



# PVSEC-30 & GPVC 2020

Hybrid Conference  
On-site & On-line

**The 30<sup>th</sup> International Photovoltaic Science and Engineering Conference (PVSEC-30) & Global Photovoltaic Conference 2020 (GPVC2020)**

November **8**(Sun) - **13**(Fri), 2020 | ICC JEJU, Jeju, Republic of Korea

Hosted by **Korea Photovoltaic Society** 

Supported by **Jeju Special Self-Governing Province** 

## Conference Highlights

**Prof. Min Jae Ko (Hanyang University)**

**Co-chair, Technical Program Committee**

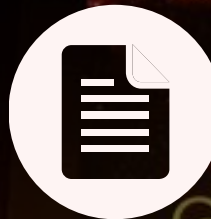


# PVSEC-30 & GPVC 2020 Summary



Registration: 1,321 from 35 countries

*\* Off-line Participants: 1,045/ Virtual Participants: 276*



Total 64 Sessions

*\* 54 sessions, 7 Satellite programs with 10 sessions, 1 Tutorial Program with 3 sessions*

Speakers: 900 speakers

Abstract: 991 papers

✓ Plenary & Keynote: 17 speakers

✓ Plenary & Keynote: 17 papers

✓ Invited: 124 speakers

✓ Invited: 131 papers

✓ Oral: 191 papers

✓ Oral: 206 papers

✓ Poster: 568 papers

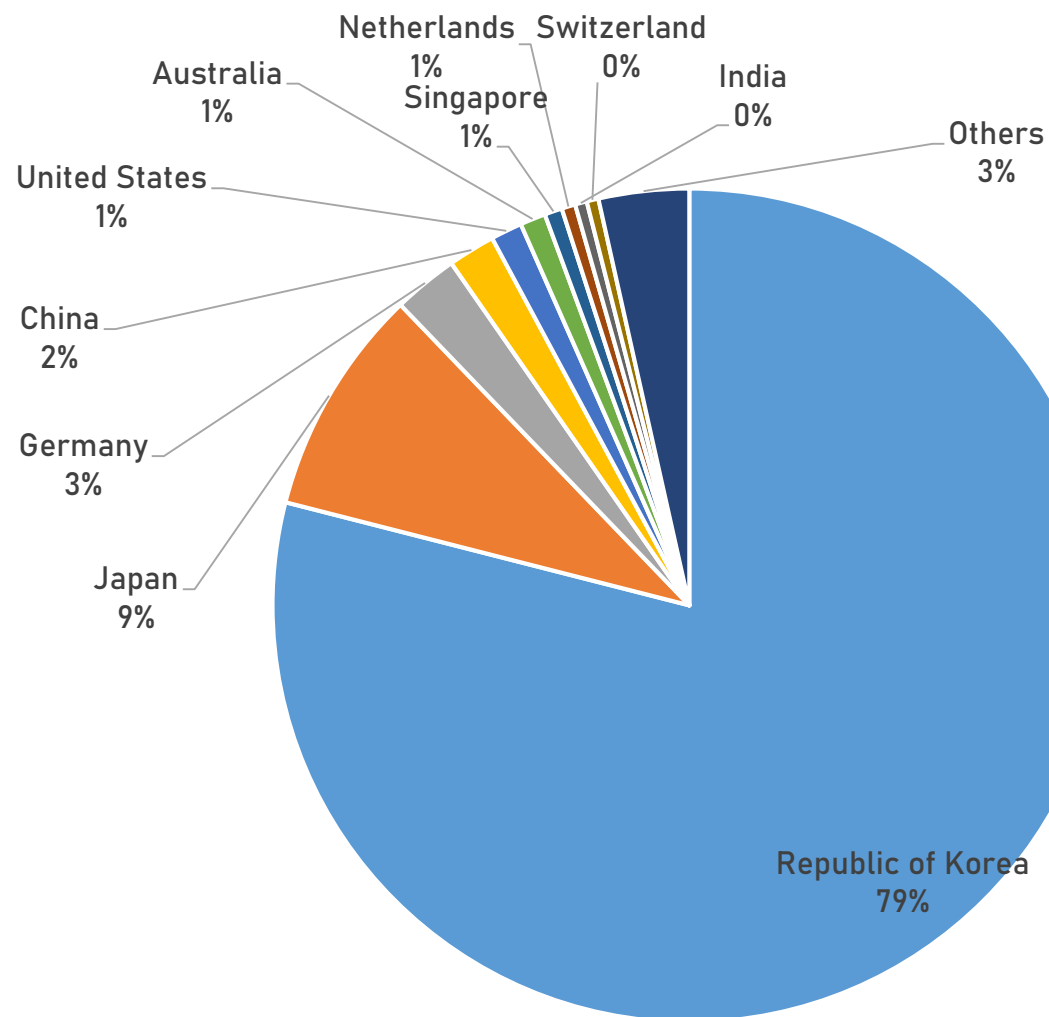
✓ Poster: 637 papers

# PVSEC-30 & GPVC 2020 Summary

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## Registration by Country

No.	Country	Participants
1	Republic of Korea	1,045
2	Japan	116
3	Germany	33
4	China	24
5	United States	16
6	Australia	13
7	Singapore	9
8	Netherlands	7
9	India	6
10	Switzerland	6
11	Others	46
Total		1,321



