State of the Industry: Floating Solar

08.10.18, ADB - Manila

Erik Berger, Sales Manager Asia - Multiconsult

Section *Renewable Energy*

State of the Industry: Floating Solar

Agenda:

- Multiconsult & Floating Solar
- Applications
- Concept
- Market Evolution and Forecast
- Systems and Market Leaders
- Economical Aspects
- Hybridization with Hydropower
- Offshore Systems
- References
- Team & Contacts

Solar, Storage and Smart Energy Services

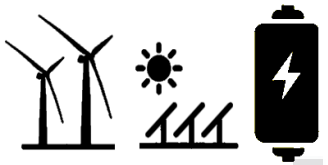
«Unlocking clean and affordable Solar Energy»

UTILITY SCALE PV SYSTEMS
From detailed engineering to third party verification. We provide services to ensure bankable quality.

FLOATING SOLAR PV
Market leader in the niche of floating solar. We are experienced in market/ technology studies, system design, hybridization and project procurement services.

MICRO GRID AND SMART GRID
At the forefront of distributed generation and smart control. Providing advice on load requirements & generation potential. Control systems and power trading via blockchain.

TRAINING COURSES AND CAPACITY BUILDING
Tailored lectures and seminars to enable clients to understand their requirements, model their own systems and procure competitively priced systems.



HYBRID SYSTEMS
From small off grid systems to hybridization of utility scale solar, hydro and wind plants. Multiconsult can help develop the business case, assure system compliance, design the control hierarchy and procure the plant.

KEY VALUE PROPOSITIONS

FLOATING SOLAR

Feasibility Analysis

- Yield Studies
- Anchoring design and pricing
- System Prices, Financial/ economic assessment
- Market and supplier analysis

Engineering

- Conceptual -> detailed technical design + drawings
- System integration (LV, MV or HV)
- Hydro/PV hybridization
- Independent verification of design

Procurement

- Tender design and execution
- Supply chain development
- Contract

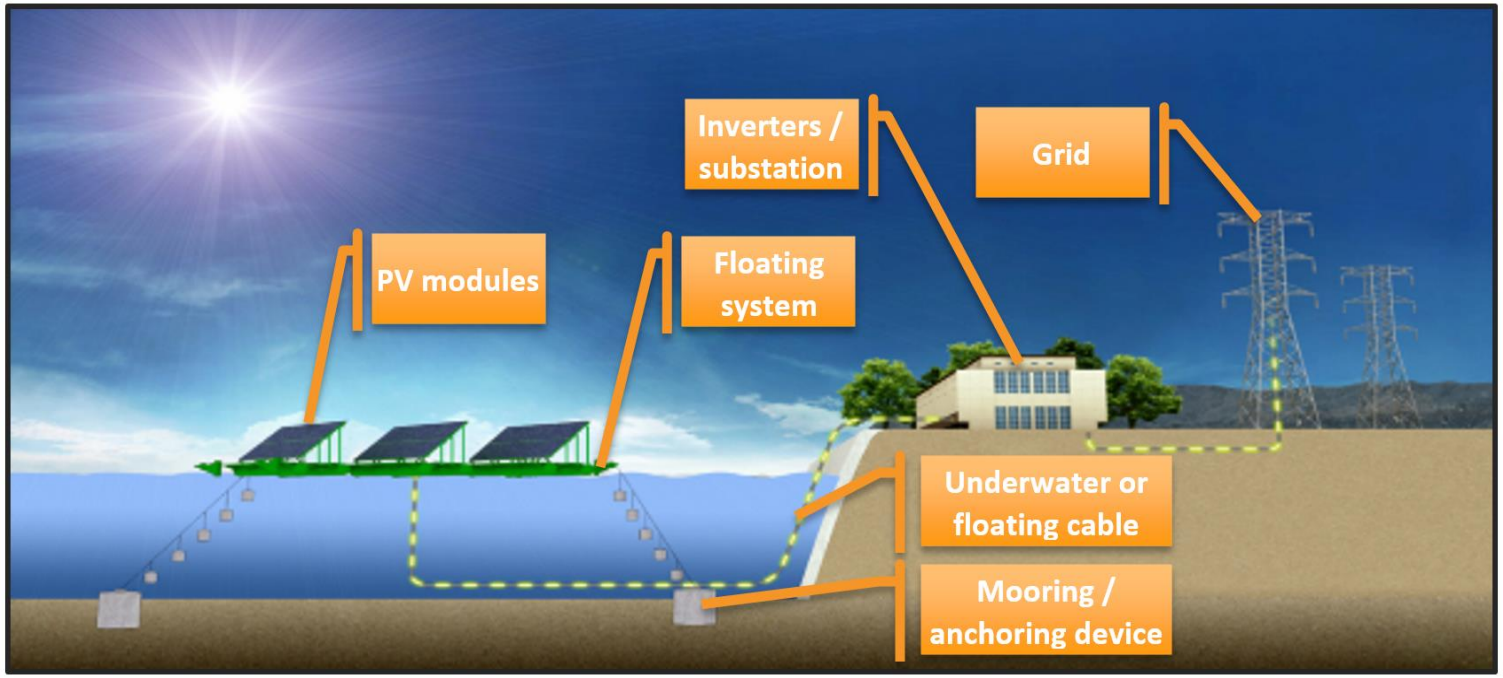
Construction Supervision

- CP Closure
- COD reporting and sign off

Floating Solar Applications:

- Lakes
- Water Reservoirs
- In relation to Hydropower Plants
- In relation to Irrigation Plants
- Ocean Salty Water, in particular for islands

