Bifacial tracking system in snowy region

http://www.pvgs.jp

This development program was performed by
'Bifacial Tracking PV system Development Consortium for Overcoming the Snow'

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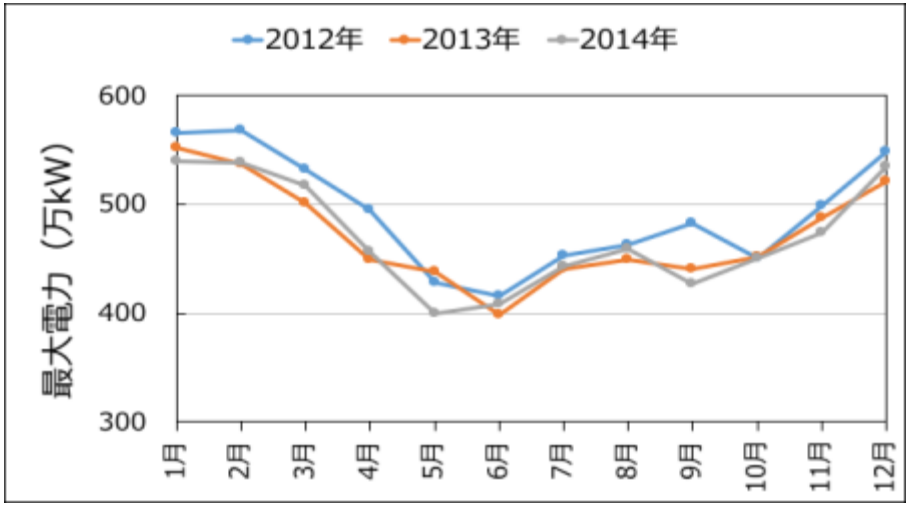
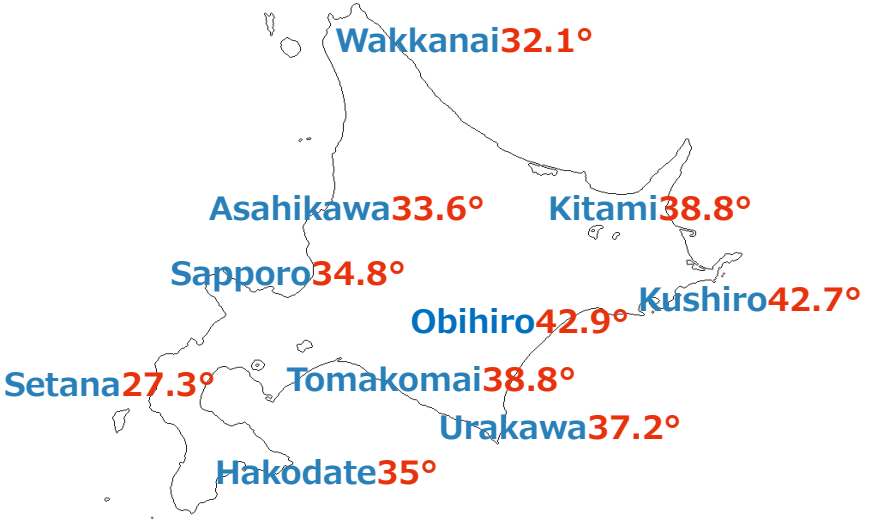
Background

- Electric demand is large in Winter in cold climates. The peak of in Hokkaido in December to February



Power demand record in Hokkaido
(Past power usage data of Hokkaido Electric Power)

- Optimum angle of inclination of the PV system is 43 degrees or less. Choices are the accept the snow or non-optimal angle.



Optimum tilt angle with annual power generation amount is the maximum (NEDO MONSOLA-11 database)

It is necessary to improve the reduction of PV power generation by snow cover for peak demand period

Motivation

- ✓Development of a solar power generation system with more than 20% capacity (utilization) factor
- ✓Promotion of renewable energy use in the cold, snowy regions.

Problem of cold, snowy regions

・Decrease in amount of electric power generated by the winter high power demand

・Increased costs due to snow cover measures of the array

Problem overcome by Bifacial and Tracking

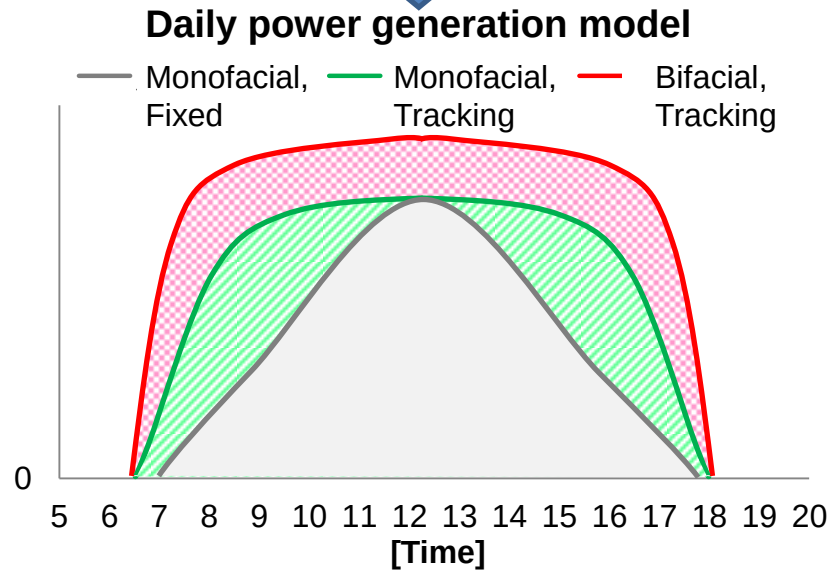
・Vertical control to suppress the snow during the snowing

