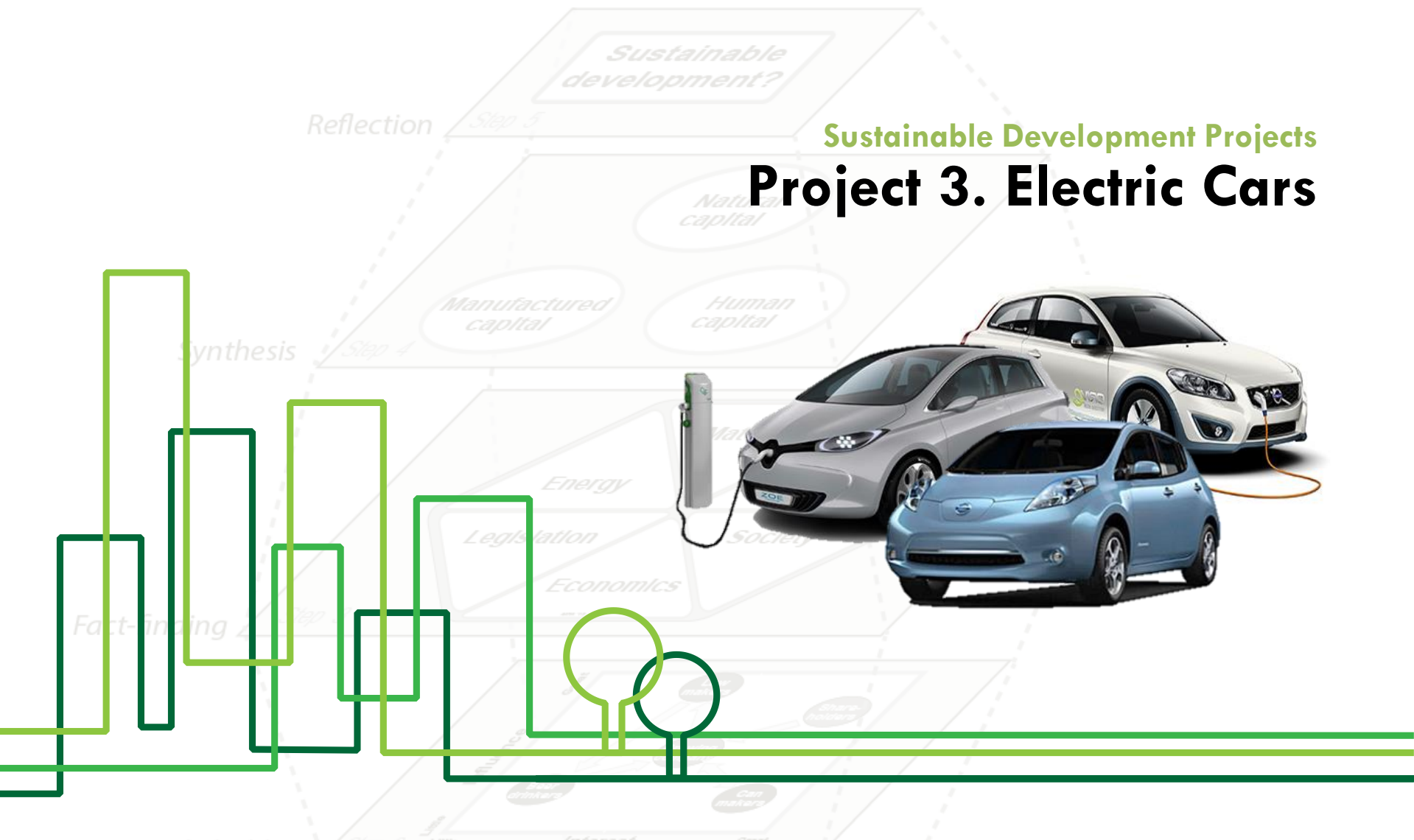
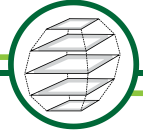


