Marin Clean Energy
Technical Committee Meeting
Monday, March 10, 2014
9:00 A.M.

San Rafael Corporate Center, Boro Room
750 Lindaro Street, San Rafael, CA 94901

Agenda

1. Board Announcements (Discussion)

2. Public Open Time (Discussion)

3. Report from Executive Officer (Discussion)

4. Approval of Minutes from 2.10.14 Meeting (Discussion/Action)

5. Presentation by Stion on US-Based Solar Module Manufacturing and Thin-Film Technology (Discussion)

6. Demand Response Update and Options (Discussion)

7. MCE ‘Shared Solar’ Program (Discussion/Action)

8. Members & Staff Matters (Discussion)

9. Adjourn
Roll Call
Present: Kate Sears, County of Marin, Chair
         Emmett O’Donnell, Town of Tiburon
         Ford Greene, Town of San Anselmo
         Ray Withy, City of Sausalito

Absent: Carla Small, Town of Ross

Staff: Dawn Weisz, Executive Officer
       Jamie Tuckey, Communications Director
       Jeremy Waen, Regulatory Analyst
       Justin Kudo, Manager of Account Services
       Rafael Silberblatt, Program Specialist
       Emily Goodwin, Internal Operations Coordinator
       Kirby Dusel, Technical Consultant

Action taken:

Agenda Item #6 – Feed In Tariff Application Process (Discussion/Action)
Kirby Dusel introduced adjustments to the Feed In Tariff Application which had been discussed in the January
Technical Committee meeting and further refined by staff. The adjustments include a reservation mechanism for
interested applicants as recommended by Board members. Mr. Dusel, Dawn Weisz and Rafael Silberblatt
responded to questions from the Committee members and the public.

M/s Withy/Greene (passed 4-0) recommendation to approve the proposed Feed In Tariff Application. Director
O’Donnell and Small were absent.

Kate Sears, Chair

ATTEST:

Dawn Weisz, Executive Officer
San Jose, Calif.--(Business Wire)--Stion, a leading US-based manufacturer of high efficiency thin-film solar modules, announced that it has produced a 23.2% efficiency thin-film cell based on its proprietary tandem junction technology. Stion has already scaled this technology to or above 20.0% efficiency on a prototype module (20 cm x 20 cm) and expects to soon scale to monolithic modules (65 cm x 165 cm) in the 20-22% efficiency range.

"Achieving 23.2% cell efficiency and 20% mini-module efficiency on this state-of-the-art technology clearly demonstrates Stion’s commitment to technology differentiation and its deep IP portfolio”

A pioneer in tandem module technology, Stion is the first to demonstrate fully integrated thin film devices at such high conversion efficiencies using scalable commercial processes. Stion will continue to implement the key technical innovations behind the 23.2% cell on its pilot production line in San Jose, CA in preparation for the commercialization of thin-film modules with >20% efficiency.

"Achieving 23.2% cell efficiency and 20% mini-module efficiency on this state-of-the-art technology clearly demonstrates Stion’s commitment to technology differentiation and its deep IP portfolio,” said Howard Lee, Stion’s Chief Technology Officer, Founder and Sr. Vice President of Technology. “Showing initial results of 20%+ is a strong validation of scalability, and our ability to provide Simply BetterTM solutions to our customers using this technology. We expect the technology to keep improving with production experience.”
Stion's unique approach to CIGS leverages proprietary materials and device expertise along with a robust, high-volume manufacturing process based on readily available, standardized equipment. Combining the simplicity of thin-film manufacturing with ultra high performance products greater than 20% efficiency is yet another example of how Stion is striving to be Simply Better™ than the competition.

**About Stion:**

Stion is a leading US-based manufacturer of high-efficiency thin-film solar panels based on state-of-the-art materials and device technology and proven production processes. Stion was founded in 2006 and is backed by Khosla Ventures, the largest institutional investor in clean technology ventures in the US. Stion opened its first mass production facility in Hattiesburg, MS in 2012. For more information, visit [www.stion.com](http://www.stion.com).