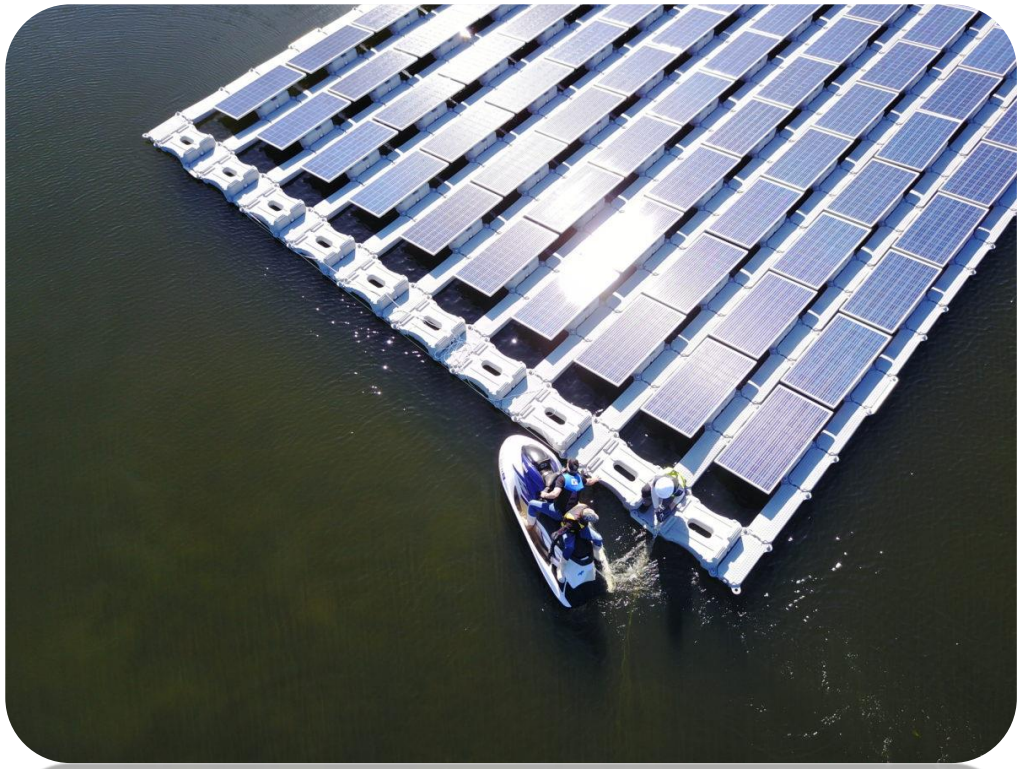
Concept - System



Credit: Multiconsult

- Floaters: Provide enough buoyancy, flexibility to waves, 25+ year lifetime
- Mooring: wind, waves, variation of water levels
- PV modules: more stringent requirements
  - PID (Potential Induced Degradation)
  - Encapsulation
- Inverter: usually onshore

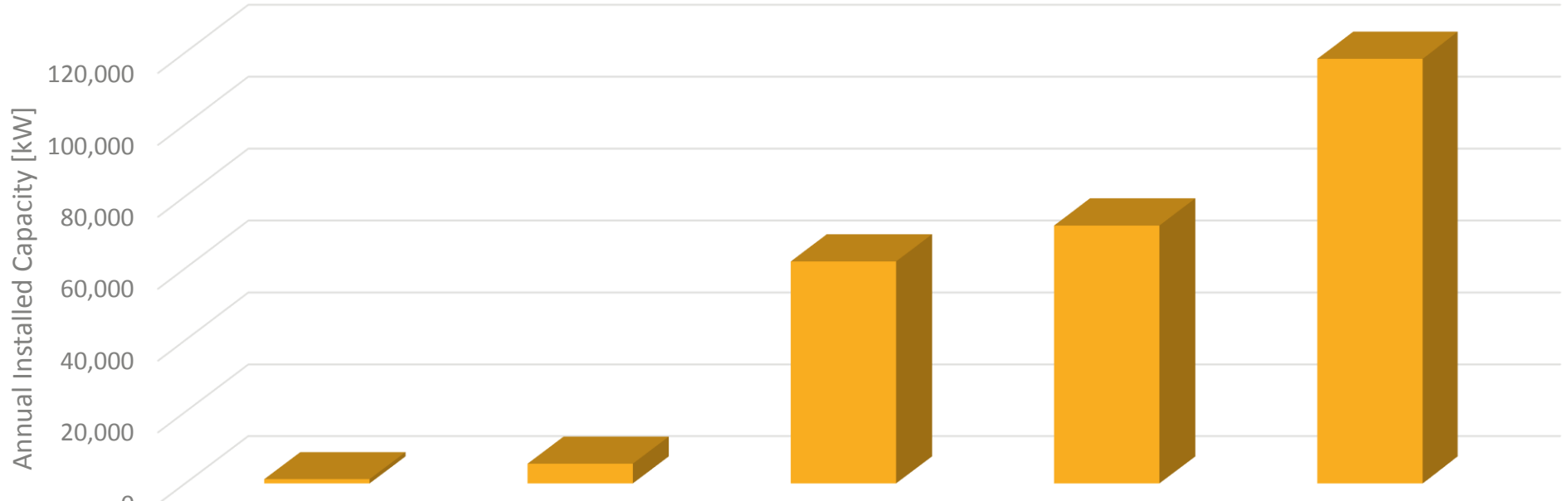
Concept - Main Advantages



Credit: Ciel et Terre.

- Deployment of PV plants on existing reservoirs that saves land space / land acquisition costs
- Better performance of the PV modules due to the cooling effect of the water
- Limited evaporation of the water under the plant.

