Existing Practices and Prospective Development of Wastes to Energy in California

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California Energy Commission

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Wastes (Organic Residuals or Resources)
To Energy in California

- Goal of California Energy Commission’s Public Interest Energy Research (PIER) Program
- Existing Practices of Wastes to Energy in California
- Prospective Development of Wastes to Energy in California
- Conclusions
Public Interest Energy Research (PIER) Program

- **GOAL:** To support energy research, development and demonstration (RD&D) projects that will help improve the quality of life in California by bringing environmentally safe, affordable and reliable energy services and products to the marketplace.

- **Buildings End-Use Energy Efficiency**
- **Energy Innovations Small Grant (EISG) Program**
- **Energy-Related Environmental Research**
- **Energy Systems Integration**
- **Environmentally-Preferred Advanced Generation**
- **Industrial / Agricultural / Water End-Use Energy Efficiency**
- **Public Interest Natural Gas Research Program**
- **Renewable Energy Technologies**
California Energy Profile

- Per Capita Income: $35,019 (2004) ranked 13th
- Total Energy Consumption: 7.9 quadrillion Btu (2001), ranked 2nd
- Per Capita Energy Consumption: 227 million Btu (2001), ranked 49th
- Total Petroleum Consumption: 78.4 million gallons per day (2002), ranked 2nd
- Gasoline Consumption: 42.5 million gallons per day (2002), ranked 1st
- Distillate Fuel Consumption: 10.3 million gallons per day (2002), ranked 2nd
- Liquefied Petroleum Gas Consumption: 1.7 million gallons per day (2002), ranked 6th
- Jet Fuel Consumption: 11.8 million gallons per day (2002), ranked 2nd
- Natural Gas: Total natural gas consumption including residual, commercial, industrial, and power industry in California is 2,366,399 MMcf (2004).
- Electricity: Total summer capacity is 58,306 MW (2004)

<table>
<thead>
<tr>
<th>State</th>
<th>Primary Fuel Source</th>
<th>Total Summer Capacity (MW)</th>
<th>Rank</th>
<th>Net Generation (MWh)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>California</td>
<td>Gas</td>
<td>58,306</td>
<td>2</td>
<td>194,780,355</td>
<td>4</td>
</tr>
</tbody>
</table>

Source: Energy Information Administration (EIA)
## Existing Practices of Wastes (Organic Residuals or Resources) to Energy in California

<table>
<thead>
<tr>
<th>Feedstock Categories</th>
<th>Technologies</th>
<th># of Operational Facilities</th>
<th>Existing Power and Fuel Production</th>
<th>Feedstock used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag, Urban, and Forest Biomass Residues</td>
<td>Direct Combustion</td>
<td>34</td>
<td>618 MW</td>
<td>4.8 million BDT/yr</td>
</tr>
<tr>
<td>Municipal Solid Wastes (MSW)</td>
<td>Transformation/Incineration using MSW disposed annually</td>
<td>3</td>
<td>70 MW</td>
<td>0.9 million wet tons/yr</td>
</tr>
<tr>
<td></td>
<td>Landfill Gas to Energy using MSW disposed annually</td>
<td>NA</td>
<td>10.61 MW</td>
<td>42.1 million wet tons/yr</td>
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<tr>
<td></td>
<td>Landfill Gas to Energy using MSW historically accumulated</td>
<td>72</td>
<td>255 MW</td>
<td>1000 million wet tons</td>
</tr>
<tr>
<td>Waste Tires</td>
<td>Co-generation</td>
<td>6</td>
<td>14 MW</td>
<td>0.07 million BDT/yr</td>
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<tr>
<td>Livestock Manures</td>
<td>Anaerobic Digestion</td>
<td>11</td>
<td>2.2 MW</td>
<td>0.05 million BDT/yr</td>
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<tr>
<td>Sewage Sludge from Domestic Wastewater</td>
<td>Anaerobic Digestion</td>
<td>10</td>
<td>38.5 MW</td>
<td>0.4 million BDT/yr</td>
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<tr>
<td>Food Processing Wastes and Wastewater</td>
<td>Anaerobic Digestion</td>
<td>1</td>
<td>0.075 MW</td>
<td>0.0001 million BDT/yr</td>
</tr>
<tr>
<td></td>
<td>Fermentation</td>
<td>2</td>
<td>7.5 million gallons of ethanol</td>
<td>0.075 million BDT/yr</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>139</td>
<td>1005 MW power + 7.5 million gallons ethanol</td>
<td></td>
</tr>
</tbody>
</table>
Existing Operational Direct Combustion Facilities using Ag. Urban, and Forest Residuals

