The consumer appeal of low-carbon innovation

Charlie Wilson

SPRU, University of Sussex, January 2018
Historical energy transitions are characterised by **new &/or improved energy services**

- lighting
- mobility
Historical energy transitions have been ‘pulled’ by the appeal of **novel attributes** for consumers.

- **novel attributes**
  - functionality, versatility, multiple uses
  - convenience, ease of use, reliability
  - cleanliness (at point of use)

  + more efficient & lower cost energy service

---

Most **low C** innovations in 1.5 - 2°C scenarios offer cleaner, more efficient **substitutes**
Most **low C** innovations compete on **attributes** already valued in mainstream markets

**novel attributes**
- functionality, versatility, multiple uses
- convenience, ease of use, reliability
- cleanliness (at point of use)

* + more efficient & lower cost energy service
* + lower CO$_2$ emissions [reliant on policy]
  
* mobility

[Image of cars]
Most low C innovations compete on attributes already valued in mainstream markets.

**novel attributes**

- functionality, versatility, multiple uses
- convenience, ease of use, reliability
- cleanliness (at point of use)

+ more efficient & lower cost energy service

+ *lower CO₂ emissions* [reliant on policy]

energy production
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?

what are the innovations & attributes? who are the consumers? how do the innovations spread? how big is the impact on emissions?
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?

what are the innovations & attributes?
who are the consumers?
how do the innovations spread?
how big is the impact on emissions?
Disruptive innovations offer novel attributes to users ... and can rapidly change markets

*Sustaining innovations* -> improve currently valued attributes

- power -
- speed -
- storage -
- low cost per MB -

- portability -
- versatility -
- codeability -
- low cost per unit -

*Disruptive innovations* -> offer novel attributes, create new value
Examples of potentially disruptive innovations to mobility: alternatives to car ownership

*Sustaining innovations* -> improve currently valued attributes

*based on ownership*
- upfront cost
- in-car ‘features’
- status signalling

*Disruptive innovations* -> offer novel attributes, create new value

*based on ‘usership’*
- care-free
- relational
- choice variety
Convergence of digital + energy creates new value propositions: mobility-as-a-service (MaaS)

“Mobility-as-a-service will reduce energy demand by 80% and emissions by over 90%”

Arbib & Seba (2017). Rethinking Transportation 2020-2030. RethinkX.
Convergence of **digital + energy** creates new value propositions: *vehicle-to-grid (V2G)*

The end of petrol and diesel cars? All vehicles will be electric by 2025, says expert
Market surveys & consumer behaviour reports identify potentially disruptive low C innovations.

Innovations & novel attributes
- mobility
- food
- buildings & cities
- energy supply & distribution
Workshop with diverse innovation actors to identify potentially disruptive low C innovations

Innovations & novel attributes
- mobility
- food
- buildings & cities
- energy supply & distribution

Energy = innovation:
10 disruptive technologies

Innovator workshop
‘Most disruptive’ and ‘lowest C’ innovations for mobility = EVs, MaaS, car-sharing

- Mobility innovations
  - Electric vehicles
  - Mobility-as-a-service
  - Car-sharing

10 Mobility Innovations

- Potentially very disruptive
- Not potentially disruptive at all

- Electric vehicles
- Mobility-as-a-service
- Car-sharing
- H2FC vehicles
- Advanced biofuels
- Fuel-efficient ICES
- Tele-commuting
- Ride-sharing
- Autonomous vehicles
- E-bikes

Large potential increase in emissions vs. large potential reduction in emissions
‘Most disruptive’ and ‘lowest C’ innovations across four different domains

- **mobility**
  - electric vehicles
  - mobility-as-a-service
  - car-sharing

- **buildings & cities**
  - internet-of-things
  - net zero-energy building design

- **food & agriculture**
  - urban (vertical) farming
  - reduced meat diet

- **energy supply & distribution**
  - solar PV + storage + peer-to-peer trading
  - smart grids + demand response (+ V2G)

*Hard!* tend to be infrastructural

*Hard!* tend to be behavioural

*Hard!* tend to be upstream
‘Most disruptive’ and ‘lowest C’ innovations for mobility: novel attributes valued by users?

**mobility**
- electric vehicles
- mobility-as-a-service
- car-sharing

**novel attributes valued by actual early adopters**
[excluding already valued attributes e.g., cost, efficiency]

- pay per use, service-based
- multiple uses
- active involvement + clean at point of use
- ease of use, control
- relational
- choice variety
- active involvement
Different disruptive low carbon innovations offer **common attributes** of appeal to end users.

<table>
<thead>
<tr>
<th>novel attributes (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Different disruptive low carbon innovations offer **common attributes** of appeal to end users

<table>
<thead>
<tr>
<th>novel attributes -&gt; (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>internet of things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Different disruptive low carbon innovations offer **common attributes** of appeal to end users.

<table>
<thead>
<tr>
<th>novel attributes (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
</tr>
<tr>
<td>internet of things</td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
</tr>
<tr>
<td>urban (vertical) farms</td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
<td><img src="#" alt="graph" /></td>
</tr>
</tbody>
</table>
Different disruptive low carbon innovations offer **common attributes** of appeal to end users

<table>
<thead>
<tr>
<th>novel attributes -&gt; (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>internet of things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban (vertical) farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV + storage + peer-to-peer trading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Different disruptive low carbon innovations offer **common attributes** of appeal to end users.

