Renewable Power Generation from Biomass - Perspective from Essent

International Delegation
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Welcome at the Amer: the largest European co-firing power plant

- Amer 9 (600 MWe, 350 MW heat)
  600kT biomass co-firing /y $\approx 1150$ GWh

- Amer 8 (645 MWe, 250MW heat)
  300kT biomass co-firing /y $\approx 525$ GWh

- Wood gasifier ($\approx 33$ MWe)
  90kT biomass /y $\approx 130$ GWh

- Biomass unloading and temporary storage
As of October 2009 Essent has been integrated into the RWE Group

- Integration of RWE Energy Nederland into Essent’s Dutch operations
- Combination of Essent’s wind activities and RWE Innogy’s renewable portfolio
- Integration of Essent’s trading organisation into RWE Supply & Trading
Essent is the largest producer of renewable power in the Netherlands

### Renewable Mix 2008 (GWh)

<table>
<thead>
<tr>
<th>In GWh</th>
<th>2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind energy</td>
<td>843</td>
</tr>
<tr>
<td>Hydropower</td>
<td>30</td>
</tr>
<tr>
<td>Solarpower</td>
<td>-</td>
</tr>
<tr>
<td>Landfill gas and biogas</td>
<td>42</td>
</tr>
<tr>
<td>Stand-alone clean biomass</td>
<td>164</td>
</tr>
<tr>
<td>Fossil replaced by clean biomass</td>
<td>1,512</td>
</tr>
<tr>
<td><strong>Of which</strong></td>
<td></td>
</tr>
<tr>
<td>Solid biomass</td>
<td>1,149</td>
</tr>
<tr>
<td>Liquid biomass</td>
<td>363</td>
</tr>
<tr>
<td>Other biomass (e.g. waste incineration)</td>
<td>465</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>3,055</td>
</tr>
</tbody>
</table>

### General figures (2008)
- 5000 employees
- 9 billion Euro turnover
- Clients: 2.6 million electricity and 2 million gas
- 6000 MW installed

### Biomass Facts Essent
- 2 TWh realized with biomass
- 27% of total Dutch renewable electricity production
- 23% of Essent's supply mix is made of renewable power
- Biomass co-firing and wind are the main contributors to renewable power by far
- Essent is a European leader in biomass trading and at the leading edge in biomass certification (70% certification)
Agenda

<table>
<thead>
<tr>
<th>Biomass within the Dutch renewable target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Availability of biomass and sustainability</td>
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<td>Climate and cost effectiveness</td>
</tr>
<tr>
<td>Co-firing vision and ambition Essent</td>
</tr>
</tbody>
</table>
The Dutch target of 35% renewable electricity by 2020 is ambitious with a prominent and promising role for co-firing.

Dutch 2020 target

- **Co-firing**
- **Stand alone biomass**
- **Onshore Wind**
- **Offshore Wind**
- **Waste**
- **PV cells**
- **Hydro**

<table>
<thead>
<tr>
<th>Source</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hydro 2008 = 102 GWh, PV 2008 = 38 GWh</td>
<td>2008 Actual</td>
</tr>
<tr>
<td>ECN ‘Verkenning Schoon en Zuinig’, April 2009</td>
<td>2020 35% target</td>
</tr>
</tbody>
</table>

- **6 Mton biomass**
- **550% growth**

Feasibility by ECN and Essent match

- Old coal capacity included
- Learning curve for newcomers and new plants limits growth to 20%
- Co-firing in experienced plants to 30-50%
- Pre-treatment technologies not included

Feasibility

- Offshore Wind: technically capped by construction of 1000 MW/year (= 3.4 TWh/year)
- Onshore Wind: 4000 MW seems feasible. Additional 2000 MW strongly hindered by institutional and social resistance (= 12 → 8 TWh)
- Dedicated Biomass: 6.8 TWh is based on 100% utilization of the theoretical maximum of available feedstock in NL
- Waste to Energy: mainly capped by the availability of domestic waste
- Energy from Water & PV: only marginal contribution expected in the coming decades
## Agenda