34 facilities
618 MW

<table>
<thead>
<tr>
<th>Project</th>
<th>County</th>
<th>Net MW</th>
<th>Start Up</th>
</tr>
</thead>
<tbody>
<tr>
<td>Colmac Energy</td>
<td>Riverside</td>
<td>47.0</td>
<td>1992</td>
</tr>
<tr>
<td>Thermo Ecotek Delano</td>
<td>Tulare</td>
<td>48.0</td>
<td>1991</td>
</tr>
<tr>
<td>Soledad Energy</td>
<td>Monterey</td>
<td>13.5</td>
<td>1990</td>
</tr>
<tr>
<td>Thermo Ecotek Mendota</td>
<td>Fresno</td>
<td>25.0</td>
<td>1990</td>
</tr>
<tr>
<td>Tracy Biomass</td>
<td>San Joaquin</td>
<td>19.5</td>
<td>1990</td>
</tr>
<tr>
<td>Diamond Walnut</td>
<td>San Joaquin</td>
<td>4.5</td>
<td>1981</td>
</tr>
<tr>
<td>Chinese Station</td>
<td>Tuolumne</td>
<td>22.0</td>
<td>1987</td>
</tr>
<tr>
<td>Thermo Ecotek Woodlake</td>
<td>Yolo</td>
<td>25.0</td>
<td>1990</td>
</tr>
<tr>
<td>Wheelerbrator Martell</td>
<td>Amador</td>
<td>18.0</td>
<td>1987</td>
</tr>
<tr>
<td>Rio Bravo Rocklin</td>
<td>Placer</td>
<td>25.0</td>
<td>1990</td>
</tr>
<tr>
<td>Sierra Pacific Lincoln</td>
<td>Placer</td>
<td>8.0</td>
<td>1985</td>
</tr>
<tr>
<td>Wadham Energy</td>
<td>Colusa</td>
<td>26.5</td>
<td>1989</td>
</tr>
<tr>
<td>Georgia Pacific</td>
<td>Mendocino</td>
<td>15.0</td>
<td>1987</td>
</tr>
<tr>
<td>Ogden Pacific Oroville</td>
<td>Butte</td>
<td>18.0</td>
<td>1986</td>
</tr>
<tr>
<td>Sierra Pac. Loyalton</td>
<td>Sierra</td>
<td>17.0</td>
<td>1990</td>
</tr>
<tr>
<td>Sierra Pacific Quincy</td>
<td>Plumas</td>
<td>25.0</td>
<td>1987</td>
</tr>
<tr>
<td>Collins Pine</td>
<td>Plumas</td>
<td>12.0</td>
<td>1986</td>
</tr>
<tr>
<td>Sierra Pac. Susanville</td>
<td>Lassen</td>
<td>13.0</td>
<td>1986</td>
</tr>
<tr>
<td>Ogden Westwood</td>
<td>Lassen</td>
<td>11.4</td>
<td>1985</td>
</tr>
<tr>
<td>Honey Lake Power</td>
<td>Lassen</td>
<td>30.0</td>
<td>1989</td>
</tr>
<tr>
<td>Big Valley Lumber</td>
<td>Lassen</td>
<td>7.5</td>
<td>1983</td>
</tr>
<tr>
<td>Sierra Pacific Burney</td>
<td>Shasta</td>
<td>17.0</td>
<td>1987</td>
</tr>
<tr>
<td>Ogden Burney</td>
<td>Shasta</td>
<td>10.0</td>
<td>1985</td>
</tr>
<tr>
<td>Burney Forest Products</td>
<td>Shasta</td>
<td>31.0</td>
<td>1990</td>
</tr>
<tr>
<td>Wheelerbrator Shasta</td>
<td>Shasta</td>
<td>50.0</td>
<td>1988</td>
</tr>
<tr>
<td>Wheelerbrator Hudson</td>
<td>Shasta</td>
<td>6.0</td>
<td>1981</td>
</tr>
<tr>
<td>Sierra Pacific Anderson</td>
<td>Shasta</td>
<td>4.0</td>
<td>1998</td>
</tr>
<tr>
<td>Pacific Lumber</td>
<td>Humboldt</td>
<td>23.0</td>
<td>1988</td>
</tr>
<tr>
<td>Simpson Paper</td>
<td>Humboldt</td>
<td>29.0</td>
<td>1980</td>
</tr>
<tr>
<td>Fairhaven Power</td>
<td>Humboldt</td>
<td>17.3</td>
<td>1987</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td>618.2</td>
<td></td>
</tr>
</tbody>
</table>
1. Southeast Resource Recovery Facility (SERRF), Built in 1988, 36 MW, 1290 Tons/day, Cost: $108 million
2. The Commerce Facility, 1981, 11.5 MW, 360 tons/day
3. The Stanislaus Resource Recovery Facility, 1989, 22.5 MW, 800 tons/day
Existing Operational Landfill Gas to Energy Facilities using MSW Accumulated