・When the array vertical can also generate by bifacial

The advantage of the cold, snowy regions

・Cool climate = power generation efficiency increasing

・Reflection of snow = bifacial power generation output increasing



Concept

bifacial PV

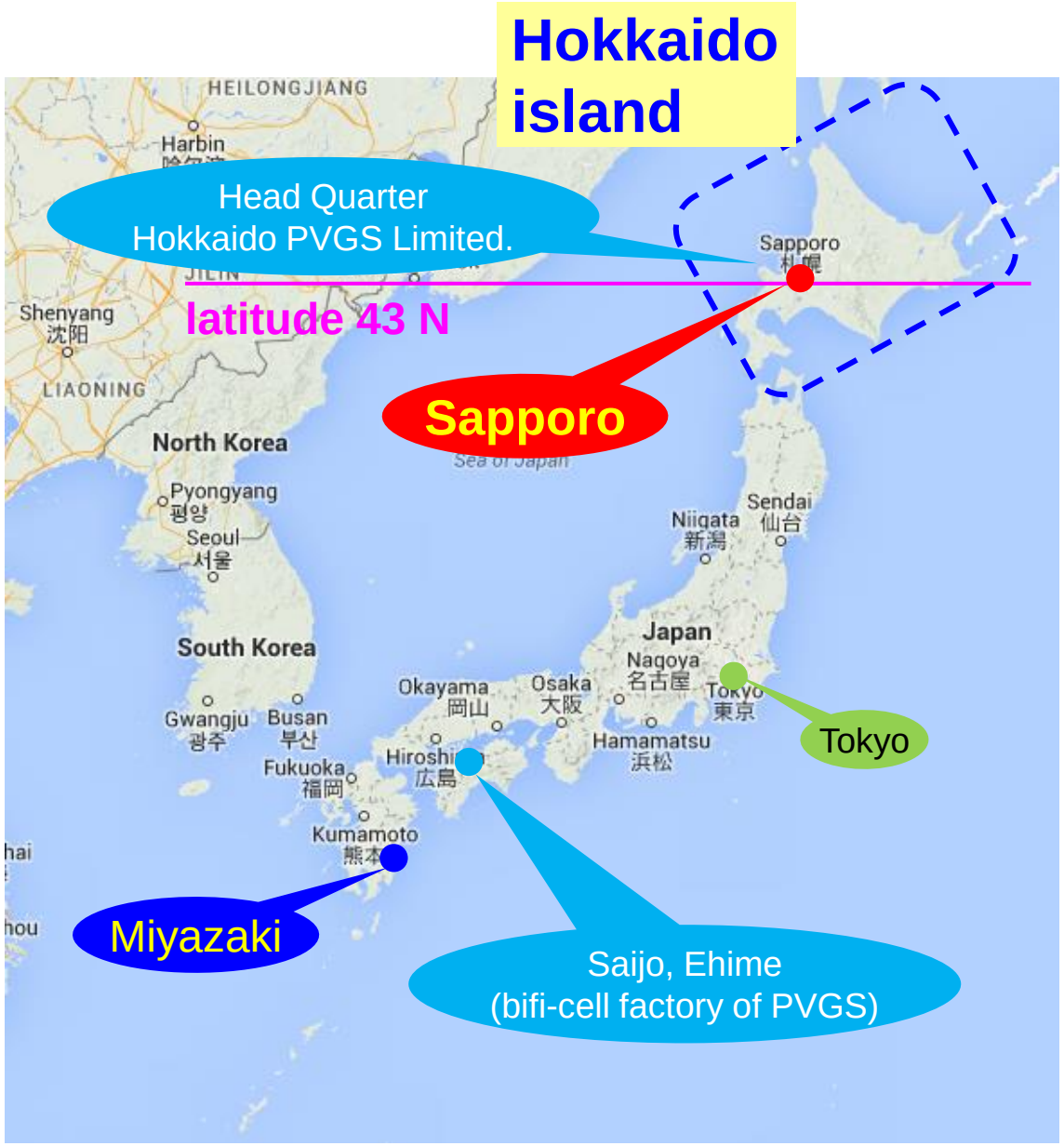
1.2 times power generation
in bifacial for the mono-facial

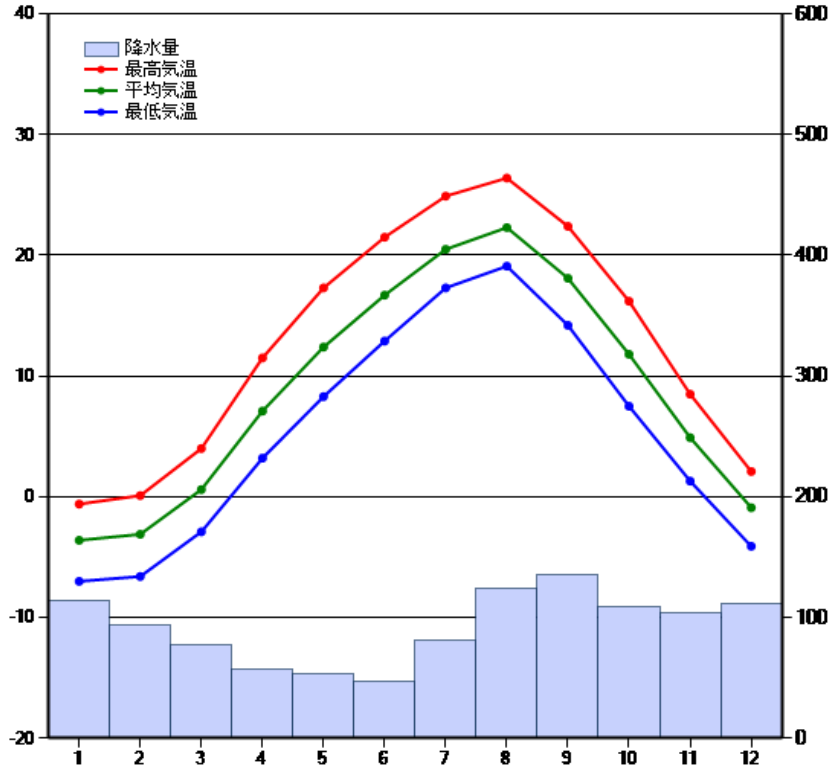
Tracking system

1.4 times power generation
in tracking for the fixed

Power Yield: 1.4times by Tracking X 1.2 times by bifacial = 1.68 times
Capacity factor: Traditional of 13% X 1.68 times = 21.8%

