bio RAFFINADERI ØRESUND

Even a Green Coin has two sides …

Conference in Lund
26 October, 2011

Lennart Holm
Chairman Perstorp Group

Perstorp a chemical company with green roots

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- History:
  - Established **1881** in the forests of South Sweden
  - Original raw material was biomass (Beech), dry distillation **biorefinery** producing Acetic Acid and Formaldehyde
  - Switched to petrochemicals in the 50's
- Today:
  - Specialty Chemicals group with a **1.7 bn € turnover** and 2 200 employees across the globe
  - Delivers vital properties to modern products in surface materials and composites
  - Big scale **reentry in biorefinery** business in **2007** through the investment into Scandinavia's largest plant for production of **Biodiesel** (160.000 ton/year)
  - Performs active R&D in the field of renewable rawmaterials / biorefinery concepts since 2005
  - Introduced several "green" products during recent years

Mo och Domsjö's Chemistry Tree *1945*

Biomass → Chemicals

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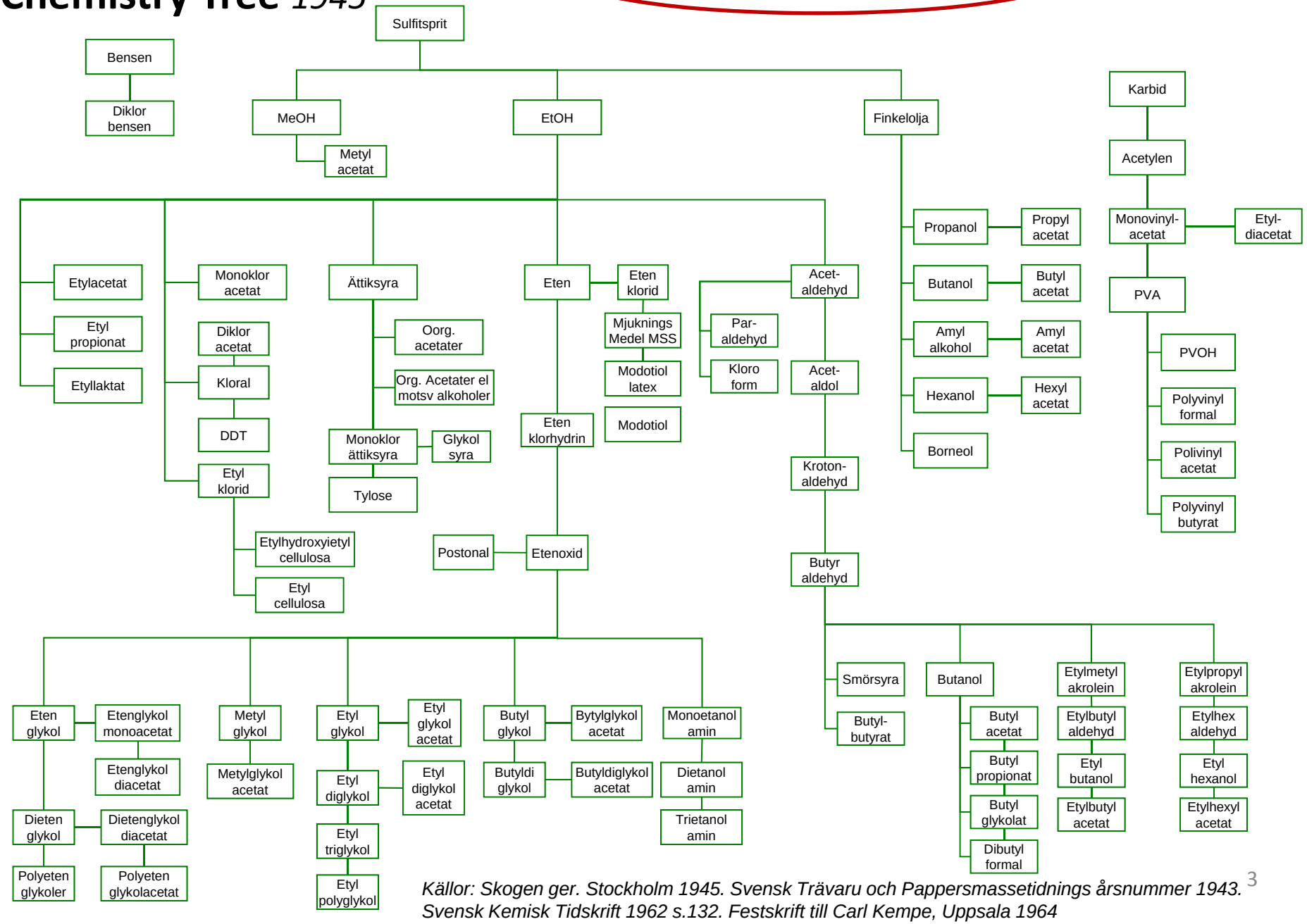

Källor: Skogen ger. Stockholm 1945. Svensk Trävaru och Pappersmassetidnings årsnummer 1943. Svensk Kemisk Tidskrift 1962 s.132. Festskrift till Carl Kempe, Uppsala 1964

Up to 1945 utilization of oil was limited by its availability, then came the “Oil Economy” …