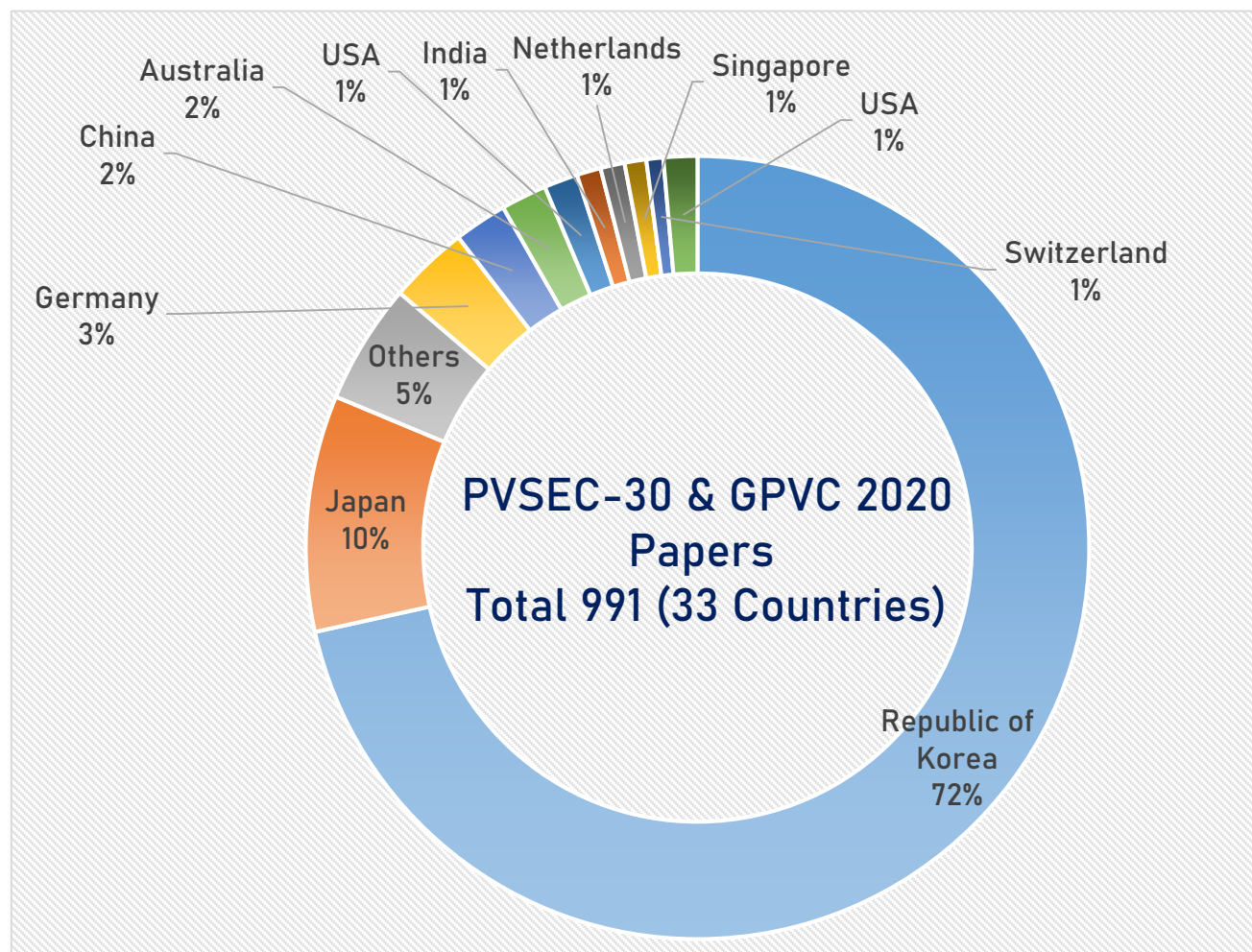


# PVSEC-30 & GPVC 2020 Summary

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## Abstracts by Country of Presenting Authors (991 abstracts from 33 countries)

No.	Country	Papers
1	Republic of Korea	719
2	Japan	98
3	Others	50
4	Germany	33
5	China	22
6	Australia	19
7	USA	14
8	India	10
9	Netherlands	10
10	Singapore	9
11	Switzerland	7
Total		991



## Abstracts by Country of Presenting Authors (991 abstracts from 33 countries)

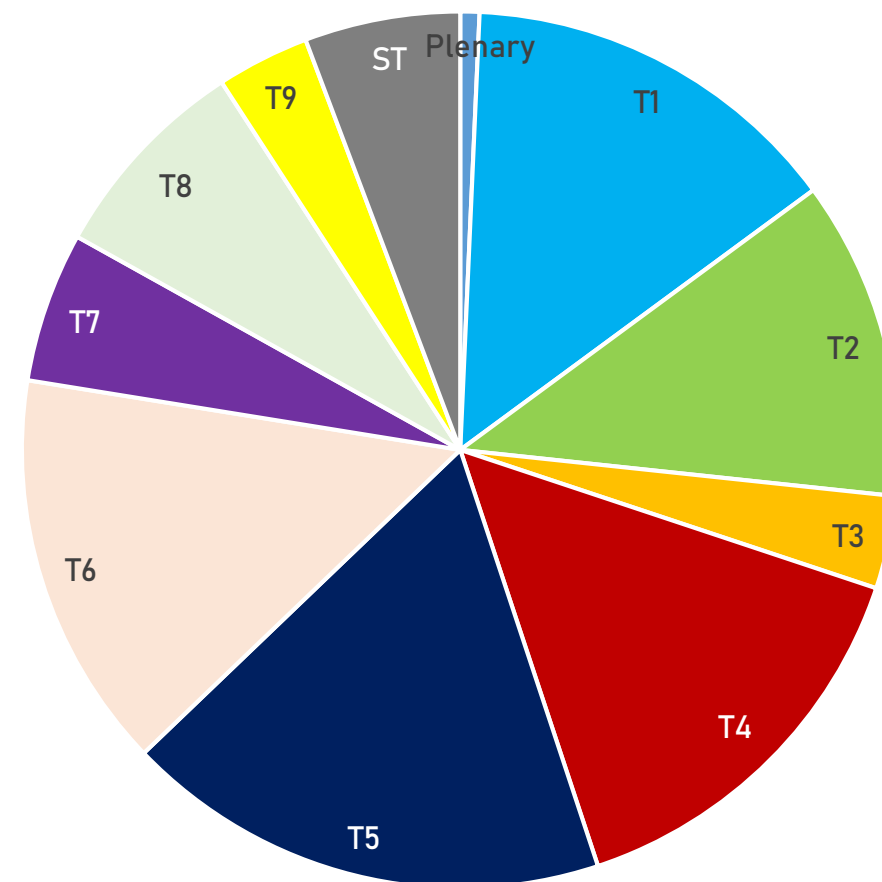
No.	Country	TTL	No.	Country	TTL
1	Republic of Korea	719	18	Brazil	2
2	Japan	98	19	Finland	2
3	Germany	33	20	France	2
4	China	22	21	Israel	2
5	Australia	19	22	Qatar	2
6	USA	14	23	Russia	2
7	India	10	24	Saudi Arabia	2
8	Netherlands	10	25	Spain	2
9	Singapore	9	26	Austria	1
10	Switzerland	7	27	Denmark	1
11	Sweden	5	28	Italy	1
12	Belgium	4	29	Luxembourg	1
13	Hong Kong	4	30	Mexico	1
14	Indonesia	4	31	Portugal	1
15	Malaysia	3	32	UK	1
16	Taiwan	3	33	Vietnam	1
17	Thailand	3	TTL		991

