Innovations for sustainability

Yoram Krozer, University Twente – CSTM,
Sustainable Innovations Academy

Paradoxes of the common goods

- Drinking is individual good, ambient water is collective. Why do we spoil ambient water?
- Good army and environment prevent risks. Why do we invest in army not in environment?
- Materials are cheap, experts costly. Why do we pay more for the experts' services?
- Religions and environment are imagines. Why offerings voluntary, environment tax obligatory?

Theories on innovations for sustainability

Who are the “innovators”

“Doing things differently”, Schumpeter (1939),1958, p.59

- Consumers that create new lifestyles.
- Youngsters that challenge vested interests.
- Social organizations that activate the inactive.
- Firms that deliver new products and services.
- Investors that change financing strategies.
- Authorities that introduce new instruments.

Successful innovators are mostly entrepreneurs; about 2/3 of innovations come from SME’s

Technology development

Technology: transformation of natural and cultural resources into welfare attributes

Technological change (or progress): performance to cost (typical annual rate for the environmental technologies).

- Structure: shifts materials to labour to know-how (2% - 5%)
- Adaptations: for environmental technology (5% - 15%)
- Innovations: cleaner technology, eco-products (10% - 25%)
- Diffusion: innovations dissemination in time (5% - 100%)
  (System or transition; institutional changes , slow)

Adaptations given technology

- Producers' improvement, learning by doing
- Improvement during use, learning by using

Performance impediments

- improvements cause more use, rebound effects, e.g. mobility less fuel/km but more km/year
- learning decreases as technologies mature, e.g. less changes in road constructions than computers
- improvements decrease at the marginal units, e.g. less progress at the small and medium size enterprises

Innovations, a new technology

- Innovation: (new) use of a (new) process, product, service, images, model, attribute, etc.
- Investment years before beneficial sales (risky)

Performance impediments

- Pervasive systems, old technologies at place, habits resist changes e.g. roads stay for centuries
- Complexities, various stakeholders interests, e.g. electric cars
- Unforeseen side-effects e.g. waste disposal nuclear power

Diffusion (expansion, commercialisation)

- Supply: profit-driven technology sales (sales if better than rival technologies).
- Adoption: benefit-driven technology use (price-quality comparison with alternatives).
- In time: a logistic -S- function of sales (product life cycle - start, acceleration, saturation; do not confuse with LCA)
- Innovation-rent: expected present value of profits and benefits in lifetime (profit can oppose benefit)
- Innovators risk is expressed as higher interest of the rents or chance of success (given rent)

Technology developer profitability

$$P = I - \sum_{t=1}^{n} \alpha \, S_m \; i^{-t}$$

P profit , *I* investment , α success chance, S_m sales, product *m*, interest *i*, time *t*

- Investment: research & development, business model, demonstration and expansion
- Sales during diffusion with learning
- Risk: years of investment before uncertain sales
- Success: α is probability function of social and customers demands

Users benefits

$V = e_s[\sum_{t=1}^{n}(B_m - E_m)\, i^{-t} - \sum_{t=1}^{n}(B_o - E_o)\, i^{-t}]$

V gain $B_m - E_m$ benefit minus expenditures, products *m* ("eco") and *o* ("regular"), sustainability valuation e_s interest i, time t

- Expected net benefit of alternatives during use
- Discounted costs-benefits in life time (learning)
- Risks: performance decrease in life time, slow learning, incompliance with future demands
- Valuation e_s : social sensitivity for sustainability

For common goods, like environment

Activities can cause unintended effects, external effects, market tend to internalize positive side-effects, e.g. picking know-how, and externalize the negative ones, pollution

If nobody made responsible ("internalized")

- private exclusivity is difficult to establish, e.g. air pollution and epidemic
- private gains are made at collective costs (free riding), e.g. traffic and corruption

Market deficiencies

Perfect markets only in timeless and riskless private negotiations (after Ronald Coase, 1963)

Imperfections obscure individual costs and benefits (after Baumol and Oates, 1968)

For environmental issues, in addition:

- Link use to effect is complex, e.g. fuels to climate change.
- Impact appear after many years, e.g. occupation hazard.

Hence,

- Price incentives absent or fictive, e.g. price of nature

Policy deficiencies

Bias in decision making towards an “average” and “well-known” (after Kahnemann, 2011)

For environment, in addition:

- Horizontal integration: many domains involved.
- Vertical integration: many policy levels involved.

Hence,

- Unbalanced multi-criteria policymaking, e.g. health risk versus space use

Innovations under deficiencies

Deficient price and policy obscure private benefits

Hence,

- Additional innovators' risks, double externality after Jaffe and Stavins 2005, because
  - Poor price signal for resources allocation
  - Laborious deliberations about sound criteria
- Innovators face conventions (agreements), and rule of law (policy), and taxes (surrogate price).

Neo-classic (mainstream) view

Regulations should correct the external effects (Pearce and Turner, 1990).

- Level-playing field for innovators with regulation that internalizes the effects (prevent free riding).
- Regulations through prices or quota's with free choice of solution to strengthen competition.

For the sustainable innovations more competition within rule of law (Ashford, 1992).