Location and Climate of demonstration site

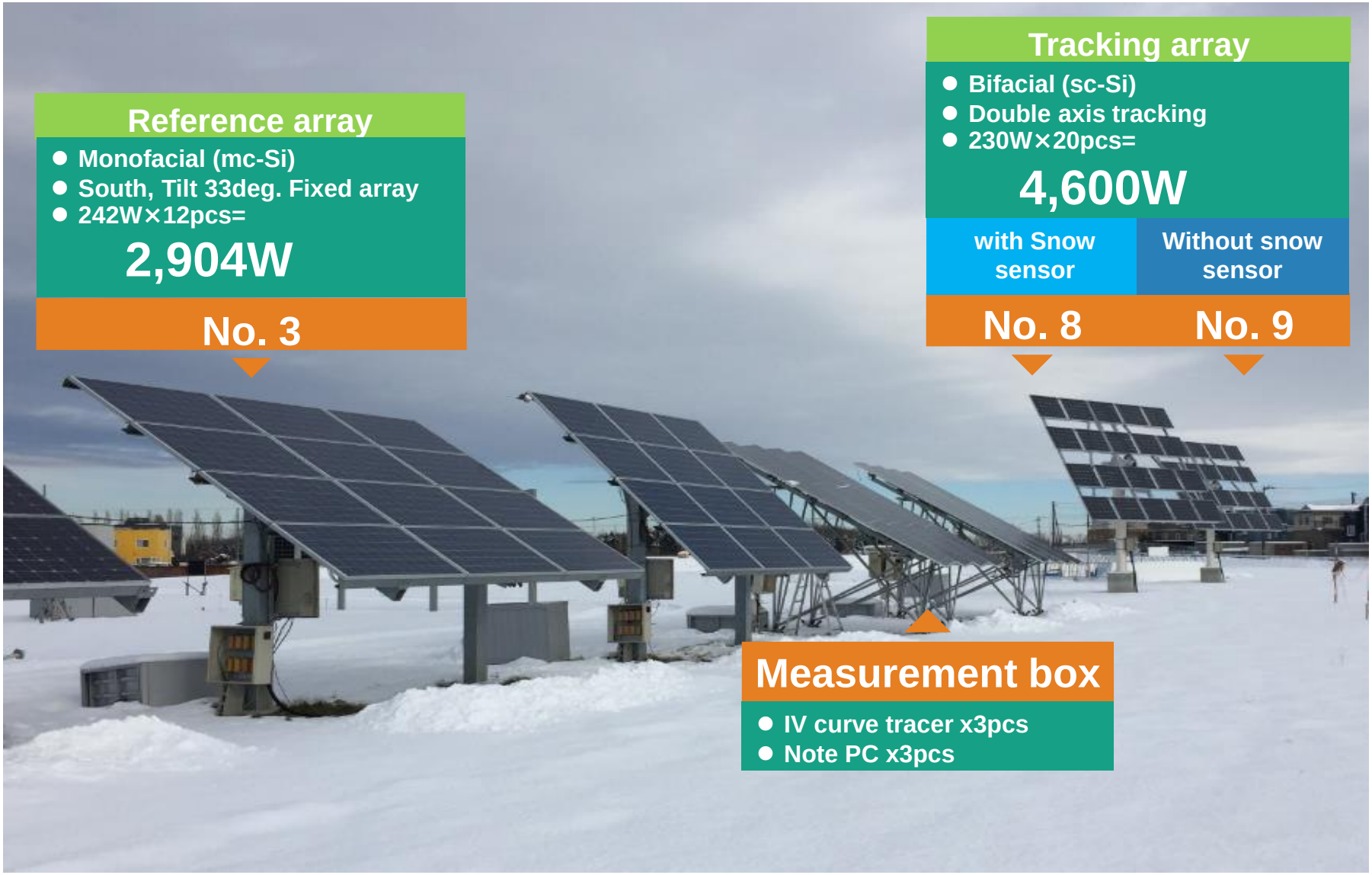




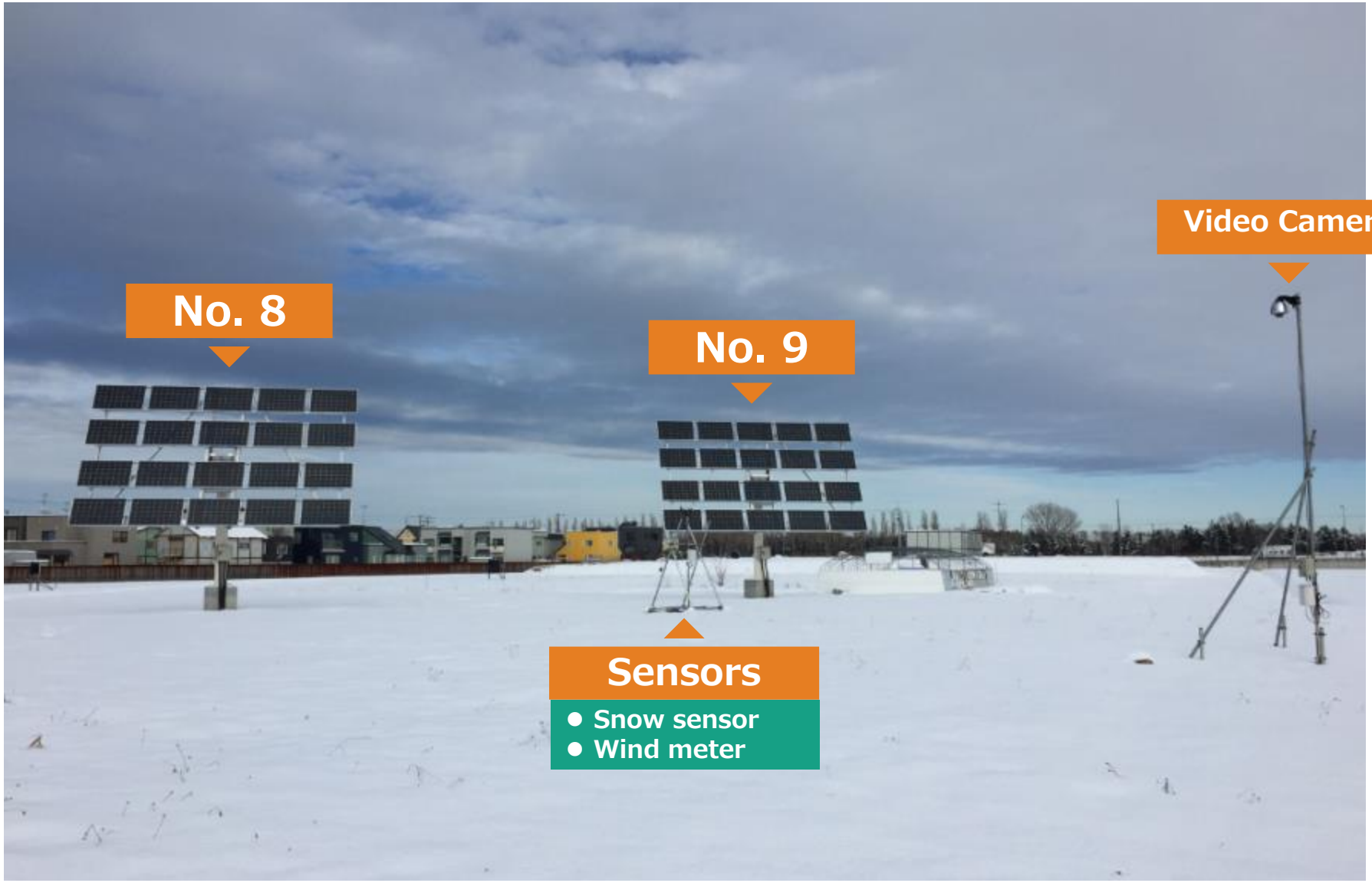
札幌 年平均気温：8.9 ℃ 年降水量：1106.5 mm 統計期間：1981~2010

	1月	2月	3月	4月	5月	6月	7月	8月	9月	10月	11月	12月
最高気温(℃)	-0.6	0.1	4.0	11.5	17.3	21.5	24.9	26.4	22.4	16.2	8.5	2.1
平均気温(℃)	-3.6	-3.1	0.6	7.1	12.4	16.7	20.5	22.3	18.1	11.8	4.9	-0.9
最低気温(℃)	-7.0	-6.6	-2.9	3.2	8.3	12.9	17.3	19.1	14.2	7.5	1.3	-4.1
降水量(mm)	113.6	94.0	77.8	56.8	53.1	46.8	81.0	123.8	135.2	108.7	104.1	111.7

Demonstration test facility



Demonstration test facility



Demonstration test facility

Demonstration test facility

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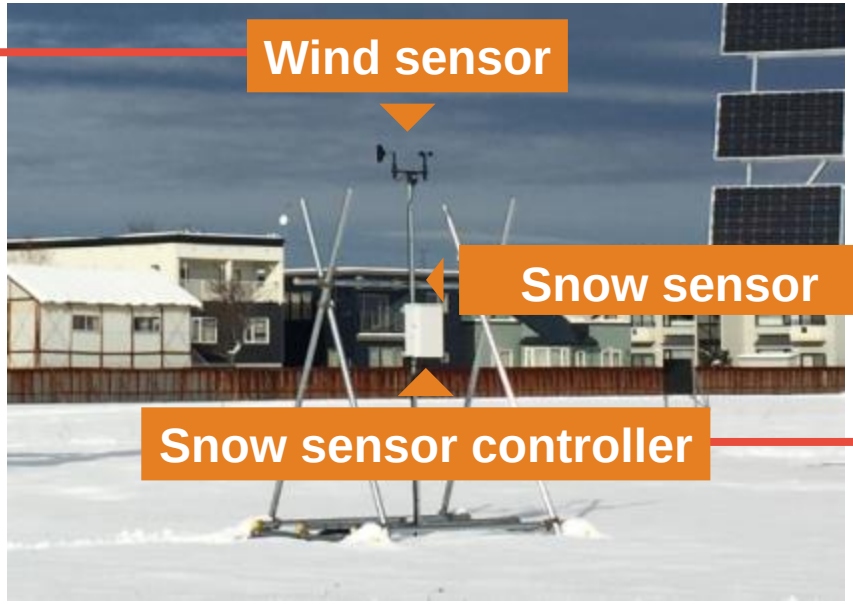
Wind sensing