Sustainable Development Projects

Project 3. Electric Cars



Step 1: Project, prime objective and scale



Prime objective and scale

- *Decarbonize road transport*
- *Replace petrol/diesel by electric*
- *10% electric by 2020*

Background

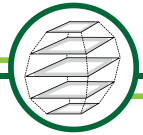
*Global car production : 60 million units per year
15 % of global fossil fuel CO₂ release comes from cars*

Thus



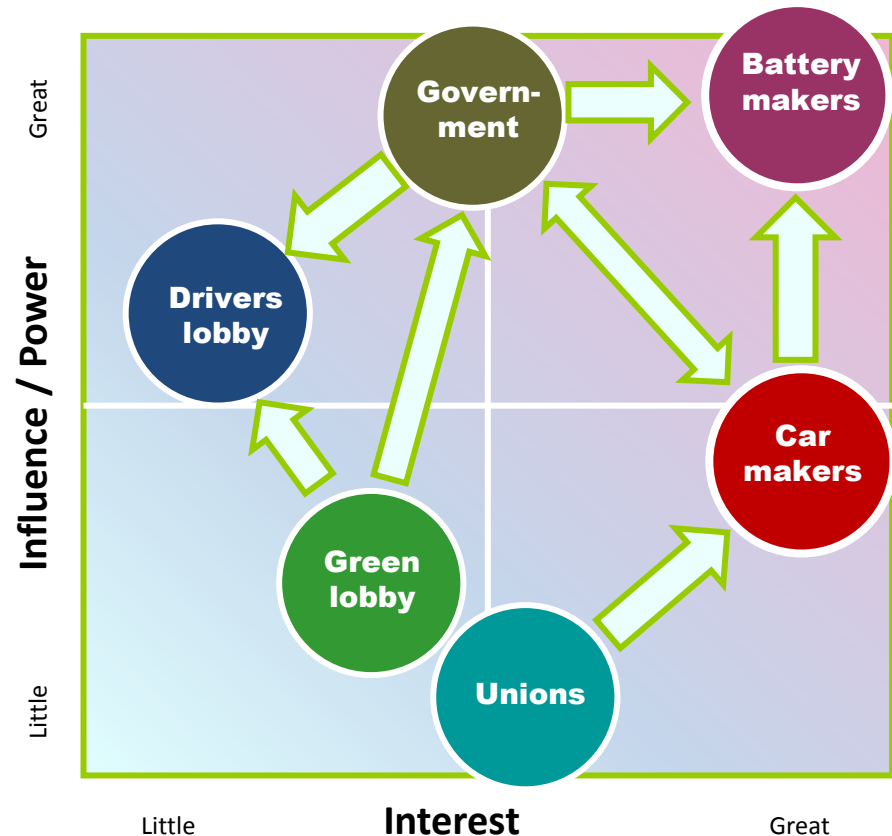
- *8 million e-cars per year by 2020*

Step 2: Stakeholders and concerns

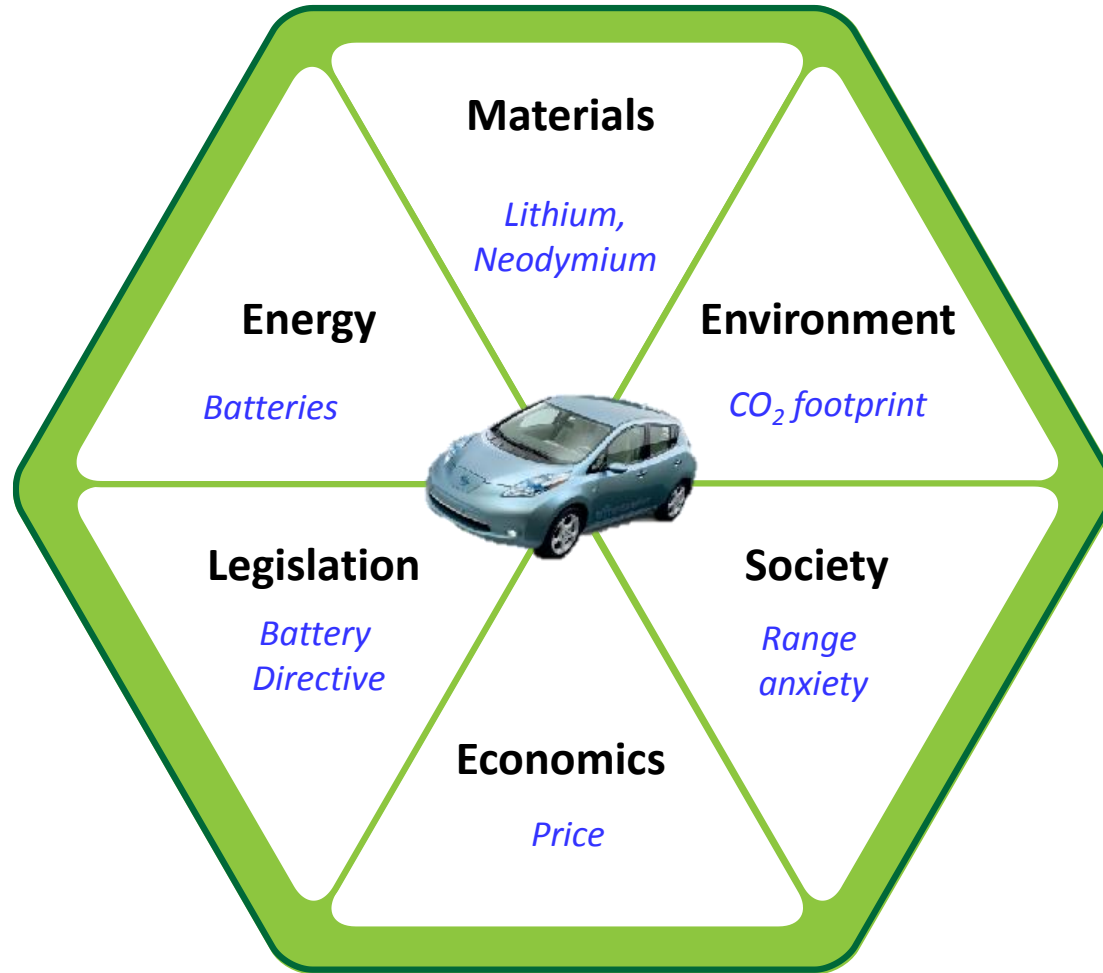
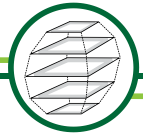


- National and local government
– *carbon targets*
- Car makers and distributors
– *sales*
- Battery makers
– *Supply chain, recycling*
- Labor Unions
– *employment, rights*
- Drivers, Automobile Associations
– *range anxiety, cost*
- Environmental campaigners
– *carbon footprint*

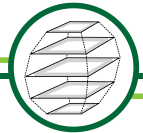
Stakeholder diagram



Step 3: Fact-finding



Fact-finding: Materials / Energy / Regulation



Electric car

| Bill of materials | kg |
|--------------------------------|---------------|
| Carbon steel | 790 |
| Cast iron | 151 |
| Wrought aluminum (10% recycle) | 30 |
| Cast aluminum (35% recycle) | 64 |
| Copper / Brass | 26 |
| Magnesium | 0.3 |
| Glass | 39 |
| Thermoplastic polymers | 94 |
| Thermosetting polymers | 55 |
| Rubber | 33 |
| Platinum, exhaust catalyst | 0.007 |
| Electronics, emission control | 0.27 |
| Lithium | 7.3 kg |

