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Environmentally friendly insulation for Switchgear systems

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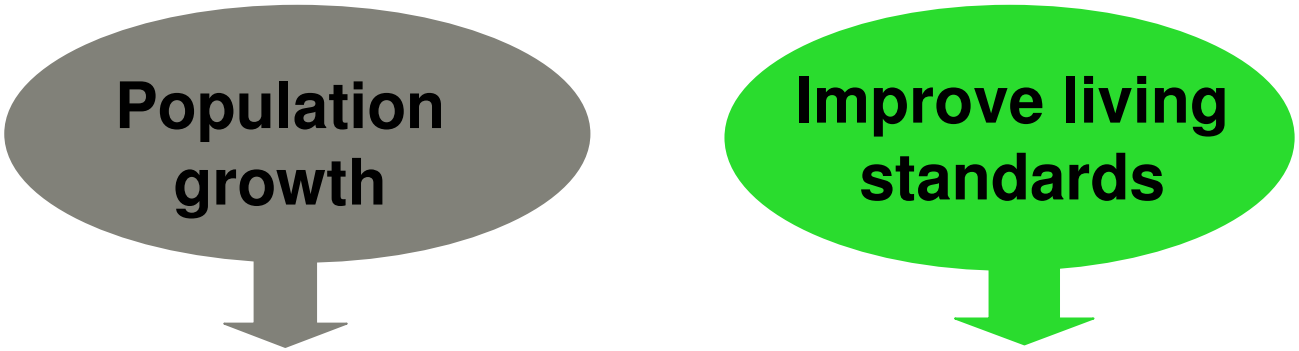
Environmental Impacts Legislation & Directives

What for the future ? - predictions



- **Strong growth in energy demand expected to double from 2004 to 2030 (*2.6% per year on average*)**
- **Development of access to electricity in an integrated and sustainable approach**

Answering to:

"*meet the needs of the present without compromising the ability of future generations to meet their own needs*"

(" Our common future" published in 1987 by World Commission on Environment and development – Brundtland report)

Effect on our planet

- Any human activity (*may be a process, product or service)* generates environmental impacts

Waste

Water pollution

Soil pollution

Air pollution

2.6btonne of industrial/agricultural/domestic waste each year in Europe

Environmental impacts

- **Different kinds of environmental impacts**
  - **Greenhouse effect**
  - **Ozone depletion layer**
  - **Acidification**
  - **Eutrophication**
  - **Photochemical Ozone, toxicity and ecotoxicity**
  - **Raw Material depletion**
- **These impacts can be:**

Local → Regional →

Global

Environmental impacts
Greenhouse effect & Ozone depletion layer

- **Greenhouse: Natural energy equilibrium destroyed by specific gases**
  - **CO_2 (96.4%), N_2O (1.5%), CH_4 (2.1%), SF_6, HFC & PFC (Kyoto proposal)**
  - **CFC ,VOC,HCF,H2O**

	CO_2	CH_4	SF_6
Life duration (years)	**150**	**15**	**3200**
Radiative forceful potential	**1**	**25**	**22200**

Data from European Environmental agency

  - **Sources: Energy (26%), Industry (21%), Transportation (21%), Agriculture (10%), Waste(3%) & others (19%)**

- **Ozone depletion: Destruction of the ozone layer by man made gases**
  - **Halocarbons: CFC (80%) HCFC,HFC,HBFC and Halons (CF_X Br_y)**
  - **Tetrachloromethane, methyl chloride, methyl bromide & nitrous oxide**
  - **Sources: Cleaning solvents, propulsion gases (aerosols), fridge gases, foaming agents, pesticides, fire extinguishers**