**Contacts**

Stion
Frank Yang
408-284-7205
fyang@stion.com
Stion residential installations in the US and Europe. Stion's Gen 2 tandem-based product will deliver superior energy density for smaller, space constrained projects, as well as the same all-black aesthetics featured in Stion's Gen 1 module. (Photo: Business Wire)
Better Design Leads to Superior Performance

January 2014
BETTER PERFORMANCE THROUGH DESIGN

SIMPLY BETTER DESIGN ADVANTAGES

• Unique combination of materials and superior device design
  - Temperature coefficient of -0.26%/°C
  - Exceptional kWh/kW performance in virtually any geography

• Long cell architecture creates excellent shade tolerance
MORE POWER IN REAL WORLD APPLICATIONS

<table>
<thead>
<tr>
<th>Shading</th>
<th>Percent Full Power</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>100%</td>
</tr>
<tr>
<td>Debris</td>
<td>33-66%</td>
</tr>
<tr>
<td>50% vert</td>
<td>1%</td>
</tr>
<tr>
<td>12.5% diag</td>
<td>49%</td>
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</table>

<table>
<thead>
<tr>
<th>STION</th>
<th>Percent Full Power</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>100%</td>
</tr>
<tr>
<td></td>
<td>90% (loss proportionate to covered area)</td>
</tr>
<tr>
<td></td>
<td>48%</td>
</tr>
<tr>
<td></td>
<td>63%</td>
</tr>
</tbody>
</table>

- In partial shade conditions Stion’s vertical cell patterning minimizes power loss

*Stion module vs. c-Si module under STC conditions
WHEN THE HEAT IS ON, STION DELIVERS THE POWER

LOWER TEMPERATURE COEFFICIENT

Stion = -0.26 %/°C

c-Si = -0.40 %/°C to -0.50 %/°C

Lower cold temp. peak power → smaller inverter for same nameplate power

Additional energy generation from Stion, same nameplate power
ENERGY YIELD ADVANTAGE

• 1.2 kW Side-by-side:
  • Tier 1 c-Si
  • Stion SN 120
  • Identical array design
• Stion outperforms:
  • 10.7% more peak power
  • 7.9% more daily energy generation
• Middle East Desert Climate
• Typical day in March

• Stion SN 120:
  • Temperature coefficient = -0.39%/°C
• New STO 150
  • Temperature coefficient = -0.26%/°C, will outperform c-Si by 10-15%
NATIONAL RENEWABLE ENERGY LAB

GOLDEN, CO

- System size = 1.82 KW
- Module Type: STN 130
- Commission date = Sept 2012
- Performance Ratio > 85%

Agenda Item #5: Att. B-Stion Product History and Performance
EXCELLENT WARM CLIMATE PERFORMANCE

SANDERS, AZ

- System size = 59.6 KW
- Module Type: SN 120
- Commission date = June 2012
- 1863 kWh/kWp/yr
  - 1st year performance within 2% of PVSyst estimate

Stion Model | Temperature Coefficient (%/°C) | Predicted performance increase above Stion SN at this location
--- | --- | ---
SN | -0.39 | 4%
STN | -0.34 | 4%
STO/L | -0.26 | 10%
OUTPERFORMING c-Si in Cold Climates

BELGIUM

- System size = 5.4 kW
- Commission date = Dec 2011
- Customer demonstration site
- Module Type: SN 120
- Outperforming Tier-1 c-Si by 5.7%
  - 24 month totals
    - Stion = 1887 kWh/kW
    - c-Si = 1776 kWh/kW
  - Cold climate relative to most of US
OUTPERFORMING c-Si in Cold Climates

HOLLAND, MI

- System size = 10.5 KW
- Commission date = Jan 2013
- Customer demonstration site
- Module Type: STN 130
- Outperforming Tier-1 c-Si by 7-10% per month
OUTPERFORMING CdTe

ALBANY, NY

- System size = 23.8 KW
- Commission date = January 2012
- Application = Commercial Roof
- Module Type: SN 110
- Outperforming CdTe by 9.5%
MISSISSIPPI POWER
5 KW DEMONSTRATION PROJECT

GULFPORT, MS

- System size = 4.8 KW
- Commission date = February 2013
- Module Type: STN 135
- Stion executed the entire project from permitting to interconnection to system installation.