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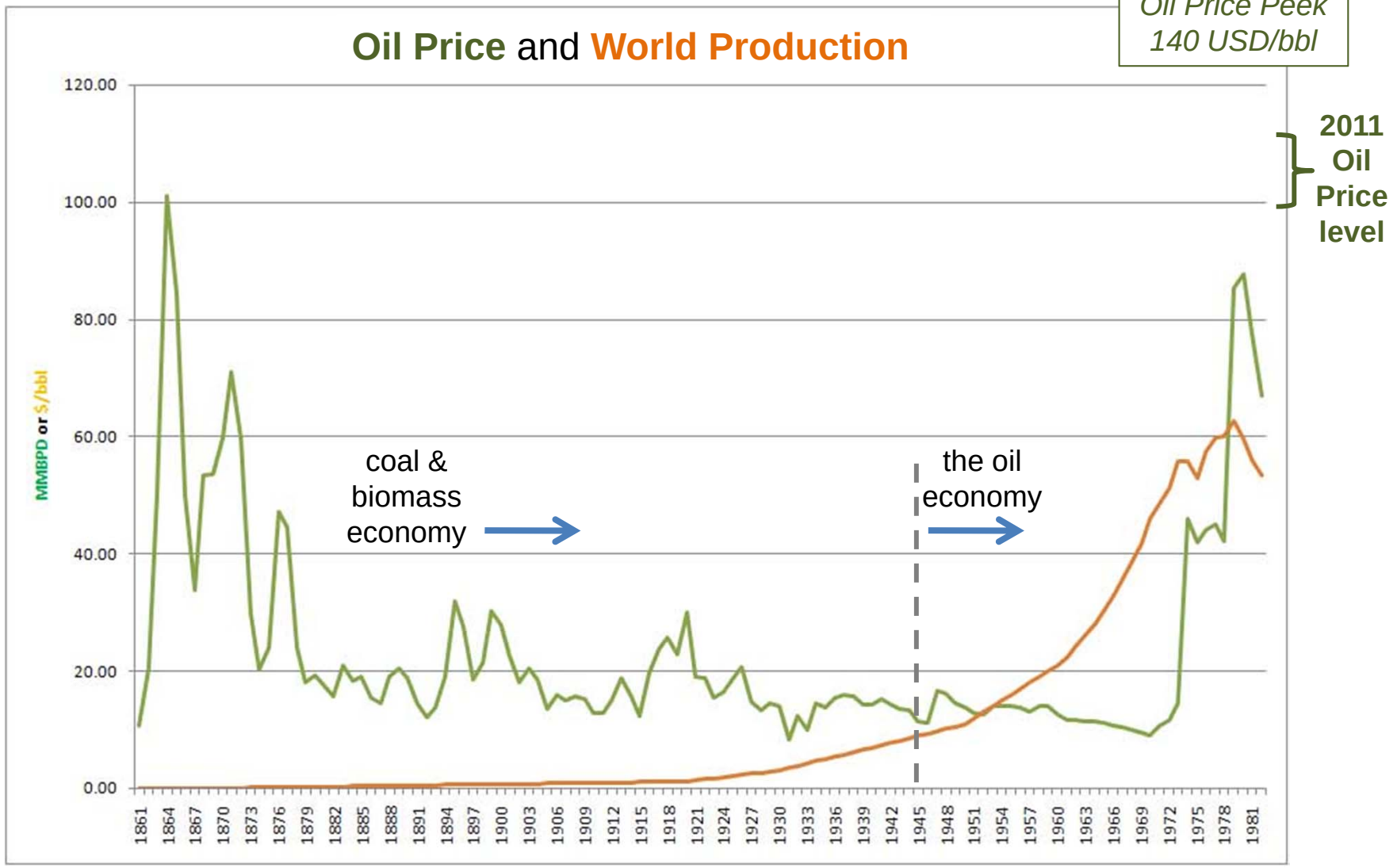
2007/08
Oil Price Peek
140 USD/bbl



2011 Oil Price level

The Oil Economy

Product composition of a Naphtha Cracker

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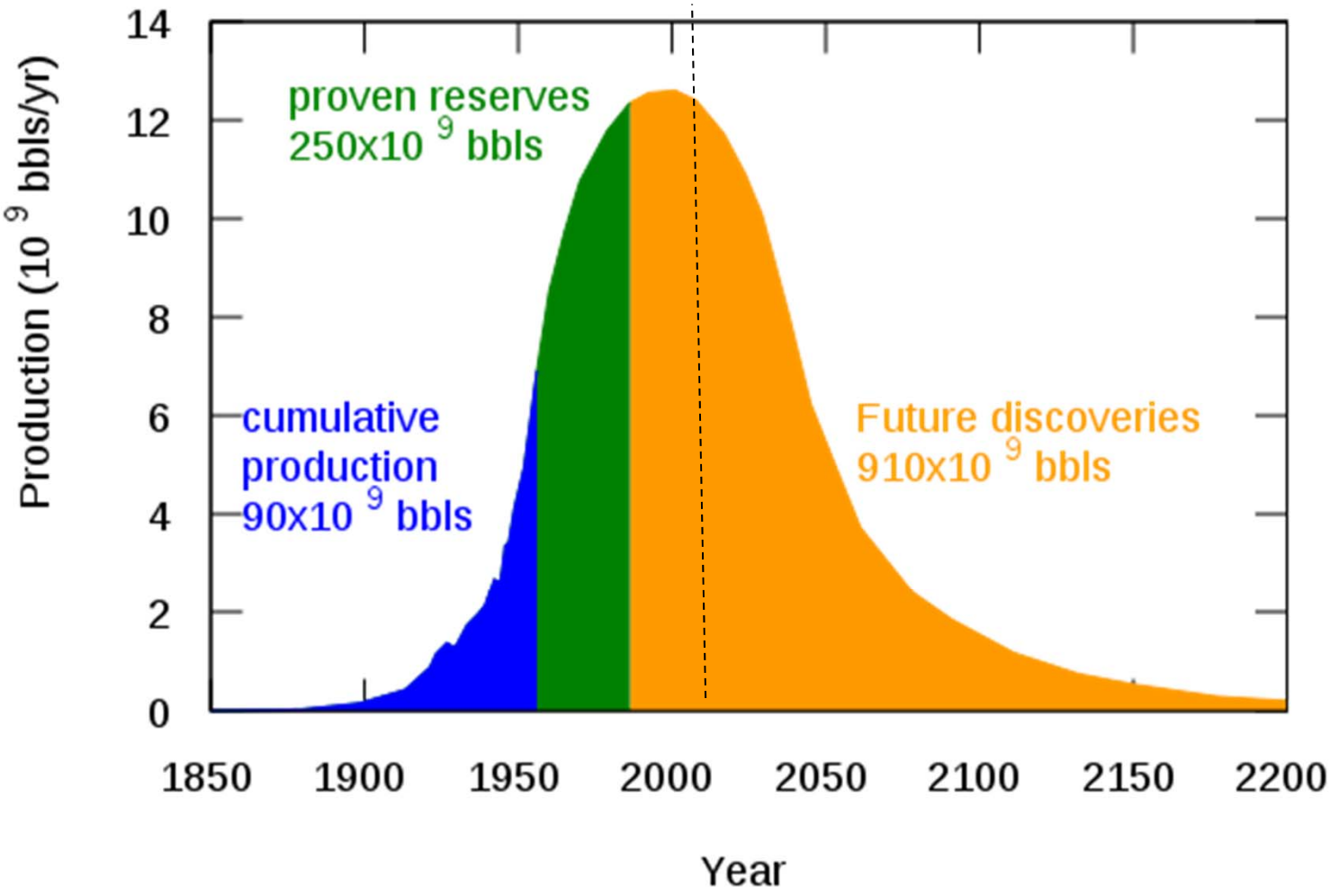
Oil ➔ Naphtha

