First Solar’s Module Collection and Recycling Program

Lisa Krueger, Vice President
Sustainable Development
First Solar Overview

- Formed in 1999 and launched production of first commercial products in 2002
- Raised $450 million in November 2006 IPO. Publicly traded on NASDAQ (FSLR)
- Largest photovoltaic (PV) module manufacturer in the world
- Lowest cost PV manufacturer in the world, $0.81/watt, breaking the $1 per watt price barrier in the fourth quarter of 2008
- First pre-funded module collection and recycling program in the PV industry
- Added to the S&P 500 in October of 2009

First Solar Manufacturing Plant, Frankfurt (Oder), Germany
First Solar Mission

To create **enduring value** by enabling a world powered by **clean, affordable solar electricity**

**clean + affordable = sustainable**
Technology & Manufacturing

Fully Integrated, Automated and Continuous Thin Film Process

- 98-99% reduction in semiconductor material
- Fully integrated, continuous process vs. batch processing
- Large 60 x 120cm (2' x 4') substrate vs. 6'' wafers

Conventional Crystalline Silicon Batch Technology

Polysilicon  ➔  Ingot  ➔  Wafer  ➔  Solar Cell  ➔  Solar Module
Cost Reductions Achieved Through Scale

First Solar Manufacturing Capacity
First Solar Module Cost per Watt

$2.94
$1.59
$1.40
$1.23
$1.08
$0.00
$0.50
$1.00
$1.50
$2.00
$2.50
$3.00
$3.50
0
200
400
600
800
1,000
1,200

10 MW
25 MW
~100 MW
308 MW
716 MW
1,228 MW

2004
2005
2006
2007
2008
2009

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First Solar Values: "Safety First"

- The safety of our associates and local communities is a core value at First Solar.
- First Solar’s manufacturing processes include comprehensive and conservative environmental health and safety (EHS) protocols and processes.
- We use state of the art engineering controls, operational procedures, housekeeping methods, and personal protective equipment to ensure the health and safety of our employees as well as the community.
### Governance Systems

#### ISO 14001 and OHSAS 18001

<table>
<thead>
<tr>
<th>Date</th>
<th>Certification and Audit Process</th>
</tr>
</thead>
<tbody>
<tr>
<td>Feb 2005</td>
<td>PBG-ISO 14001:1996</td>
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<tr>
<td>May 2007</td>
<td>PBG-ISO 14001:2004</td>
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<tr>
<td>Nov 2008</td>
<td>FFO-ISO 14001:2004</td>
</tr>
<tr>
<td>July 2009</td>
<td>PBG OHSAS 18001:2007</td>
</tr>
<tr>
<td>Sept 2009</td>
<td>KLM-ISO 14001:2004</td>
</tr>
</tbody>
</table>

#### ISO 9001

<table>
<thead>
<tr>
<th>Date</th>
<th>Certification and Audit Process</th>
</tr>
</thead>
</table>

- **ISO 14001**: Certification for environmental management systems
- **ISO 9001**: Certification for quality management systems
- **OHSAS18001**: Certification for health and safety management systems
Environmental Responsibility

First Solar’s Commitment to Environmental Excellence

1. Convert mining byproducts to clean, renewable energy
2. Reduce emissions by substituting solar energy for fossil fuels
3. Minimize environmental impacts by producer collection and recycling

Clean. Affordable. Sustainable.
Module Collection and Recycling Program

Established in 2005

Glass cullet

FS recycling

CdTe

Cd

Te

FS modules

Developers & system integrators

Customer site

25+ years

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Module Collection & Recycling Program Overview

- Designed to create a truly sustainable energy supply by combining affordable solar modules with a product life cycle management approach.

- **Collection program** is designed to maximize collection rates and to minimize environmental impacts.

- **Recycling technology** is designed to recover valuable raw materials, maximize amount of material recycled and minimize environmental impacts.

- **Financing** is designed to ensure that the collection and recycling program is free of cost to end-users and is protected from the insolvency of First Solar.
Program: Unconditional, Convenient and Free

Overview

• Program is *unconditional* – Anyone in possession of First Solar modules can request collection and recycling at any time.

• Program is *convenient* – Customers dismantle and package in accordance with First Solar instructions.

• Program is *free* – First Solar provides all packaging materials, transportation and recycling costs.