<table>
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<th>The Dutch renewable target</th>
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</tbody>
</table>
Wood is the preferred biomass feedstock for direct combustion

<table>
<thead>
<tr>
<th>Product</th>
<th>Qualification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forestry</td>
<td>• Logs</td>
</tr>
<tr>
<td></td>
<td>• Thinnings</td>
</tr>
<tr>
<td></td>
<td>• Paper &amp; pulp</td>
</tr>
<tr>
<td></td>
<td>• Residue</td>
</tr>
<tr>
<td></td>
<td>• High energy content</td>
</tr>
<tr>
<td></td>
<td>• Low ashes</td>
</tr>
<tr>
<td></td>
<td>• Large supply potential</td>
</tr>
<tr>
<td></td>
<td>• Sustainability is manageable</td>
</tr>
<tr>
<td>Agro</td>
<td>• Conventional energy crops</td>
</tr>
<tr>
<td></td>
<td>• Grass, oil and rape</td>
</tr>
<tr>
<td></td>
<td>• Sugar and starch crops</td>
</tr>
<tr>
<td></td>
<td>• Lignocellulosic feedstocks</td>
</tr>
<tr>
<td></td>
<td>• Algae</td>
</tr>
<tr>
<td></td>
<td>• Medium energy content</td>
</tr>
<tr>
<td></td>
<td>• High ash content</td>
</tr>
<tr>
<td></td>
<td>• Energy vs. food problem</td>
</tr>
<tr>
<td>Waste</td>
<td>• Agricultural waste</td>
</tr>
<tr>
<td></td>
<td>• Industrial waste</td>
</tr>
<tr>
<td></td>
<td>• Construction waste</td>
</tr>
<tr>
<td></td>
<td>• Sewage</td>
</tr>
<tr>
<td></td>
<td>• Low price</td>
</tr>
<tr>
<td></td>
<td>• Low energy content</td>
</tr>
<tr>
<td></td>
<td>• Medium ashes</td>
</tr>
<tr>
<td></td>
<td>• Regionally abundant</td>
</tr>
</tbody>
</table>
Global availability of biomass is sufficient to fulfill a major role in our ambition towards a more sustainable world

By development of 2nd generation biofuels woody or fibrous biomass will eventually become a major feedstock for the biofuel sector as well

When looking at the availability of biomass for energy purposes both biofuels as well as heat and power have to be taken into account

Under those circumstances analysis by the IEA Task 40 (see figure) shows sufficient availability of sustainable biomass for the coming decades

Half of the world energy demand in 2050 can be met by the total potential of sustainable biomass

10 Mton = global pellet production = 0.2 EJ

Source: Technical biomass supply potentials, sustainable biomass potential, expected demand for biomass (primary energy) based on global energy models and expected total world primary energy demand in 2050. Adapted from Dornburg et al. (2008) based on several review studies.
Our current certification system offers a way to guarantee the sustainability of biomass all the way through the supply chain.

Independent audit on sustainability of the feedstock results in certificate (Control Union).

Certified biomass is tracked and traced throughout the supply chain.

Essent applies the Green Gold Label developed in 2000.

Biomass certificate received at power plant.

Copernicus study shows that there are currently 59 sustainability systems worldwide. Harmonization is essential to enable growth towards a liquid market in biomass.

New Systems
- NTA8080 / 81 (NL)
- ISCC (Du)
- EU – RES directive
- GBEP (global)
- RSB (Round table sustainable biofuels, global)

Commodity specific
- RSPO (palm oil)
- FSC (wood)
- RTRS (soya)
Agenda

- The Dutch renewable target
- Availability of biomass and sustainability
- **Climate and cost effectiveness**
- Co-firing vision and ambition of Essent
Woody biomass contributes to CO2 reduction by closing a continuous natural cycle and offering significant optimization opportunities

7 million households would appr. require a forest the size of Zuid-Holland (ZH)

3.500 km²

1 household/yr
≈ 3.500 kWh
≈ 3.5 m³

1 m³ = 750-850 kg CO₂

Standing volume US South
135-302 m³/ha

Growth rates in forestry

<table>
<thead>
<tr>
<th>Country</th>
<th>12-25</th>
<th>4-5</th>
<th>7-9</th>
<th>5-7</th>
</tr>
</thead>
<tbody>
<tr>
<td>m³/ha/year</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Oxygen
1,62 ton

CO₂
1,83 ton

7 million households would appr. require a forest the size of Zuid-Holland (ZH)
In combination with modernization of the current production park co-firing of biomass is very effective in reducing CO2 emissions.