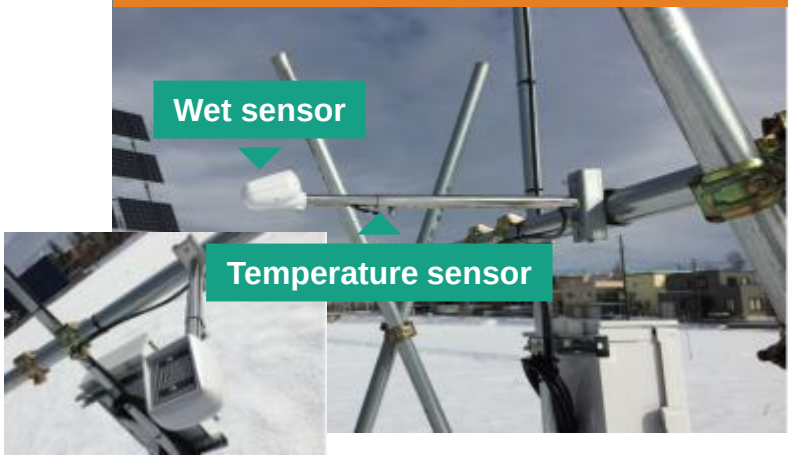
- Wind speed
- over **10m/s**

+

- time **3[sec]**



Snow sensor



Snow sensor controller

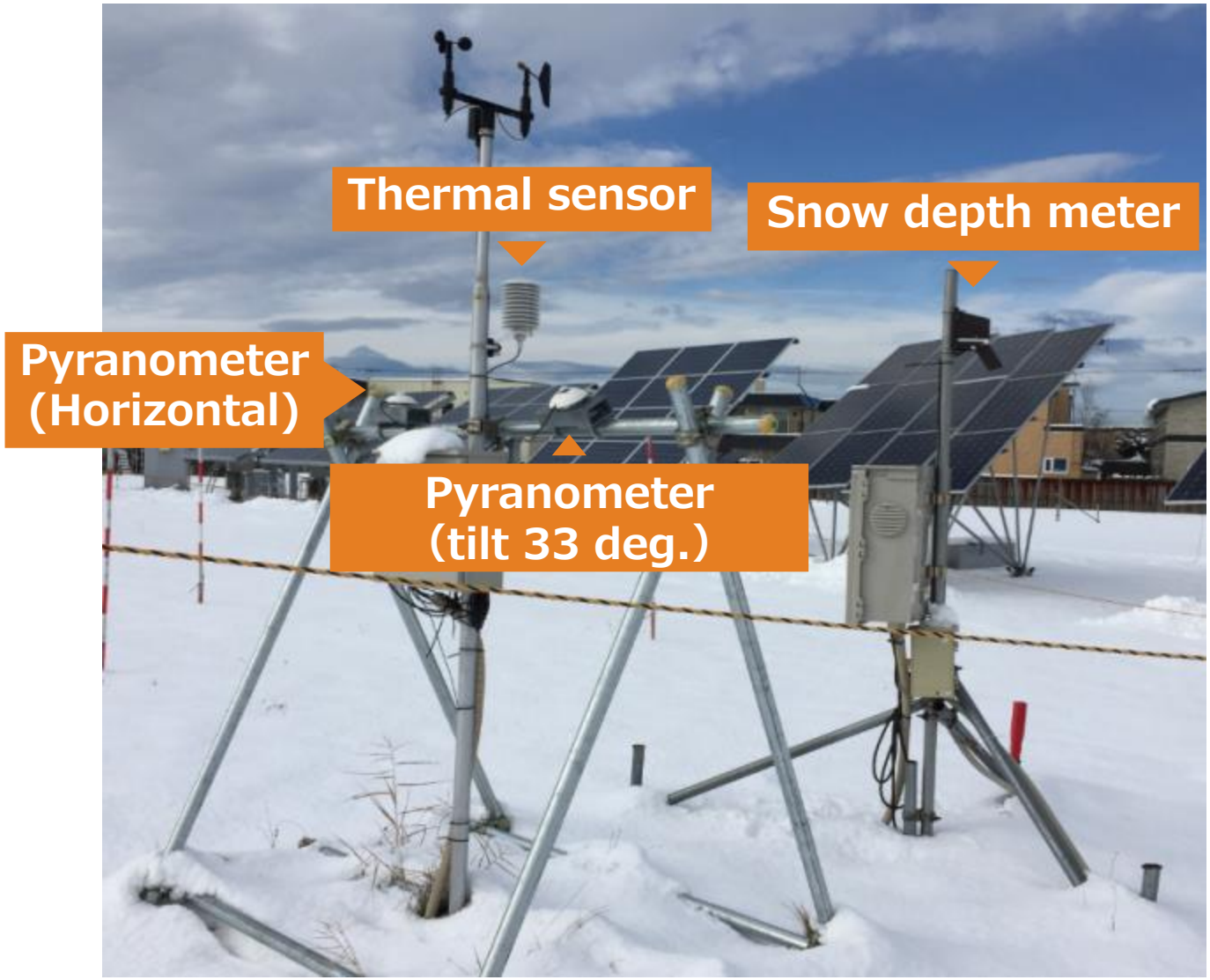
Snow sensing

- Temperature
  under **2 degree C.**

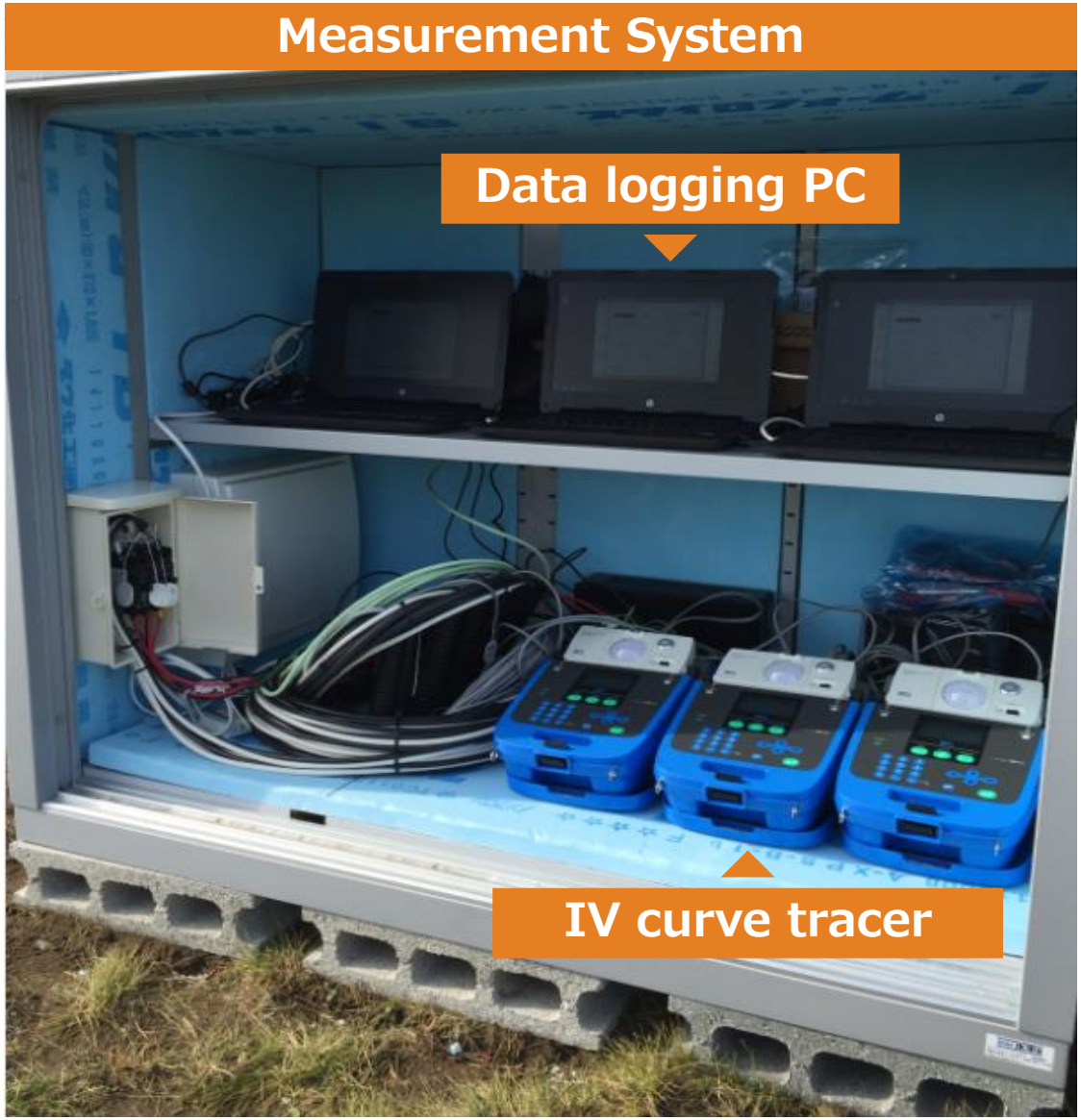
+

- Wet sensing **0 min**

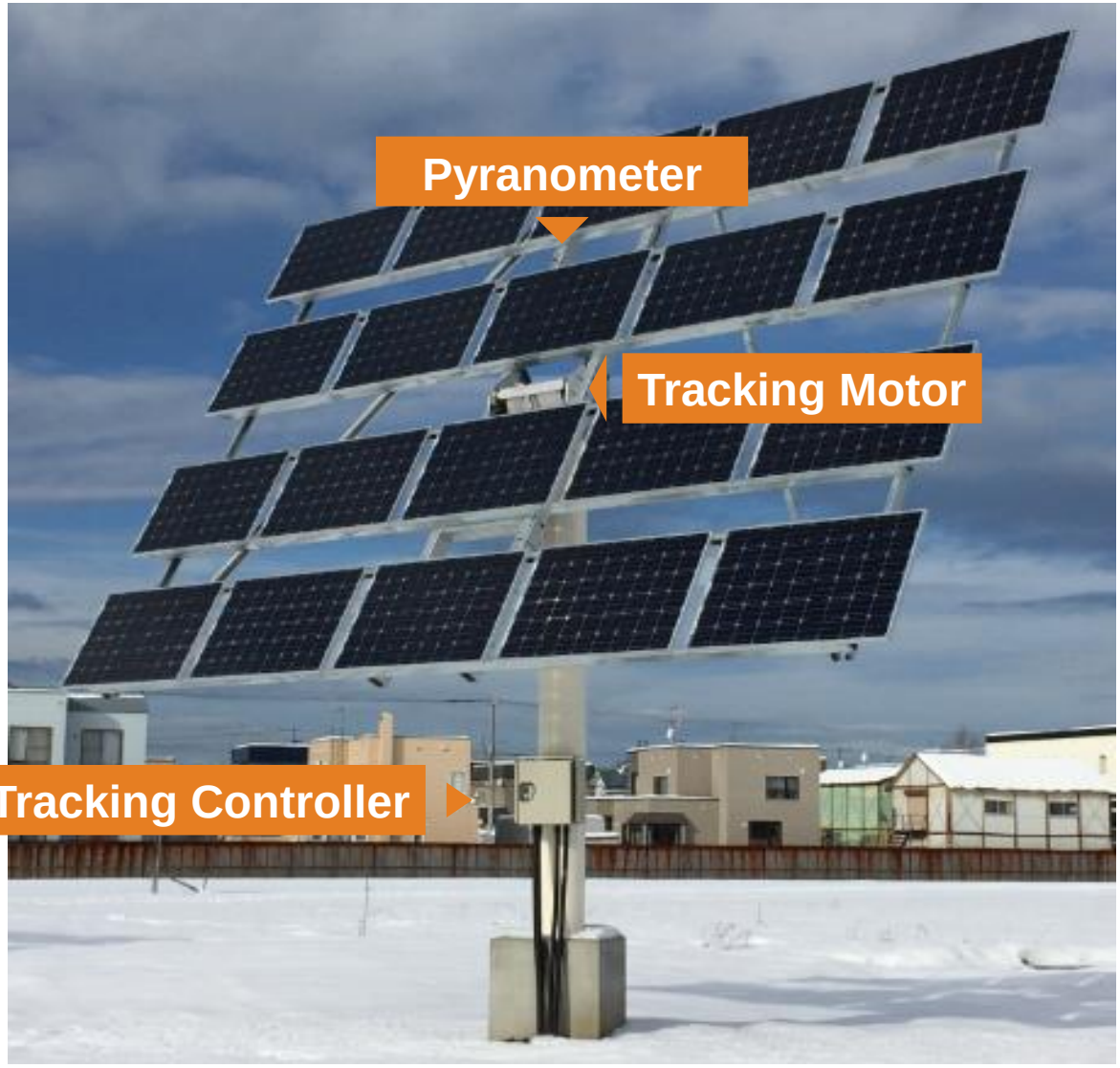
Demonstration test facility



Demonstration test facility



Tracking system



Normal

- Elevation tracking each time the sun altitude is 3 ° to move
- Azimuth tracking each time the sun orientation is 3 ° to move
- Vertical waiting after sunset at sunrise direction
- Azimuth tracking range : 240°
- Elevation tracking range : 90°