<table>
<thead>
<tr>
<th>novel attributes (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational</th>
<th>active involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>internet of things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban (vertical) farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV + storage + peer-to-peer trading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

> emphasis of business models for disruptive low C innovations

> atypical early adopters?

> broadly consistent with historical transitions ...

> except ease of use
Next steps: **factor analysis** (to reduce attributes) then **cluster analysis** (to group innovations)

<table>
<thead>
<tr>
<th>novel attributes (relative to displaced incumbent)</th>
<th>pay per use</th>
<th>service-based</th>
<th>multiple uses</th>
<th>choice variety</th>
<th>relational involvement</th>
<th>ease of use</th>
<th>control</th>
<th>autonomy</th>
<th>clean at point of use</th>
</tr>
</thead>
<tbody>
<tr>
<td>electric vehicles (EVs)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>car clubs, car sharing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>internet of things</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>urban (vertical) farms</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PV + storage + peer-to-peer trading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**clusters of innovations** (with similar appeal)

**groupings of attributes**

*then ...*

do these groupings and clusters make sense? are early adopters similarly clustered?

- **spring 2018** structured elicitation of how attributes are perceived
- **summer 2018** large-scale survey questionnaire *(adopters & non-adopters)*
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?

what are the innovations & attributes?  who are the consumers?  how do the innovations spread?  how big is the impact on emissions?
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?

what are the innovations & attributes? 
who are the consumers? 
how do the innovations spread? 
how big is the impact on emissions?
<table>
<thead>
<tr>
<th>TRL^b</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7</th>
<th>8</th>
<th>9</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basic Research</td>
<td>Applied Development</td>
<td>Demonstration</td>
<td>Market Formation</td>
<td>Rapid Diffusion exponential^c</td>
<td>Maturity materiality^c</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>1.5 - 2°C mitigation options in global IAMs</th>
</tr>
</thead>
<tbody>
<tr>
<td>bioCCS</td>
</tr>
</tbody>
</table>

Sources:

^a Wilson & Grubler (2014)

^b EC (2017)

^c Kramer & Haigh (2009)

^d Bento & Wilson (2016)
<table>
<thead>
<tr>
<th>TRL</th>
<th>Basic Research</th>
<th>Applied Development</th>
<th>Demonstration</th>
<th>Market Formation</th>
<th>Rapid Diffusion</th>
<th>Maturity</th>
<th>Technology Lifecycle</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
<td>6</td>
</tr>
<tr>
<td>1.5-2°C mitigation options in global IAMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>bioCCS</td>
<td></td>
<td>fossilCCS</td>
<td>solar power</td>
<td>wind power</td>
<td>nuclear power</td>
<td>biofuel vehicles</td>
<td>electric vehicles</td>
</tr>
<tr>
<td>1.5-2°C mitigation options in global IAMs</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mobility-as-a-service</td>
<td>autonomous vehicles</td>
<td>cultured meat</td>
<td>internet of things</td>
<td>electric vehicles</td>
<td>peer-to-peer electricity trading</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Sources:

- Wilson & Grubler (2014)
- EC (2017)
- Kramer & Haigh (2009)
- Bento & Wilson (2016)
Can consumer-facing innovations offering novel attributes help stimulate demand for a low-carbon future?

what are the innovations & attributes?  
who are the consumers?  
how do the innovations spread?  
how big is the impact on emissions?

are these even meaningful and/or useful questions to ask?!?
There is no consensus on the meaning or relevance of *disruptive* low-carbon innovation.

innovator workshop

disruptive innovation
= innovation

There is no consensus on the meaning or relevance of *disruptive* low-carbon innovation.

**Innovator workshop**

- Disruptive innovation = innovation

**Researcher workshop**

- System not discrete innovations = necessary unit of analysis
- System processes not consumers = determinant of diffusion
- Continuity not disruption = desirable narrative

Special Section on 'Disruptive Innovation and Energy Transformation'
Energy Research & Social Science

Innovation-centric explanations of adoption and diffusion have a very robust evidence base.

**Diffusion** = communication over time about an innovation among members of a social system.

Five attributes of innovations determine adoption rates:

1. Relative advantage
2. Compatibility
3. ...
Multi-level perspective provides a compelling account of **system change** (and stability)

"With regard to consumers and households ... crossovers to traditional adoption approaches (Rogers, 1996) ... are under-explored, perhaps because of an excessive fear of using reified analytical categories."


Usefulness to MLP of diffusion of innovations’ explanatory power seems worth exploring

MLP, meet diffusion of innovations

locally-rich explanation of diffusion and role of social networks (and users)

clusters of innovations (by attribute) with linked diffusion processes

‘mainstream’ innovations (in terms of rules, markets)

(1) relative advantage
(2) compatibility
Conclusions: disruptive low C innovations can engage (or even potentially excite) consumers

Disruptive innovations offer novel attributes valued by consumers (a missing constituency of low C transformation)

Disruptive innovations are primarily about business models and users (not radical technological breakthroughs)

Novel attributes of potentially disruptive low C innovations in different domains include:

- pay-per-use (rather than ownership)
- multiple uses & functionality (rather than single purpose)
- relational & active involvement (rather than isolation & passivity)
- control & autonomy (rather than dependence on systems)

Digitalisation of daily life enables many of these novel attributes
The consumer appeal of low-carbon innovation

Charlie Wilson

SPRU, University of Sussex, January 2018