# PVSEC-30 & GPVC 2020 Summary

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## Abstracts by Technical Area

Area	Plenary	TTL
Plenary	Plenary Talks	7
T1	Crystalline and thin film silicon PV	141
T2	Chalcogenide thin film PV	117
T3	Compound semiconductor, concentrator and space PV	34
T4	Organic and dye-sensitized solar cells	147
T5	Perovskite solar cells	178
T6	Advanced concepts and new emerging materials & PV energy storage, solar fuels and novel applications	146
T7	Weather and grid connection performance, reliability and standardization	55
T8	Systems including BOS components and integrations	77
T9	PV deployment: Industry, market, policy and financing	34
ST	Satellite Programs	55
TTL		991



\* ST: Satellite Programs

# PVSEC-30 & GPVC 2020 Summary

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## 1. PLENARY SPEAKERS

Plenary Talk 1



**Dr. Michael Graetzel**  
École Polytechnique Fédérale  
de Lausanne (EPFL)

Plenary Talk 2



**Dr. Noritaka Usami**  
Nagoya University

Plenary Talk 3



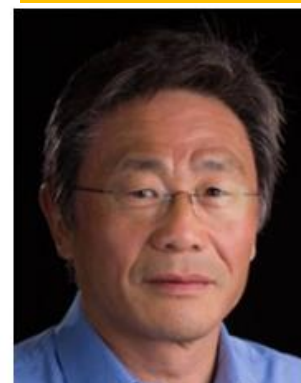
**Dr. Yongfang Li**  
University of Chinese  
Academy of Sciences

Plenary Talk 4



**Dr. Stefan Nowak**  
NET Nowak Energy &  
Technology Ltd.

Plenary Talk 5



**Dr. Jian Ding**

Plenary Talk 6



**Dr. Ralf B. Wehrspohn**  
Fraunhofer Institute

Plenary Talk 7



**Dr. Shigeru Niki**  
New Energy and Industrial  
Technology Development  
Organization

## 2. Keynote Speakers



**Dr. Christian Breyer**  
Lappeenranta University of  
Technology



**Dr. Ralph Gottschalg**  
Fraunhofer CSP Lab



**Dr. Sarah Kurtz**  
University of California  
Merced



**Dr. Jae Sung Lee**  
Ulsan National Institute of  
Science and Technology



**Dr. Jörg Müller**  
Hanwha QCELLS GmbH



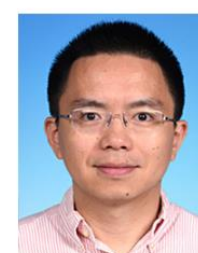
**Dr. Noren Pan**  
Microlink Devices



**Dr. Jang Won Seo**  
Korea Research Institute of  
Chemical Technology  
(KRICT)



**Dr. Ayodhya N. Tiwari**  
Empa - Swiss Federal  
Laboratories for Material  
Science and Technology



**Dr. He Yan**  
The Hong Kong University of  
Science and Technology



**Dr. Masafumi Yamaguchi**  
Toyota Technological  
Institute

## Area 1 Crystalline and thin film silicon PV

- UNIST reported efficiency improvement of transparent c-Si solar cell from 13.5% to 14.6% using textured PDMS thin film.
- NREL, ISFH, and ULVAC are developing IBC poly-Si/SiO<sub>x</sub> contact cell and ULVAC announced 734.9mV iVoc for n+ layer, and 706.3mV for p+ layer.
- 24.0% of passivating contact cell is reported by Julich Research Center using nc-SiC:H.
- Toyo Aluminum K.K. demonstrated world first passivated contact cell metallized with only front Al-fingers: PERT cell  $\eta$  = 19.5%.
- Hanwha Q CELLS has mass production line of 10GW in 2020, and they uses single wafer tracking system and machine learning algorithms with their roadmap to switch to n-type passivated contact solar cells.
- AIST reported 23.5% heterojunction cell efficiency obtained by replacement of p a-Si:H with p nc-Si:H, and 21.1% TiO<sub>x</sub>-based hole selective contact cell using TiO<sub>x</sub> as hole selective layer.
- Nagoya University is also working on development of TiO<sub>x</sub>-based carrier selective contact solar -cell, and reported max. effective lifetime of 891us after FGA



