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Sustainable Technology Project

Mike Ashby
Didac Ferrer
Jordi Segalàs

Department of Engineering
University of Cambridge,
Granta Design, Cambridge and
Universitat Politècnica de Catalunya

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Fuel efficient, but sustainable?

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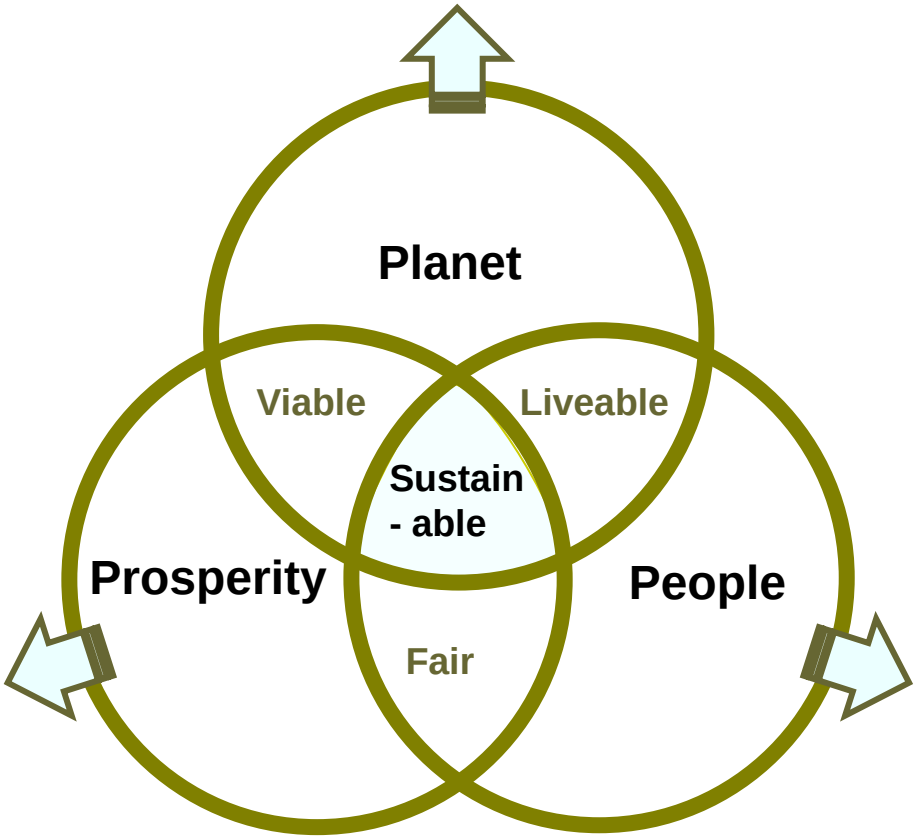
Safe, but sustainable?

SUSTAINABILITY ?

- *Energy*
- *Materials*
- *Environment*
- *Emissions*
- *Safety*
- *Legality*
- *Social acceptance*
- *Space*
- *Economics*

Triple Bottom Line accounting



Corporate sustainability report:

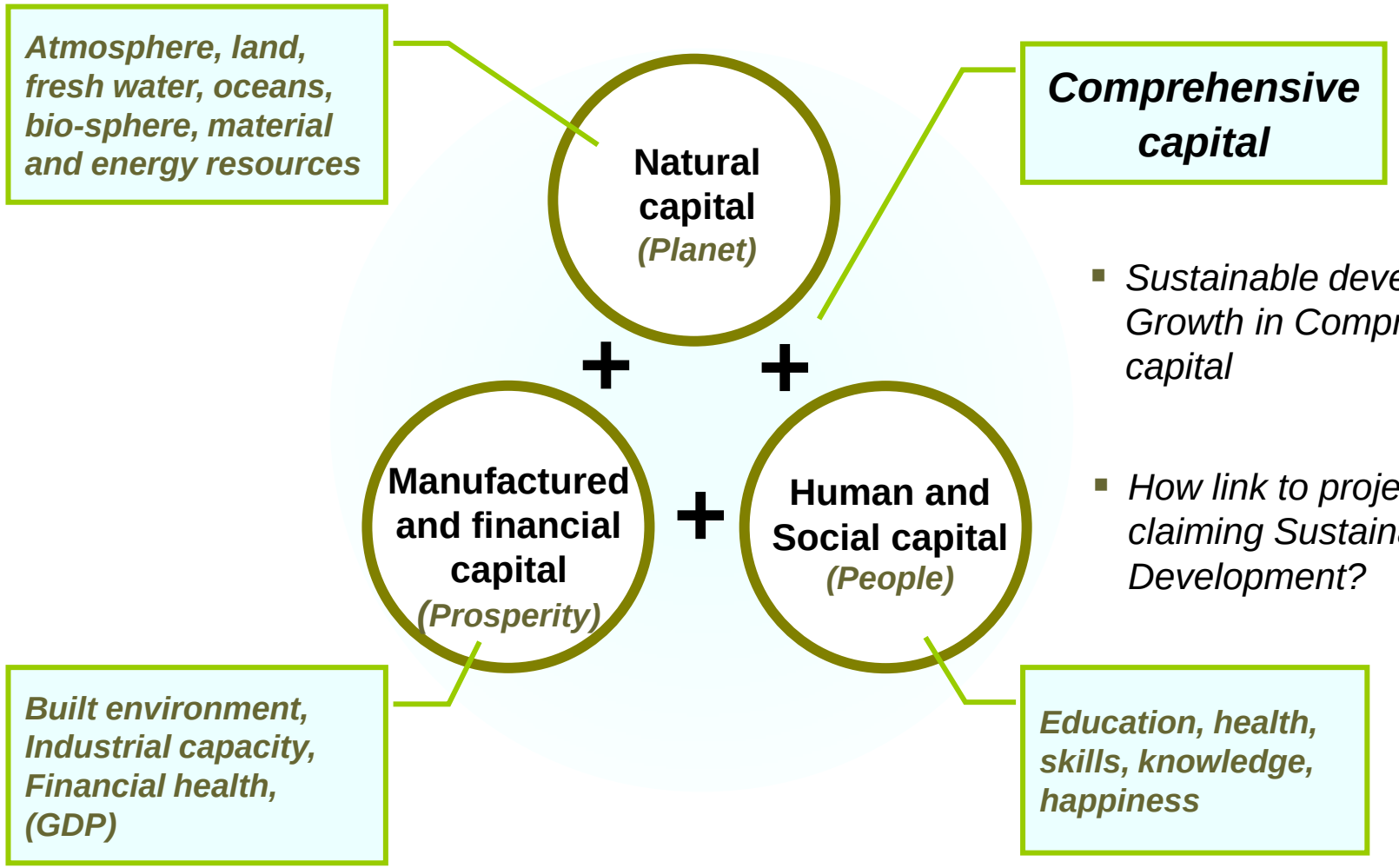
- *Financial bottom line*
- *Social / ethical performance*
- *Environmental performance*

- *Dow Jones Sustainability Index*

- *But what can Engineer do?*

- *Decouple – unpack meaning*

Macro-economic view: the Three Capitals



- *Sustainable development = Growth in Comprehensive capital*
- *How link to projects claiming Sustainable Development?*

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Articulations of sustainable development

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Many single actions ("articulations") claim to support sustainable development

Motivation *(Prime objective)*	Articulation	Unintended consequence
▪ *Reduce dependence on oil*	**Bio-fuels Bio-polymers**	*Competition with food production (People)*
▪ Stimulate low-carbon economy	**Carbon taxes**	Increase energy price *(Prosperity)*
▪ Stimulate circular materials economy	**Mandatory recycling**	Inhibits use of advanced materials *(Planet)*

Each articulation has a **Prime Objective** with a { **physical scale** / **time scale**

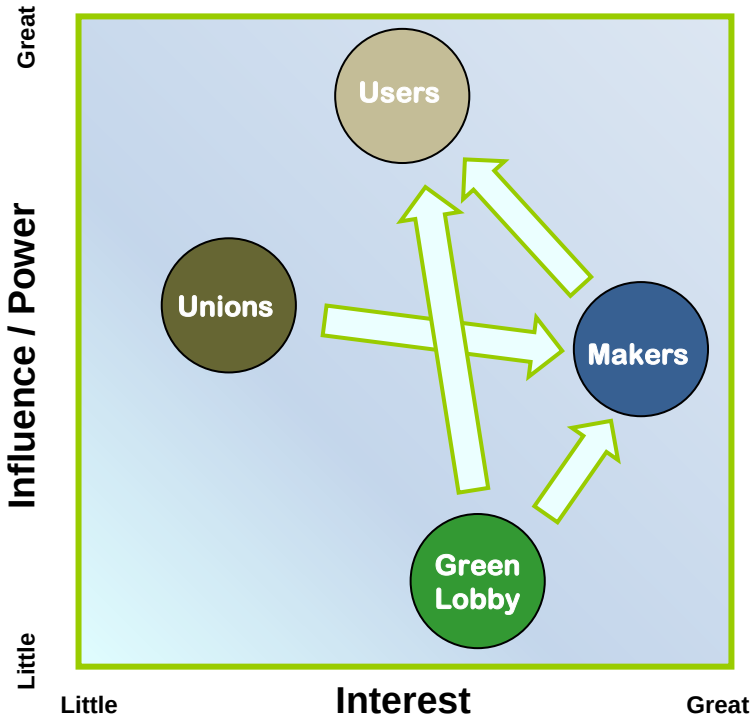
The Stakeholders

Stakeholders

- *Who are they?*
- *What are their concerns?*
- *What power do they have?*

- *Government*
- *The public*
- *Local communities*
- *Owners*
- *Manufacturers*
- *Suppliers*
- *Trade Unions*
- *Customers*
- *Lobbyists*
- *Investors*
- *National press*
- *Managers, colleagues, team*