Cracker complex in Stenungsund, Sweden

- Hydrogen (ca. 1%)
- Ethylene (26–31%)
- Propylene (14–17%)
- C_4-cut (8–11%)
- C_5-cut (4–5%)
- Aromatics (18–21%)

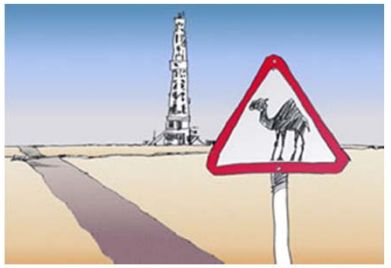
Oil is a fantastic raw material, concentrated energy in liquid form

Availability of Oil and Gas is not endless , “Peek Oil” is a reality but when?



… but we will not run out of oil & gas!

- Supply and demand will regulate consumption
- The consequence will be substantially higher oil and gas prices
- When will oil & gas demand will outstrip supply?
  - Fewer new findings
  - More expensive and risky exploration (deep sea)
  - Consumption in China, India and other fast growing regions is rising fast



Green Pentaerythritol as a Green Product Example
Voxtar™ gives you pure performance every time

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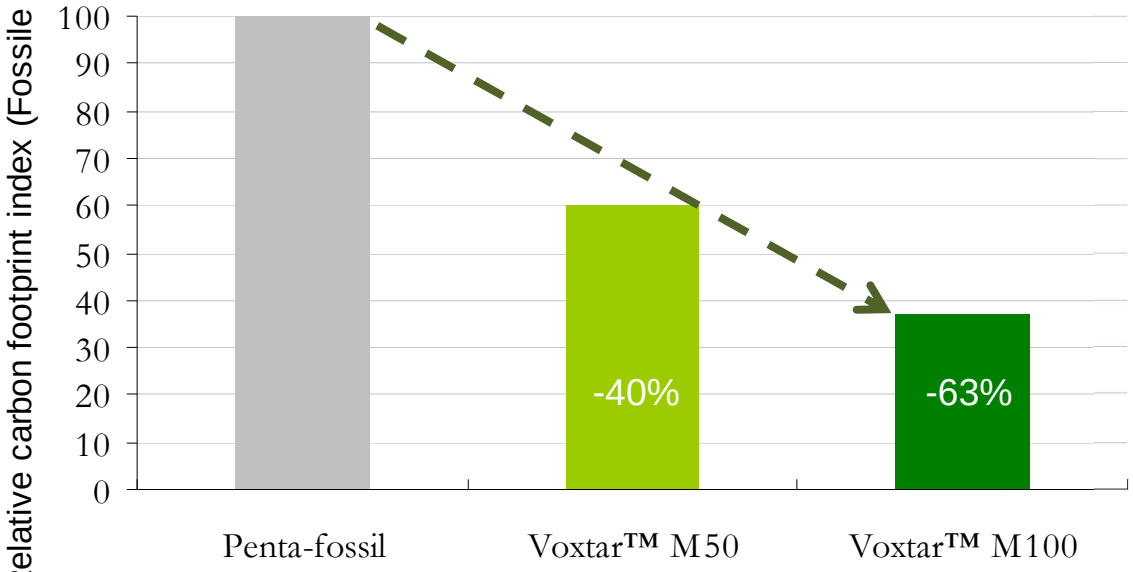
Effect on **carbon footprint** (cradle to grave) when comparing Voxtar M100 & M50 with fossile-based pentaerythritol.



Relative cradle to grave carbon footprint comparison between Voxtar™ M100 & M50 and Penta-fossil made

Perstorp – All chemicals can be produced from renewable feedstocks

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Biomass

- Forestry-based
- Agricultural residues (potato juice, barley, straw, etc.)

Pre-treatment

- Hydrolysis (basic, acidic)
- Enzymatic treatment
- Steam explosion
- Extraction

Fermentation /enzymes / chemical transformation

- Synthesis gas
- Biogas

Gasification of residuals

- Propionic acid → Methacrylic acid
- 3-Hydroxypropionic acid → Acrylic acid, Polyester
- 3-Hydroxypropionaldehyde → 1,3-PDO
- Furan dicarboxylic acid → Furan diol
- Butanol → Acrylates
- PHA

Targets

➔ Sustainable industrial processes
~20 kt by 2015

➔ Reduced carbon footprint (>75%)

Challenges

➔ Raw material supply
➔ Efficient pre-treatment
➔ Process: stability, yield, productivity
➔ Downstream processing
➔ New technologies

Activities

➔ Biobutanol
➔ VINNOVA x 2
➔ Carbon footprint
➔ EcoBuild
➔ Furanics
➔ Greenchem
➔ PHA
➔ Gasification

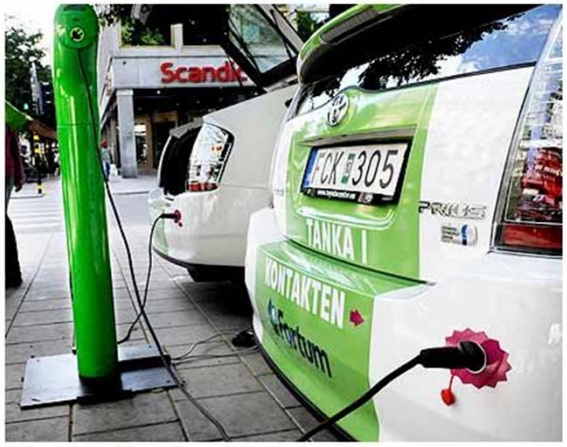
… so what's the problem going green?