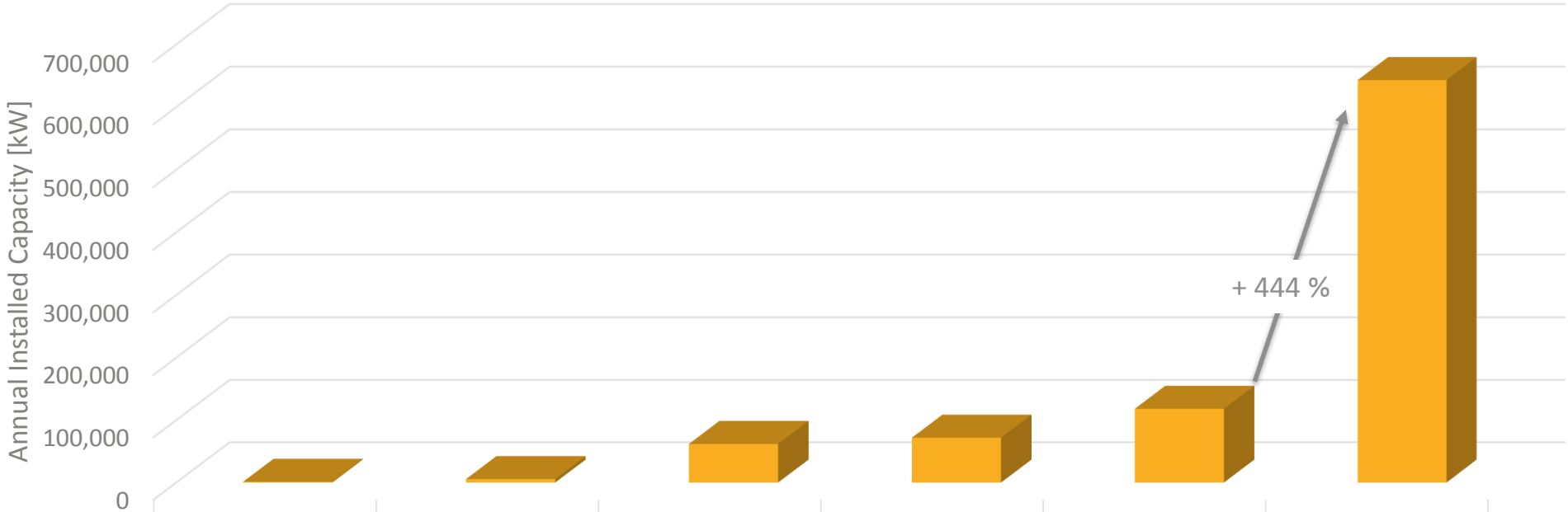
Market Evolution 2013 - 2017



	2013	2014	2015	2016	2017
Total	1,185	5,521	61,890	71,872	118,218

- Global Cumulative Installed Capacity by end of 2017: **259 MW**

Forecast 2018



	2013	2014	2015	2016	2017	2018
Total	1,185	5,521	61,890	71,872	118,218	643,100

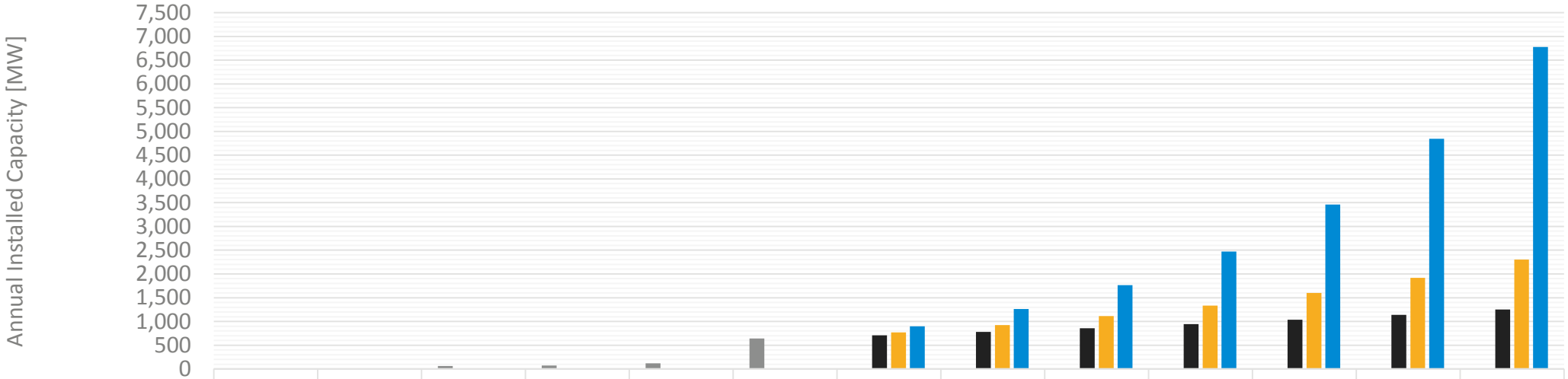
- Based on known projects only
- Excludes the 10 GW tender announced in India

India's SECI to roll out 10 GW floating solar tender

The Solar Energy Corporation of India will invite expressions of interest (EOI) from developers eager to build, own and operate floating PV installations at selected sites across the country.

DECEMBER 19, 2017 IAN CLOVER

Scenarios 2025



	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Historical data	1	6	62	72	118	643							
Low scenario							707	778	856	942	1,036	1,139	1,253
Medium scenario							772	926	1,111	1,334	1,600	1,920	2,304
High scenario							900	1,260	1,765	2,471	3,459	4,842	6,779

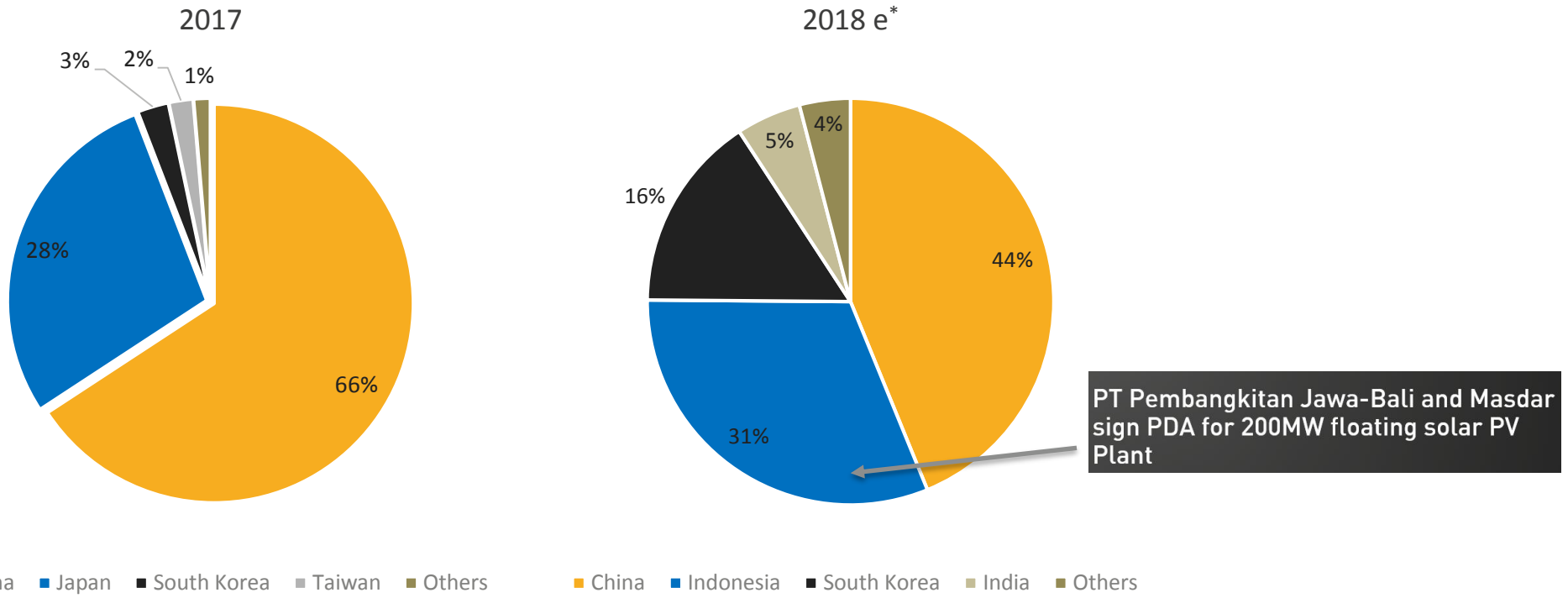
- Low: 10 %/yr Medium: 20%/yr High: 40%/yr (Global PV historical data: app. 30 %/yr)
  - High uncertainty, many considering entering the market