Stakeholder diagram



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Map of Articulations

What do we learn? Group under

- Materials
- Environment
- Design
- Regulation
- Society
- Economics

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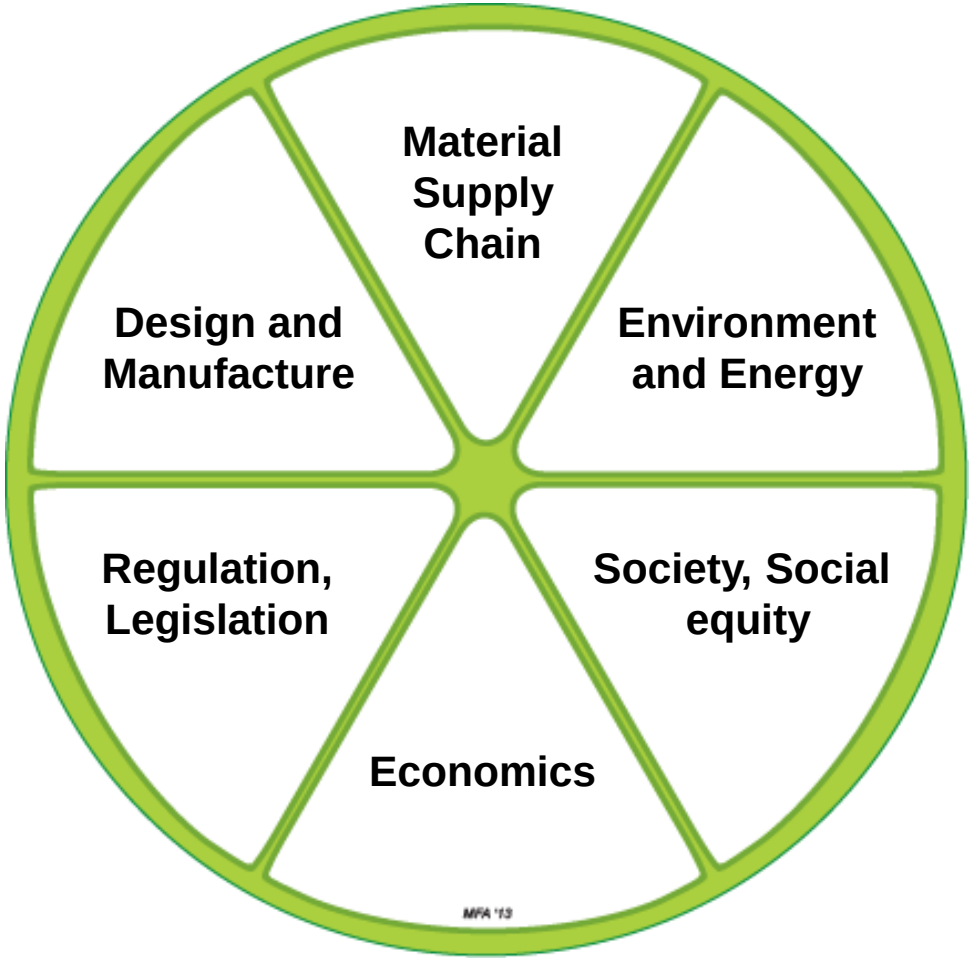
Analysing an “articulation”