- Overall system efficiency?
  - Global perspective
  - Resource consumption
  - Environmental impact
  - Long time effects
  - Function and true need of product
  - Compared to alternatives

Taking a **holistic view** is complex and things are often not what they appear to be at first sight!

Which gives the best resource utilization?

Electrical Car



Top of the Class Performance

- Loading time: 3,5 hours
- Range: 395 km
- Infrastructure: partly existing

Diesel / Gasoline Car

Standard Performance

- Loading time: 3 minutes
- Range: 1000 km
- **Infrastructure: existing**

Eco footprint: Zero emission cars?

Tesla Roadster

- Fuel consumption: 2,27 km/MJ
- CO2 emission from coal: 263 g CO_2/MJ

➔ **116 g CO_2/km**

Audi A3 1,6 Tdi

- Fuel consumption: 0,65 km/MJ
- CO2 emission from oil: 73 g CO_2/MJ

➔ **112 g CO_2/km**

… and with new hybrid diesel utilizing RME → < 35 CO_2/km)

Facts from Tesla, Audi & ENS, all distribution and transformation losses have been accounted for.

Eco footprint: Your pet vs. your car …

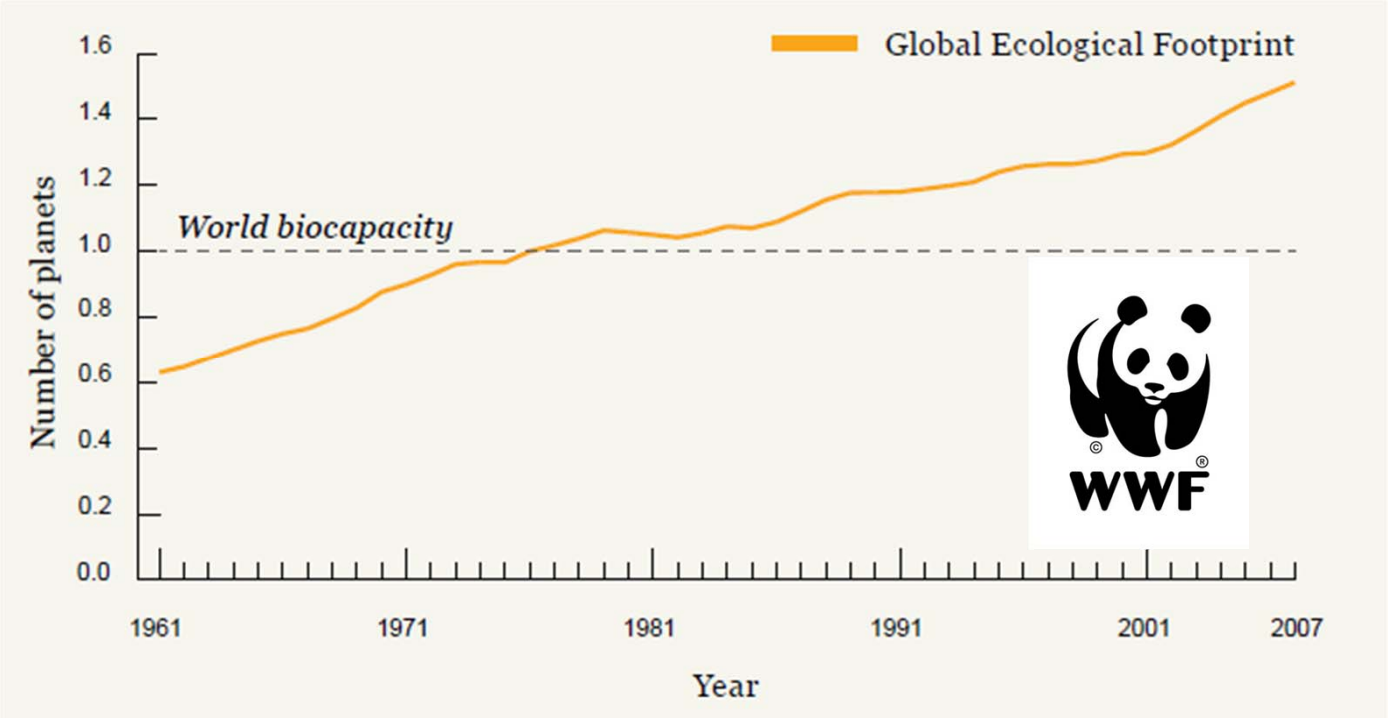
Eco footprint:

- Large Dog: 1,10 Ha
- SUV: 0,41 Ha

Source: New Scientist

Our resources are limited!