Evolutionary view

Knowledge-based search and selection process evolving toward lock-in patterns (Dosi, 1982, Arthur, 1990)

- Steering the patterns (transition management)
- Strong policy demands (technology forcing)
- Foster disruptive innovators (new patterns, Christensen, 2000)

For sustainable innovations support know-how and demonstrations

Behavioral view (organizational)

Decisions are taken under bounded rationality
Social dilemma's in decision making (Simon, 1970)

Decision on biking on distance < 1km	
Sustainable	Unsustainable
If you do I also do **++**	If you do I do not need **+/-**
If you don' t I should do **-/+**	If you don't I don't **--**

For sustainable innovations sense of urgency to act with social mechanisms to enhance actions (Krozer 2008)

Practices in sustainable innovations

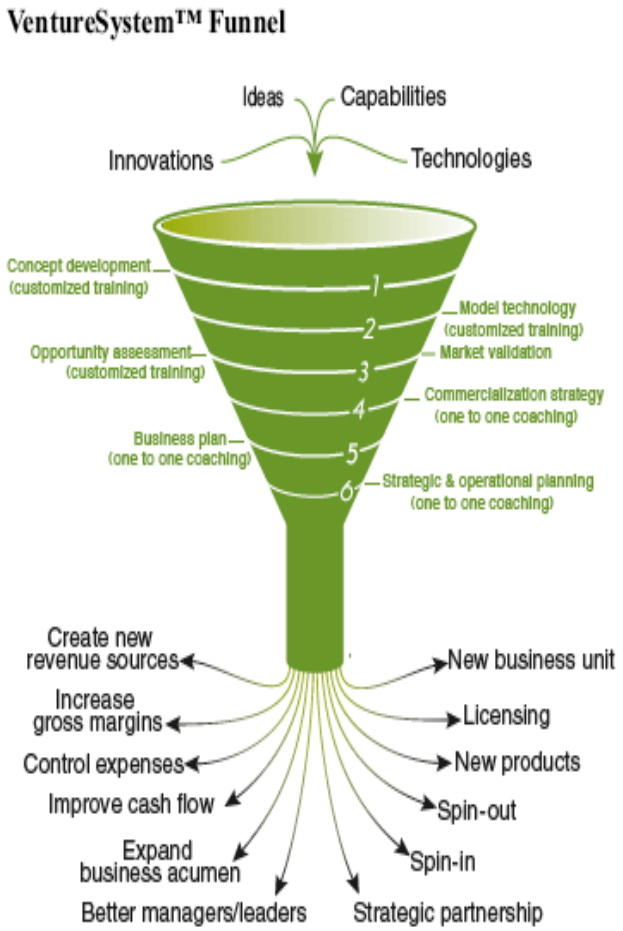
Some achievements so far

Emerged	**Issued**	**Innovations**
1950s-60s	Health	Infra-structure
1970s-80s	Pollution	Clean technology
1990s-00s	Resources	Eco-efficiency*
2000s – now	Consuming	Life cycle management
Emerging	Behaviour	Sustainable Innovations

(*) global investments > USD 2 800 billion/year; international trade > USD 580 billion/year
(based on Lanjouw and Moody, 1996, OECD, 2003)

Supply driven innovations (funnel)

Innovation process: idea, model, proof, expansion



> 10 engineer ideas for 1 invention

> 10 inventions for 1 innovation

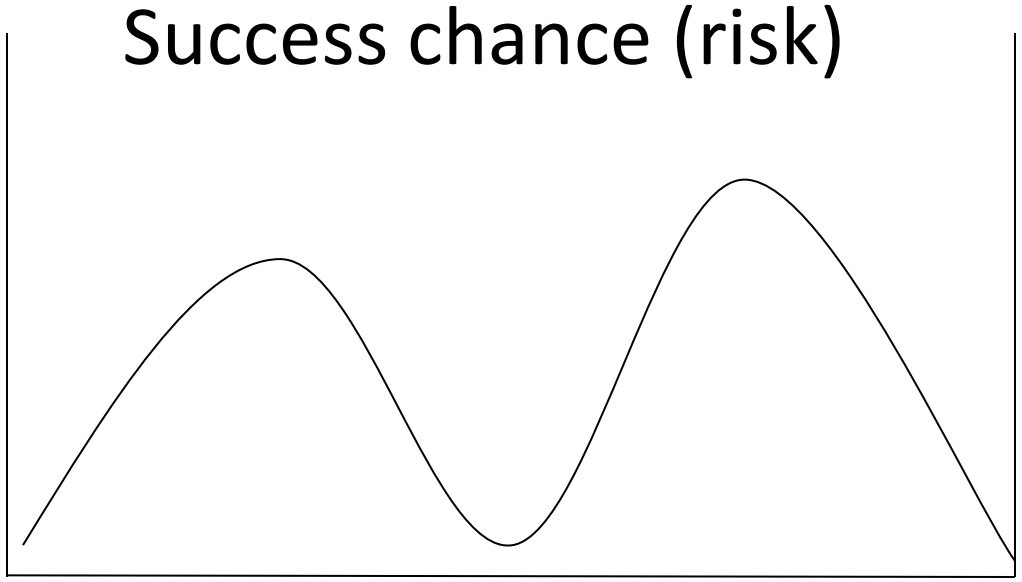
Why innovation funnels don't work and why rockets do.