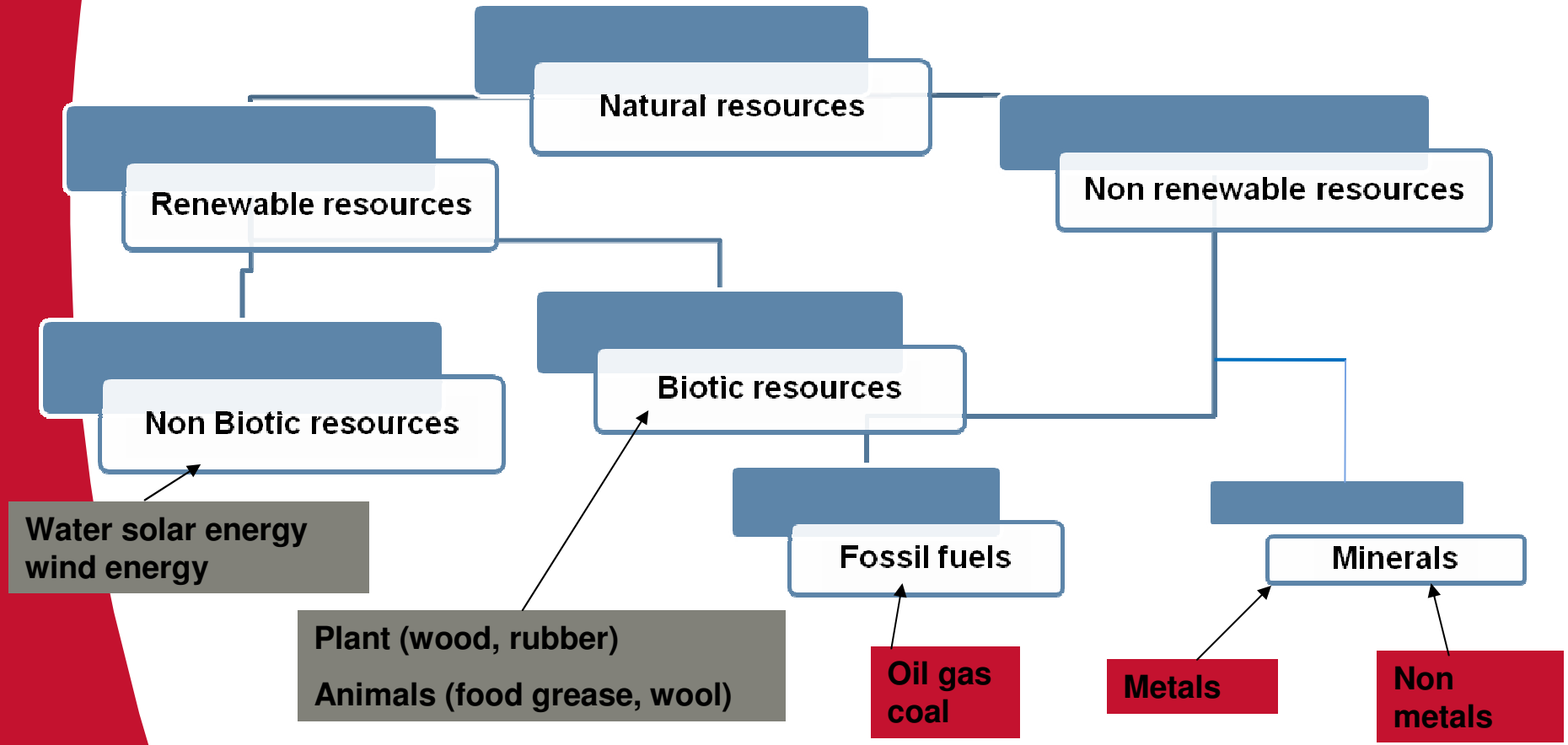
Environmental impacts

Acidification, Toxicity, Photochemical ozone & Eutrophication

- **Acidification: liberation of mainly NO_X and SO_X (HCl, HF,H_2S & NH_3) reacting with moisture in the upper atmosphere**
  - Sources: Energy (26%), Industry (13%),Transportation (25%), Agriculture (31%), Waste(1%) & others (4%)
- **Toxicity (human) & Ecotoxicity (Ecosystems):**
  - **Several hundred chemical substances are known to be toxic e.g Pb,Hg,Cd, Polychlorobiphenols, phthalates, benzene & asbestos**
- **Photochemical ozone: sunlight reacting with nitrogen oxides & VOC to form ozone smog**
  - Sources: Transportation (52%), Industry (12%), Energy (8%), Agriculture 4%), Waste(1%) & others (23%)
- **Eutrophication: enrichment of aquatic ecosystems by nutrients:**
  - **Sources: Fertilizers & detergents (nitrogen, phosphorus based compounds) urban & industrial effluents (organic matter)**

Environmental impacts
Raw material depletion

Raw Material classification



Environmental impacts
Raw material depletion

Depletion of non renewable resources

Form of Energy	Proven fossil fuel reserves (2005) (Million Toe)*	Average annual Production (2001-2003) (Million Toe)	Static number of remaining years
Oil	156700	3620	43
Coal	501200	2370	212
Natural Gas	158200	2290	69

*Toe Energy contained in a metric ton (1000 kg) of crude oil.

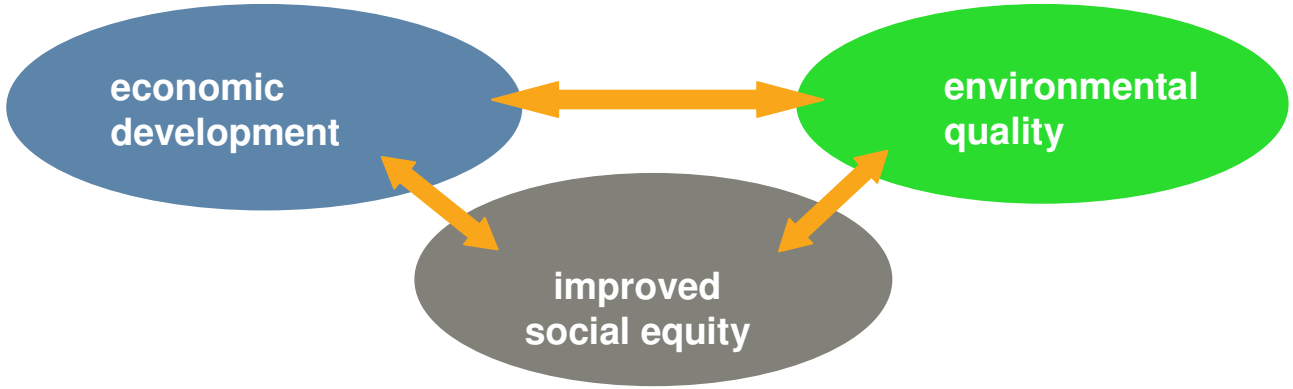
1Toe equivalent to 10^7 kilocalories

Source: International Energy Agency BP plc


What
to do?