WWF - Living Planet Report 2010

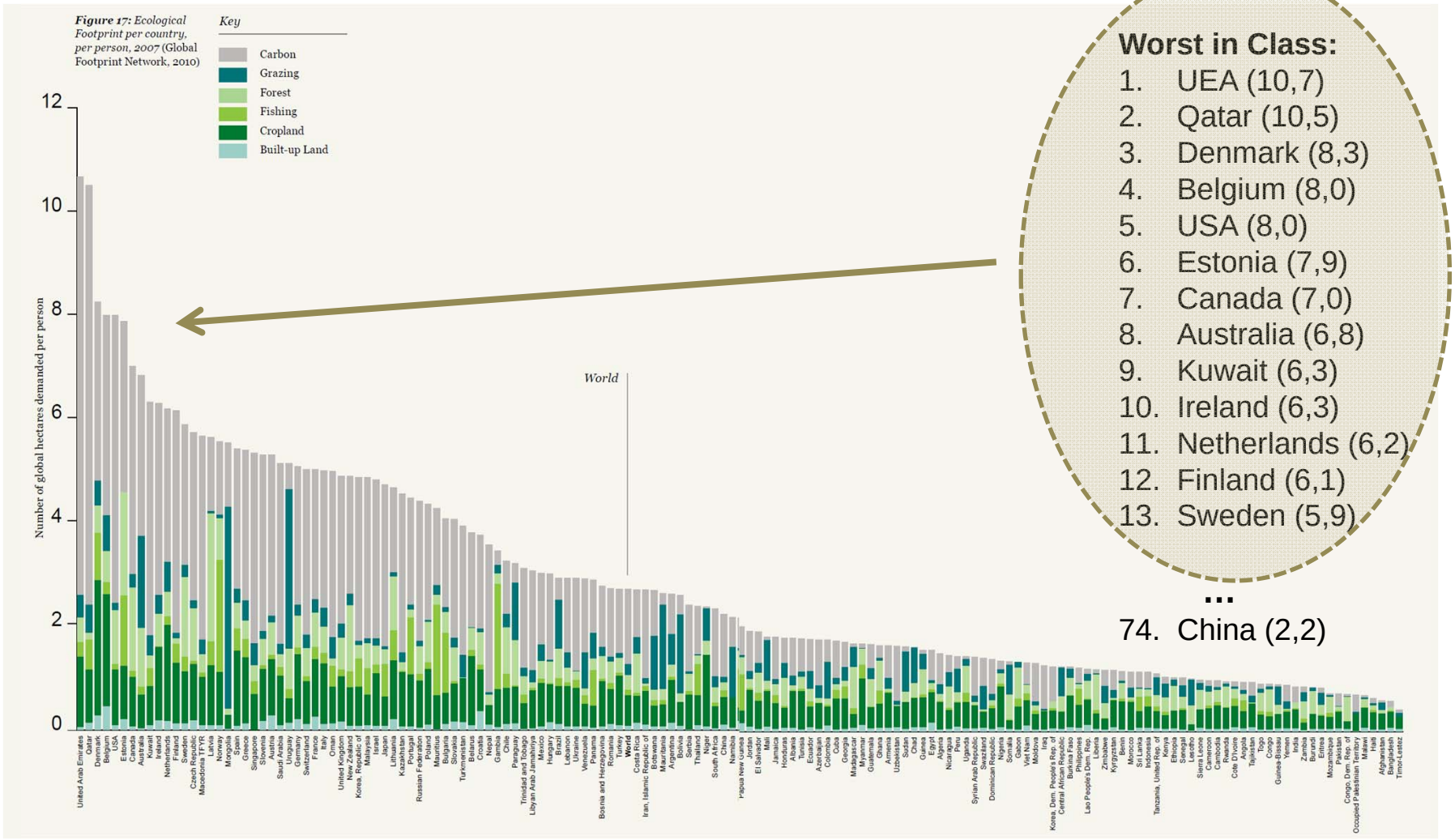


Human demand on the biosphere more than doubled from 1961 to 2007 (Global Footprint Network 2010)

Population consumption!

The Living Planet Index (LPI)

Reflects changes in the health of the planets ecosystems



Worst in Class:

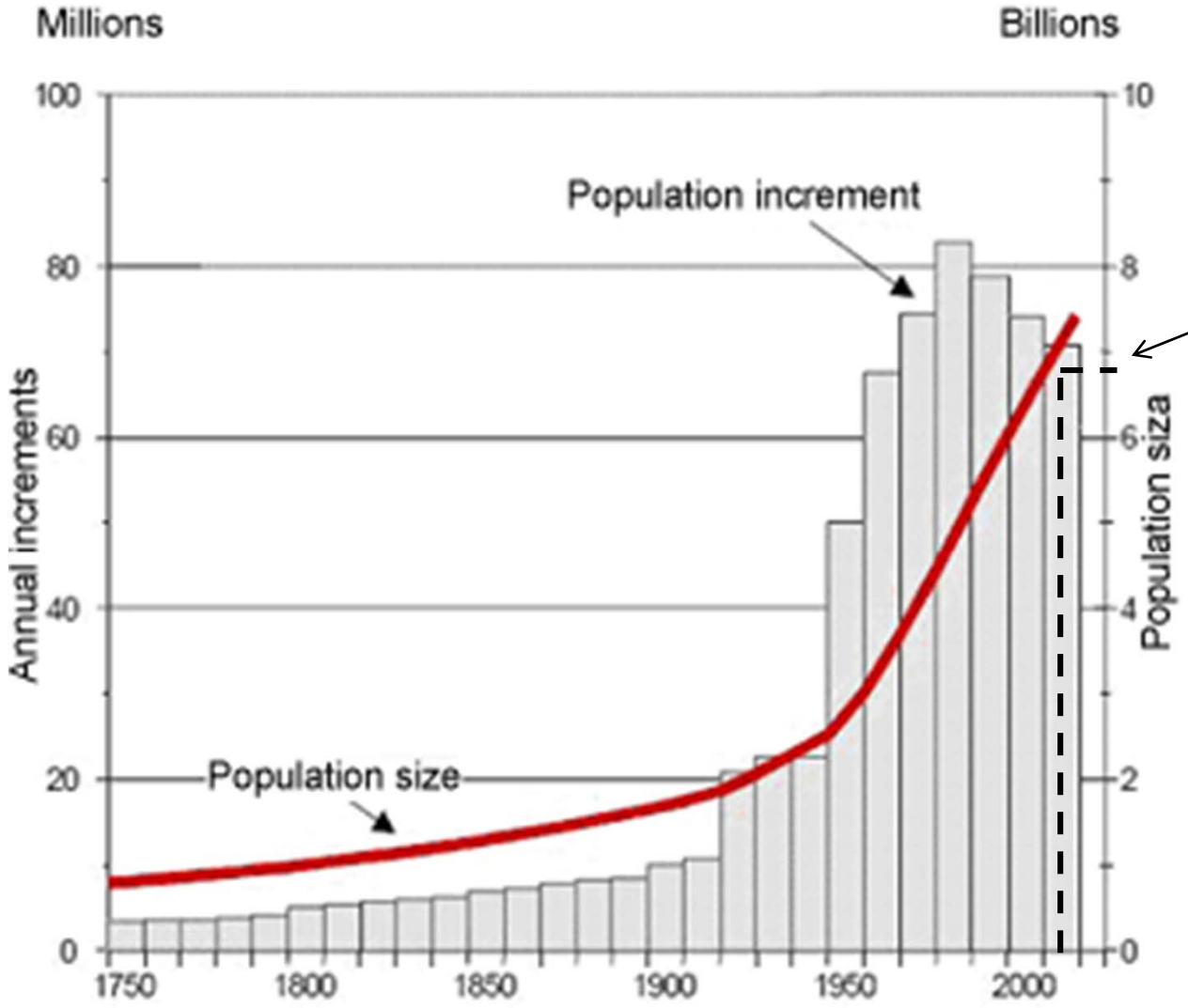
1. UEA (10,7)
2. Qatar (10,5)
3. Denmark (8,3)
4. Belgium (8,0)
5. USA (8,0)
6. Estonia (7,9)
7. Canada (7,0)
8. Australia (6,8)
9. Kuwait (6,3)
10. Ireland (6,3)
11. Netherlands (6,2)
12. Finland (6,1)
13. Sweden (5,9)

...

