Photovoltaic Array Icing and Snow Accumulation: A Study of a Passive Melting Technology

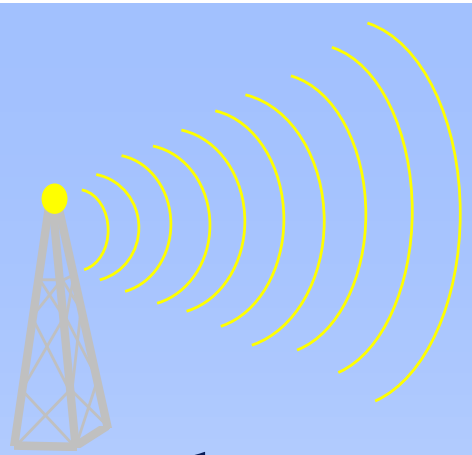
Michael Ross and Eric Usher

Energy Diversification Research Laboratory

Partners:

- Energy Diversification Research Laboratory (PV for the North)
- Science Institute of the Northwest Territories
- TN Conseil

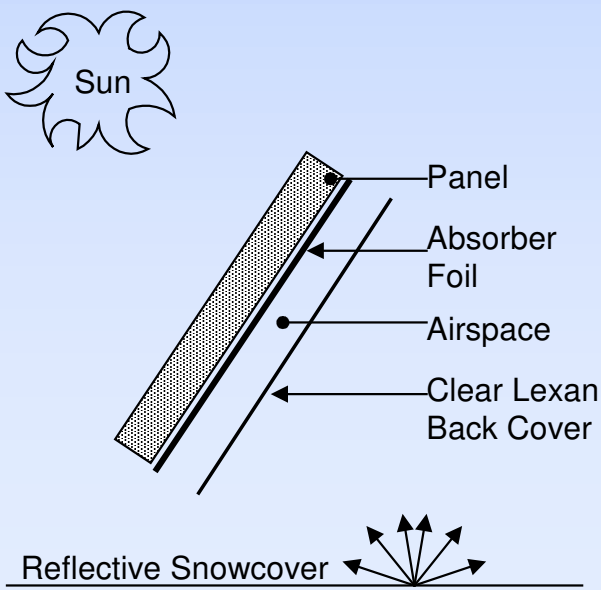
The Problem:



- PV systems are remote and must be very reliable
- Snow and ice accumulate on the arrays
- The electrical output of the arrays drops
- The battery bank must be oversized or the system will fail

The TN Conseil Solution:

- Passive technology
- Solar thermal stagnating-air collector
- No electrical power used for heating
- No moving parts



The Questions:

- What is the extent of the problem of snow/ice accumulation on PV panels?
- What are the effects of snow/ice accumulation on PV?
- How well does the TN Conseil technology work?
- Will the higher panel temperatures cause problems?

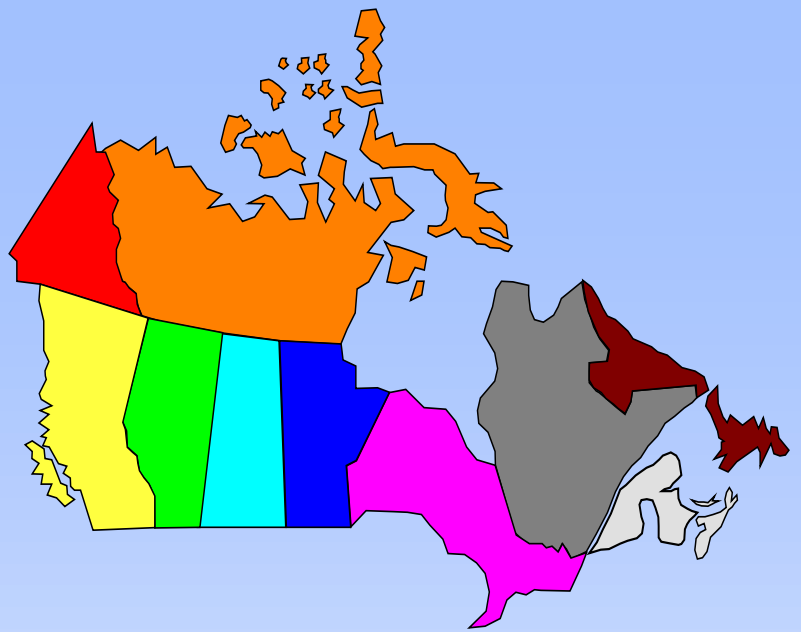
Snow:

- Most snow removes itself from PV arrays fairly quickly, especially with large tilt angles
- Wet snow that freezes onto the array may bond to the array
- Wet snow can accumulate on vertical surfaces

What is Rime?