## Area 2 Chalcogenide thin film PV

CIGS						CdTe	Perovskite		
	Solar Frontier	ZSW/ Shenhua/ Manz	CNBM/ Avancis	Hanergy Solibro	Hanergy Miasole	Hanergy GSE	First Solar	Perovskite  Global	<div> <div>Perovskite /Si</div> <div>Perovskite /CIGS</div> </div>
									<div> <div>HZB</div> <div>HZB</div> </div>
R&D	23.4%* 1cm <sup>2</sup>	22.6%* 0.5cm <sup>2</sup>		22.92%* 1cm <sup>2</sup>	20.56%* 0.85cm <sup>2</sup>	20.06% 1cm <sup>2</sup>	22.1%* 1cm <sup>2</sup>	25.2% 0.1cm <sup>2</sup>	<div> <div>29.1%* 1cm<sup>2</sup></div> <div>24.2%* 0.5cm<sup>2</sup></div> </div>
Mini-module	19.8%* 7cm*5cm			19.3% 100cm <sup>2</sup>	19.05% 136.5cm <sup>2</sup>			17.4%* 17cm <sup>2</sup>	
Sub-module	19.2%* 841cm <sup>2</sup>		18.2% 900cm <sup>2</sup>	18.9% 900cm <sup>2</sup>		17.3% 994.05cm <sup>2</sup>		11.7% 703cm <sup>2</sup>	
Champion module				18.7%*AA 17.59%TA	18.64%*AA 1.07m <sup>2</sup>	16.4% 0.806m <sup>2</sup>	18.6%*AA		

- EMPA (Switzerland, Keynote), HZB (Germany) & imec (Belgium) presented inspiring research data of CIGS/perovskite tandem solar cells. Best efficiencies of tandem cells so far, achieved by HZB are 29.1% for Perov./Si & 24.2% for Perov./CIGS as shown in the table above. HZB showed how the surface roughness of CIGS bottom cell in relation with the intermediate layer affects in achieving high efficiency 2-terminal monolithic Perovskite/CIGS tandem solar cell.
- TNO (Netherlands), KIER (Korea), ZSW (Germany), and Univ. Luxembourg (Luxembourg) presented some interesting papers mainly on the widening of application fields of CIGS solar cells and modules by demonstrating flexible and semitransparent devices.

### Area 3 Compound semiconductor, concentrator and space PV

- There were Four oral sessions and one poster sessions, and 18 oral papers and 15 poster papers were presented.
- The technical topics most highlighted were a high specific power(KW/Kg), III-V on Si epitaxial growth technics, and light concentrating such as novel hybrid concept with LSC, nano/micro pattern and Lens technology.
- A 3J(InGaP/GaAs/InGaAs) ELO solar cell with a record efficiency of 37.75% was presented. High specific power (3.8 KW/Kg) of 20 cm<sup>2</sup> 3J ELO cell and thin film solar cell sheet product of 1.5KW/Kg has been developed for UAV application(T3-01-KN-1).
- Recent progress of III-V on Si based epi-taxial growth technology was reported. A record 23.4% efficiency of III-V/Si tandam cell and new CSS(compressive strain superlattice) approach were addressed(T3-01-IN-2). Also low temperature buffer layer growth was studied and developed to reduce TDD dramatically by MBE(T3-02-OP-2&T3-04-OP-4).
- LSC(Luminescent Solar Concentrator), Micro Prism and Nano-structure were integrated with flexible III-V thin film solar cell were presented, and showed the enhancemed optical and electrical properties in various application(T3-03-IN-1, T3-02-OP-3, and T3-04-OP-5)

### Area 4 Organic and dye-sensitized solar cells

- Tandem DSSCs with a porphyrin sensitizer and liquid electrolyte showed an efficiency of over 14.7%.
- Exeger presented various self-powered electronic products based on DSSCs.
- Organic solar cells with non-fullerene acceptors achieved an efficiency of 18.1%.
- Organic solar cells with flexible and heavy-duty transparent electrodes exhibited the best efficiency of 15.41%.
- All-printed semitransparent organic solar cells via showed an efficiency of 9.5% via ink engineering.