74. China (2,2)

… the situation is not improving!

resource consumption = population growth **x** *standard of living*!



2010:
6,8 bn
people

Our resources are limited!

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Taking the right decision / making the correct priorities is not easy!

And each individual stakeholder tends to favor his / her needs above the holistic solution …

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Experts
Recognition?

NGO
Influence?

Industry leader
Profit?

Politician
Re-election?

Scientist
Funding?

Public servant
Pension?

Citizen
Higher Material Standard?

Stakeholders
… what are their true intentions ?

Eco footprint: biofuel vs. biochemical?

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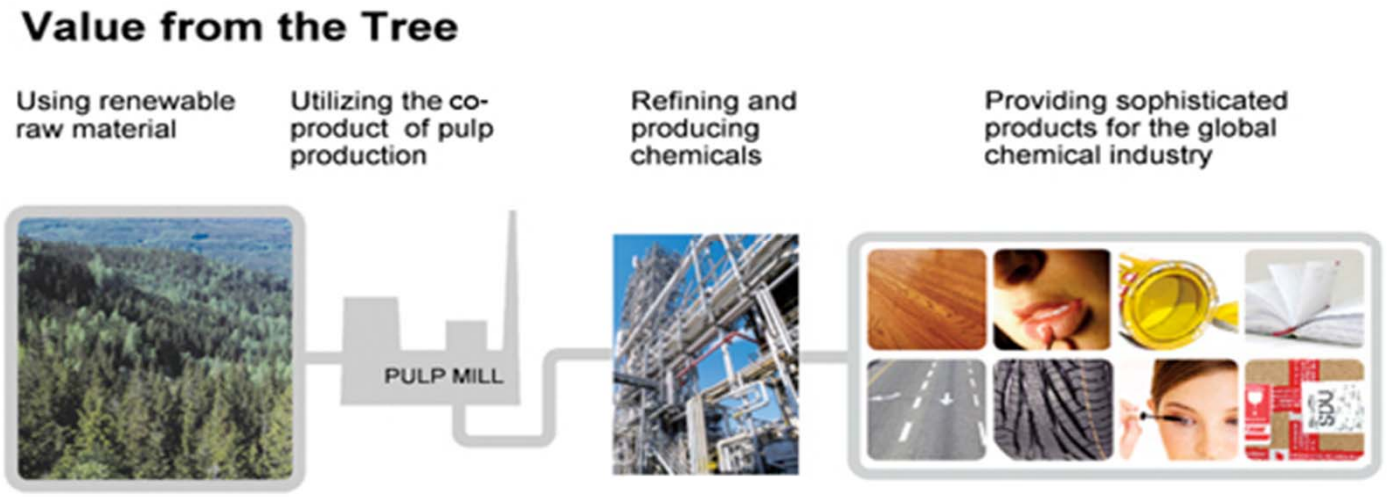
TODAY – HIGH VALUE FUNCTIONAL GREEN CHEMICALS

Arizona Chemical in Sandarne:

- Tall oil biorefinery producing high value sustainable functional chemicals for a wide variation of applications
- A sustainable and competitive alternative to petrochemical raw materials in products such as lubricants and chewing gum to printing inks, tires, fuel additives, adhesives and paints.
- Utilizes Crude Tall Oil (residue from black liquor recycling)
  - Top fraction = Tall Oil Rosin (TOR) → ”green” binders & adhesives
  - Middle fraction = Tall Oil Fatty Acids (TOFA) → “green” additive in paper, paint, etc
  - Bottom fraction = Pitch → Pitch Fuel → “green” heavy fuel oil



Eco footprint: biofuel vs. biochemical?

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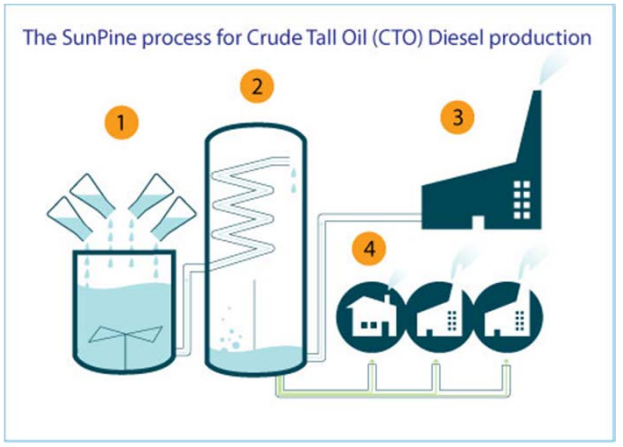
TOMORROW - LOW VALUE BIODIESEL with questionable LCA profile and Economy

- **Production of Biodiesel from Tall Oil:**
  - Swedish high profile investment heavily supported by government funding and tax incentives
  - Limited availability of raw materials, hence no real alternative to fossil diesel
  - Questionable LCA and Economy:

    1. Raw material collected at pulp mills
    2. Base product produced in Piteå
    3. Required refining done at Preem in Gothenburg
    4. Blended into Diesel and distributed to petrol stations all over Scandinavia



- **Limited Raw Material available:**
  - Consequence: Unfair price competition making Sandarne products uncompetitive vs. fossil alternatives / low value products win over high value products

Global warming will be correlated to the development of carbon sinks!