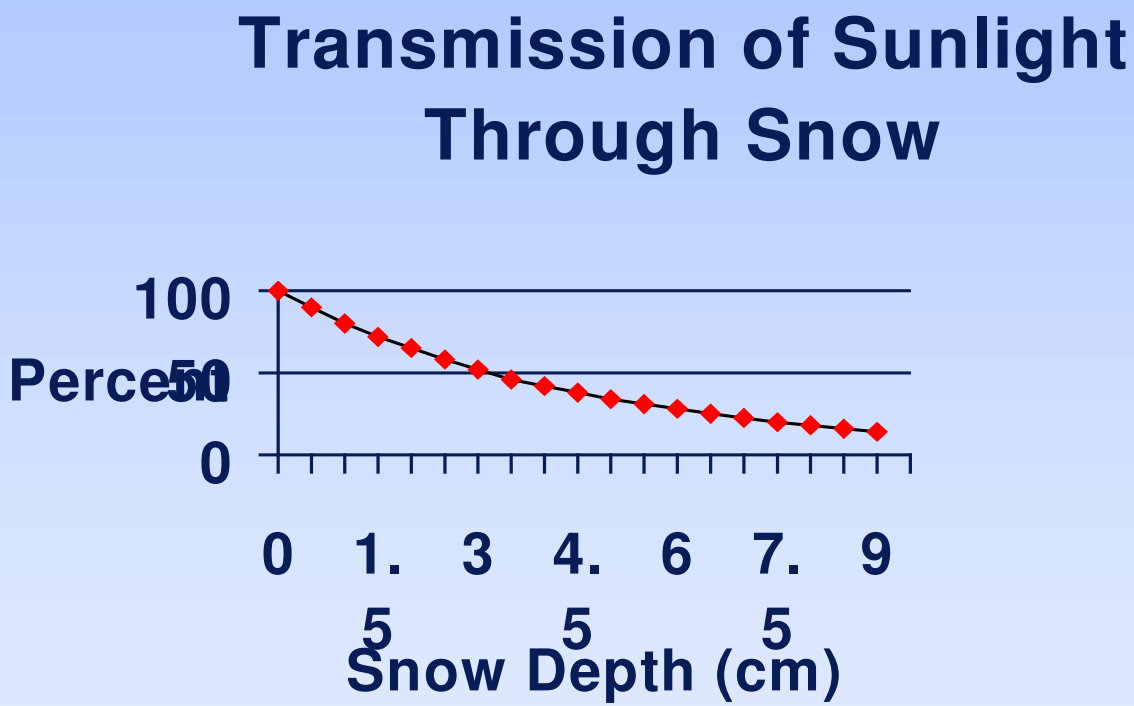
- Moist air rises to go over mountains and cools
- Water droplets form by condensation and supercool to temperatures below 0 ° C
- When they find a nucleating surface, such as a PV array, they freeze quickly
- Rate of accumulation related to wind speed, projected surface area

Rime in Canada:



- Very serious problem in mountains of B.C., Yukon, Newfoundland, and North
- Also problem due to Arctic fog
- Site specific, very unpredictable
- Three month autonomy built into battery banks

Transmission of Sunlight Through Snow and Ice



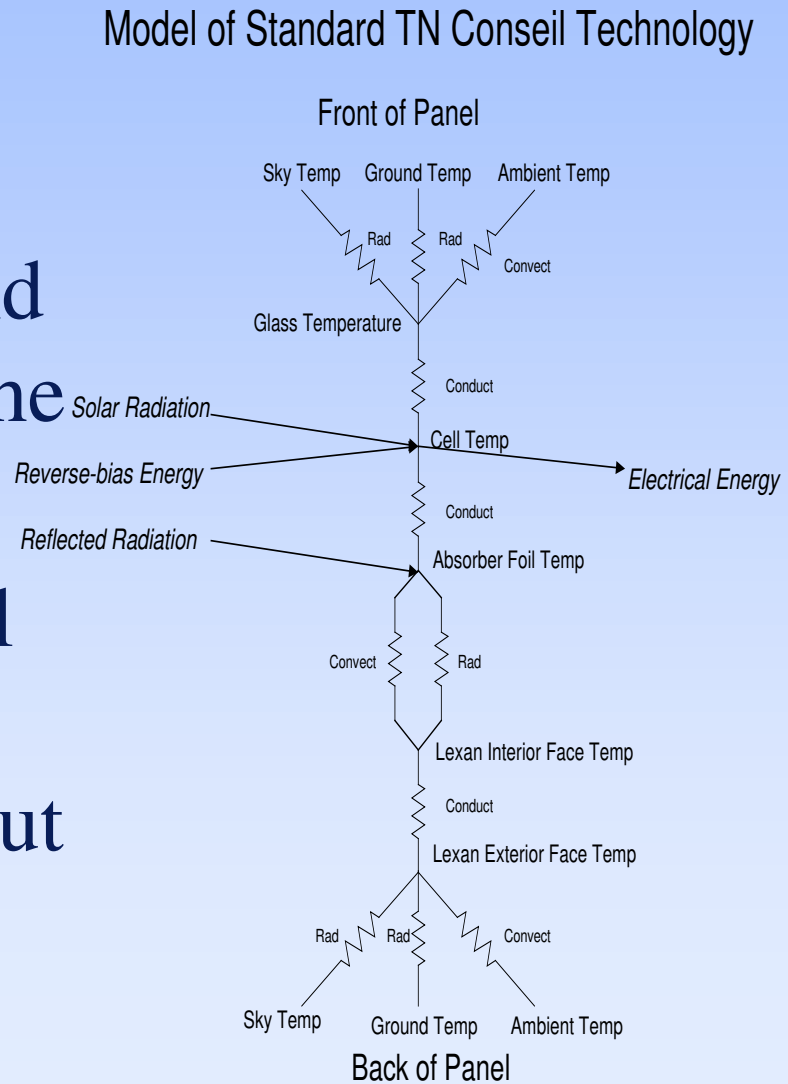
- Transmitted sunlight falls off exponentially