Linked data-tables



*Materials with
source-nation*



*Power generation
systems*



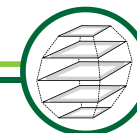
*Energy storage
systems*



Regulation and legislation



*Nations: people, governance,
human rights, economy,
development*



**Lithium-ion
batteries**



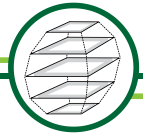
8 million cars per year, 7.3 kg Lithium per car

= 58,400 tonnes per year

Lithium production (2011)

| Nation | Tonnes/year |
|------------------|---------------|
| <i>Chile</i> | <i>12,600</i> |
| <i>Australia</i> | <i>11,300</i> |
| <i>China</i> | <i>5,200</i> |
| <i>Bolivia</i> | <i>5,000</i> |
| <i>Argentina</i> | <i>3,200</i> |
| World | 34,000 |

Li demand = 160% present world production



Lithium ion



Nickel metal hydride



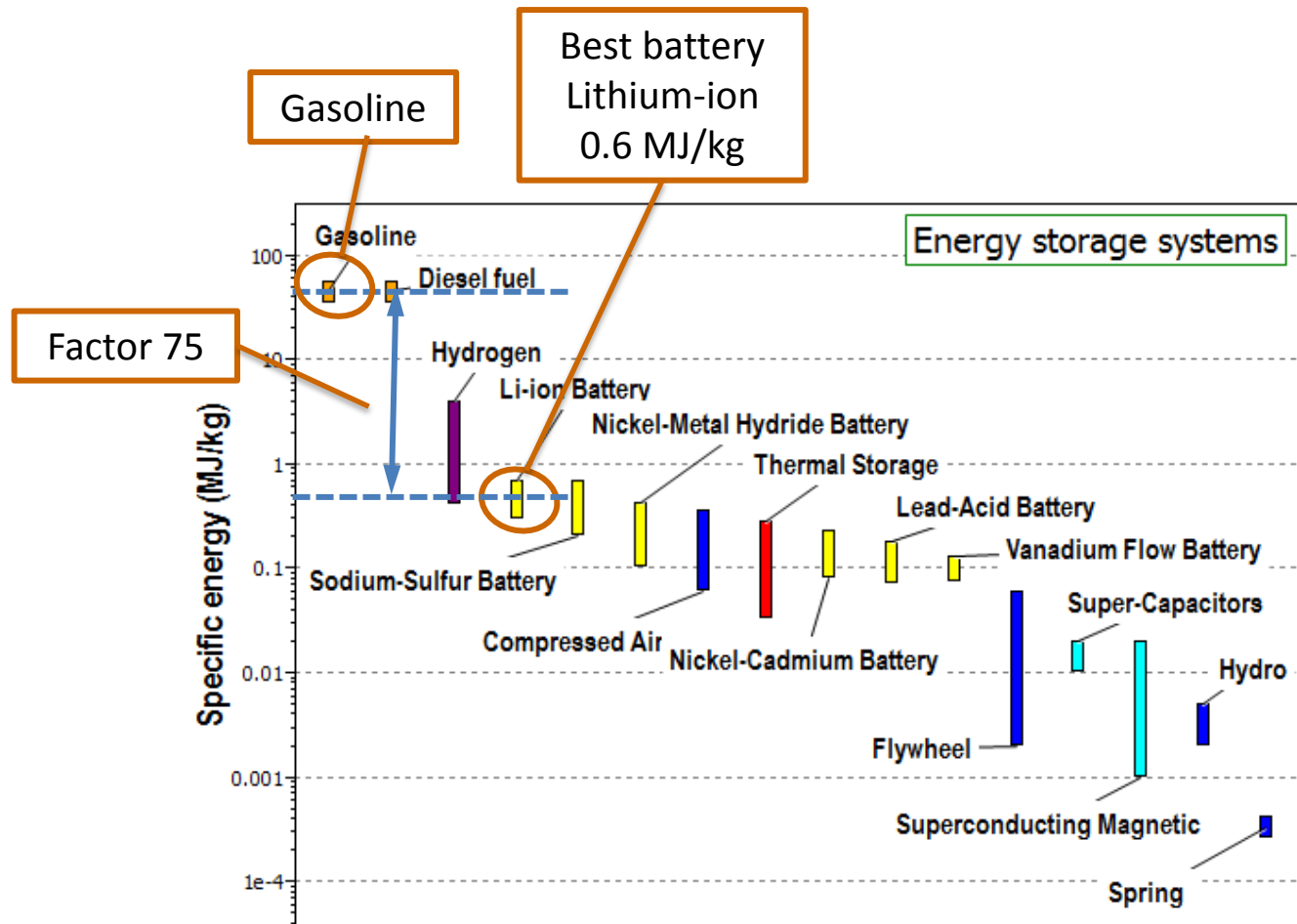
Nickel cadmium



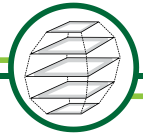
Lead-acid

Alternative batteries?

Seek high energy density (MJ/kg)

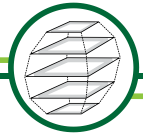


Fact-finding: Materials / Energy / Regulation



- US CAFE Standard – *Fleet mileage standard*
- EU Automotive Fuel Efficiency Standard – *Fleet mileage standard*
- EU End-of-Life Vehicles Directive – *85% recycled by 2015*
- EU Battery Directive – *No batteries to landfill*

Environment: Can Prime Objective be met?



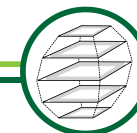
Decarbonize road transport?

Charge vehicle from the National Grid, gas / coal fired.

- CO_2 footprint, gas fired power $\approx 140 \text{ g / MJ}$
- Delivered energy to propel small car $\approx 0.6 \text{ MJ / km}$
- Efficiency of battery – electric motor set $\approx 85\%$