## Area 5 Perovskite solar cells

- Dr. Graetzel introduced recent research progress of perovskite solar cells. Dr. Seo group in KRICT obtained 18.6 % (100 cm<sup>2</sup>) of rigid type and 15 % (400 cm<sup>2</sup>) of flexible type sub-module efficiency [Keynote1, KRICT]
- Stable all perovskite-tandem solar cells with 25.6 % were achieved by using stable low bandgap Pb-Sn perovskite bottom cell [T5-01-IN-2]
- Printable mesoscopic perovskite solar cells have passed the IEC61215 qualification testing and over 9000h MPPT testing at 55±5°C and 3×200 MW pilot line and customer outdoor demonstration will be finished within next 3 years [T5-04-IN-1]
- Grain boundary functionalization in the halide perovskite solar cells is important to enhance stability [T5-04-IN-3]
- Over 25% efficiency can be achieved by phase stabilization of FAPbI<sub>3</sub> with MAI, LiTFSI doped ETL, and 2D perovskite passivation top layer. [T5-05-IN-1]
- Over 25% Si-perovskite tandem cell was achieved by defect passivated wide bandgap perovskite with PEAI:PEASCN [T5-05-IN-2]



### Area 6 Advanced concepts and new emerging materials & PV energy storage, solar fuels and novel applications

- Prof. Lee (UNIST) as a keynote speaker presented a perspective on the scale-up and dissemination of the solar hydrogen production technology. In particular, he briefly introduced the main performance results for metal-oxide absorbers and their limitation.
- Prof. Kim (SKKU) suggested the plasmon induced energy transfer in the metal oxides and clearly illustrated the rational design for enhancing these performance by harnessing novel plasmon induced resonance energy transfer (PIRET).
- Also, in this session, some new photoabsorber materials and processes were introduced: for examples, Cu<sub>3</sub>O<sub>4</sub> and BaSi<sub>2</sub> (Japan), and laser-controlled graphene growth for Si Schottky solar cell and copper assisted texturization technique.
- It is introduced that the on-chip radiative coolers are economically viable and help overcome the saturated quantum efficiencies of current optoelectronic devices that are limited by thermal effects.
- Particularly, the studies on many photoelectrochemical and electrochemical reactions were presented in poster and oral presentations of this session, which was new topics in the PVSEC.

### Area 7 Weather and grid connection performance, reliability and standardization

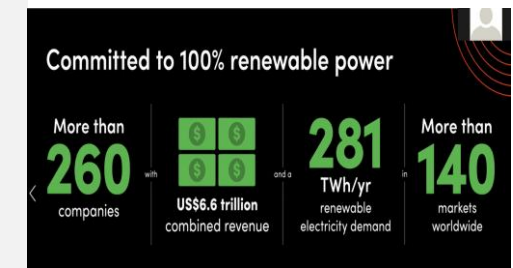
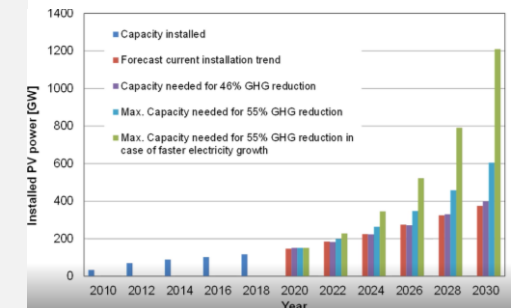
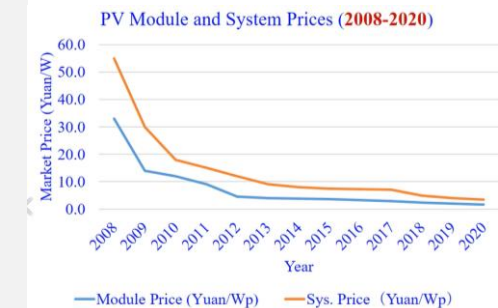
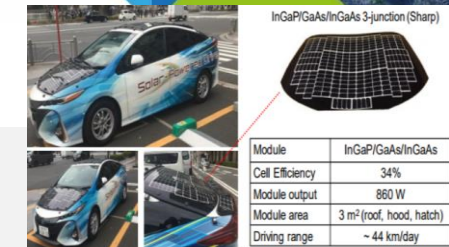
- International and domestic PV related standards were discussed.
- PV system analysis method and solar resource prediction methods were discussed.
- Standard documents that are established and amended by the IEC TC82 technical committee was discussed.
- Reliability and Assurance issues were discussed including module degradation on out-door and BIPV environment, especially elevated temperature and light induced condition. And BIPV power generation measurements and forecast are compared.
- SOLAR sharing issues are discussed including, harvest rate improvement, border effect, high-value added crops, and frame structures.