Effect of Shading on PV Performance

- If uniformly covered in snow/ice, short circuit current will be reduce linearly
- If nonuniformly covered, shaded cells resist passage of current and become reverse-biased
- Output is greatly reduced-- shading one cell 70 % reduces power by 45 %
- results in “hotspot”

Modelling of TN Conseil Technology

- Modelled radiation reflected off snow and striking the back of the array
- Modelled the thermal performance of the panel with and without snow or ice on front



Results of Modelling and Monitoring

- Model was accurate when compared with monitored data
- Panel operates 15 to 30 ° C hotter
- Melting rate is significantly improved
- Suggested design improvements: frame losses, thermal gradients in air cavity

Understanding the TN Conseil Technology

- Used thermal models to compare variations on the TN Conseil Technology
- Lexan and absorber foil have two different roles:
  - 1)Lexan cover and airspace insulates, thus raising the panel temperature
  - 2) Absorber foil increases energy gain, permitting higher melt-rates

Simulation of Performance Using Actual Weather Data

- Highly effective for a dense snow bonded to panel at Bagotville, Québec: removal is 80 to 95 % quicker
- Rime in mountains near Prince George, B.C., or Daniel's Harbour, Nfld.: 20 to 40 %
- Less effective above Arctic Circle
- Possibility of rime accumulating on back of panel

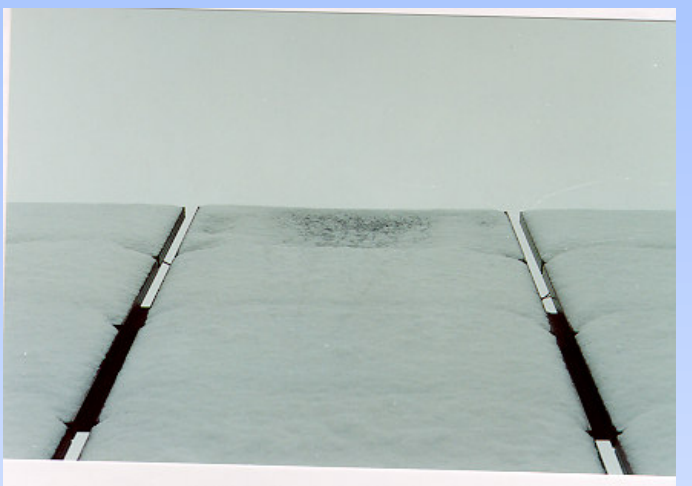
Summer Battery Charging

- Raised panel temperatures will lower panel voltage: will it be able to charge 12 V battery ?
- Used thermal models to investigate
- Large panels (with 36 cells, e.g., Siemens M55) should have no problems even under worst-case conditions

Actual Performance, March 6

9:00 AM

11:00 AM



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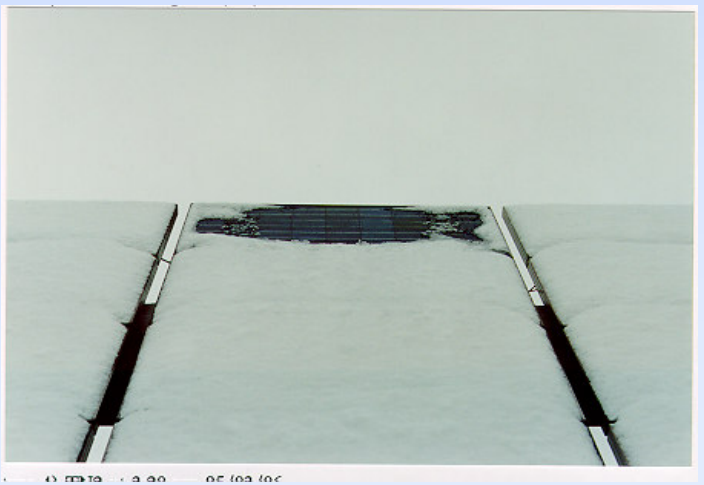

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