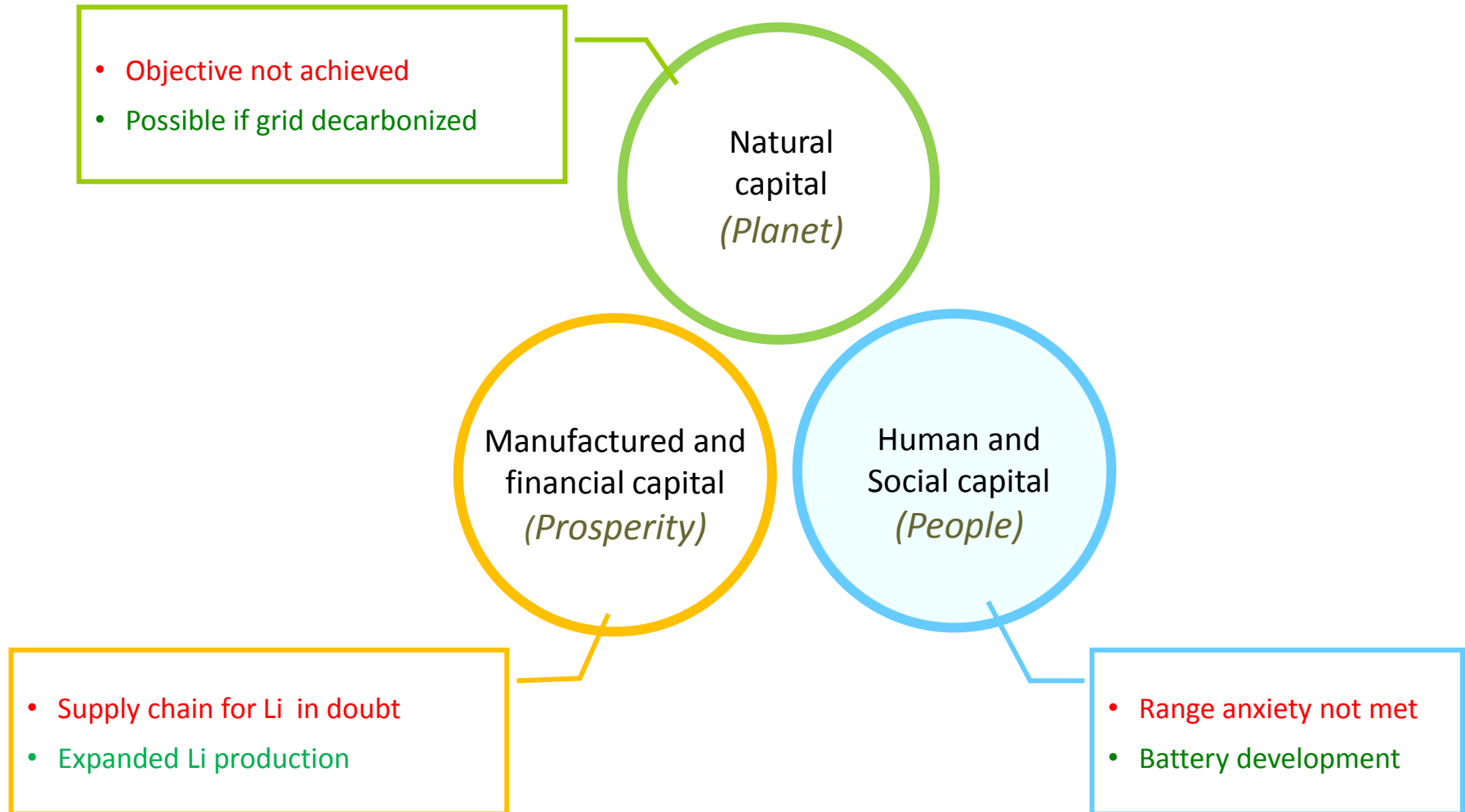
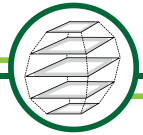
Carbon footprint of electric car $\approx 140 \times 0.6 / 0.85$