### Area 8 Systems including BOS components and integrations

- The state of California has set a target of zero-carbon energy by 2045. The state has been aggressively pursuing deployment of solar energy, resulting in about 20% of electricity generation in the state being from solar in 2020. Sarah Kurtz discuss projections of how to meet California's goals with various renewable energy sources [Univ. of California, T8-01-KN-1]
- A new approach to learn particular features of a PV system or subsystems was introduced using Genetic Algorithm optimization in terms of PV nominal power, PV tilt and azimuth angles, albedo effect, ratio of nominal PV module to nominal inverterpower (DC/AC ratio), irradiance and temperature dependency. [Fraunhofer, T8-02-OP-5]
- The optimal size and design of the reflective material for bifacial PV modules are investigated for achieving maximum efficiency depending on the different tilt angles. [Korea Polutech. Univer., T8-03-OP-2]
- Two innovative concepts for floating bifacial PV systems are introduced: retractable system and floating island. The best option is suggested after 10-month monitoring the systems. [Delft Univ., T8-04-OP-3]

## Area 9 PV deployment: Industry, market, policy and financing

- Two keynote presentations were given by New possible application area of photovoltaic technology by Prof. M. Yamaguchi (Toyota Technological Institute, Japan) on “PV-Powered Vehicle” and C. Breyer (Lappeenranta University of Technology, Finland) on “The Solar edge : The rise of solar PV and 100% renewable energy”.
- In the field of current status and future prospects for PV deployment, Sicheng Wang (China Energy Research Institute) presented "PV Current Status and Future Forecast in China", Gaëtan Masson (IEA PVPS) "PV Application 2020 Trends", Arnulf JAEGER-WALDAU (EU Joint Research Center) 'European Green Deal and COVID-19 Recovery Package', Richard Perez (University at Albany USA) PV Power Forecast, Mukund Santhanam (RE100-The Climate Group) 'RE100 and cost of renewable electric power'.
- Koreans were also presented the hot issues such as “Corporate renewable energy procurement policy”, “green new deal”, “Business model of PV O&M”, “PV energy Policy”, and “Households’ PV uptake”





### Satellite Programs\_7 programs with 10 sessions



## Full Paper Submission

- 1 Energies - *Deadline: Dec. 31, 2020*
- 2 Crystals - *Deadline: Jan. 20, 2021*
- 3 Journal of Nanoscience and Nanotechnology - *Deadline: Jan. 20, 2021*
- 4 ECS Journal of Solid State Science & Technology - *Deadline: Mar. 10, 2021*
- 5 Current Photovoltaic Research (CPR) - *Deadline: Jan. 20, 2021*
- 6 Electronic Materials Letters (EML) - *Deadline: Jan. 20, 2021*

### [Topics]

- Perovskite, organic, quantum dot, and hybrid solar cells
- Si, Chalcogenide thin film, and Compound semiconductor
- Nanotechnology for advanced photovoltaics
- Analysis and characterization for photovoltaics
- Design and synthesis of novel compounds for advanced photovoltaics
- Spectrum conversion for photovoltaic devices
- Devices and materials for scalable manufacturing, stability and performance
- Solar fuel, Module, System, and Reliability

# PVSEC-30 & GPVC 2020 Summary

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## *Special Thanks to Program Session Chairs...*

T1



Dr. Hae-Seok Lee

T2



Dr. Jihye Gwak

T3



Dr. Ho Kwan Kang

T4



Dr. Youngu Lee

T5



Dr. Sang Hyuk Im

T6



Dr. Jae Hyun Kim

T6



Dr. Hyung Koun Cho

T7



Dr. Jae Hak Jung

T8



Dr. Nochang Park

T8



Dr. Suk Whan Ko

T9



Dr. Eun Chel Cho





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