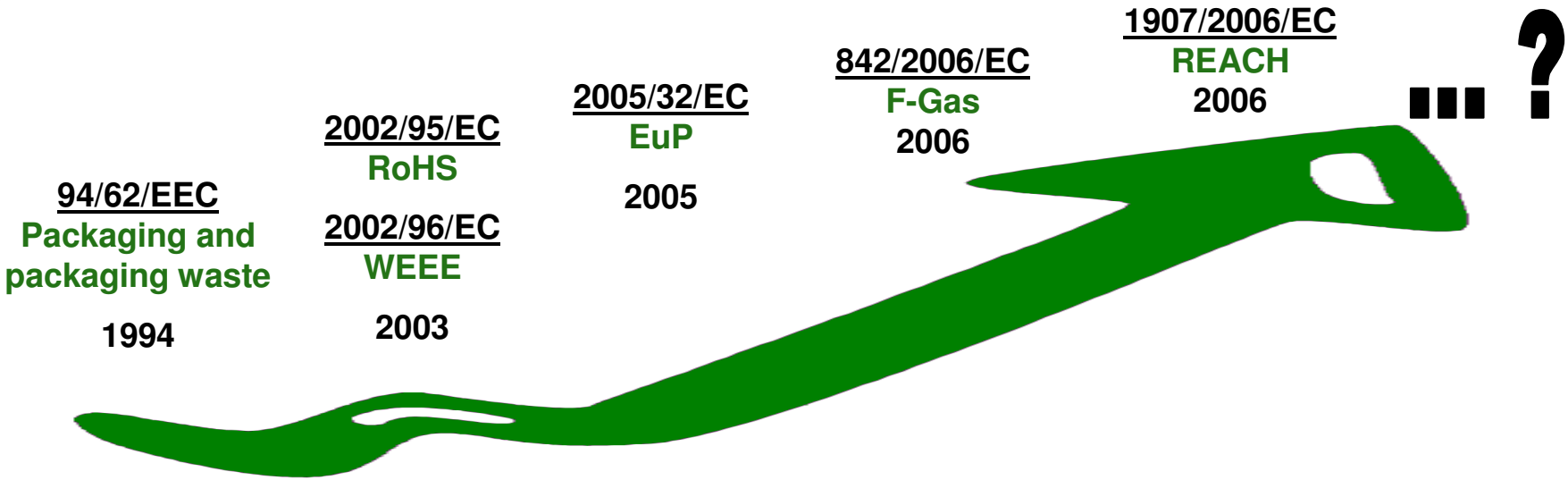
Sustainable development and approach

- **Sustainable development: a unifying approach is required, a need to satisfy and balance three basic goals**



- **Approach**
  - **Introduce regulations and legislation**
  - **Consider a Whole Life Cycle approach (cradle to grave)**
  - **Use a systematic evaluation of the environmental aspects of a product or service throughout its life**

Regulations and Legislation



- **WEEE : Improve the EoL management of electrical equipments**
- **EuP : Eco design of Energy using Products**
- **RoHS : prohibits CrVI, Pb, Cd, Polybrominated Biphenols, Polybrominated Diphenol Ethers**
- **F-Gas : Regulation on certain Fluorinated Greenhouse Gases**
- **REACH : Registration, Evaluation and Authorisation of Chemicals**

Anticipate

Eco-design Process Methods & Tools

Eco design, what does it mean?

- Ecodesign considers the environmental influences throughout the Life Cycle of the product