 $\approx 100 \text{ g / km}$

Step 4: Impact on the Three Capitals (details)

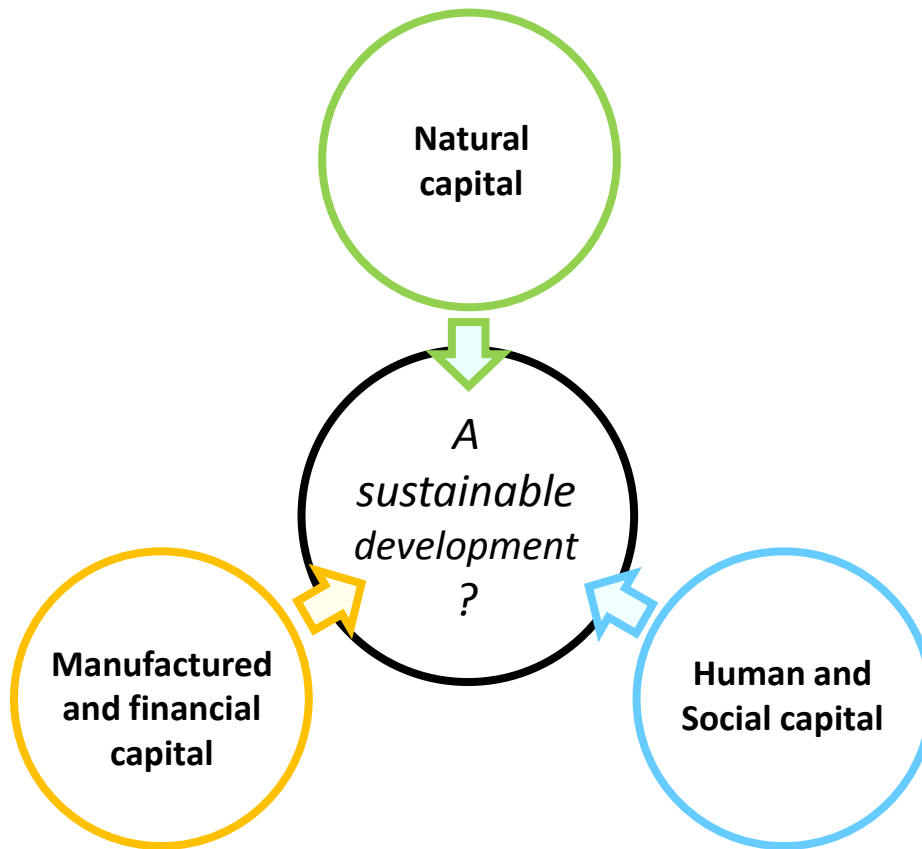
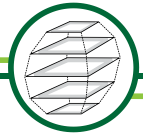