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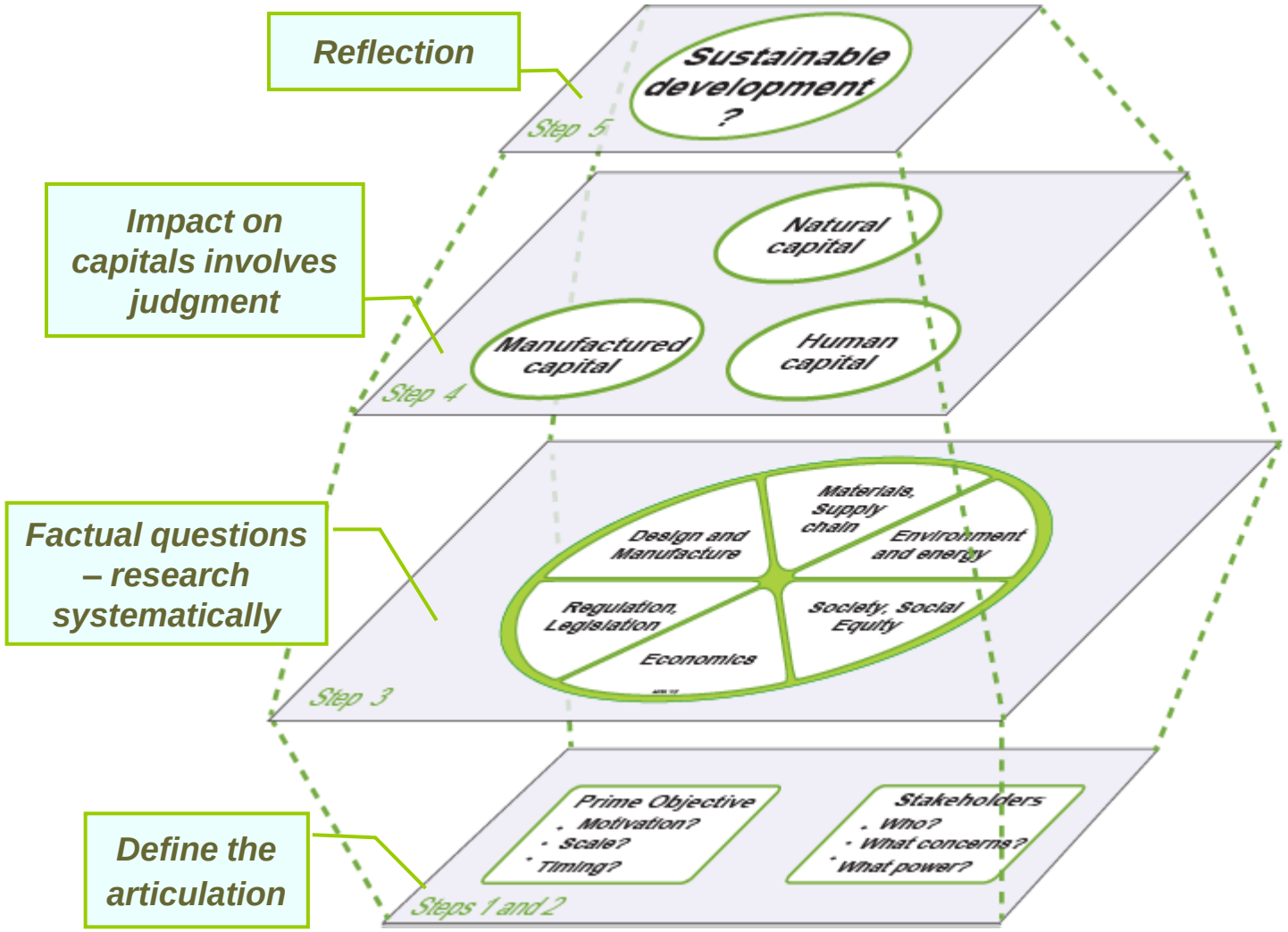

5-step method

1 Objective

2 Stakeholders

3 Fact-finding

4 Debate impact

5 Reflect

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The electric car – Step 1: Prime objective