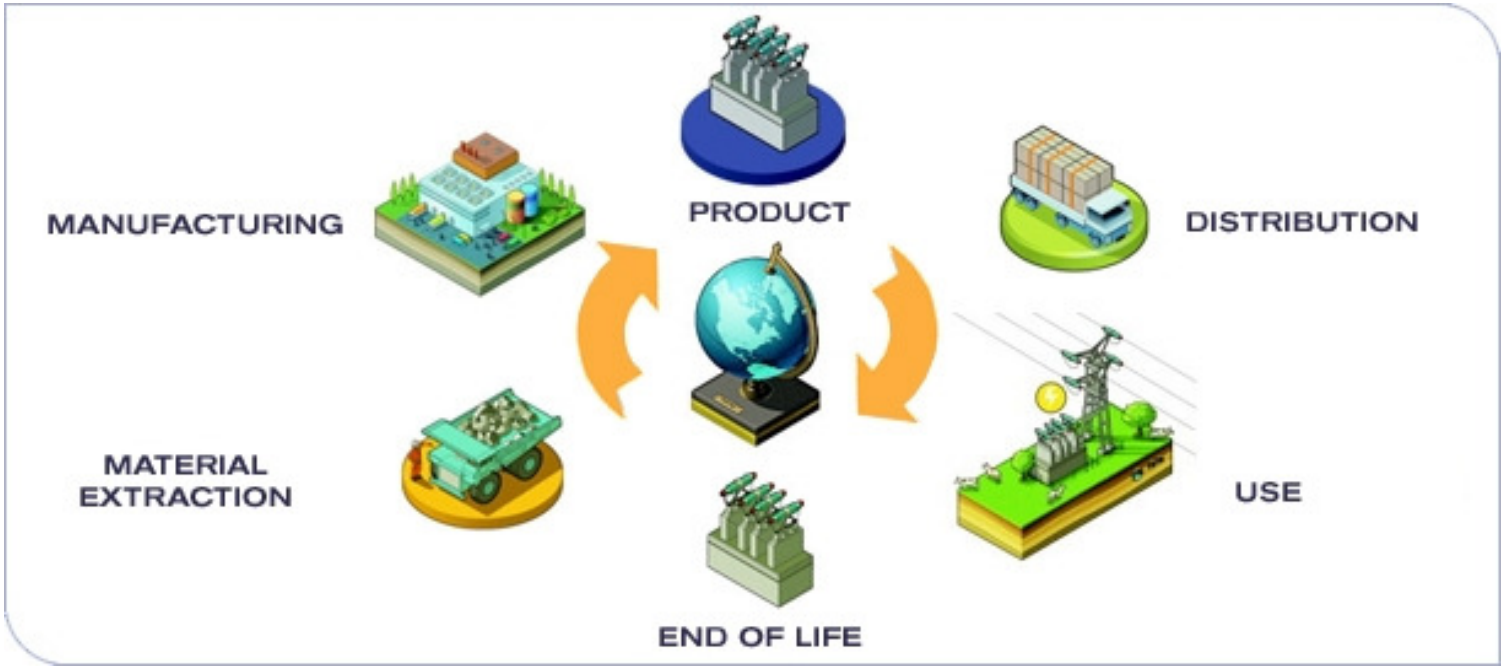
- Historically designers were reactive to environmental issues

- Now, try to integrate and minimise the environmental impact at the product design and development stage - be proactive

60-80% of life cycle impacts from products are determined at the design stage

Ecodesign How?

- **Approach methodology**
  - Quantitative environmental assessment (Software tools)
  - Qualitative environmental assessment (SQEOLC)
  - Integration of this data into the Eco design product