<table>
<thead>
<tr>
<th>Type of Engine</th>
<th># of Facilities</th>
<th>MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Steam Turbine</td>
<td>6</td>
<td>98</td>
</tr>
<tr>
<td>Reciprocating Engine</td>
<td>47</td>
<td>125</td>
</tr>
<tr>
<td>Microturbine</td>
<td>11</td>
<td>9.5</td>
</tr>
<tr>
<td>Gas Turbine</td>
<td>8</td>
<td>22.6</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>72</strong></td>
<td><strong>255</strong></td>
</tr>
</tbody>
</table>

- LFGTE from MSW Accumulated
- Electricity Service Area
  - PGE
  - SCE
  - SDG&E
  - SMUD
  - Cacnty83.shp

[Map showing operational landfills in California]
Existing Waste Tires Co-generation Facilities

13 permitted tire burning facilities
6 facilities burned 7.4 million tires (25% of total tires in 2003)
Estimated power generation: 14 MW

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Facility Address</th>
<th>Tires Burned in 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>California Portland Cement Company (Colton)</td>
<td>695 South Rancho Avenue Colton, California 92324</td>
<td>2.2 million tires (20,452 tons of tires)</td>
</tr>
<tr>
<td>Mitsubishi Cement Company</td>
<td>5808 State Highway 18 Lucerne Valley, California 92356</td>
<td>2.1 million tires (19,415 tons of tires)</td>
</tr>
<tr>
<td>Lehigh Southwest (formerly Calaveras Cement Company)</td>
<td>15390 Wonderland Boulevard Redding, California 96003</td>
<td>1.6 million tires (14,978 tons of tires)</td>
</tr>
<tr>
<td>California Portland Cement Company (Mojave)</td>
<td>9350 Oak Creek Road Mojave, California 93502</td>
<td>None</td>
</tr>
<tr>
<td>Cemex – California Cement, LLC</td>
<td>25220 Black Mountain Quarry Road Apple Valley, California 92307</td>
<td>None</td>
</tr>
<tr>
<td>National Cement Company</td>
<td>5 Miles East Of I-5 Off Highway 138 Lebec, California 93243</td>
<td>None</td>
</tr>
<tr>
<td>Riverside Cement Company</td>
<td>19409 National Trails Highway Oro Grande, California 92349</td>
<td>None</td>
</tr>
</tbody>
</table>