- Forecast Global Cumulated Installed Capacity end of 2025 (high scenario) 22,4 GW
  → FPV still represents less than 2 % of the total PV capacity in 2025.*

* Solar Power Europe Global Market Outlook 2017: 900 to 1 500 GW

Asia is Running the Market

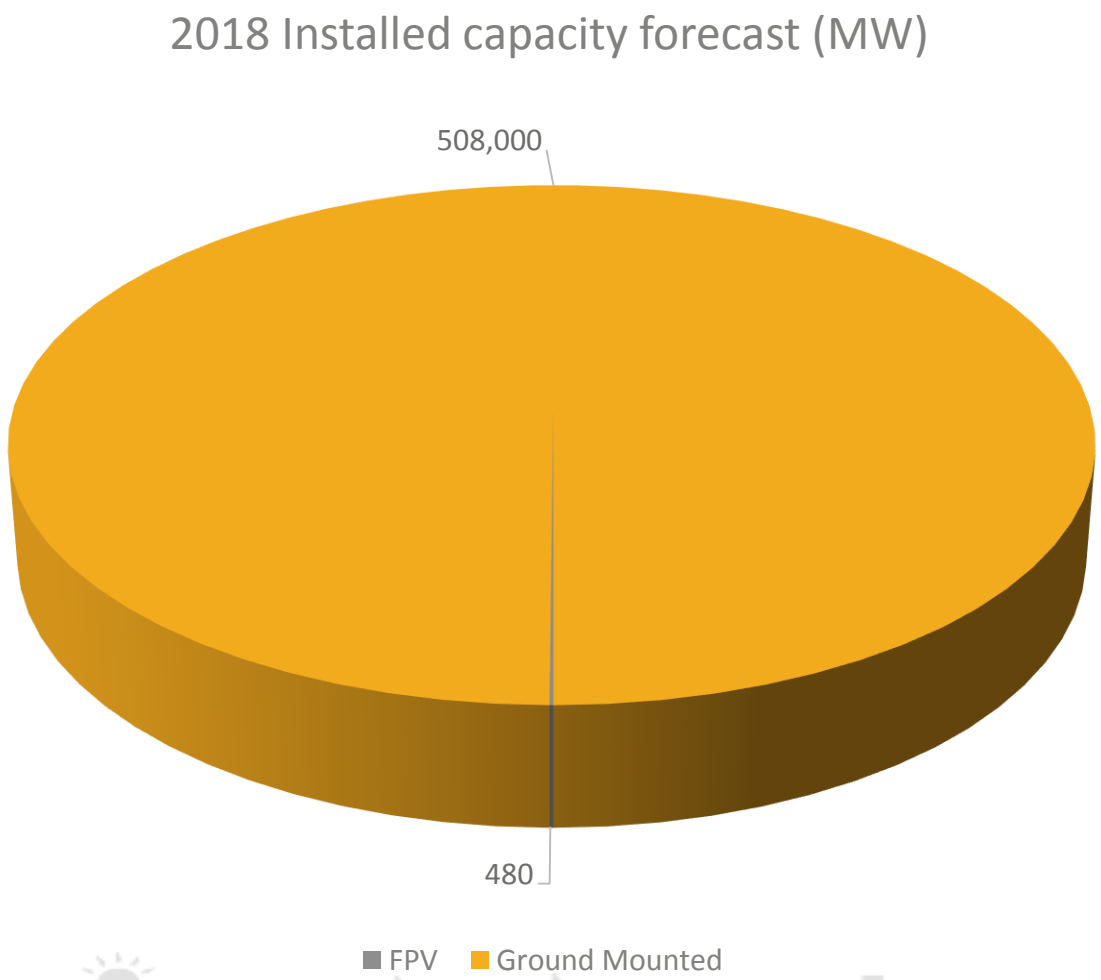
New installed floating PV capacity per year per country



- Indonesia to become a new center, although based on relatively small number of announced project
- No new projects announced for 2018 in the second largest market - Japan

* based on known projects only, without the 10 GW tender announced in India.

FPV vs Ground Mounted



- Almost 0.1%
- Big potential

Potential

Photo: Ciel & Terre

Solar on the water (fire in the sky)

In some growing solar markets, especially in East Asia, land is becoming a constraint. Much of the flat land is taken for agriculture. The land in and around cities is densely populated. Finding room for solar will only get more difficult.

One solution: **Put it on the water**! PV panels can be mounted on pontoons that float on freshwater lakes and reservoirs.

Floating PV has a few advantages: it can be built without traditional site preparation, pile driving, or fence and road construction; there's less competition for the "land"; the panels stay cooler, which boosts efficiency; and floating systems can often be built closer to loads.

SOLAR ENERGY

Floating Solar Plants Aiding India's Target of Achieving 227 GW Solar Power by 2022

Floating Solar power plant as the name suggests are bodies of water with floating solar PV plants on them, which can help us capitalise water bodies that India and will change the ecosystem for ever

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Image credit: Pixabay.com

Renewable energy

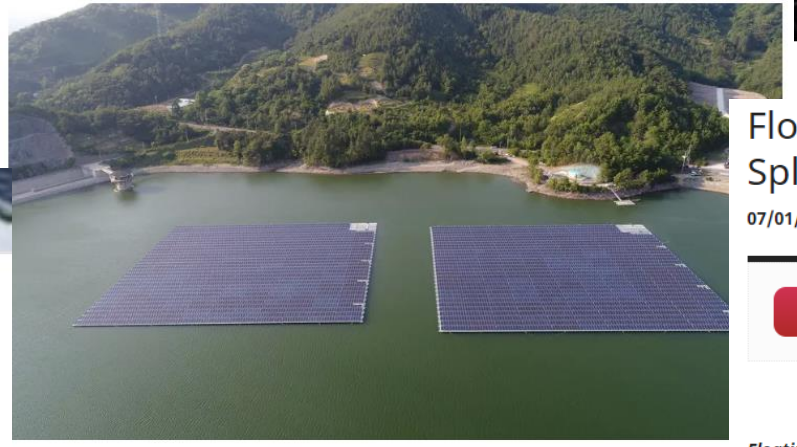
Dams spell catastrophe for Cambodia, but an alternative exists

By: Amanda Kaufmann - Posted on: September 5, 2018 | **Cambodia**

COLUMNIST | FEATURED | RENEWABLE ENERGY | SOLAR

Floating Solar PVs Are Popping Up All Over The World. Here's Why...