• Module Collection and Recycling Program is part of our product offering. We *communicate* to end-users to encourage a high collection rate:
  – Marketing materials
  – Customer contracts
  – Website
  – Module label
Collection: Available to Module Owners at Anytime

- First Solar module owners may request collection at any time via either:
  - the Web www.firstsolar.com/recycling
  - Telephone
     - International Freephone: + 800.433.32.333
     - North American Toll Free: +1.866.456.8938
- First Solar will provide packing materials and will collect and transport the modules to processing centers.
- Module owners simply have to dismantle and package the modules in accordance with First Solar instructions.
Design of First Solar’s Module Recycling Technology

**Dry Process**
- Shredder
- Hammermill
- Film removal
- Solid-liquid separation

**Wet Process**
- Glass rinsing
- Glass laminate material
- Laminate material

**Precipitation**

**Dewatering**

**Warranty/end-of-life modules and manufacturing scrap**

**Semiconductor material (filter cake)**

**Glass Cullet**

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Result: Semiconductor Material

Semiconductor Material (Metals-Rich Filter Cake)

Results: Up to ~95% recycling of semiconductor material in a metals-rich filter cake. Further processing is then performed by a 3rd party recycling partner to create CdTe for use in new modules.
Results: Clean Glass and Laminate Material

**Results**: Up to ~90% recycling of glass for use in new glass products.

**Results**: Laminate material is recovered and disposed of in accordance with local requirements.
Recycling Program

Results to Date

• Commercial scale recycling facilities are installed and operational at each First Solar manufacturing location (USA, Germany, Malaysia).

• Through December, 2009:
  – Over 1600 tons of manufacturing scrap, warranty returns, and pre-mature end-of-life modules have been recycled.
  – PV CYCLE estimated 2010 end-of-life modules in Germany and Europe to be approximately 3300 tons and 7800 tons, respectively.
Prefunded Program

• First Solar **prefunds** the estimated collection and recycling costs at the time of module sale, for 100% of modules sold.

• The funds are invested in restricted investment accounts in the name of a Trustee to be used solely for collection and recycling.

• First Solar reports the cumulative amount of deposits made and the investment returns earned as a restricted investment on our consolidated balance sheets.

• The program, including the financing structure, is audited annually by an external third-party auditor.
Environmental Responsibility

First Solar's Commitment to Extended Producer Responsibility

Extended Producer Responsibility requires companies to take responsibility for the impacts of their products: from the materials used in manufacturing to product recycling.
First Solar: Summary

- **Clean + Affordable = Sustainable**
- Focused on creating cost-effective renewable energy solutions that protect and enhance the environment.
- Embraces the environmental philosophies of extended producer responsibility and product life cycle management.
- Created the solar industry's *first* comprehensive pre-funded module collection and recycling program.
- Shares and encourages the sharing of EHS best practices.

*First Solar…making sustainable attainable.*
Questions for a Potential PV Supplier?

- What modules will be used in the system?
- What are the terms of the warranty? And the financial strength of the company behind the warranty?
- Are the manufacturer’s facilities ISO 9001 (quality management systems) and/or ISO 14001 (environmental management systems) certified?
- What is the carbon footprint of the system and/or technology? How was this determined?
- Does the company provide a collection and recycling program? If so, is the program provided free of charge?
- Given the long life of solar modules, what precautions does the company take to ensure the program will be available in 25+ years?
- What are the responsibilities of the module owner to participate in the module collection and recycling program?
- Under the program, what are the expectations or commitments for recycling in terms of recovery of raw materials?
- Under the program, what are the expectations or commitments regarding EHS and labor practices?
- Is technology currently available to recycle the particular module technology? If so, is this technology currently operating and on what scale?
- How does the company intend to address changes in the module technology and the impact on recyclability?
- How is the program communicated to end-users?
- Are there any 3rd party certifications regarding the program claims?
### First Solar Locations

