Value Chain Renewable Energy

DSM’s position in the value chain
DSM and Renewable Energy
our mission

Our purpose is to create brighter lives for people today and generations to come

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Introducing Royal DSM N.V.

<table>
<thead>
<tr>
<th>Annual net sales (2010) of € ~8.2 billion</th>
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<tbody>
<tr>
<td>Net profit (2010) of € ~500 million</td>
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<tr>
<td>Locations in five continents</td>
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<tr>
<td>~ 22,000 employees</td>
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<td>Nr 1 in Dow Jones Sustainability World Index</td>
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100 yr DSM
from coal to Life Science & Materials Science

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DSM

Technological competences:
- Mechanical engineering
- Chemical engineering
- Polymer technology
- Material science
- Fine chemicals
- Biotechnology


- Classical
- Modern
Renewable Energy
fully in line with DSM’s business drivers

People - Planet - Profit: creating value along three dimensions

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Renewable energy has a huge market potential for DSM
Bio-ethanol from biomass & waste
DSM’s opportunities in 2nd generation bio-ethanol

First generation

Second generation

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DSM’s unique combination in biomass conversion

**DSM Advanced Yeasts** capable of converting both C6 and C5 sugars

- Pilot-scale test by Abengoa (concentration in g/l)
- Start: [Graph showing concentration at different times (20 hours, 72 hours)]

**DSM leader in yeast technology**
DSM’s leadership in cellulosic ethanol technology

- Global cellulosic ethanol market expected to grow to 18bn gallons in 2022, ~ US$ 50bn
- Resulting in market value for enzymes & yeasts of ~ US$ 3-5 bn in 2022
- DSM well-positioned for cellulosic ethanol
  - no. 1 position in yeasts
  - top 3 position in enzymes

![Market expectations graph](image)

*Market expectations(*) cellulosic ethanol (global demand in billion gallons)

*: derived from Hart’s Global Energy Study

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Biogas

- Biogas market expected to grow by ~16% p.a. to ~100 BCM in 2020 (US$ 35bn)
- Market for biogas enzymes and process improvement: ~US$ 1bn by 2020
- DSM leading provider of biogas enzymes and process improvements in Europe
Wind Energy

1 MW = 3 - 3.5 tons of resin
= 0.5 - 0.6 tons of adhesive
Trends in the Wind Turbine Market

Optimizing production process and cost structure
• Shift from hand layup to infusion
• Shorter cycles times in infusion and curing
• Lower total system cost

Longer blades
• Increasing structural strength of blades

Sustainability
• Sustainable products (reduced Carbon footprint)
• Sustainable ways to produce (reduced impact on workers)

Key drivers: efficiency & reliability
DSM’s Solution Package for Wind Turbine Blades

Blade Design > Process Technology > Reinforcement > Resin > Bonding Paste > Gelcoat / Coating

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Blade Designer Expertise
- Blade Design
- Blade Manufacturing

DSM Expertise
- Resins
- Bonding Paste
- Gelcoats
- Tooling

Strong Partnership is the key to success
Solar energy market - segmentation

Photovoltaic
- Crystalline Silicon: Efficiency 13-18%, 2.5-3.5 €/Wp, 80%
- Thin film: Efficiency 6-12%, 2.5-3.5 €/Wp, 20%
- Emerging technologies: Efficiency 2-30%, >2€/Wp, <1%

Thermal Solar
- Efficiency 15-35%, 3-6€/Wp
- Efficiency 70%, 0.05€/Wth, <1%
- Concentrated collector
- Emerging technologies collector
- Heat from photons

Emerging technologies: Mono-Polysilicon
- Efficiency 13-18%, 2.5-3.5 €/Wp
- Efficiency 15-35%, 3-6€/Wp, 70%

Crystalline Silicon
- Efficiency 13-18%, 2.5-3.5 €/Wp, 80%
- Efficiency 6-12%, 2.5-3.5 €/Wp, 20%
- Efficiency 2-30%, >2€/Wp, <1%
Solar energy market - characteristics

Strong fast growing global market with many opportunities increasing demand; new emerging markets

Figure 20 - Global annual market scenarios - Moderate and Policy-Driven
Solar energy market - characteristics

Cost-down drive grid parity (€/kwh)

Estimated time schedule for reaching grid parity over Europe

PV price learning curve towards grid parity

2015

2020

2030
DSM current opportunities in solar

1 module frame
2 sealant
3 cover glass
4 encapsulant
5 solar cell
6 backsheets

AR coating technology for solar cover glass

Encapsulant material

Arnite®
Stanyl®

Junction box
Power inverter

EcoPaXX™
DSM future opportunities in solar

**c-Si modules**
- Integrated module design & production
- Building Integrated

**Thin Film materials and technologies**
- Stanyl® ForTii™ as polymeric substrate
- Graphene for electrical conductive, transparent barrier layer
- multi-layer packaging know-how
- coatings technology
- new deposition technologies

**Energy conversion and storage**
- Radical solutions in batteries, supercapacitors, photocatalysts
DSM long term opportunities in solar towards artificial photosynthesis...
# Summary

**DSM and Renewable Energy**

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<th>Bio-ethanol</th>
<th>enzymes/yeasts for 2\textsuperscript{nd} generation bio-fuels</th>
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<td>Biogas</td>
<td>enzymes for a more efficient production and higher performance</td>
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<tr>
<td>Wind energy</td>
<td>resins &amp; coatings &amp; technology for windblades</td>
</tr>
<tr>
<td>Solar energy</td>
<td>AR coatings &amp; engineering plastics for cost-effective solar modules</td>
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Successful Renewable Energy only by technology push AND market pull

“technology push” from industry


Source: 2005 Annual Report REC, Norway

“market pull” supported by government

Example: South Korea
Towards a smart world...