The 'innovation, funnel' is a widely, used method of sifting wheat from chaff. But since innovation is inevitably a messy business, needing all the help it can get, any process that inhibits creativity or imposes unnecessary stumbling blocks should be viewed with suspicion (David Nichols in *Market Leader*, Autumn 2007, pp 26-31)

Demand driven innovations

Forecasting (funnel)

Backcasting



Developer drivers: e.g. profit, interest, science

User drivers: e.g. need, desire, appeal

Technology development

Market demands

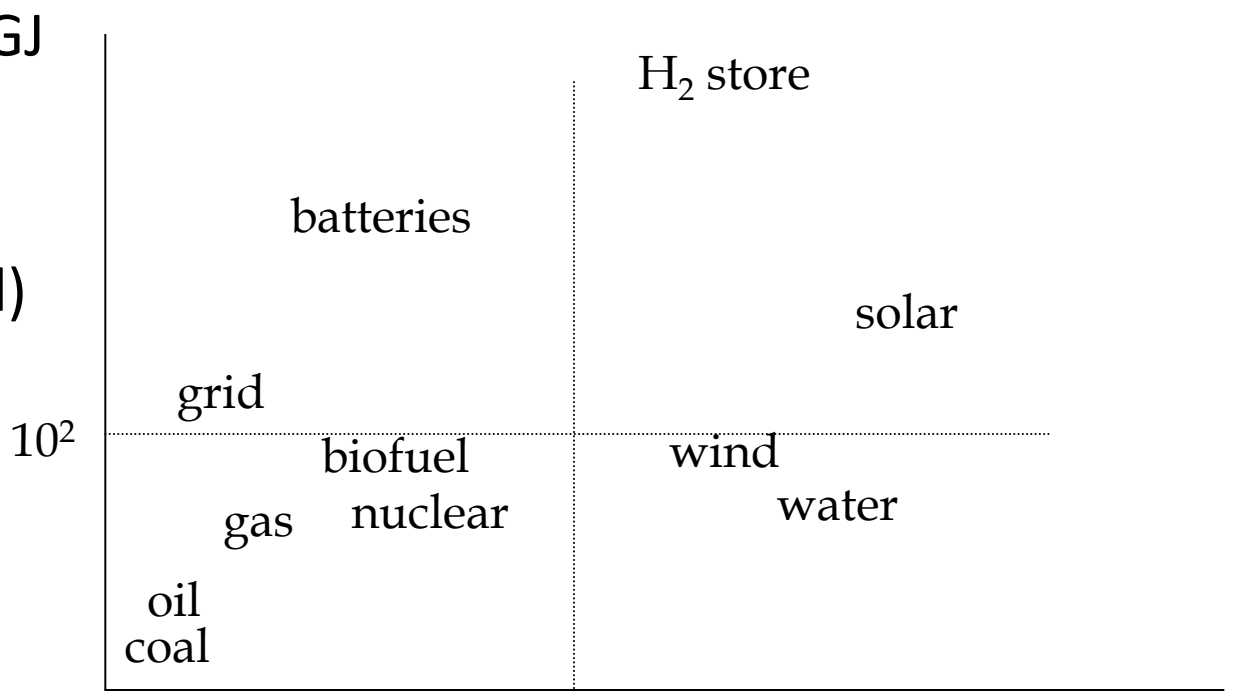
Concept/invention (patent)

Demonstration (proof of concept)

lead-time to market

Innovating in energy

A few examples



Per kW: batteries' added value is >100.000 x coal

Examples of the students' sustainable innovations

Solar energy use thanks to Han Brezet and Jelle Zijlstra

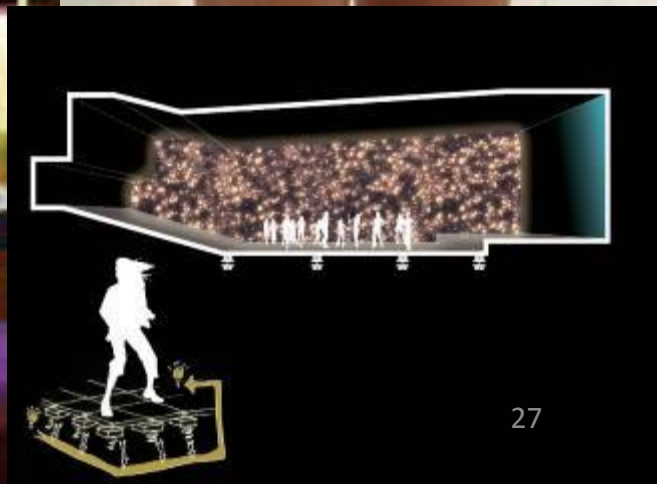
Flexible ? Whenever and whatever

Free? blue solar power all year long

Spiritual? In the forest

“Sexy”?

Rotterdam Sustainable Dance Floor, Frisian Sustain& Entertain



Workshop: whom do you need for progress
15 minutes