- Orientation operating speed : 89.4°／min
- Elevation speed of operation : 36.8°／min

Snow falling

- Elevation control to a vertical position
- Orientation continued tracking

Strong wind

- Elevation control to a horizontal position
- Azimuth tracking stop

Tracking system control

Snow falling

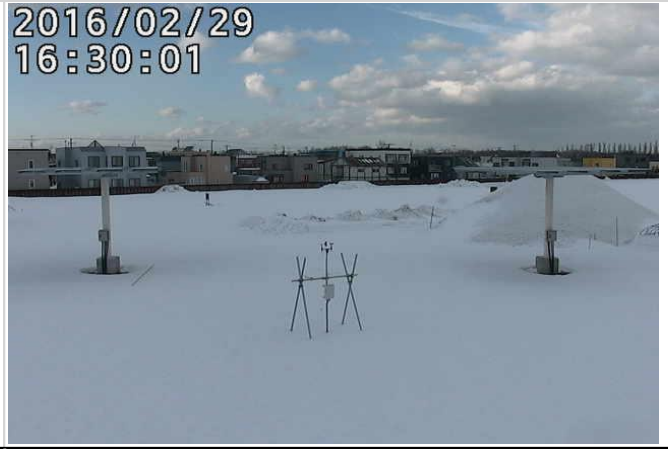
Strong wind

Evaluation items

- Comparison with the mono-facial fixed solar power system (Snowfall, power generation, stand size, cost, maintenance, etc.)
- Optimal control design for the snow to avoid (Snowfall determination method, the determination margin, elevation control range, the orientation control in accordance with the wind direction application, etc.)