Floating solar PV systems offer a host of benefits such as fewer light blocking obstacles, writes Robert Brears



The Geumjeon floating solar power plant, in South Korea. | Seaflex

Floating Solar Panel Industry Makes a Splash

07/01/2018 | Sunil Hebbalkar and Ojaswita Kutepatil

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PRINT MODE : OFF

PAGES: 1 | 2 | 3

Floating solar panel technology has been gaining traction as a favorable and cost-effective alternative to land-based photovoltaic systems. Thriving on the cusp of a massive inclination toward renewable energy adoption, the floating solar panel market stands as one of the highest-potential verticals in the go-green landscape.

Potential

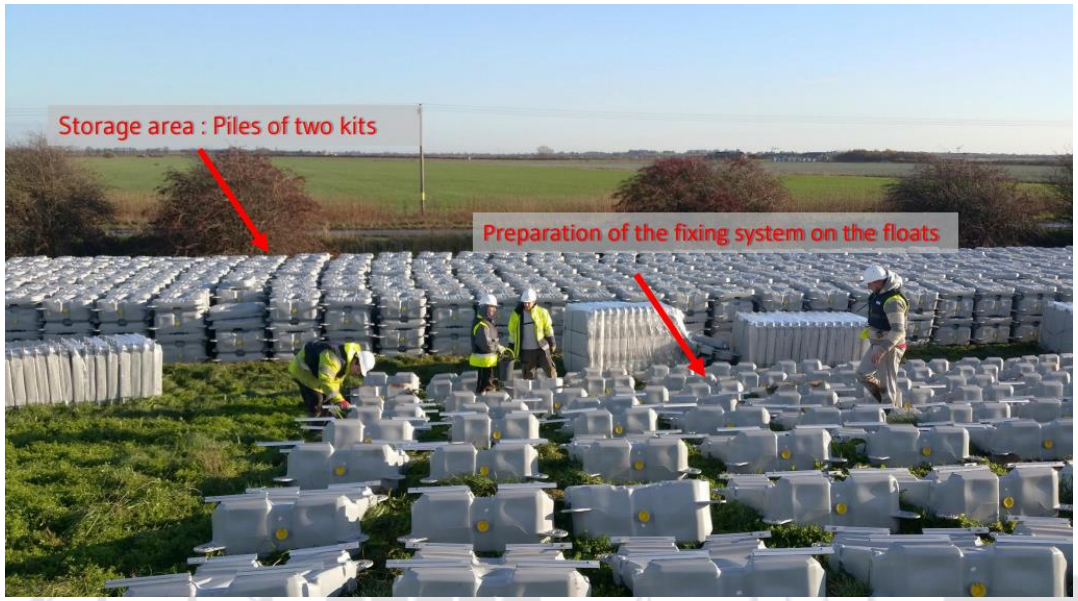
+ Availability of modules and inverters from booming PV industry
+ More land constraints in the future
+ Availability of water surfaces, even more with offshore systems
+ More hybrid hydro-connected plants

- Supply capacity of FPV suppliers

«[…] *We think the potential of FPV coupled with hydro is potentially at terawatt scale.* […]"
- Lu Zhao, Head of PV System Technology Group at SERIS (PV Magazine , October 2017)