Cogeneneration Facilities

<table>
<thead>
<tr>
<th>Facility Name</th>
<th>Facility Address</th>
<th>Tires Burned in 2003</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stockton Cogeneration Company</td>
<td>1010 Zephyr Street Stockton, California 95206</td>
<td>1.4 million tires (12,845 tons of tires)</td>
</tr>
<tr>
<td>Mount Poso Cogeneration Company</td>
<td>36157 Famoso Road Bakersfield, California 93308</td>
<td>&lt;0.1 million tires (395 tons of tires)</td>
</tr>
<tr>
<td>Port of Stockton District Energy Facility</td>
<td>2526 West Washington Street Stockton, California 95203</td>
<td>&lt;0.1 million tires (16 tons of tires)</td>
</tr>
<tr>
<td>Jackson Valley Energy Partners</td>
<td>4655 Coal Mine Road Ione, California 95640</td>
<td>None</td>
</tr>
<tr>
<td>Rio Bravo Jasmin</td>
<td>11258 Porterville Highway Bakersfield, California 93308</td>
<td>None</td>
</tr>
<tr>
<td>Rio Bravo Poco</td>
<td>16608 Porterville Highway Bakersfield, California 93308</td>
<td>None</td>
</tr>
</tbody>
</table>

Source: CARB

Total Tires Burned in 2003
7.4 million tires (68,101 tons of tires)
Existing Livestock Biogas Power Facilities

11 facilities
2.2 MW

Langerwerf Dairy
1251 Durham-Dayton Highway, Durham, CA 95938
700 head, Plug Flow Digester
- Operational date: 1982
- Capital Cost: $200,000, which included the digester, solids separating system, and all ancillary equipment. Half the project was funded by CDFA’s low interest loan program in 1980.
- Electricity Production: Estimated at 300,000 kWh/yr
- Electricity Savings: $22,000-$27,000 at an energy charge of $0.12/kWh in 1998, with no demand charge.
- Thermal Savings: $15,000, with water heating savings estimated to average about $1,000/month.
- Uses of Effluent: Liquid is used on crop irrigation. Separated solids are used for freestall and calf barn bedding and also sold as garden mulch to local gardeners at $6.00/yd3. Manure solids sales are about $6,000/year. Savings resulting from reduced number of manure pit clean-outs are estimated to be $9,000/year.
- Unquantified benefits from fly and odor control.
  “Unlimited possibilities if you keep your mind open.”
- Designer: Resource Conservation Management, Inc.
- Installer: Lee Miller.
Existing Sewage Biogas Power Facilities

10 facilities
38.5 MW

<table>
<thead>
<tr>
<th>COUNTY</th>
<th>FACILITY NAME</th>
<th>Installed MW</th>
</tr>
</thead>
<tbody>
<tr>
<td>Los Angeles</td>
<td>Hyperion TP</td>
<td>13.37</td>
</tr>
<tr>
<td>Orange</td>
<td>Orange County Sanitation Dist.</td>
<td>6.98</td>
</tr>
<tr>
<td>Sacramento</td>
<td>Sacramento Regional WTP</td>
<td>2.83</td>
</tr>
<tr>
<td>Alameda</td>
<td>East Bay MUD Special District</td>
<td>2.22</td>
</tr>
<tr>
<td>Sonoma</td>
<td>Santa Rosa - Laguna WTP</td>
<td>0.59</td>
</tr>
<tr>
<td>Riverside</td>
<td>Riverside</td>
<td>0.53</td>
</tr>
<tr>
<td>San Francisco</td>
<td>San Francisco Oceanside WPC</td>
<td>0.51</td>
</tr>
<tr>
<td>Kern</td>
<td>Bakersfield Plant 3</td>
<td>0.28</td>
</tr>
<tr>
<td>Santa Cruz</td>
<td>Watsonville WTF</td>
<td>0.27</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>Total</strong></td>
<td><strong>38.51</strong></td>
</tr>
</tbody>
</table>
Existing Ethanol and Biogas Facilities using Food Processing Wastes

Golden Cheese Company
- Ethanol: 3.5 million gallon from Cheese whey
- In full operation, the plant consumes 5,000,000 pounds of milk per day and requires 100,000 California milk cows to meet the demand.