Background

Global car production : 60 million units per year

15 % of global fossil fuel CO_2 release comes from cars

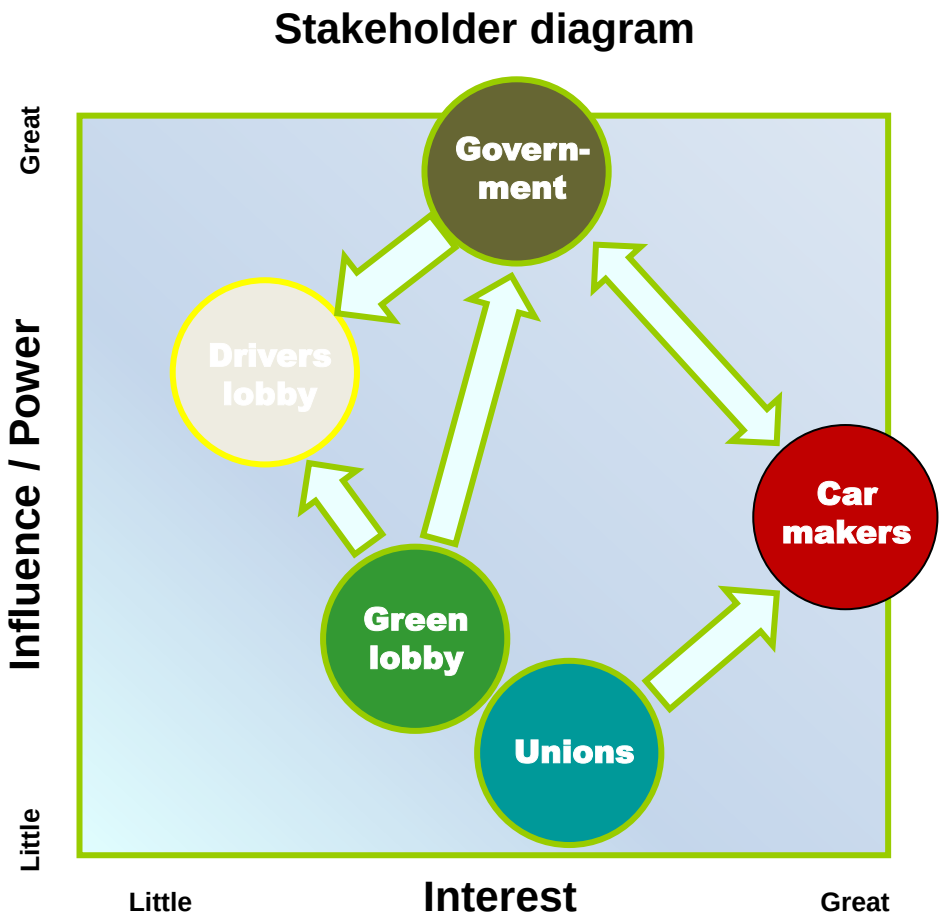
Governments offer Incentives : 20% electric by 2020

Prime objective and scale

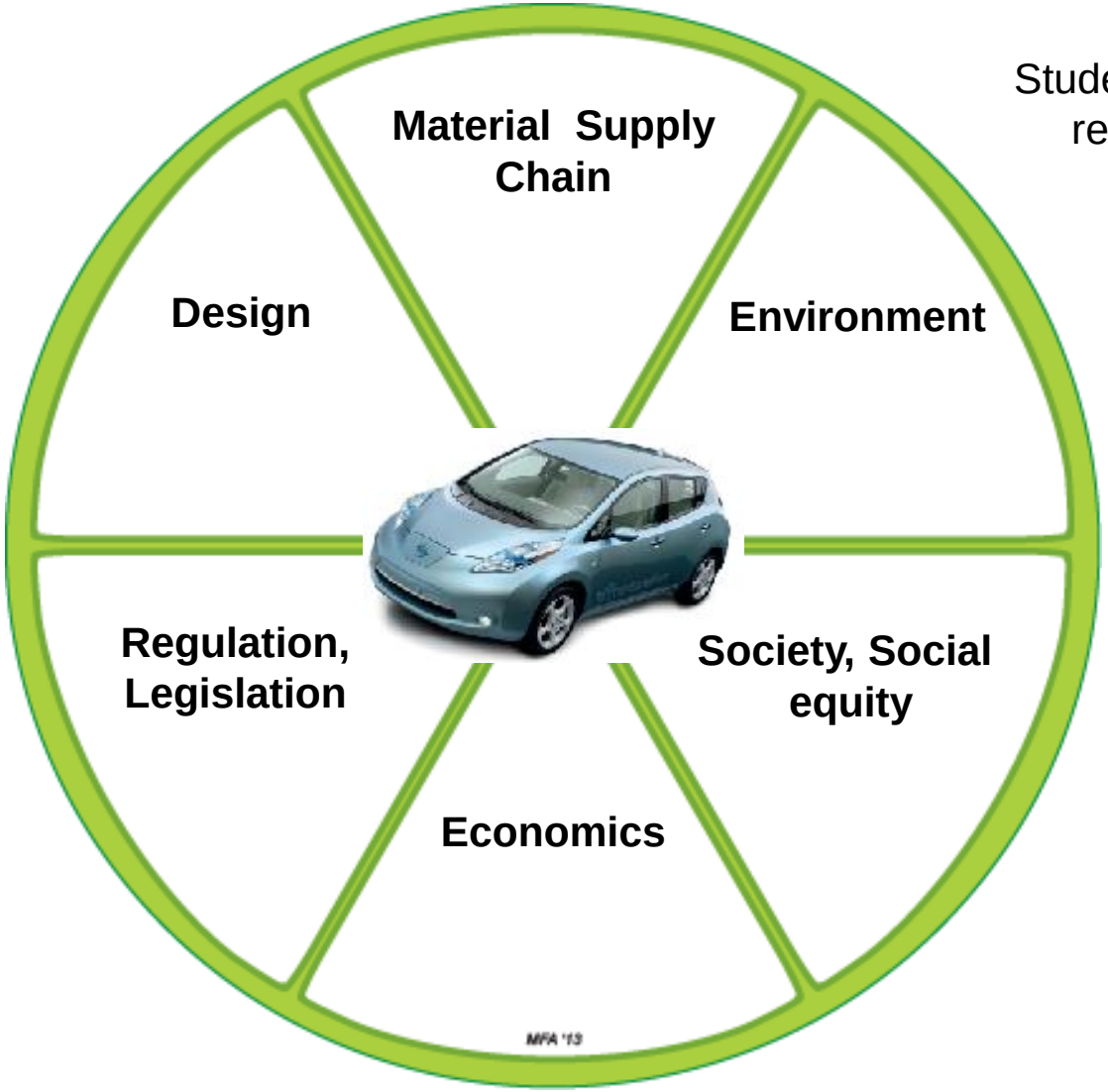
- *Decarbonize road transport*
- *16 million cars/year by 2020*