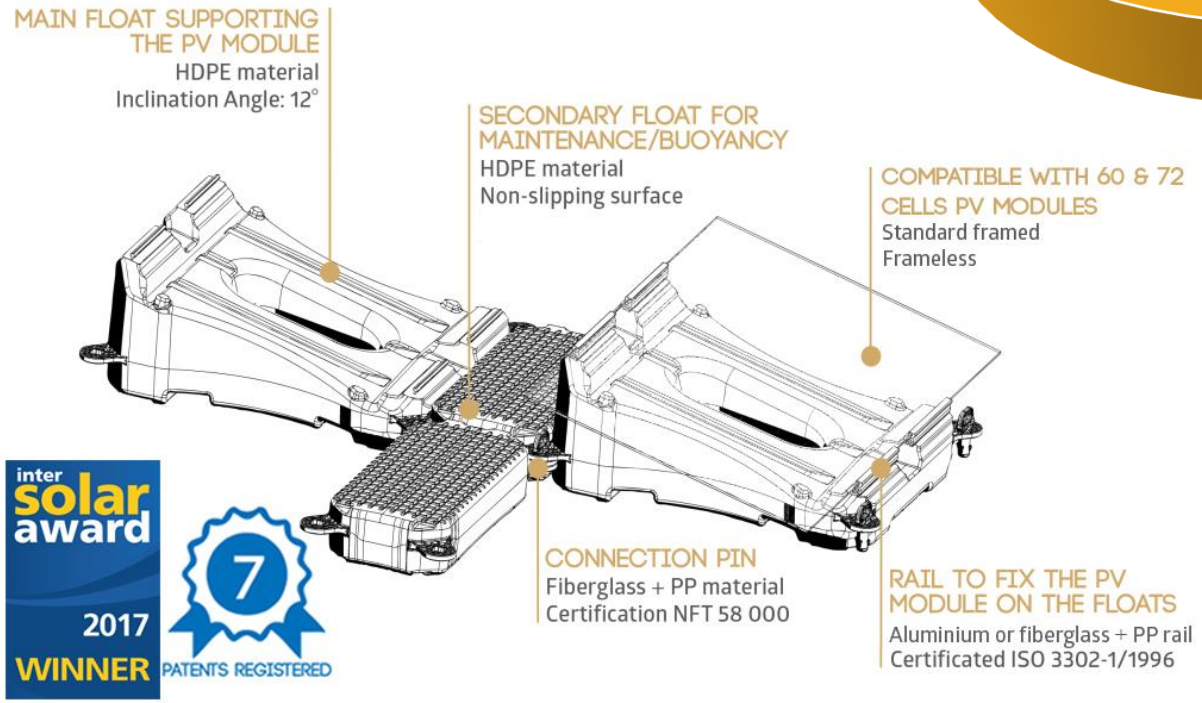
Challenges

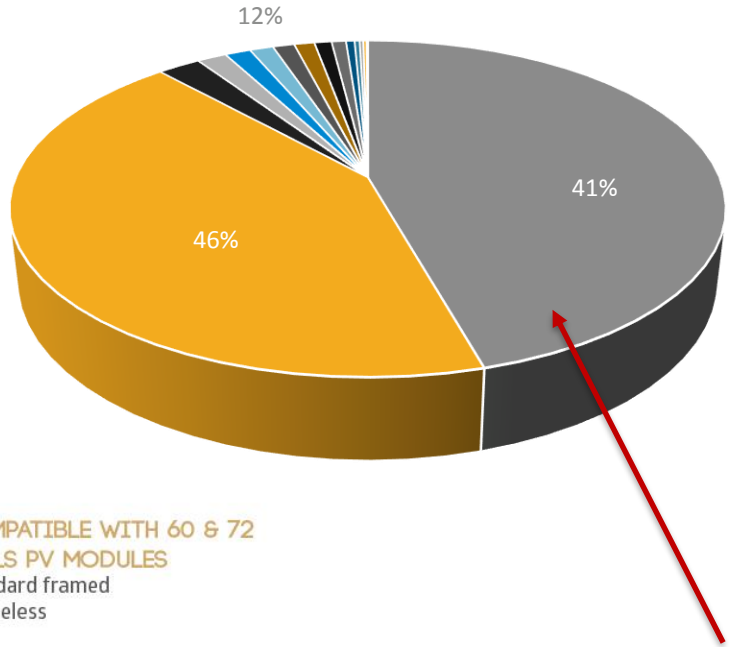
- Logistics- Floaters typically do not transport cheaply
  - 18-25 containers per MW (40 foot)
- Soiling- bird droppings a particularly big issue
- Resilience– offshore still presents a challenge
- Costs…



Ciel et Terre: Leader by Far… For Now

- FPV since 2011
- Patented Hydrelio system



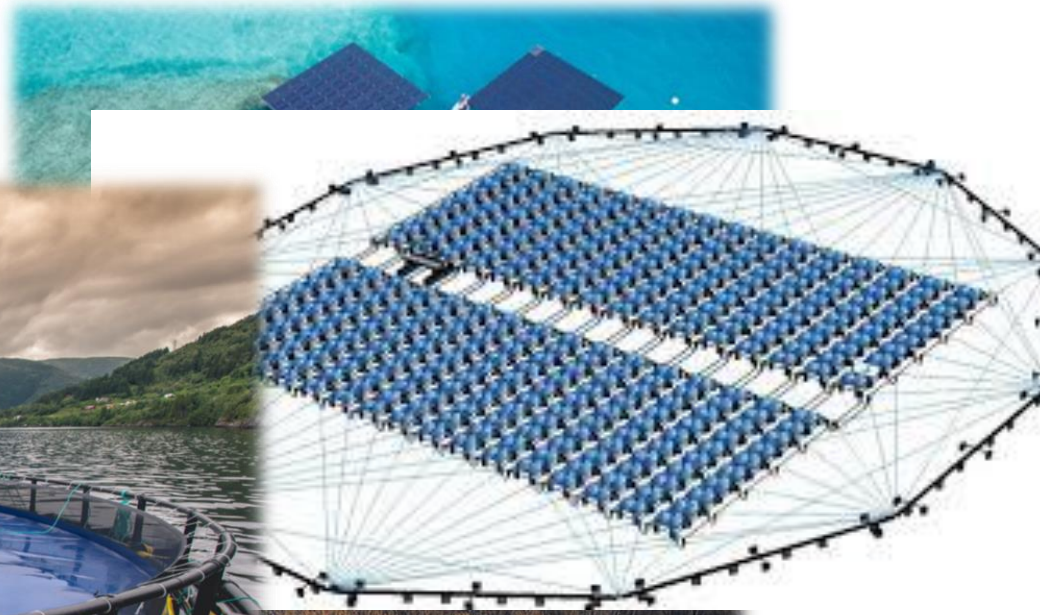


- UNKNOWN
- Ciel & Terre
- LG CNS
- Sumitomo Mitsui Construction
- Reservoir Solar Company
- Environmental-Resources Development
- Takiron Engineering
- West Energy Solutions & Kyoraku
- K-water
- Ibiden Engineering
- Towa Arcs & Otos
- Techwin
- Adtech Systems
- Thompson Technology Industries, Inc.
- Swimsol
- Sunfloat
- Solaris Synergy
- REC Solar

No. 2 Sumitomo

Technology Race: 15+ systems

Credit: Ciel et Terre.