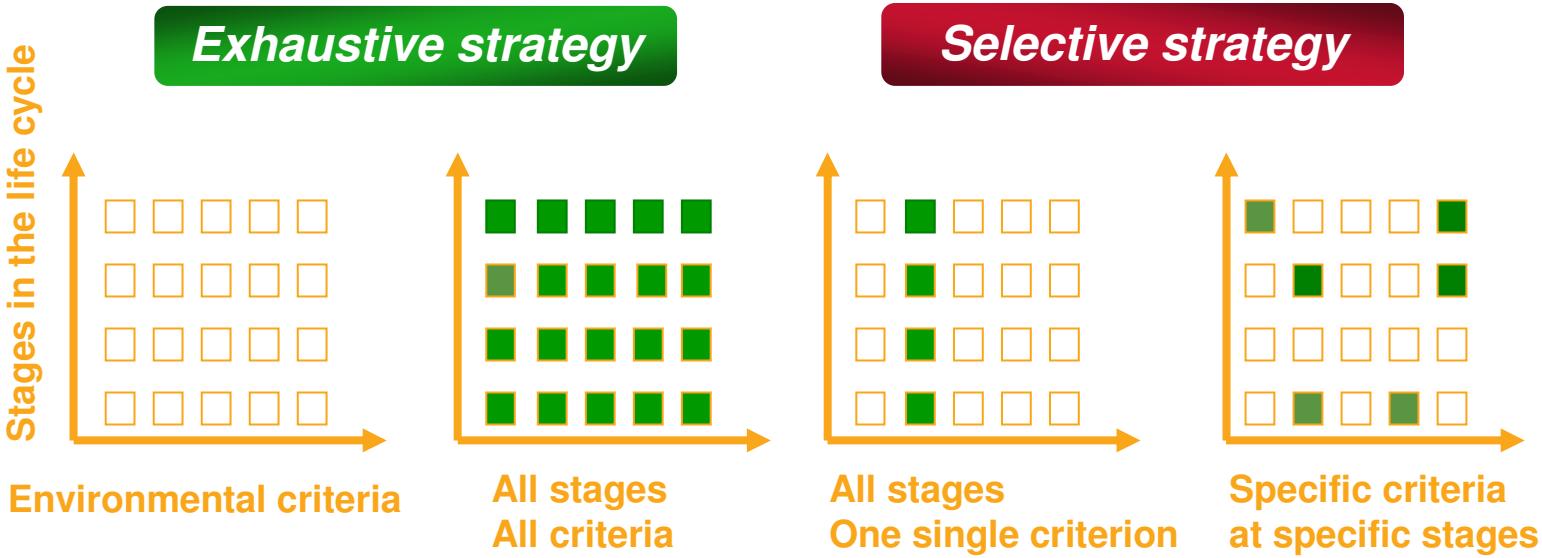


- **Global approach –life cycle from cradle to grave**

Ecodesign Strategy

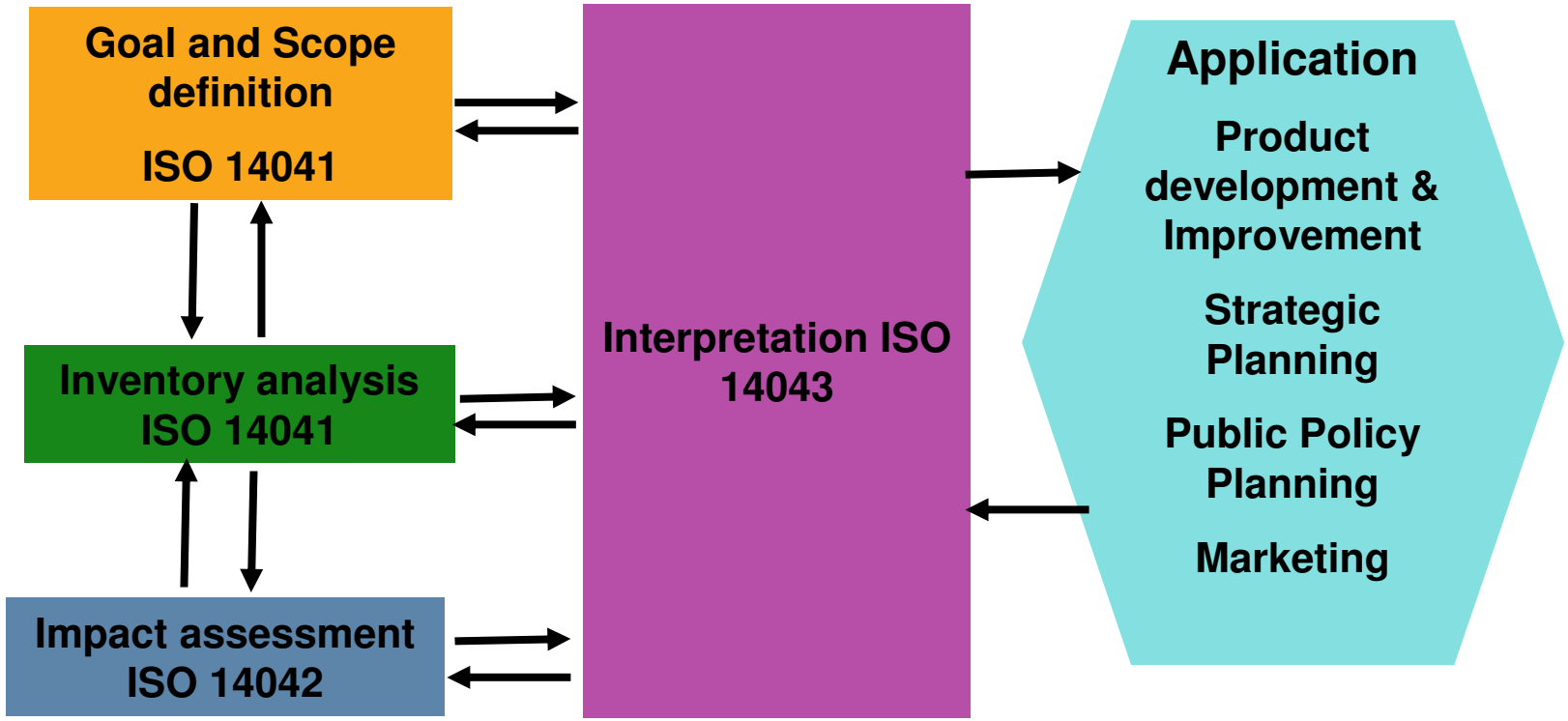
- It is important to establish an environmental strategy to fix the objectives and priorities
- The management has to indicate the methodology of ecodesign
  - Two different approaches:

⇒ Investigation methods



ISO 14040 Life Cycle Assessment

- ISO has standardised this framework within the series ISO 14040 on LCA



Ecodesign Software systems

- **Software Systems**
  - GABI- automobile
  - UMBERTO- general
  - SIMAPRO- general
  - EIME - developed by electrical & electronic companies in 1995

- **Advantages:**
  - Normalised methodology
  - Reference method for evaluation
  - Identification of environmental impacts