Transport of pellets is comparable to coal or regional chips.

Source: Essent Team Analysis
Within the merit order co-firing even results in the highest net CO2 savings

Net CO2 savings by technique (gram/kWh)

<table>
<thead>
<tr>
<th>Technique</th>
<th>CO2 Savings (gram/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wind</td>
<td>591^1)</td>
</tr>
<tr>
<td>Co-firing</td>
<td>793</td>
</tr>
<tr>
<td>Stand alone (wood chips)</td>
<td>487</td>
</tr>
<tr>
<td></td>
<td>325</td>
</tr>
</tbody>
</table>

1) When wind capacity strongly increases it will also start replacing coal capacity at night

Explanation

- A power plant is operated based on its fuel or so called “marginal” cost
- Based on the electricity demand the production unit with the lowest cost switches on first then the next cheapest and so on
- Within this order coal plants are positioned upfront of various types of gas plants
- Wind has no marginal cost so it will always produce
- When the wind is increasing the windmill parks will start pushing out the last producing unit within the order followed by the next in line and so on
- As the marginal cost for stand alone biomass plants is higher than for co-firing it will also replace gas capacity
- Co-firing merely replaces coal in the same production unit not affecting the order
Together with onshore wind co-firing will remain the most cost efficient sustainable solution towards 2020 and beyond

2020 integral cost based on the 54 TWh Dutch renewable program

- **Close to competitive with conventional power**
- **Significant support required on top of e-price**

**Source:** ECN, Essent Team Analysis

March 2010
Innovation and optimization of the supply and value chain will contribute to further reduction of cost and CO2

<table>
<thead>
<tr>
<th>Forestry</th>
<th>Pelletization</th>
<th>Pre-treatment</th>
<th>Logistics</th>
<th>Power Plant</th>
</tr>
</thead>
</table>
| - optimized plantation management will increase output
  - modern harvesting technology
  - fast growing trees and energy crops
  - Species optimized for energy purposes | - micro chipping → homogenous product facilitates further process
  - using logging remains for drying purposes (avoid CO2 emissions due to rotting) | - develop industrial scale continuous processes to facilitate
  - improved grinding
  - storable (hydrophobic, no biological activity)
  - commodity capable | - special pellet vessels will reduce cost and CO2
  - large potential in storage and handling
  - logistic chain is key to further cost reduction | - boiler behavior with co-firing above 35% mass
  - CFD modeling
  - Reduce efficiency losses
  - Improve availability of mills and reduce stops |

Stable investment climate driver for long term investments and innovation
Torrefaction is a promising technology which is currently being brought to the next level with support of substantial contract volumes.

Essent recently contracted a total of 150 kton/year of torrefied biomass.

For comparison, hard coal typically has 6.5-7.5 MWh/ton.

Bio-coal (step 2)
- 9-10 MWh/ton
- Hydrophobic
- Uniform properties
- Ideal to gasify
- Excellent total economics
- New applications
- > 16 times bulk energy density*

Bio-coal (step 1)
- 6.5 MWh/ton
- Hydrophobic
- Uniform properties
- Possible to gasify
- 8 times bulk energy density*

In 1-2 years

In 4+ years ??

For comparison, hard coal typically has 6.5-7.5 MWh/ton.