Step 2: Stakeholders and concerns

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



Step 3: Fact-finding



Students (in groups) research facts

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Fact-finding : Materials

Lithium-ion batteries

Neodymium-boron magnet motors

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
Neodymium	**1.5 kg**
Lithium	**4.8 kg**

16 million cars per year, 4.8 kg Lithium per car

= 76,000 tonnes per year

Lithium

Producing Nation	Tonnes/year 2011
Chile	*12,600*
Australia	*11,300*
China	*5,200*
Bolivia	*5,000*
Argentina	*3,200*
World	**34,000**

***Li** demand = **230%** present world production*

Fact-finding: Design

Alternative batteries?

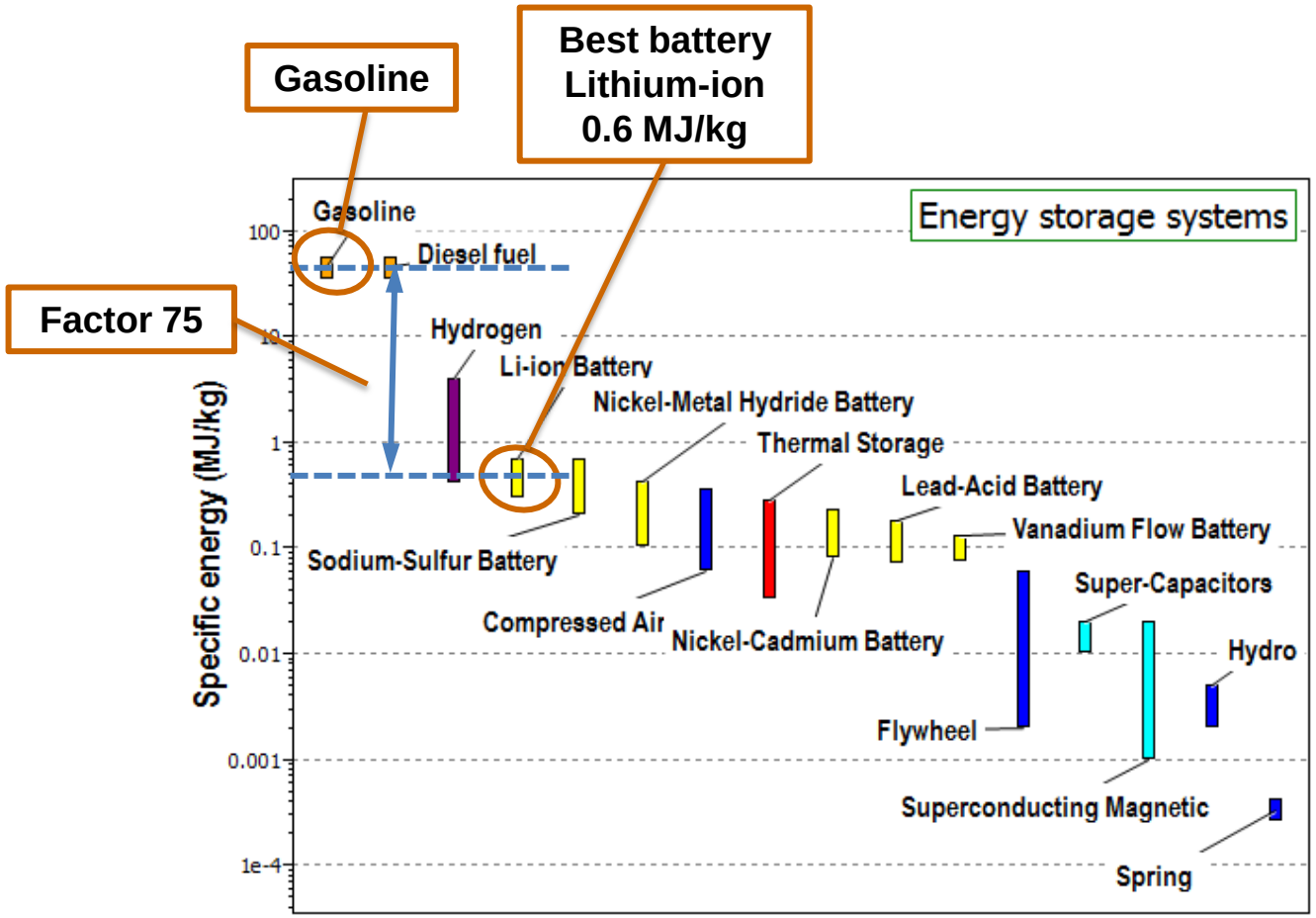
Seek high energy density (MJ/kg)