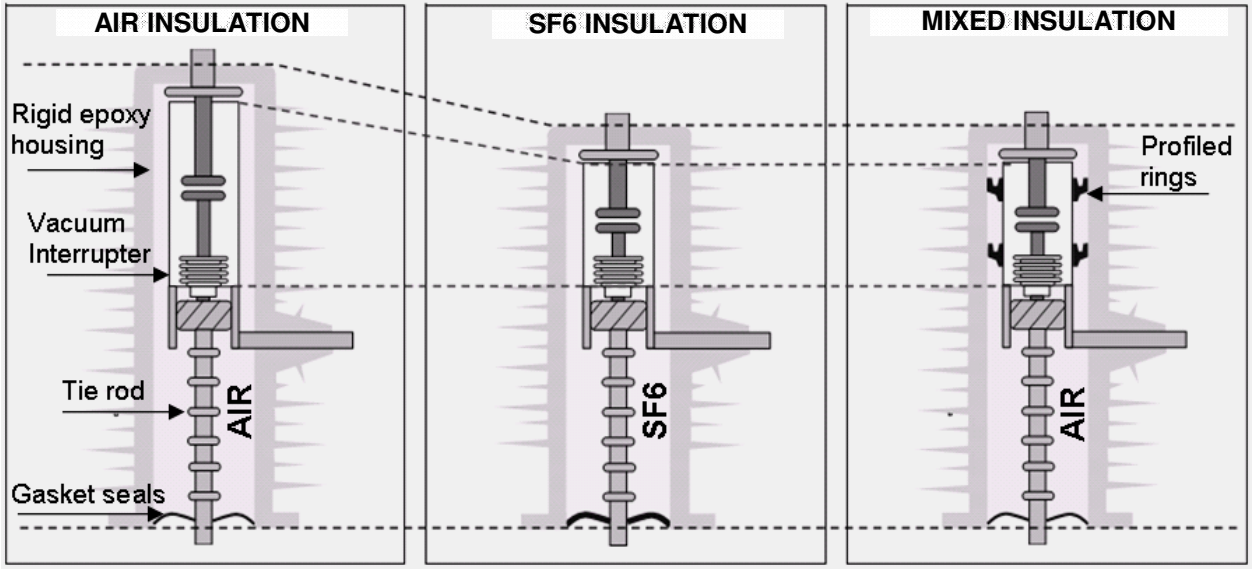
- **Disadvantages:**
  - Data availability
  - Costly in time and expertise
  - Some results are scientifically debatable

Ecodesign
Simplified Qualitative Evaluation over Life Cycle (SQEOLC)

- **Approach**
  - Limited global view with smaller data base, identifying critical parameters with continuous improvements of impacts-qualitative study of impacts by experts
  - Advantage of clearer & simpler technique
- **Reduce the environmental impact by :**
  - Material input –less hazardous, renewable, low energy content, recycled
  - Production and distribution – cleaner processes, decrease energy consumption and waste production, reusable packaging, recyclable, local sourcing and ease of transportation
  - Use- reduction in electrical or energy consumption, use of renewable energy
  - End of Life- mass, volume, assembly route, dismantling, collection and recycling
  - Life span- durability, modular or standardisation of components

Medium voltage switchgear
Feasibility study

Medium Voltage Switchgear



Two main functions of medium voltage switchgear:

- **Interrupt the current**
- **Provide electrical insulation from the external surroundings;**
- **Compare the environmental impact:**
  - **Air : Low dielectric strength of dry air increases the overall size & weight of the equipment**
  - **SF6 : Good dielectric strength. Disadvantage : Pressure of 1.5 bar and SF6 tightness. Despite the compact design, the SF6 is a green house gas : 22000 x GWP of CO2**
  - **Mixed insulation :Combination of profiled silicone rings with dry clean air at n.t.p. Physical barrier to increase the creepage distance against electrical flashover. Similar to the SF6 design.**

Medium Voltage Switchgear
Design weight (kgs)

