SOLAR SNOW MANAGEMENT – “LET THE SUN SHINE IN!’

2020

Tom Guttormson, PE
Principal Technology Engineer
130,000 member customers
1,000 square miles territory
44 substations
12.5 kV 9,000 miles of line
92% residential by customer
System peak demand 550 MW
Wholesale Power Supplier – Great River Energy

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Background – Solar + Storage Facilities

“Snowmagedon” 2019

“Solar Snow” Clearing Experience

• Process
• Operations
• Value
All storage charging from solar generation
Clear day! after snow fall!

Snow covered panels...

irradiance
solar
storage
MINNESOTA....

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Panels owned by 3rd party – permission to clear "Letter of Understanding"

- Scope of Work – trial basis
- Operator Qualifications
- Safety Protocol
- Blowing process
- Notifications
- Documentation

2019 – Q1: trial basis, clear “snowmagedon”
BLOWING EQUIPMENT

Ground Blower on Skid Steer

Hydraulic Debris Blower
Model # BT-HYSS2HS
GROUND CLEARING A PATH
POST GROUND CLEARING

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INITIAL LESSONS LEARNED:

Not very effective with heavy snow, ice pack
Ground blowing needed to clear level path for panel blower
Ground blowing enables room for self clearing

Initial trial after snowmagedon ... not effective.
Try again next season...
2019-20 Season: trial basis – clear before snow gets deep!
Solar Snow Process – Forecast & Notification

Notification to Clear
- Initial notification "heads up" to C&M lead
- Likely operation notification
- Site Inspection – determine clearing scope & schedule
- Complete JSP – obtain ENGIE authorization
- Authorization complete, communicate to mobilize

DSO lead to C&M lead & ENGIE Ops
DSO lead to C&M lead & ENGIE Ops
DSO lead & C&M lead
DSO lead prepare & submit, initials from C&M
DSO lead notify C&M lead, C&M lead notify contractor

Clearing Operation
- Mobilize to site
- Notification to enter site & begin clearing to CNX Sys Ops, ENGIE Ops
- Perform clearing
- Notification complete for the day, leaving site
- Repeat notifications of entering & leaving site until clearing completed

Clearing crew
Clearing crew
Clearing crew
Clearing crew
Clearing crew

Operation Close-out
- Complete JSP – submit to ENGIE, file
- Document Operation & Results
- File report & media

DSO lead prepare & submit, initials from C&M
DSO lead, input from C&M lead, clearing crew
DSO lead
Hydraulic Snow Blower HIGH SPEED
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<table>
<thead>
<tr>
<th>Notification &amp; Request to clear</th>
<th>Date start</th>
<th>Date complete</th>
<th>Comments</th>
<th>Battery dispatch</th>
</tr>
</thead>
<tbody>
<tr>
<td>12-5-19</td>
<td>12-6-19</td>
<td>12-6-19</td>
<td>Clear ground path at Athens</td>
<td></td>
</tr>
<tr>
<td>1-10-2020</td>
<td>1-15-2020</td>
<td>1-16-2020</td>
<td></td>
<td>1-16-2020</td>
</tr>
<tr>
<td>1-17-2020</td>
<td>1-18-20</td>
<td>1-18-20</td>
<td>Athens only – ice on Anoka panels</td>
<td>1-20 Cancelled</td>
</tr>
<tr>
<td>1-31-2020</td>
<td>Panels self-cleared; no operation</td>
<td>Jon Plan Cancelled</td>
<td></td>
<td>2-4-2020</td>
</tr>
<tr>
<td>2-7-2020</td>
<td>2-11-2020</td>
<td>2-12-2020</td>
<td>Full clear Anoka, partial clear Athens</td>
<td>2-13-2020</td>
</tr>
</tbody>
</table>
Costs / Benefit??

Size of Solar Fields: Anoka Athens
16 Acres 13,851 modules 40 Acres 27,189 modules

Cost to clear (machines, labor, fuel)
• Ground and panels both sites: $12-14K
• Panels only $ 6-10K

Accelerated PV production - 2 days
• Dec & Jan – additional snow moved in 1-2 days after clearing
• Feb – several clear days after clearing, gained ~ 2 days production
Economics:

Accelerated PV production for charging batteries  EFFECTIVE
• Cleared and gained production as needed to charge for dispatch within 1 day
• \[
\frac{\text{(Incremental demand response value)}}{\text{cost}} = \frac{5}{1}
\]

Added solar production from panel clearing  NOT effective
• Added (or accelerated) solar generation ~ 2 days
• \[
\frac{\text{(Incremental generation kWh sales)}}{\text{cost}} = \frac{1}{4}
\]
LESSONS LEARNED / BEST PRACTICES

- Be familiar with the ground – know where the swales & potholes are
- Have a spotter on site
- Clear ridge at base of panels:
  - Enable self clearing – room to snow to fall
  - Provides stable path for panel blowing machine
- Effective for up to 2-3 inches of light or lightly compacted snow
- Does not kick up chunks that risk damaging panels on impact
- Blow in direction of wind
- Move forward only – do not reverse to get snow you missed
  - Even clearing some or most will accelerate self clearing the remainder
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Questions

Discussion