Policy dependent LCA outcomes, with examples on climate policy instruments

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Survey

1. Mechanism induced by technology change are at several System Levels
2. Climate policy instruments create and co-determine outcomes of mechanisms
3. In two case examples selected mechanisms are shown.
   1. Increased efficiency of coal fired power stations
   2. Bioethanol replacing gasoline
4. Conclusions: essential influence of choice of climate policy instruments on outcomes of consequential analysis in LC(S)A
Technology choices for sustainability

The ultimate question to be answered:

Would the World get better by making the Right Choice at hand?

- environmentally,
- socially, etc.

• Technology relations prime in “old-fashioned” LCA
• **Replacement** reasoning to better link to choices
• Micro-Close-by
  – as a **proxy** to effects on the Macro-Global World
  – as a **first step** for better approaching effects on the Macro-Global World
Environmental effects of *decisions on technologies*

- Consequences of choices analyzed as:
  - Direct/Indirect or Primary/Secondary effects
  - Consequential LCA
  - Rebound
  - Life Cycle Sustainability Analysis (LCSA)

- Outside LCA as:
  - Impact Assessment, with all similar discussions, including on *rebound*
  - CBA; Integrated Assessment; etc.
Technology choices embedded

Technologies are embedded in:

- **Culture**
  Eg: Will cheap lamps affect lighting behavior, as a rebound?

- **Institutions**
  Eg: Will biofuel lead to deforestation in the tropics?

- **Policies**
  Eg: Will emission savings of high efficiency lighting become zero under cap-and-trade policies?

- **Economics**
  Eg: To what other purchases will the income effect of this cheap product lead?
Effect Mechanisms for Technology Choices analyzed only partially

- **Culture:**
  Some direct/local rebound mechanisms

- **Institutions:**
  Implicitly? Markets not a natural phenomenon

- **Policies:**
  Biofuel as effect yes, but not as consequence: *instruments determining effect mechanisms*

- **Economics:**
  Some (relatively direct) market mechanisms
  ➔ Choice of instruments may determine outcomes
Policy’s double relation to environmental (and other) analysis of technologies

- In LCA, effect mechanisms only as induced by technology choice; *other things being equal*
- Ceteris paribus assumption “reasonable” if induced *mechanisms are independent from the choice* situation
- Climate policy is to induce technology choices, with *alternatives to be analyzed*

⇒ Technology choices depend on (climate) policy instruments
⇒ Consequences of technology choices depend on (climate) policy instruments

Here: *analysis of consequences of climate policy instruments*
Example 1: Efficient heat exchanger on coal fired power station

Efficiency increase of 1 percent point,
from 45% to 46%
Process level emissions down
from 0.84 to 0.82 ton CO₂ / MWh
→ -20kg/MWh

System level 1: full supply chain, technically, “old LCA”:
Also but not here:
fewer methane emissions at coal mining, etc.
Coal power efficiency: policy instruments considered

- **No climate policy instruments**
  Economic mechanisms lead to improvement

- **Carbon pricing as Carbon Tax**
  Adapted economic mechanisms lead to improvement

- **Carbon pricing as Cap-and-Trade (ETS)**
  Adapted economic mechanisms lead to improvement
System levels covering “consequences”: Coal

- **Process level:** Emissions down from 0,84 to 0,82 ton CO₂ / MWh (-20kg/MWh)
- **System level 1:** full supply chain, technically, “old LCA”
  Fewer methane emissions from coal mining, etc.
- **System level 2:** product-specific “rebound”
  Cheaper electricity: more electricity use
- **System level 3:** remaining general income effect, after ‘2’
  Spending income on *anything else*
- **System level 4:** *directly induced market mechanisms*
  Lower coal prices, etc. Here overlap with level 2
- **System level 5:** indirectly induced market mechanisms
  Lower natural gas prices, etc.
- **System level 6:** induced changes in other activities
  More electric cars, etc.
- **System level 7:** institutional and policy changes
  Adaptation of Kyoto targets, acknowledging cheaper emission reduction costs

→ **NO systematic approach to System Levels now available**
→ **Mechanisms per level to be independent**
Efficient coal fired power station

Assumed efficiency increase of 1 percent point, from 45% to 46%

• System level 4/5: (in)directly induced market mechanisms:
  – Lower electricity prices, with higher volumes; related to elasticity of demand
  – Lower coal prices, with lower volumes; related to elasticity of supply
  – If ETS: Lower ETS trading prices, with higher volumes of other CO2 emitting activities
System improvement policy instrument dependent

Process level: *Technical analysis of installation*
*Direct emission reduction* \(\sim 20\) kg/MWh

System level 4:

- **Under no-climate-policy:**
  *Indirect emission reduction* \(\sim 10\) kg/MWh

- **Under carbon tax:**
  *Indirect emission reduction* \(\sim 10\) kg/MWh

- **Under cap-and-trade (ETS-type):**
  *Indirect emission reduction* \(\sim 00\) kg/MWh
Example 2: Bio-ethanol replacing gasoline

Bioethanol 100% (as in Brazil; in EU/US lower %)

System level 1: Supply chain to-the-wheels, $CO_2$ emissions

- **Bioethanol:** 13g/L
- **Gasoline:** 63g/L

(specific mass 0.9; carbon content 72% by mass; upstream emissions adding 10%)

Emission reduction: 50g/L
System levels covering “consequences”: bioethanol replacing gasoline

- **Process level:** [no/hardly emission changes]
- **System level 1:** emission reduction of 50g CO₂/L
- **System level 2:** product-specific “rebound”
  [see 4/5; negative rebound]
- **System level 3:** remaining general income effect, after ‘2’
  [spending less income on anything else]
- **System level 4:** induced direct market mechanisms
  [more expensive combustion car driving: less use]
- **System level 5:** indirectly induced market mechanisms
  [lower natural gas prices; in CAP-and-Trade: lower permit prices; etc.]
- **System level 6:** induced changes in other activities
  [more/fewer electric cars, depending on net effects of different mechanisms, etc.]
- **System level 7++:** Induced institutional and policy changes
  [better and better implemented spatial policies in tropics]
Bioethanol replacing gasoline

System level 1 emission reduction: - 50g/L

• System level 4/5: (in)directly induced market mechanisms:
  – Lower gasoline/oil prices, with higher volumes; related to elasticity of demand
  – Lower gasoline/oil prices, with lower volumes; related to elasticity of supply
  – [Not here: higher food prices; increased intensity in global agriculture, etc.]
Bioethanol as car fuel: policy instruments considered

- **Obligatory percentage bioethanol** (EU & US existing policies)
- **Carbon/ CO$_2$ tax** induced bioethanol (generic instrument, as by upstream administered emission tax / carbon tax / carbon deposit)
- **Cap-and-Trade in CO$_2$ emission permits** (generic instrument also on car driving, upstream administered, *not* as ETS now)
Bioethanol outcomes related to policy instruments

System level 1 reduction: 50g CO$_2$/L

Obligatory percentage bioethanol:
Elasticity of S and D of fossil oil/gasoline reduce ~ 50% of prime effect: 25g CO$_2$/L

Carbon/ CO$_2$ tax:
Idem, ~ 50% of prime effect: 25g CO$_2$/L

Cap-and-Trade in CO$_2$ emission permits:
Emission space filled to cap: 0g CO$_2$/L
Conclusions

1. Systematic views on adding most relevant consequences to technology LCA are lacking: *Anything goes*

2. Climate policy instruments (help) create technical alternatives, to be analyzed in LC(S)A++

3. Instruments of climate policy have very different consequences