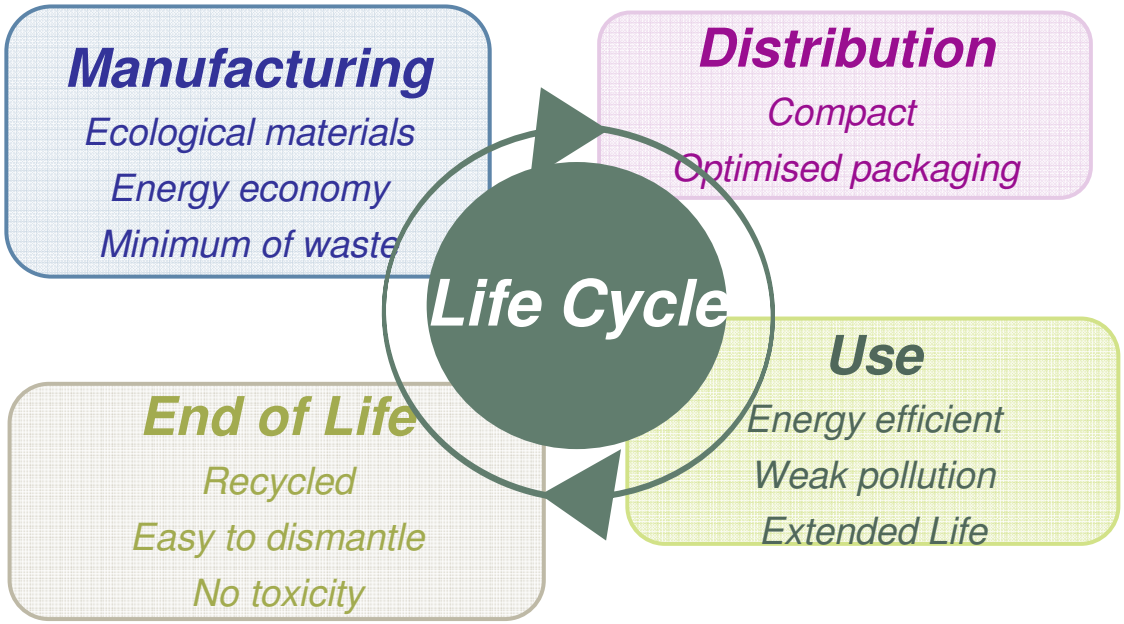
- Comparison of materials for each design (kg)

Material	Mixed	SF6	Air
Metals	9.6	9.6	**10.7**
Thermoplastics	0.4	0.4	0.4
Thermosets	6.1	6.1	**7.0**
Elastomers	**0.45**	0.26	5×10^{-2}
Ceramics	1.3	1.3	**2.6**
SF6	0	**6×10^{-2}**	0
Others	5×10^{-3}	0	0
TOTAL	**17.87**	**17.74**	**20.8**

- Air design worst for materials
- SF6 worst for greenhouse gas

Medium Voltage Switchgear
Life cycle

- **Life Cycle Assessment- consider the different phases**
  - **Quantitative analysis using EIME for manufacture**
  - **Qualitative modified analysis for the other phases**



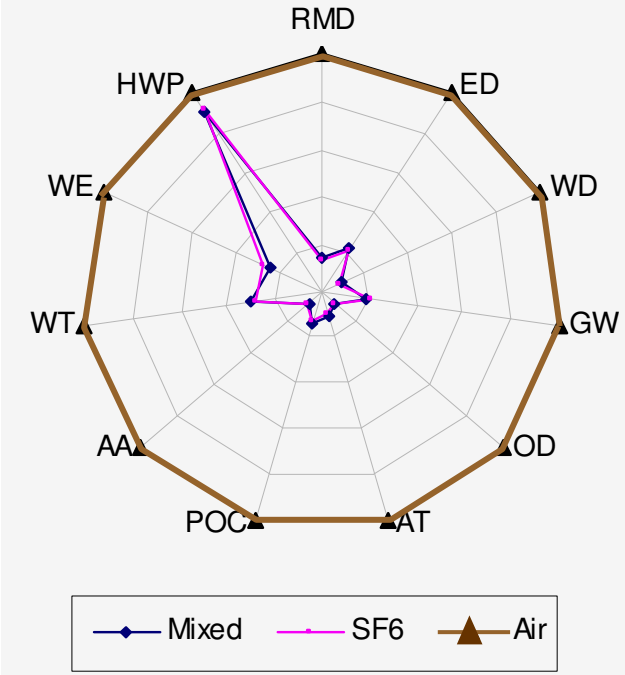
- **Perform a comparison of the three insulation systems**

Medium Voltage Switchgear Manufacture phase

Environmental LCA

- EIME -11 environmental burdens and their weightings
  - Hazardous Waste Production 5
  - Ozone Depletion 5
  - Global Warming 5
  - Energy Depletion 5
  - Water Depletion 3
  - Raw Material Depletion 3
  - Water Toxicity 3
  - Air Toxicity 1
  - Acid Acidification 1
  - Photochemical Ozone Creation 1
  - Water Eutrophication 1

Visual evaluation using a radar diagram



	Air	SF6	Mixed
Rank	3rd	1st	1st

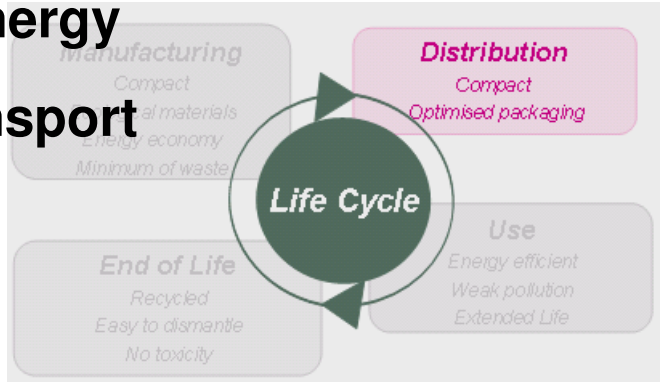
Medium Voltage Switchgear
Distribution phase