Sources: BioMass Capital analysis

Now

Standard pellets
- 5 MWh/ton
- Improved handling and combustion
- 4 times bulk energy density*

Wood chips

*In comparison to woodchips
## Agenda

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</tr>
</tbody>
</table>
10 years of investment and improvement have resulted in a substantial share of renewable energy from biomass mainly by co-firing

<table>
<thead>
<tr>
<th>Year</th>
<th>Description</th>
<th>Capacity</th>
<th>Fuel type</th>
<th>Start Year</th>
</tr>
</thead>
<tbody>
<tr>
<td>1999</td>
<td>Stand alone plant Cuijk</td>
<td>25 MW</td>
<td>forest residues</td>
<td>1995</td>
</tr>
<tr>
<td>2000</td>
<td>1st biomass mill Amer 9</td>
<td>83 MW</td>
<td>waste wood</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>Installation hammer mills Amer 8</td>
<td>96 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>Bio-oil Claus A (test 2002)</td>
<td>92 MW</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2009</td>
<td>2nd biomass mill Amer 9</td>
<td>83 MW</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Facts & figures

- 130 mio Euro of investments, of which 60 mio Euro in gasification
- 1,5 TWh in 2009 from wood pellets alone
- 755 kton wood pellets out of 1 Mton biomass
- Co-firing capacity Amer 9 of 35% on a mass basis (short term ambition 50%)
- Savings of 1 million ton of CO2
Essent has the ambition to expand its renewable portfolio to 10 TWh for which it has a well positioned co-firing pipeline.

### Essent renewable ambition (TWh)

<table>
<thead>
<tr>
<th>Year</th>
<th>Biomass</th>
<th>Wind</th>
</tr>
</thead>
<tbody>
<tr>
<td>2008</td>
<td>1.9</td>
<td>0.4</td>
</tr>
<tr>
<td>2020</td>
<td>5-6</td>
<td>6,3</td>
</tr>
</tbody>
</table>

### Biomass project pipeline Essent

<table>
<thead>
<tr>
<th>Project</th>
<th>2020 Ambition (TWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>0.4</td>
</tr>
<tr>
<td>B</td>
<td>0.5</td>
</tr>
<tr>
<td>C</td>
<td>0.8</td>
</tr>
<tr>
<td>D</td>
<td>2.4</td>
</tr>
<tr>
<td>E</td>
<td>4.1</td>
</tr>
<tr>
<td>F</td>
<td>5.5</td>
</tr>
<tr>
<td>G</td>
<td>6.3</td>
</tr>
</tbody>
</table>

### 2020 assumptions:

- **Wind:** ~ 40%
  - 1.200 MW installed (on-/offshore)
  - pending successful application for subsidies and permits
- **Biomass:** ~ 60%
  - Dependent on development wind portfolio
  - Stand alone Cuijk will phase out
  - Waste to Energy will be not part of portfolio (0.5 TWh in 2008)
The Netherlands are looking for an alternative co-firing system while current subsidies are phasing out forcing investments to a halt.

Renewable support systems in EU

- No policy
- Subsidy
- Certificate system
- Combination

Dutch co-firing target is under pressure

- Granted 10 year subsidy schemes (2003-2005) for co-firing are phasing out
- No new basis for investments in place to date
- Average project takes 4 years from start to implementation
- Plant revision takes place only every 4 years
- Separately 6 million tons of biomass has to be secured usually in 4-5 year contracts

Dutch government applies subsidies to stimulate renewables

- As of 2006 no new subsidies for co-firing due to:
  - reduced support to finance “fuels”
  - targets not guaranteed
- EU systems assessed in search for alternative
We see the hybrid supplier obligation as a solution for a stable market based system with an impulse to drive technology and secure targets.
Key Messages

Why Co-Firing

1. Large scale co-firing is crucial in achieving the 20% sustainable energy goals of the government in 2020.
2. It is the most cost effective solution for society
3. It has the highest CO2 reduction potential
4. Large volumes are sustainably available worldwide without competition for food

Next steps

Hurdles
- Development of a professional biomass supply chain / scale economics
- An effective (international) regulatory framework
- Consolidated (international) environmental sustainability standard
Essent Biofuels team (now RWE Supply and Trading) renewable portfolio – 2009

We source ~ 1.3 mln tons on annual basis.