The operation of the attitude control system

Strong winds (over 9m/sec)

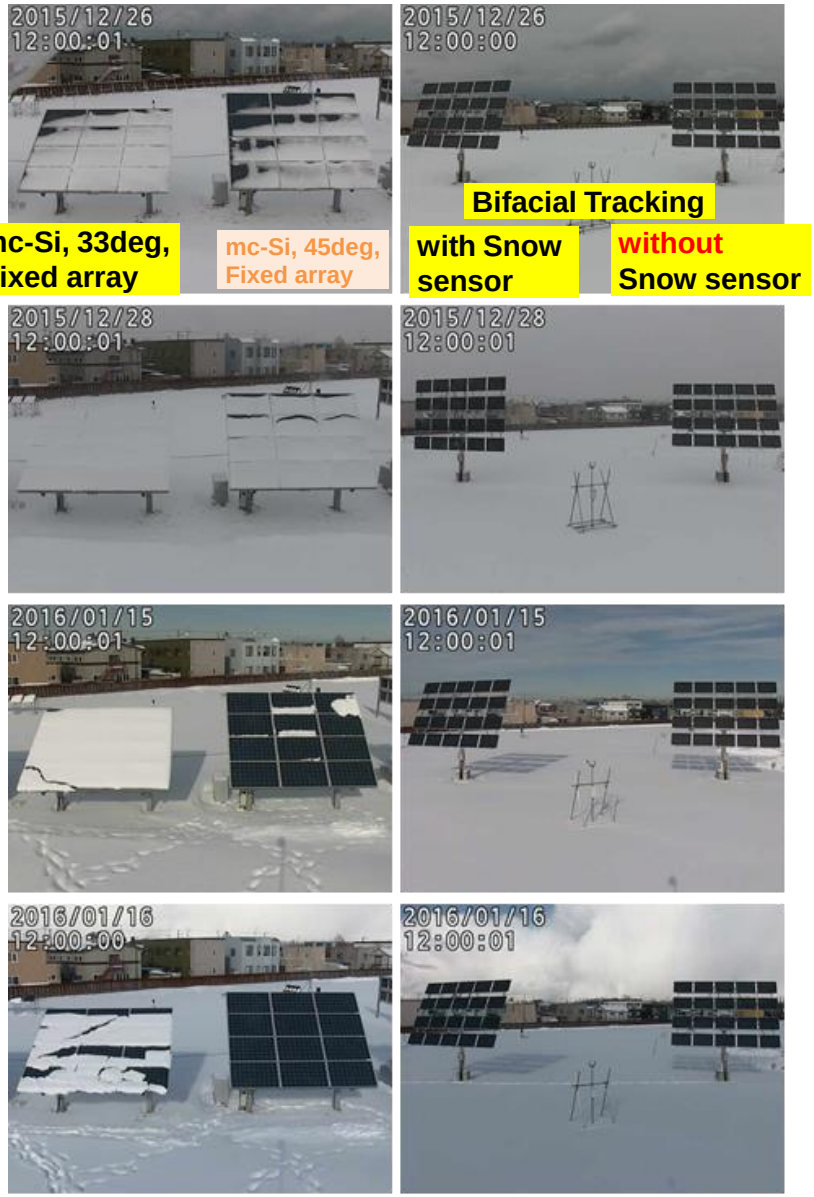
Date	Max wind speed	Camera image
2015/12/19 7:09	10.4 m/sec	
2016/2/9 22:17	9.5 m/sec	
2016/2/14 19:23	9.3 m/sec	
2016/2/29 16:30	10.9 m/sec	

The operation of the attitude control system

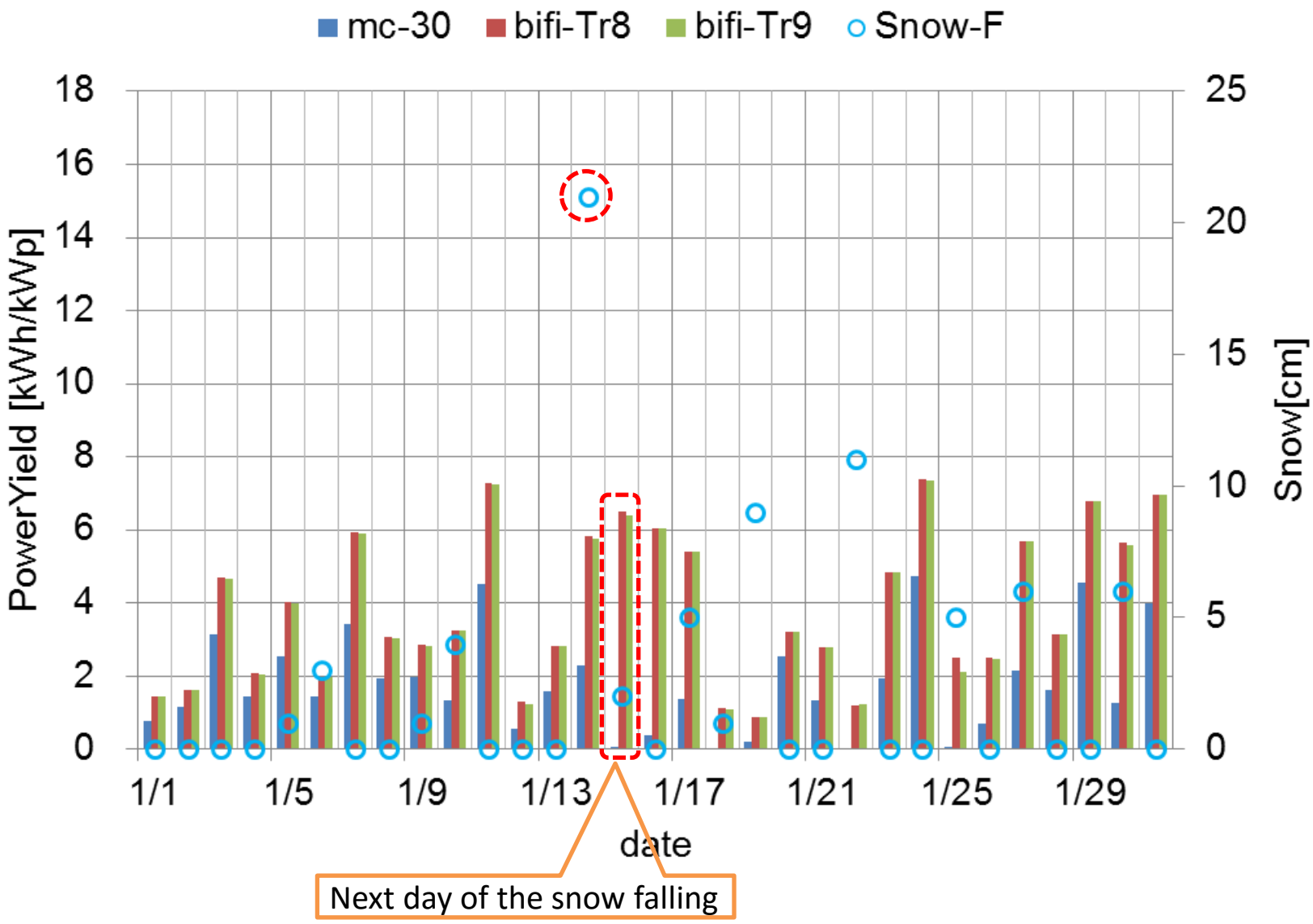
Heavy snow (10cm/day)