Lithium ion

Nickel metal hydride

Nickel cadmium

Lead-acid



Fact-finding: Regulation

- **US CAFÉ 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?

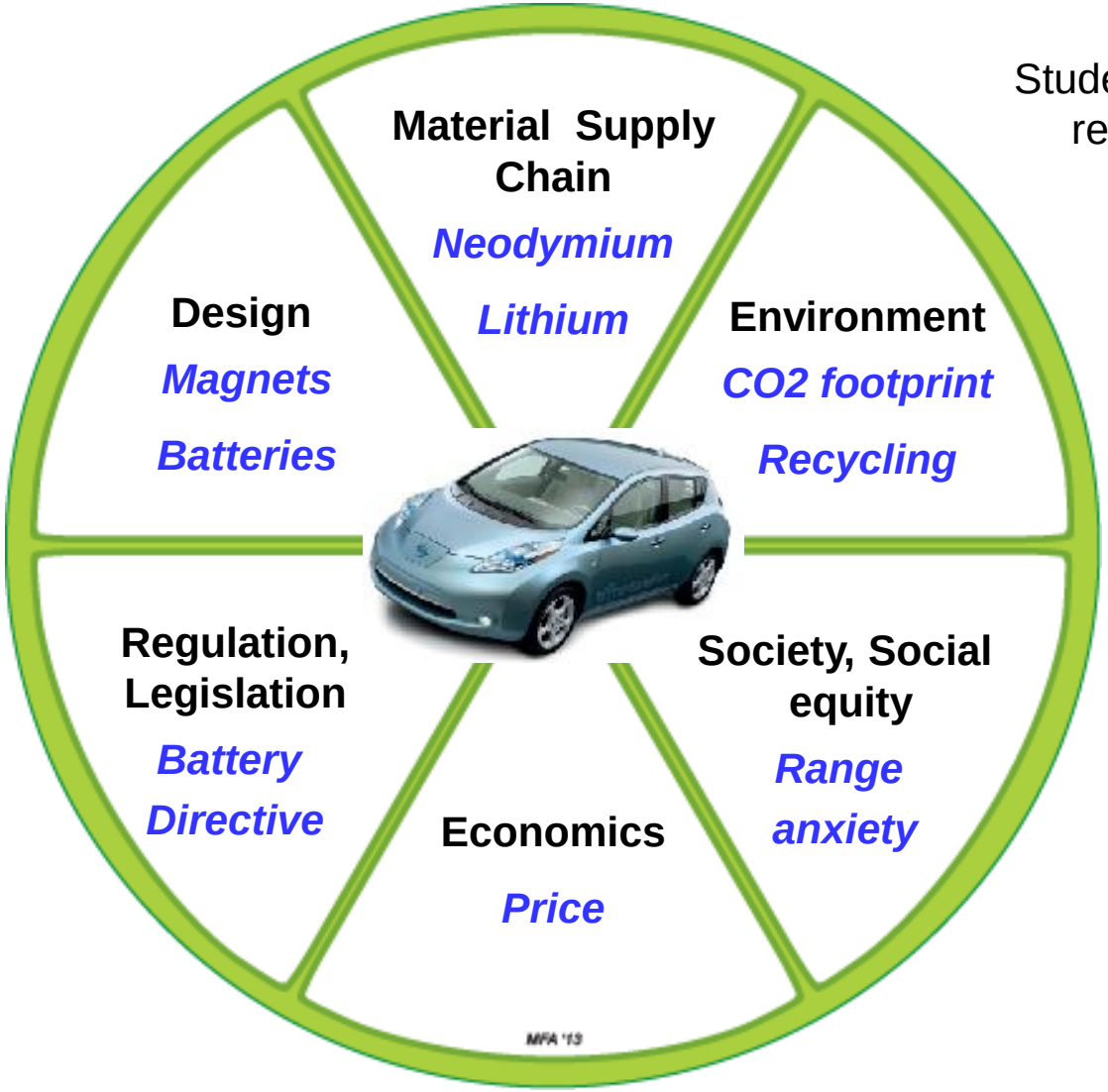
Charge vehicle from the National Grid, gas / coal fired.