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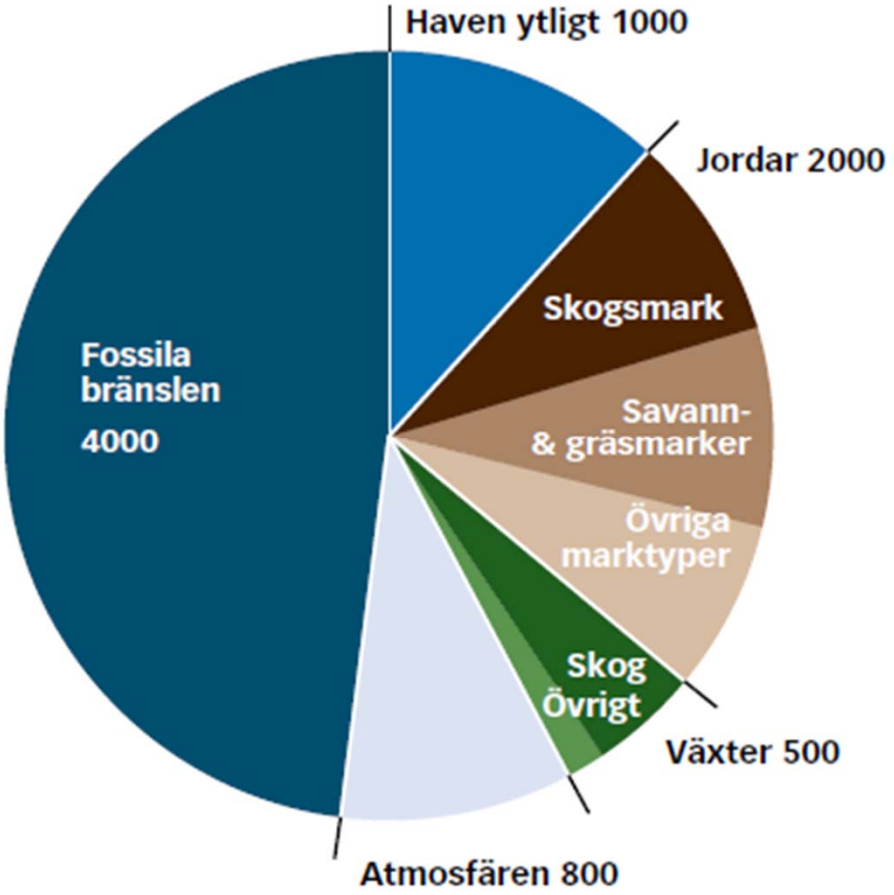
The Carbon Cycle

Unit: Gt = 1 billion tons

Living biomass:	500 Gt
Soil (1 m):	1500 Gt
Ocean (surface):	1000 Gt

Emissions from industries and combustion of fossil fuels:

- 10 Gt per year (global)



Forest as forest or …

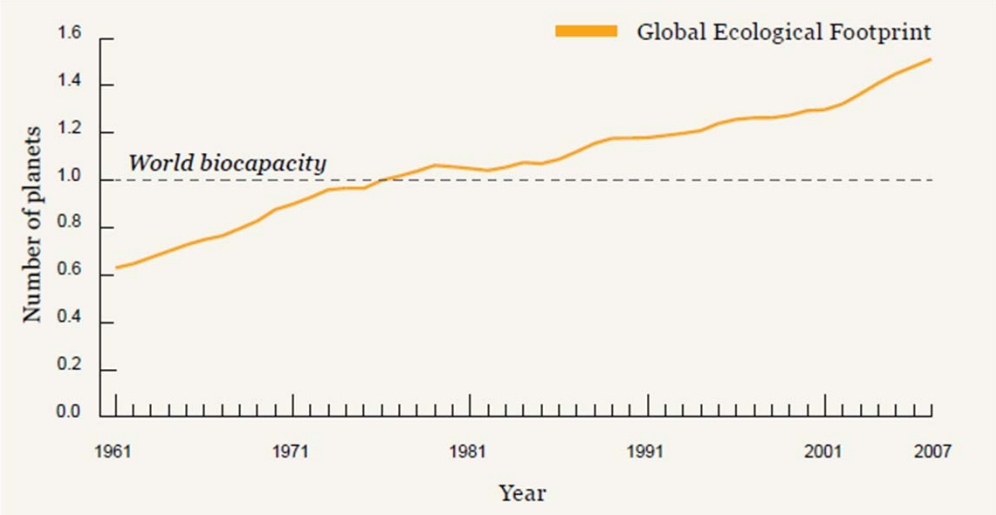
US South:
rotation time 15 years

Central Sweden:
rotation time 75 years

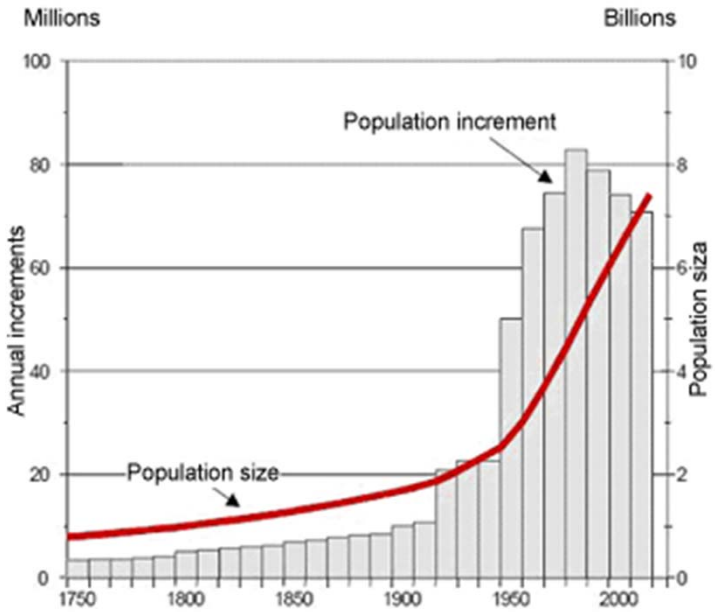
- We are not always as green as we believe …

Focus on the problem not the symptoms

Our resources are limited and we are many who need to share



Human demand on the biosphere



Growing population

… even a green coin has two sides!