Date	Snow fall	Camera image
2015/11/24	18cm	
2015/12/18	15cm	
2015/12/25	14cm	
2016/1/14	21cm	

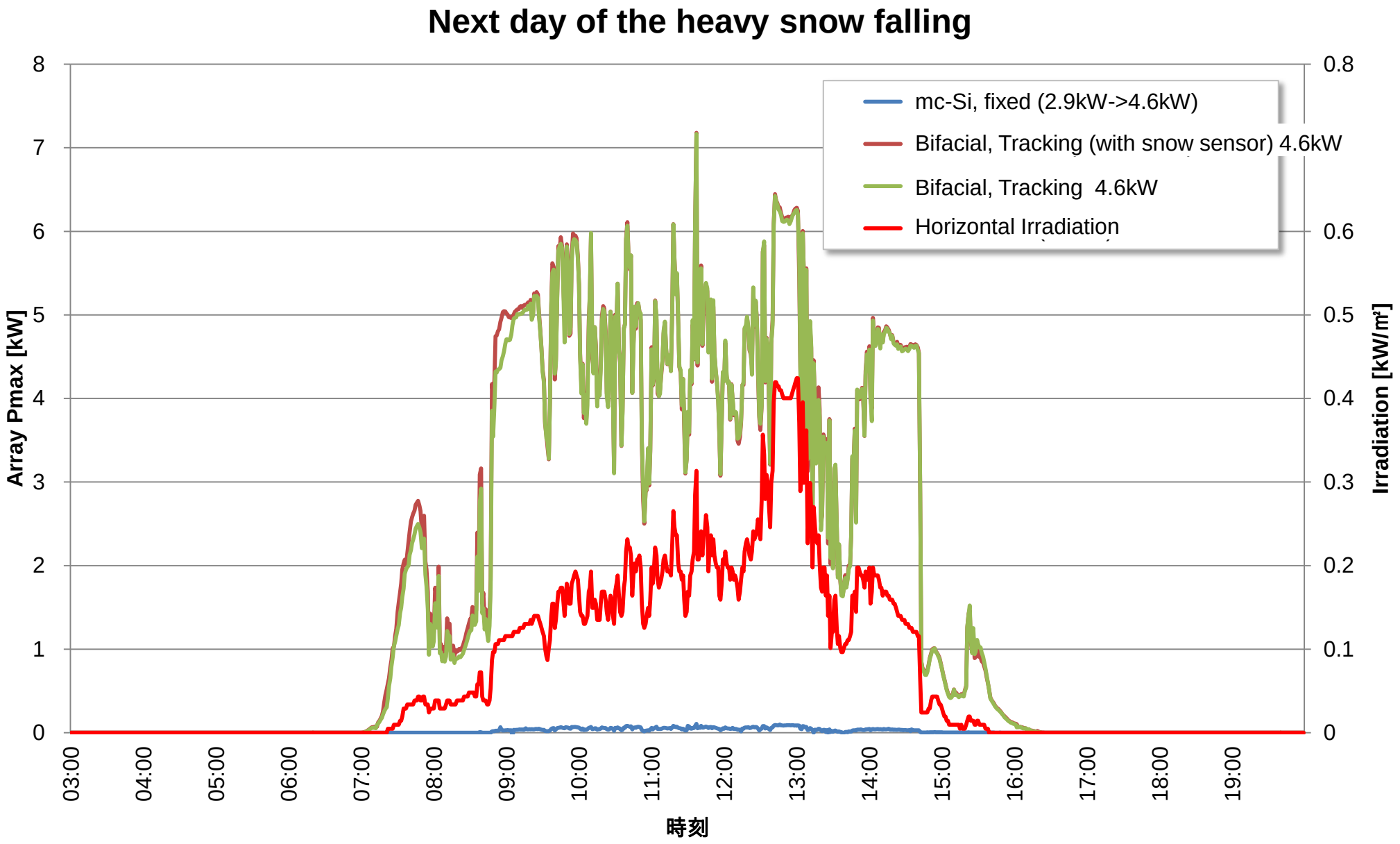
Difference of snow accumulation on PV array