| | Human and social capital - People Health? Wellbeing? Convenience? Culture? Tradition? Associations? Perceptions? Contributes to equality? Morality? | Natural capital - Planet <i>Can prime objective be met?</i> <i>Are stakeholder concerns addressed?</i> <i>Are there unwanted consequences</i> | Manufactured capital - Prosperity Cost – Benefit? (Cost facts vs. Eco facts) Legitimacy? (Conformity with law) |
|--|---|--|--|
| Materials | (–) Creates dependence on rare-earth and lithium-producing nations | (–) Creates demand for critical elements, notably Lithium and Neodymium, in kg-quantities per car (+) Use of Li and Nd in kg-scale components makes collection for recycling easier | (–) Requirement to create recycling infrastructure for lithium- and rare-earth elements |
| Energy | (+) Could reduce dependence of imported fossil fuels in oil-poor nations | (–) Very little contribution to carbon emissions unless national grid is decarbonized | (+) Creates employment in energy sector (–) Need for additional power stations (–) Need for investment in recharging point |
| Environment | (+) Reduces emission levels in large cities | (+) Offers potential for clean energy for transport | – |
| Legislation | (+) Helps meet the nation's commitments to reduce emissions | (+) Take-back and recycling legislation reduces waste stream, contribute to a circular economy | (–) Meeting end-of-life regulations creates additional costs |
| Economics | (–) Need to subsidize sales of electric cars adds becomes a “green” tax. | | (–) Profitability uncertain without government subsidies (–) Large capital investment in new electricity generating plant to provide for charging |
| Society | (+) Satisfaction in using an “emission-free” transport (–) Range anxiety (–) Paucity of charging points | | (+) Creates employment in high-tech industry (+) Creates jobs, stimulates local industry |
| Synthesis (the most telling facts) | (+) Satisfaction reducing environmental impact (–) Dissatisfaction with green taxes used to subsidize green transport | (+) Ultimate success dependent on new battery technology, decarbonized grid and adaptation to range limitations – impossible in short term (+) But potentially possible in the long term. | (–) Electric cars not, at present, economic. Many issues to be resolved to make it so. |

Step 4: Impact on the Three Capitals (overview)



Step 5: Reflection



Short term – 7 years

- Not in envisaged scale and time

Long term – 25 years

- Establish infrastructure

Alternative strategies?

- Re-think (re-define?) car use

Sustainable Development Projects

This resource:

- **Projects**

- Project 1 : Greener Beer Cans
- Project 2 : Expanding Biopolymer Production
- ▶ **Project 3 : Electric Cars**

- **Resources**

- Students**

- Problem statement
- Templates
- Assessing Sustainable Development

- Educators**

- ▶ **Summary Presentation**

- Sample Analysis
- Related Projects

A White Paper called Materials and Sustainable Development and a book of the same name describe this methodology and the rationale behind it in more detail.

<http://teachingresources.grantadesign.com/Type/Papers/PAPSSDEN13>

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