- CO_2 footprint, gas fired power ≈ 140 g CO2/ MJ
- Delivered energy to propel small car ≈ 0.6 MJ / km
- Efficiency of battery – electric motor set ≈ 85%

Carbon footprint of electric car ≈ 140 x 0.6 / 0.85

≈ **100 g CO2 / km**

Step 3: Fact-finding



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Step 4 Integration – impact on the 3 capital

	NATURAL CAPITAL	HUMAN CAPITAL	MANUFACTURED CAPITAL
MATERIAL	• Drain on scarce resources (rare earths) • Potential for recycling high		• Supply chain for lithium, neodymium inadequate
ENVIRONMENT	• 100 g CO_2/km = Objective not achieved • Gain possible if grid decarbonised		
REGULATION	Mandatory recycling		• Lack of recycling infrastructure for lithium, neodymium
SOCIETY		• Range anxiety not met • Creates jobs	• High cost of car an obstacle
DESIGN			Technically proven

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Step 5 – Reflection

Short term – 7 years

- Not in envisaged scale and time

Sustain-able?

Long term – 25 years

- Establish infrastructure

  Low carbon grid,

  Material supply chain

  Li and Nd recycling facilities

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

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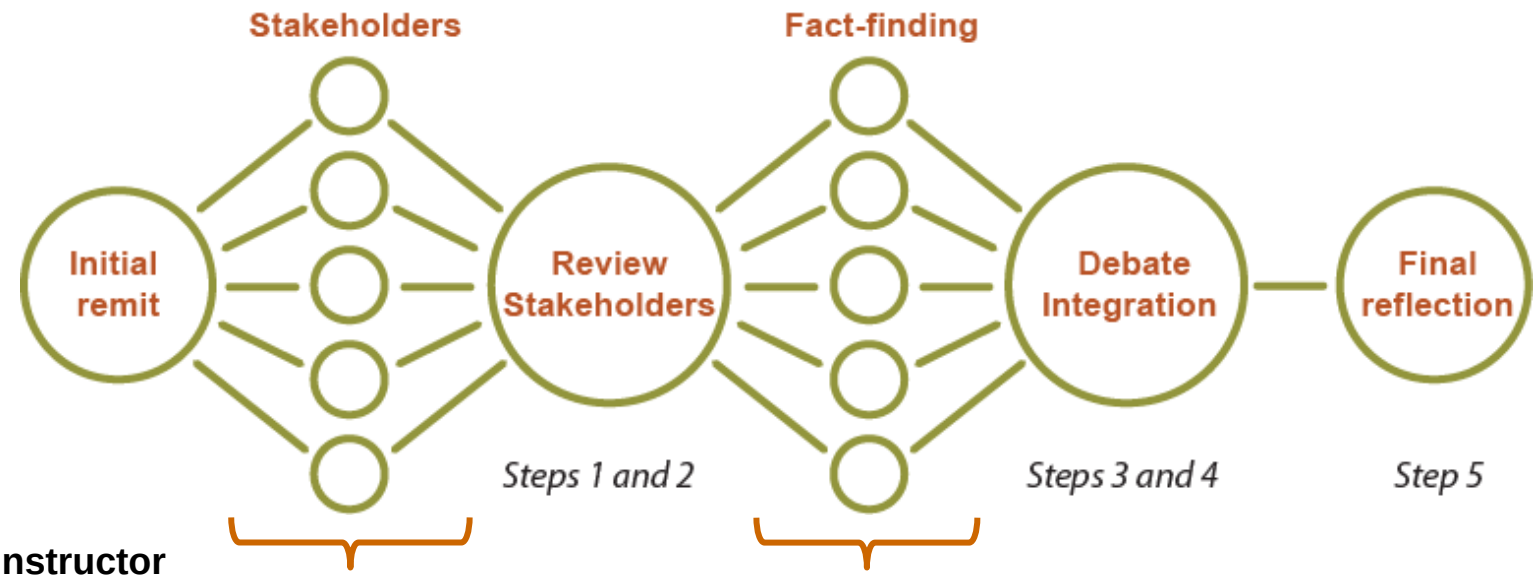
Running the project



Instructor introduces project

Students in groups

Discuss as class

Students in groups

In-class debate

Open question to class