- **Distribution of equipment to site is influenced by two parameters : mass and volume**

Product + Packaging	Air	SF6	Mixed
Mass of Product (kg)	20.1	17.72	17.85
Mass of packaging (kg)	7	5	5
Volume of packed product	1.5X	X	X
Rank	3rd	1st	1st

X =Unit volume of SF6 unit

- **larger & heavier items use more energy**
- **Smaller packaging and shorter transport distances favoured**



Medium Voltage Switchgear
Use phase

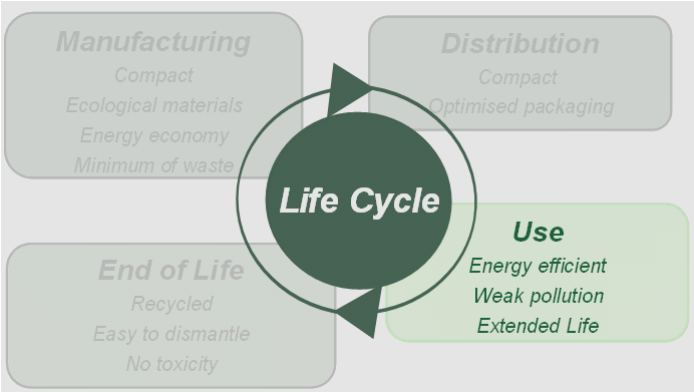
- During the use phase the two major influences:
  - electricity consumption
  - SF6 leakage

	Air	SF6	Mixed
Rank	1st	3rd	1st

- Similar service life - same potential of energy depletion

- SF6 at greatest risk

1g during 20 years is equivalent to 22 kgs of CO_2



Medium Voltage Switchgear
End of life phase

After decommissioning product experience shows:

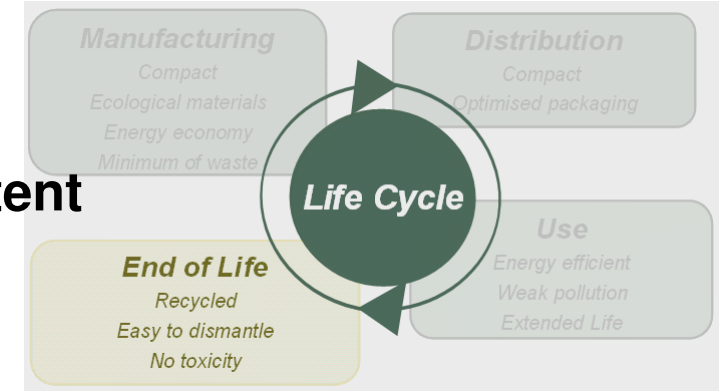
- **Reuse by dismantling**
  - Simple sorting preferable to grinding & mechanical sorting
  - Dismountable components give 10% higher materials for recycling
- **Recycling**
  - Maximise recovery of materials or components ~65-85%
  - Benefits the environmental impacts with reduction in raw material - preserve natural resources and energy
- **Landfill –worst destination**
  - ~15-35% of initial mass,
  - expensive,
  - occupies space
- **Hazardous substances**
  - Complies with RoHS & WEEE with removal of heavy metals etc

Medium Voltage Switchgear
End of life phase

- duration time for decontamination, dismantling and material sorting
- Previous company experience

End of life -disposal	Air		SF6		Mixed	
		rank		rank		rank
Dismantle (minutes)	20	1	50	3	20	1
Recycle and reuse (%)	77	3	83	1	84	1
Landfill (%)	19	3	12	1	12	1
Incineration (%)	4	1	5	1	4	1
Total		8		6		4
Overall Rank		3rd		2nd		1st

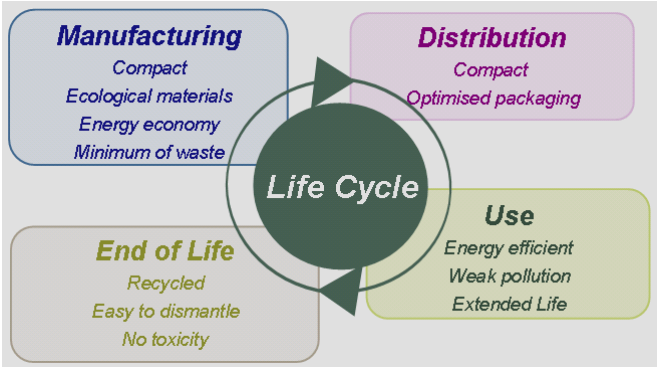
- Based upon previous material content



Medium Voltage Switchgear
Whole life cycle

	Air Rank	SF6 Rank	Mixed Rank
Manufacturing	3	1	1
Distribution	3	1	1
Use	1	3	1
End of Life	3	2	1
Global impact	10	7	4
Rank	**3rd**	**2nd**	**1st**

- **Outcome: the mixed insulation technology is the most ecologically friendly**



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Thank you!