Credit: Solaris Synergy

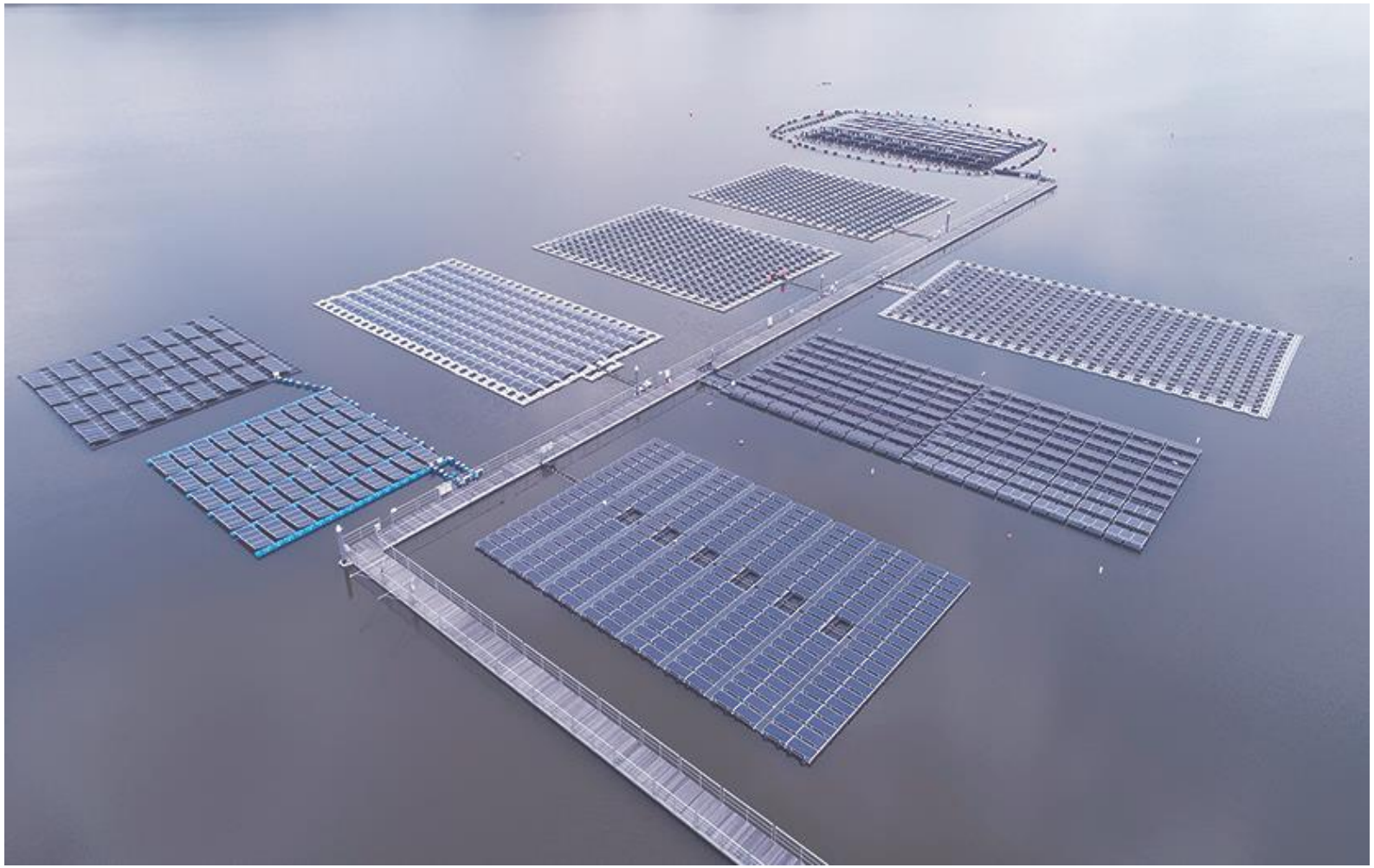
Credit:ISI Floating

Credit: NRG Energia.

Credit: Adtech Systems.

SERIS Floating solar Testbed

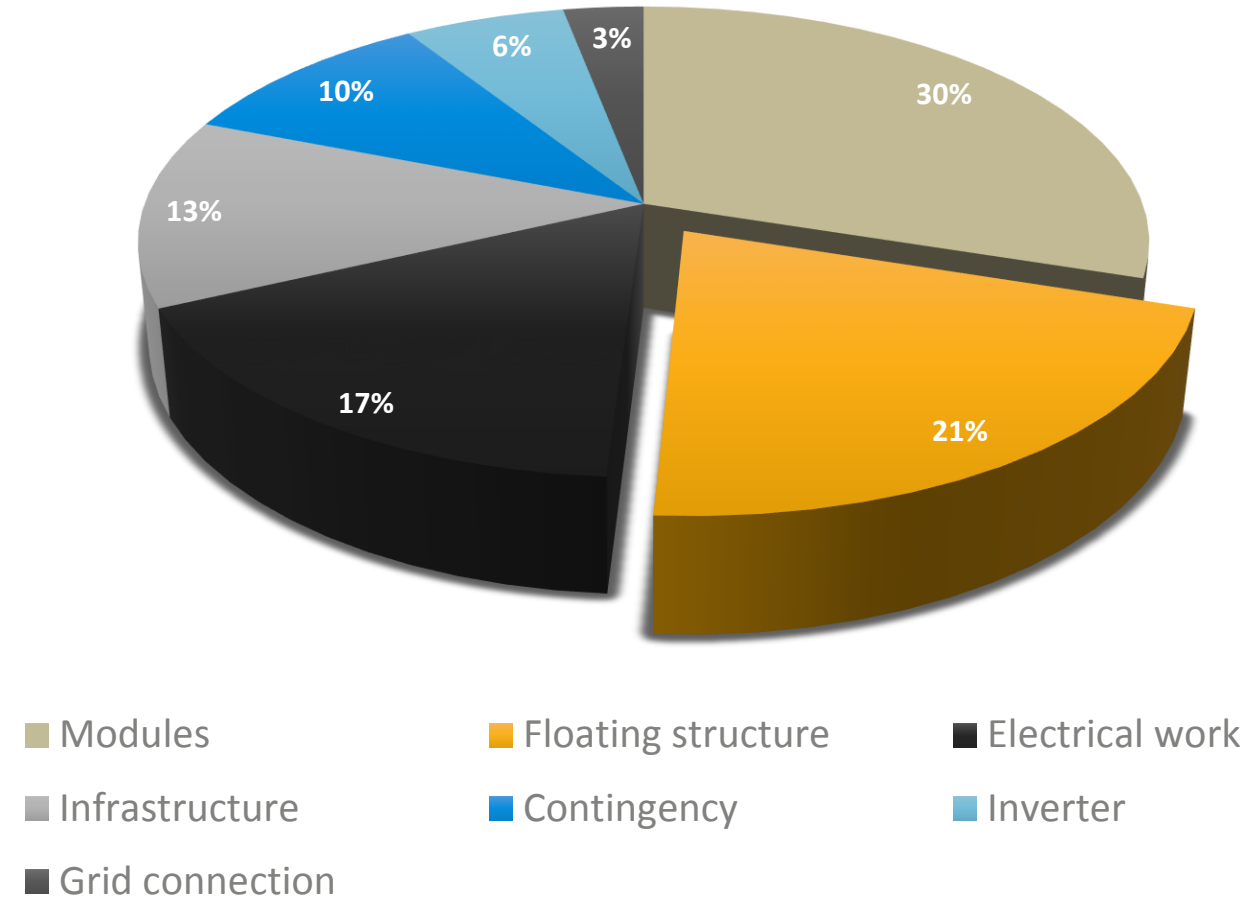
- Project manager of the floating solar testbed
- Conduct tests, comparisons and compile reports
- Organizers of the annual IFSS (International Floating Solar Symposium)