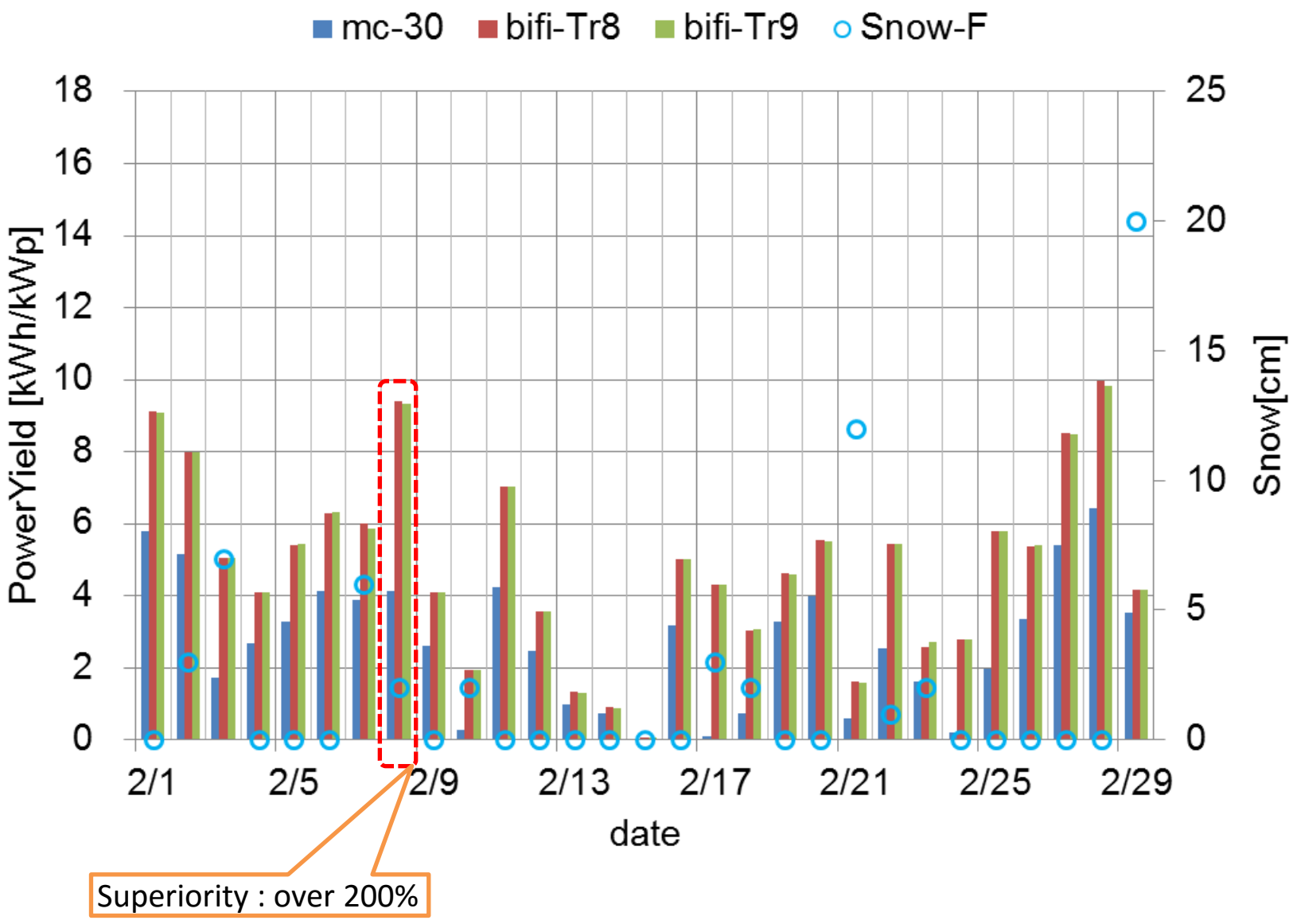
Yield in January



Time chart of yield in Jan 15



Yield in February



Monthly accumulated yield

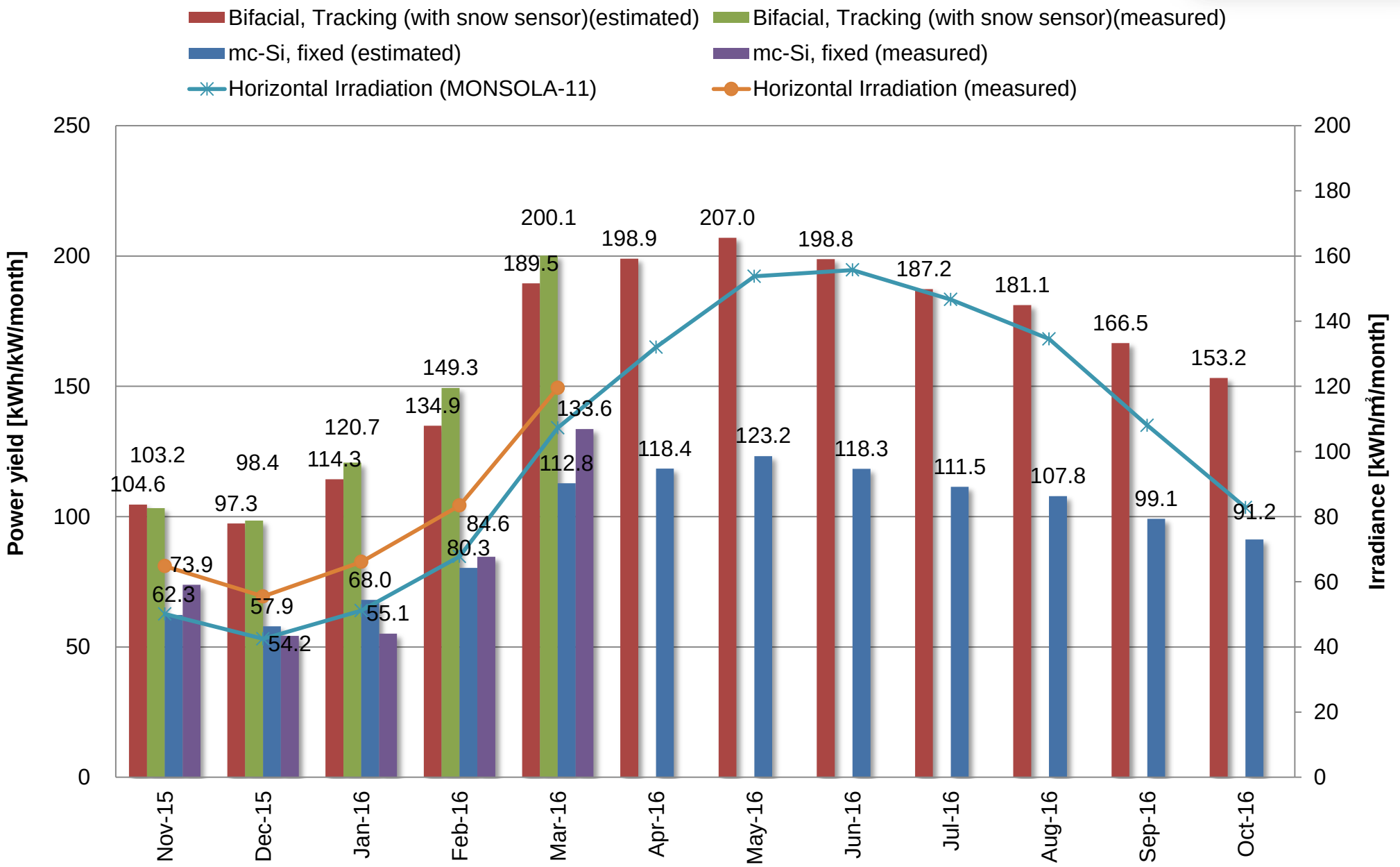


Table of monthly yield

Month	Bifacial, tracking (with snow sensor) [kWh/kW]	mc-Si, fixed [kWh/kW]	Increase ratio of power
Nov, 2015	**103.2**	73.9	**140%**
Dec, 2015	**98.4**	54.2	**181%**
Jan, 2016	**120.7**	55.1	**219%**
Feb, 2016	**144.1**	78.9	**183%**
Mar, 2016	**199.0**	133.8	**149%**
Total of 5 months	**665.4**	395.8	**168%**
Total of a year (Target)	**1,875.3**	1,116.3	**168%**

Evaluation of equipment utilization factor

Month	Bifacial, Tracking (with snow sensor) utilization factor	mc-Si, fixed utilization factor
Nov, 2015	**14.3%**	10.3%
Dec, 2015	**13.2%**	7.3%
Jan, 2016	**16.2%**	7.4%
Feb, 2016	**20.7%**	11.3%
Mar, 2016	**26.7%**	18.0%
Total of 5 months	**18.2%**	10.9%
Total of a year (Target)	**21.8%**	13.0%

Conclusion

- **Power yield from November, 2015 to March, 2016**

  Bifacial tracking (with snow sensor)
  ＝ 1.68×(Mono-facial,33deg-fixed)

- **Capacity (utilization) Factor**

  - Bifacial tracking = 18.2 %
  - Monofacial 33deg-fixed = 10.9 %

- **Snow sensor**

  Because snowfall was considerably less than in previous years, the difference between the snowfall sensor using or not had not be cleared.

- **We will continue to evaluate this system.**

Thank you for your attention.

This development program is ...
Supported by
- Hokkaido Government
- City of Sapporo