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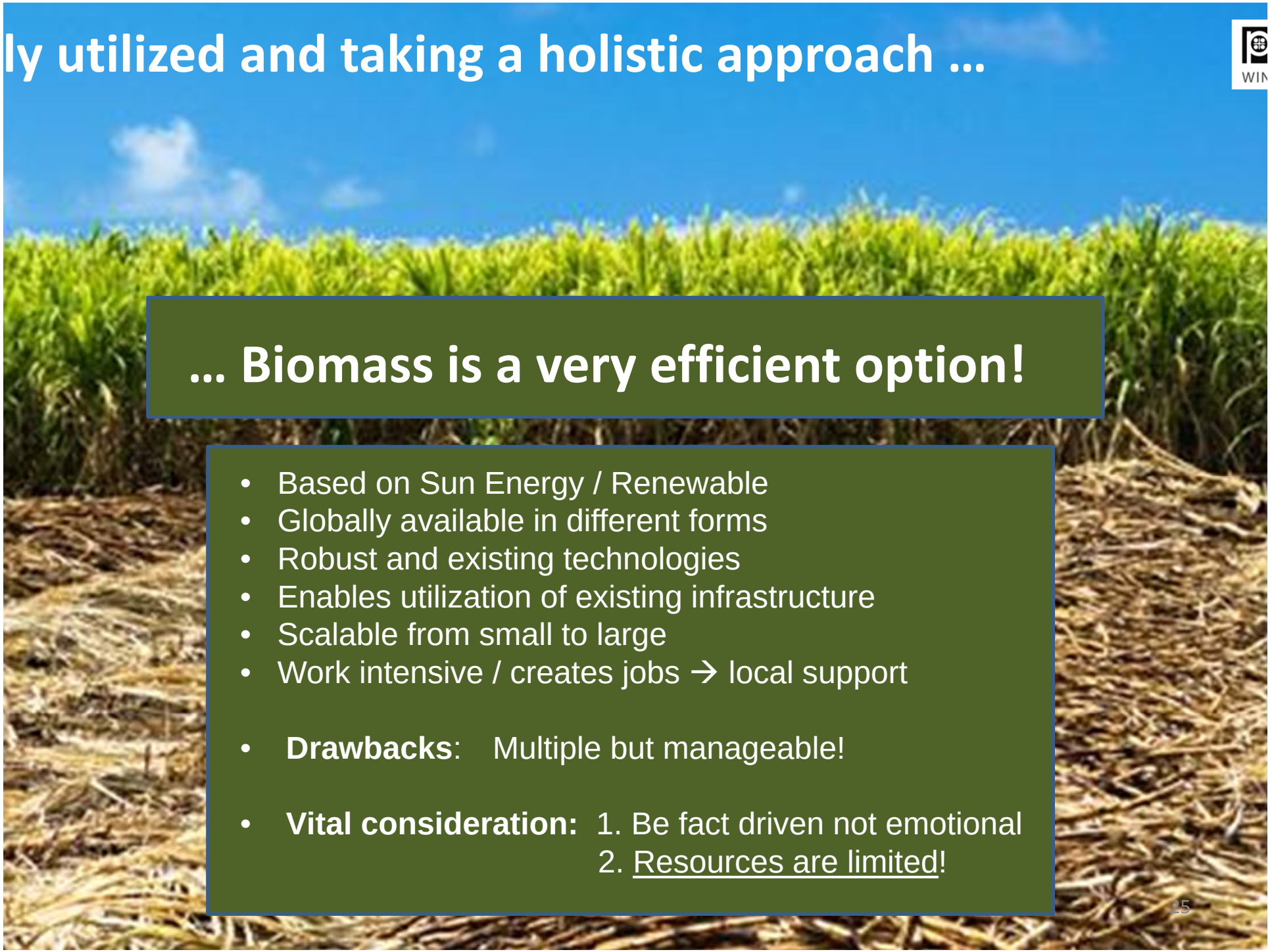
- Best solution often to do without? → No resource consumption!
- Better alternative solutions ? → Optimal resource utilization!
- What are our true motives? → Global perspective not for individual!

- When should we go for **biomass** solutions and when not? → incorrect utilization of biomass will add to resource depletion / global warming …

  - Depletion of natural forests and biodiversification
  - Destruction of ecosystems
  - Competition with production of food
  - Destruction of existing infrastructure
  - Increased global warming

ly utilized and taking a holistic approach …



… Biomass is a very efficient option!

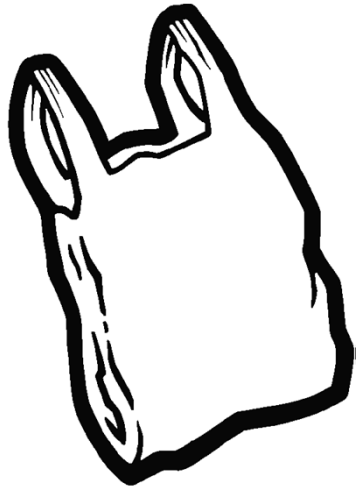
- Based on Sun Energy / Renewable
- Globally available in different forms
- Robust and existing technologies
- Enables utilization of existing infrastructure
- Scalable from small to large
- Work intensive / creates jobs → local support

- **Drawbacks**: Multiple but manageable!

- **Vital consideration:** 1. Be fact driven not emotional
  2. Resources are limited!

“Green” Chemicals - BioPlastics as example …

Transformation of Sugar Cane into Bioethylene / Bio PE



- Global production of Ethylene: ~120 million tpa

- What would it take to convert this to “Green Ethylene”?

  - **Agricultural perspective:**
    - Only viable option: Brazilian sugar cane
    - Volume corresponds to ~240 million liters of Ethanol
    - Brazilian sugar cane give ~ 6000 l/ha, year
    - Surface required: **40 mHa = 60 % of Brazil’s entire cropland**
    - Serious competitor to food production / price increases

  - **Financial perspective:**
    - Investment in Bioethylene capacity: ~ 2000 USD/ton capacity
    - The volume would require a **Capex of 230 bn USD** (~ 50 % of the entire investment budget for the global chemical industry under 10 years)

  - **Market perspective:**
    - Massive overcapacity would be created / price collapse