Agenda Item #5: Att. B-Stion Product History and Performance
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Simply Better Stability
# STABILITY SUMMARY

<table>
<thead>
<tr>
<th></th>
<th>Pmax Yearly Change</th>
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<tbody>
<tr>
<td>Shell CIGS @ NREL</td>
<td>0.07% +/- 0.04%</td>
</tr>
<tr>
<td>Stion CIGS @ NREL</td>
<td>1.06% +/- 0.62%</td>
</tr>
<tr>
<td>Stion CIGS @ Stion Mississippi</td>
<td>1.7% +/- 2.2%</td>
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</table>

• Stion and CIGS modules with related construction show Pmax stability overtime.

• Excerpt from Photovoltaic Degradation Rates — An Analytical Review, Jordan & Kurtz, NREL/JA-5200-51664, June 2012

> “It was shown that degradation rates can vary significantly depending on module type. Musikowski and Styczynski demonstrated **virtual stability of a CIGS array in Germany**. The performance was evaluated for different temperature and irradiance windows and showed **no measureable degradation after 6 years of operation**. A comparable observation was made by Jordan et al. at NREL in Colorado, USA. Outdoor observation **showed no significant decline after 5 years of operation**. This was confirmed by indoor measurements. Only one out of 14 modules showed appreciable degradation owing to an initial manufacturing defect.”

• The modules described above (Shell and Manz) share a similar dual glass, EVA, butyl rubber edge seal construction with Stion. In fact, the Stion design is from the same lineage as the Shell design.
STABILITY MONITORING (NREL)

Test site at the National Renewable Energy Lab in Golden, CO
Stion modules are exhibiting similar stability to Shell CIGS array

Shell CIGS 1.12 kW Array
Installed 01/09/2006
Zero degradation after 8 years

Stion 1.82 kW Array
Installed 9/26/2012
Zero degradation after 1.5 years

Data analysis shows that the energy production improved 1.42% +/- 0.53%.
No degradation, just measurable improvement.

<table>
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<tr>
<th>Method</th>
<th>Rd (%/year)</th>
<th>Uncertainty (%/year)</th>
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<tbody>
<tr>
<td>Stion</td>
<td>DailyPRcorr Tmod</td>
<td>1.42</td>
</tr>
<tr>
<td>Shell</td>
<td>DailyPRcorr Tmod</td>
<td>0.07</td>
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Shell modules are CIGS on glass with near identical packaging (EVA, butyl rubber edge seal) and circuit creation process to Stion.
STABILITY MONITORING

Hattiesburg, MS

- System size = 58.3 KW
- Module Type: SN 120
- Commission date = April 2012
- April 2013 – Stion randomly selected 8 modules for surveillance after 1 year in the field.
  - No visible sign of damage
  - All 8 were flash tested and compared to the flash test results at time of manufacture.

<table>
<thead>
<tr>
<th>Serial #</th>
<th>Apr-2012</th>
<th>Apr-2013</th>
<th>1 Year Change</th>
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<tbody>
<tr>
<td>12725</td>
<td>113.63</td>
<td>113.6</td>
<td>1.000</td>
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<tr>
<td>13883</td>
<td>113.25</td>
<td>115.1</td>
<td>1.017</td>
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<td>114.98</td>
<td>119.8</td>
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<tr>
<td>13979</td>
<td>108.73</td>
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<tr>
<td>12621</td>
<td>113.19</td>
<td>119.0</td>
<td>1.051</td>
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Average 1.017
StDev 0.022

Flash test results indicate the modules have increased power output by 1.7% +/- 2.2%
LONG-TERM RELIABILITY OF CIGS ON GLASS

NREL TEST ARRAY

- >7yr stability
- CIGS on glass with near identical packaging and process to Stion
- Zero degradation from PVUSA baseline

1.12 kW CIGSS Array

"The system continues to show no degradation within the measurement uncertainty."
- NREL, July 2013
LESSER THIN-FILM STABILITY

Amorphous Silicon

• Non-crystalline structure formed at low temperatures
  - Weak inter-molecular bonds
  - Staebler – Wronski Effect (10-30% power degradation in first few months of sun exposure)
    • “Amorphous silicon (a-Si) is one of the earliest thin film PV technologies and exhibits a well-known light-induced degradation effect, in which efficiencies degrade by ~10-30% in the first several hundred hours of light soaking [1].

CdTe

• Cu diffuses from the back-contact area through the CdTe absorber
  - “The magnitude of this initial efficiency loss is approximately 4–7% within the first one to three years, depending on climate and system interconnection factors, as shown in Fig. 5.”


Figure 5. First Solar CdTe PV system degradation profile.