence Risk Direction (by bearing higher risk)
 - both Upstream (R&D) and Downstream (deployment/diffusion), to enable riskier innovation to move through commercialization
 - Be Patient (long-lead times, cumulative action problems)
- Public funds playing larger role in clean energy markets, as private funds move to short term / low risk.



Green Procurement (Pull / Grow)

Gov't is biggest buyer - lead by example

1. Lower gov't environmental footprint

- Internal government pollution price (rising, life cycle)
- Ambitious internal performance standards (buildings, vehicles)
- Systems (carbon budgets, performance review, reporting)
 - These help esp. to deploy / diffuse (ready technologies)

2. Innovation: Early adopter, showcase for clean tech

- Give critical first contracts (unlock private \$s)
- Target 1-2% of spending on promising clean techs (e.g. SBIR)
- Incentives, information (expert advice)
- Evidence shows procurement programs can drive clean innovation
- Canada lags in clean procurement (changing?)



3: “Push” – Research and Development

- Strong case for public funding of *clean* innovation (high spillovers?)
- Cndn R & D capacity good; must better *target* clean innovation
 - Public labs, granting councils, and private incentives (*targeted* SRED?)
 - Ensure these are aligned with later programs, priorities (commercialize)
- Make some big bets at D & D stage (aligned with strategy)
 - Co-invest (w/ industry) in breakthrough clean techs in key sectors
 - Tools: grand challenges, prizes, etc.



4: “Strengthen” the Clean Innovation System

Clean tech is not a ‘sector’. It is a wide mix of technologies and processes, which can serve (or disrupt) multiple sectors.

To strengthen system, promote transitions and overcome inertia, needs

(a) spaces for connection, exchange, support. experimentation:

- e.g. clusters, incubators, accelerators, networks
- Both at *local scale* (mentoring, capacity building, peer learning)
- And broader *system scale* (connect with customers, investors)

(b) forums for systems thinking and broader strategy

- Define direction (mission), identify niches, set priorities
 - to guide & align investments and choices across different stages and actors
- Bring together key actors across public, private sector – pull together
- Integrate clean innovation into sector strategies (hard... disruptive)



4. Strengthen the Clean Innovation System

(c) Build experimentation, risk-taking, learning into all actions

- Try different things, learn from them (quickly), evaluate, revise
- This is central to innovation -- *hard for government to do (lessons?)*

ARPA-E example

- Multiple experiments, nimble / expert, works across stages, systems thinking
- Good for a decentralized innovation system (Canada)

(d) Other system needs

- Better data – enable evidence-based decisions, evaluation
- Skills for innovation: training, immigration



Looking Ahead: Challenges for Canada

- Driving clean innovation in a **resource and energy-intensive economy**
 - Identify clean innovation opportunities in those sectors (advantage for Canada?)
 - Overcome innovation inertia in resource sectors (*how?*)
- Driving clean innovation in a **economy heavily tied to US** (weak climate policies, big tax cuts). Can we...
 - Pursue L-T upsides of clean innov., & buffer S-T transition / downsides
 - Promote clean innovation (costs), but stay cost-competitive overall (*examples?*)
 - Work with eco-leading states (N-E, Calif), diversify to non-US markets



Key Messages

Clean innovation is vital for the environment *and* economy (all sectors)

Clean innovation needs more / different public support than other types

- Multiple market failures – esp. affects commercialization and demand
- Transitions: disrupt existing systems (energy, transport), overcome tech lock-in
- Achieve public missions (climate); tilt whole system to favour clean innovation

Driving clean innovation system requires an aligned mix of tools

(comprehensive, credible, consistent, coherent)

- Pull: Key public role to boost *demand* for clean innovation (policy, procurement)
 - Grow: De-risk for private *investors* (arm's length, transitional)
 - Push: Target *R&D* to clean innovation; align across stages, strengths (strategy)
 - Strengthen innovation systems – clusters, strategy*, data, skills, etc.
- Mix of top-down (set direction) and bottom-up (experimentation).
- **Be bold.** Promote experimentation, risk, learn from failure (hard)