<table>
<thead>
<tr>
<th>Renewables Portfolio</th>
<th>Renewable Fuel Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>Baltic</td>
<td>Wood pellets</td>
</tr>
<tr>
<td>Other</td>
<td>Wood chips</td>
</tr>
<tr>
<td>Canada</td>
<td>Demolition wood</td>
</tr>
<tr>
<td>US</td>
<td></td>
</tr>
<tr>
<td>Netherlands</td>
<td></td>
</tr>
</tbody>
</table>
We import bio energy from all over the world…

Origination market very active
Potential new sourcing markets

Canada
- Wood pellets
- Bio Coal

US
- Peanut
- Wood Pellets

Mexico/Brazil
- Coffee husk
- Bagasse

Netherlands
- Wood pellets
- Demolition wood
- Wood chips
- Bio Coal

Baltics
- Wood pellets

Germany
- Wood pellets
- Olive cake

Italy
- Olive cake

Portugal
- Wood pellets

Sub-Saharan Africa
- Wood Pellets
- Cocoa

South Africa
- Wood pellets

Thailand
- Wood Pellets

Vietnam
- Rice Husk

Russia
- Wood pellets
- Sun flower husk

China
- Wood Pellets
- Bamboo Pellets

Australia (Malaysia/Indonesia)
- Wood Pellets

Origination market very active
Potential new sourcing markets
… like we are importing coal energy from all over the world.

**Coal supply for Third-parties**

6 million tons

**Key supply Markets**
- US
  - Wide range of qualities
  - Arbitrage domestic / South America / Europe
- Colombia
  - High NCV
  - Premium markets
- Russia
  - Low sulphur coals
  - Un-economic in long distances
  - Germany / Baltics or premium market (UK)
- Venezuela
  - High NCV
  - Premium markets
- South Africa
  - Low volatile, low Sulphur
  - Cape size port
  - Atlantic-Pacific swing market
- Indonesia
  - High volatile, lower NCV
  - Pacific market coals

**Potential supply Markets**
- Germany / Baltics or premium market (UK)
- South Africa
  - Low volatile, low Sulphur
  - Cape size port
  - Atlantic-Pacific swing market
- Indonesia
  - High volatile, lower NCV
  - Pacific market coals
- Venezuela
  - High NCV
  - Premium markets

**Coal supply for Essent Portfolio**

3 million tons
Three key principles in sourcing biomass (1)

- **Sustainable Resource.**
  - We actively ask commitment from our suppliers to confirm the sustainability of their sources ("green gold certification")
  - We offer Longer term contracts to suppliers, in order to help them building their business in a sustainable way
  - We know our Customer/Supplier
Three key principles in sourcing biomass (2)

- **Sustainable price** for our suppliers
  - We give our suppliers long term price certainty (even if we are not having certainty on biomass support mechanism post 2012)
  - We are not going for the lowest price; we need comfort that the supplier can deliver for the agreed price
  - We value sustainability of resources (see previous slide)

- **Sustainable price** for us
  - We are in a highly competitive market
  - We also sell to third parties
  - We are taking significant risks (credit, freight, technical, sunk costs, …)
Our view is that we need to get an integrated supply chain to ensure reliable supply

Initial core business
Current expanded core business
Ambitions for growth

Further vertical integration will increase security of supply and better supply chain optimization. It will also provide more flexibility for trading and allow secured supply to 3rd parties.
Three key principles in sourcing biomass (3)

- Carbon FootPrint needs to be significant better than fossil fuels (‘we do not want to burn subsidy money’)
  - We calculate and discuss carbon footprint of our long term contracts and projects
  - We try to take ‘whole chain’ into account (see next slides)
  - We are open to openly discuss and improve our models provided we have a constructive win/win dialogue (“we want to learn something as well”).
  - We believe Carbon Footprint and Costs should play a key role in designing support mechanisms.
Shaping the future..
.. with your help

- Making biomass a global commodity (including working together on sustainability standards)
- Keeping things simple
- Keep up the high ethical standards
- On support mechanisms: look at carbon footprint and costs and above all: be consistent and transparent and realize that long term certainty is key. Realize Europe is an energy importing country
- Like Amsterdam/Rotterdam/Antwerpen is the standard for European coal (and TTF for European gas), we should in Benelux establish the standard for European biomass
Thank you very much for your attention