Parallel Products
Ethanol: 4 million gallon from waste beer, brewers yeast, outdated soda syrup and fruit juices, waste ice cream, spent alcohol and wine from retail business and industry.
# Potential Wastes to Energy in California using Existing Technologies

<table>
<thead>
<tr>
<th>Feedstock Categories</th>
<th>Technologies</th>
<th>Feedstock used/Total</th>
<th>Total feedstock available</th>
<th>Potential Power and Fuel Addition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ag, Urban, and Forest Biomass Residues</td>
<td>Direct Combustion</td>
<td>34%</td>
<td>14.3 million BDT/yr</td>
<td>1200 MW</td>
</tr>
<tr>
<td>Municipal Solid Wastes (MSW)</td>
<td>Transformation/Incineration using MSW disposed annually</td>
<td>2.1%</td>
<td>0.9 - 43 million wet tons/yr</td>
<td>0 - 3274 MW</td>
</tr>
<tr>
<td></td>
<td>Landfill Gas to Energy using MSW disposed annually</td>
<td>100%</td>
<td>43 - 0 million wet tons/yr</td>
<td>10.61 - 0 MW</td>
</tr>
<tr>
<td></td>
<td>Landfill Gas to Energy using MSW historically accumulated</td>
<td>100%</td>
<td>1000 million wet tons</td>
<td>252 - 0 MW for limited yrs</td>
</tr>
<tr>
<td>Waste Tires</td>
<td>Co-generation</td>
<td>25%</td>
<td>0.28 million BDT/yr</td>
<td>42 MW</td>
</tr>
<tr>
<td>Livestock Manures</td>
<td>Anaerobic Digestion</td>
<td>1.39%</td>
<td>3.6 million BDT/yr</td>
<td>156 MW</td>
</tr>
<tr>
<td>Sewage Sludge from Domestic Wastewater</td>
<td>Anaerobic Digestion</td>
<td>50%</td>
<td>0.80 million BDT/yr</td>
<td>38.5 MW</td>
</tr>
<tr>
<td>Food Processing Wastes and Wastewater</td>
<td>Anaerobic Digestion</td>
<td>0.20%</td>
<td>0.05 million BDT/yr</td>
<td>37.43 MW</td>
</tr>
<tr>
<td></td>
<td>Fermentation</td>
<td>5%</td>
<td>1.5 million BDT/yr</td>
<td>142.5 million gallon ethanol/yr</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td></td>
<td>5000 MW (assume transformation consumes all of the MSW disposed annually) + 142.5 million gallon ethanol/yr</td>
</tr>
</tbody>
</table>
Other Fuel Options from Wastes to Energy

- Ethanol: gasification or fermentation using lignin-cellulosic material
- Methanol: gasification
- Biodiesel
- Bio-oils (pyrolysis)
- Syngas
- Hydrogen
- Others
Existing and Prospective Development of Wastes to Energy under the PIER Program

- Dairy Power Production Program
- Valley Fig Grower (VFG) Biogas Digester
- Commerce Energy Co-Digestion of Dairy manure and Food Processing Wastes
- Inland Empire Utility Agency European Designed Complete Mix Anaerobic Digesters
Dairy Power Production Program

Drivers

❖ Energy
■ Electricity and heat
■ Fuel

❖ Environment
■ Increasing concerns over odor, water, air, and land qualities

❖ Legislation
■ Legislation addressed peak electricity demand problems in 2001 by directing $10 million SB5x fund to develop commercially proven biogas electricity systems that can help California dairies offset the purchase of electricity and providing environmental benefits
## Dairy Power Production Program (10 projects awarded)