<table>
<thead>
<tr>
<th>Region</th>
<th>Locations</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Global Headquarters</strong></td>
<td>Tempe, Arizona, USA</td>
</tr>
<tr>
<td><strong>Europe</strong></td>
<td>Berlin, Germany&lt;br&gt;Brussels, Belgium&lt;br&gt;Madrid, Spain&lt;br&gt;Mainz, Germany&lt;br&gt;Paris, France</td>
</tr>
<tr>
<td><strong>North America</strong></td>
<td>Bridgewater, New Jersey, USA&lt;br&gt;Oakland, California, USA&lt;br&gt;New York, New York, USA&lt;br&gt;Sarnia, Ontario, Canada</td>
</tr>
<tr>
<td><strong>Manufacturing</strong></td>
<td>Frankfurt (Oder), Germany&lt;br&gt;Kulim, Malaysia&lt;br&gt;Perrysburg, Ohio, USA</td>
</tr>
<tr>
<td><strong>Asia/Pacific</strong></td>
<td>Sydney, Australia</td>
</tr>
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</table>
PV Module Price Experience Curve since 1979 (2009 $/W)

Historical price experience curve:
Doubling of cumulative sold volume reduces price by 22%

Source: SET for 2020, EPIA 2009

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Life Cycle Assessment for PV

M/Q: Material and energy inputs
E: Effluents (air, water, solid), or outputs
Carbon Footprint – Comparison Across Technologies

<table>
<thead>
<tr>
<th>Technology</th>
<th>Carbon Footprint (g CO₂-eq/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal</td>
<td>900</td>
</tr>
<tr>
<td>Oil</td>
<td>850</td>
</tr>
<tr>
<td>Gas CC</td>
<td>400</td>
</tr>
<tr>
<td>Coal + CCS</td>
<td>262</td>
</tr>
<tr>
<td>IGCC + CCS*</td>
<td>245</td>
</tr>
<tr>
<td>Biomass CHP</td>
<td>45</td>
</tr>
<tr>
<td>PV multi-Si</td>
<td>25</td>
</tr>
<tr>
<td>Nuclear (US)</td>
<td>24</td>
</tr>
<tr>
<td>PV CdTe</td>
<td>14</td>
</tr>
<tr>
<td>Wind*</td>
<td>12</td>
</tr>
</tbody>
</table>

Gas CC = Natural Gas Combined-Cycle
IGCC = Integrated Gasification Combined Cycle
CCS = CO₂ Capture and Storage

LCA Benefits

Energy Payback Time (EPBT) - Rooftop Application

CdTe has the fastest energy payback time.

Note: Southern Europe 1700 kWh/m²/year irradiance.

Energy Payback Time is <1 Year

- **EPBT**: The amount of time a system must operate to produce the amount of electricity that was required to fabricate the system.

- **Objective**: Minimize EPBT
  - Supports rapid scalability
  - <1 year EPBT ensures industry growth does not create near-term energy deficit.

LCA Benefits
Carbon Footprint Comparison for Rooftop PV

**Notes:** Southern Europe 1700 kWh/m²/year irradiance. Excludes impact of NF₃, a greenhouse gas released in the production of silicon-based PV.

<table>
<thead>
<tr>
<th>Technology</th>
<th>Carbon Footprint (g CO₂-eq/kWh)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mono Si</td>
<td>14.0%</td>
</tr>
<tr>
<td>Multi Si</td>
<td>13.2%</td>
</tr>
<tr>
<td>Thin-film Si</td>
<td>8.5%</td>
</tr>
<tr>
<td>CIGS</td>
<td>11.0%</td>
</tr>
<tr>
<td>Ribbon</td>
<td>13.2%</td>
</tr>
<tr>
<td>CdTe</td>
<td>10.7%</td>
</tr>
</tbody>
</table>

CdTe has the lowest carbon footprint of all PV technologies.
CdTe PV Technology

• Uniquely capable of producing high-volume, affordable modules, making widespread cost-effective solar electricity a reality

• Superior light absorption properties result in higher output under cloudy and diffuse light conditions such as dawn and dusk

• Low-temperature coefficient that results in better performance at higher temperatures (i.e. lower drop in performance at higher temperatures)

• Environmental benefits
  – Lowest carbon footprint
  – Fastest energy payback time
Commitment to Environmental Excellence

- “... First Solar is outstanding with respect to certification in environmental protection, work safety, recycling and cooperation.”, Murphy & Spitz, 2009

- First Solar ranked 48th out of 500 in Newsweek’s Greenest Big Companies in America based on environmental impact, as well as green policies and reputation among peers and environmental experts.