<table>
<thead>
<tr>
<th>Dairy Name</th>
<th>Cows</th>
<th>Type of System</th>
<th>kW</th>
<th>Total cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hilarides Dairy</td>
<td>6000 heifers</td>
<td>Cov'd lagoon</td>
<td>250</td>
<td>$1,500,000</td>
</tr>
<tr>
<td>Gallo Cattle Company</td>
<td>5081</td>
<td>Cov'd lagoon</td>
<td>300</td>
<td>$1,289,520</td>
</tr>
<tr>
<td>Blakes Landing Dairy</td>
<td>237</td>
<td>Cov'd lagoon</td>
<td>75</td>
<td>$135,800</td>
</tr>
<tr>
<td>Castelanelli Bros. Dairy</td>
<td>1600</td>
<td>Cov'd lagoon</td>
<td>160</td>
<td>$772,925</td>
</tr>
<tr>
<td>Koetsier Dairy</td>
<td>1500</td>
<td>Plug flow</td>
<td>260</td>
<td>$381,850</td>
</tr>
<tr>
<td>Van Ommering Dairy</td>
<td>600</td>
<td>Plug flow</td>
<td>130</td>
<td>$489,284</td>
</tr>
<tr>
<td>Meadowbrook Dairy</td>
<td>1900</td>
<td>Plug flow</td>
<td>160</td>
<td>$524,898</td>
</tr>
<tr>
<td>Calif Polytechnic State University Dairy</td>
<td>175</td>
<td>Cov'd lagoon</td>
<td>30</td>
<td>$75,000</td>
</tr>
<tr>
<td>Lourenco Dairy</td>
<td>1258</td>
<td>Cov'd lagoon</td>
<td>150</td>
<td>$229,557</td>
</tr>
<tr>
<td>Inland Empire Utilities Agency</td>
<td>4700</td>
<td>Plug flow</td>
<td>563</td>
<td>$1,546,350</td>
</tr>
<tr>
<td>Eden-Vale Dairy</td>
<td>770</td>
<td>Plug flow</td>
<td>150</td>
<td>$661,923</td>
</tr>
</tbody>
</table>
Valley Fig Growers Biogas Project
Fig Washing Process

- An average of 45,000 gallons of fresh water is used each day for fig washing process.

- Wastewater generated have BOD$_5$ concentrations ranged from 1000 – 6500 mg/l and SS concentrations ranged from
- 100 – 1500 mg/l (1993-2003)

- Valley Fig is currently paying over $100,000 each year to discharge the wastewater to the city sewer.
Valley Fig Growers Biogas Project
BOD5 and SS from...
Valley Fig Growers Biogas Project
City Bill Paid in Every Two Months
Valley Fig Growers Biogas Project
Biogas Energy Anaerobic Digester

- The California Energy Commission’s PIER Renewables Program awarded the VFG biogas project in 2002
- The total project cost is about $1.2 million in which $476,000 is funded by the CEC
- Install a biogas system including a covered lagoon and Ingersoll Rand 75 kW micro-turbine
- Reduce city sewer fees
- Capture and use biogas
- Generate electricity
- Capture and use waste heat
Commerce Energy Co-Digestion of Dairy manure and Food Processing Wastes

Manure or Food Waste Hauling Truck

Food Waste Storage Tanks

Dairy Manure/Food Waste Digester (#4)

Biological Gas cleaning
Inland Empire Utility Agency European Designed Completed Mix Anaerobic Co-digestion system

Goal: To design, build, and operate a centralized, cost effective, European designed completed mix anaerobic co-digestion system at IEUA RP5 to produce 1.5 MW biogas electricity to be used on site

Digester Information

- Number of Digesters: 2
- Digester Diameter: 62 ft. (18.8 m)
- Digester Height: 55.5 ft. (16.9 m)
- Volume of each tank: 1,100,468 gallons
- Detention time: 25 days
- Top Mounted Agitator: One per tank
Inland Empire Utility Agency European Designed Completed Mix Anaerobic Co-digestion System

Expected Results

- Use the results collected under co-digestion of food processing waste with dairy manure (Commerce Energy PIER program)
- Process 300 tons/day of dairy manure and 90 tons/day of food processing waste to produce biogas power 1500 kW to be used on site
- Compare the technical and economical results of the European designed digester with the existing plug flow digester at Regional Plant 5 of IEUA
- Complete the project by February 2007
Conclusions

Resources: Tremendous resources available
Technologies: Unlimited options

Need:
- **Existing Technologies**
  - Straightforward policies acknowledging the true motivations for renewable energy and fuels
- **New Technologies**
  - Validated data on fundamental research results at different scales
  - Dedicated people to work on
  - Long term study
  - Shift from waste management to resource management philosophies