Source SERIS, summer 2017

Estimated Capex

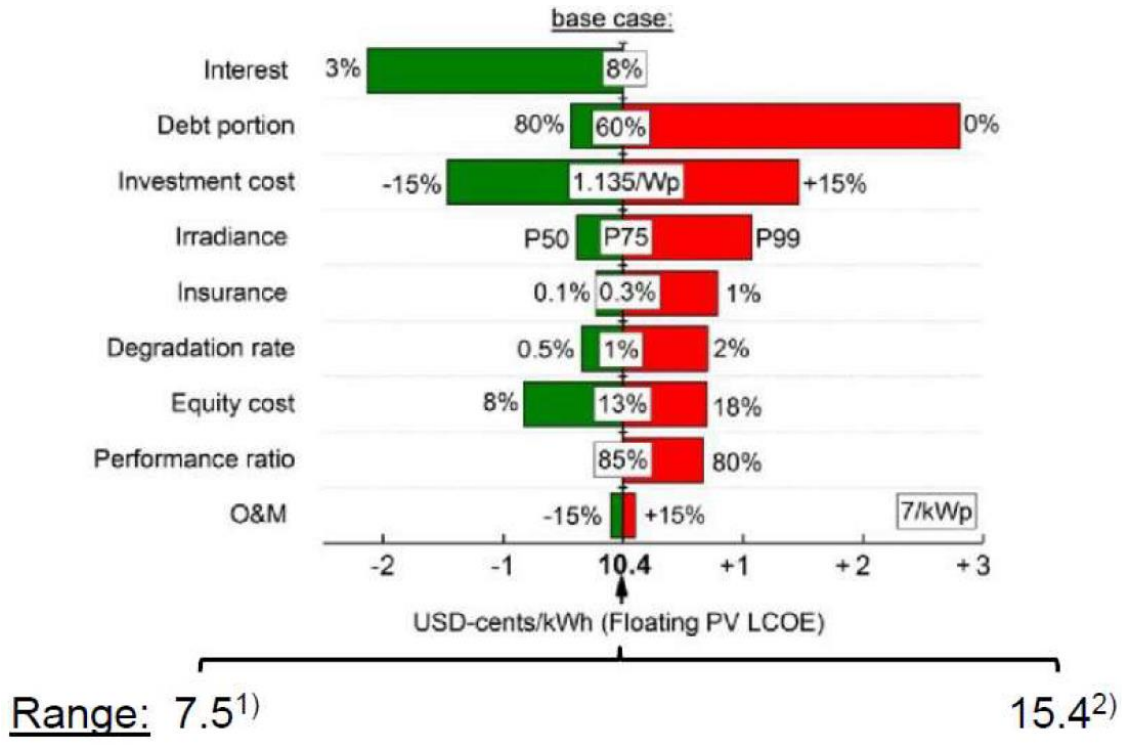
- Capex[a]: 1,13 - 1,14 USD/Wp
  (PV modules: 0,34 USD/Wp)



[a]: Source SERIS, summer 2017

Estimated LCOE (Levelized Cost of Electricity)

- LCOE[a] base case: 10,4 USDc/kWh



- Assumptions:
  - Capacity 50 MWp
  - Yield 1 420 kWh/kWp.yr
  - Operation 20 years
  - Degradation rate 1%
  - OPEX 1,3% of CAPEX
    - 25% higher than benchmark ground-mounted
    - incl. O&M, insurance, replacement cost
  - Debt portion 60%
  - Debt cost 8%
  - Debt term 10 years
  - Equity cost 13%
  - Discount rate 9%
  - Inflation 3,5%
  - Corporate tax rate 20%

[a]: Source SERIS, summer 2017

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Frontiers of FPV

Hybridization with Hydropower

- Electrical infrastructure / grid connection already existing
- Dry seasons (less water) = high solar irradiation
  - Reducing seasonal variations
- Support day-time peak load for evening peaks
- Increased generation for same water flow
- PV variability compensated by fast-responding turbines
  - Reduce spinning reserve in grid → lowering operation cost
- Facilitate black-start capabilities for hydro

Rabagão dam, Montalegre, Portugal. Credit: Ciel et Terre.

Off Shore Systems

- Almost all systems today are designed for inland lakes or dams
- The first small-mid scale projects are coming online in the last years

Key Technical Challenges

- Wave height
- Salt water corrosion
- Anchoring
- …

Credit: Swimsol

Credit: Ocean Sun.

Multiconsult

Selected References

SALT WATER FLOATING PV 4 MWp - THE SEYCHELLES

TENDER AGENT.

CLIENT: CONFIDENTIAL

TENDER DESIGN | SITE STUDY | TECHNICAL & LEGAL ADVISORY | IPP FRAMEWORK

2017 - ongoing

PRE-FEASIBILITY STUDY HYBRID MT COFFEE, LIBERIA

FLOATING SOLAR / HYDRO HYBRID

CLIENT: KfW

PRELIMINARY DESIGN | YIELD ASSESSMENT | HYBRIDIZATION

2018

SALT WATER FLOATING PV
200 kWp
ENGINEERING DEMO PROJECT

CLIENT: OCEAN SUN

YIELD ASSESMENT | SYSTEM DESIGN AND LAYOUT | INTEGRATION WITH STORAGE & DIESEL

2017 - 2018

Photo: John Alvsvåg

OPPROTUNITY ASSESSMENT, KYRGYZSTAN

FLOATING SOLAR / HYDRO HYBRID

CLIENT: ASIAN DEVELOPMENT BANK

SITE ASSESSMENT | CAPACITY BUILDING | PILOT PROJECT DESIGN

2017

OUR TEAM

SOLAR, STORAGE AND SMART ENERGY

Klas Ljungberg

Klas leads the S&S team and works with our clients to realize value in renewable energy transactions and strategic discussions. Klas holds a MSc and a MBA and has for many years worked on matters concerning energy and on renewable energy project finance.

Dr. Bjørn Thorud

Bjørn is a senior solar PV expert with more than 16 years of professional experience. He holds a PhD in Energy and Process Technology and for the past 11 years, Bjørn has worked exclusively with renewable energy with a heavy focus on solar PV systems in Africa and Europe. He has previously worked for Scatec Solar as Head of Technology

Håkon Person

Håkon is focused on how solar power can integrate with smart systems in cities and buildings. He is currently heading up Multiconsult's work within the NCE Smart Energy Markets cluster.

Simon Gazdowicz

Simon is a solar advisor with a particular focus on floating solar and off-grid micro/grid projects in international markets. He holds a MSc in Innovation and a BSc in Science. He has previously worked for Scatec Solar focusing on business development in Asia-Pacific

OUR TEAM

SOLAR, STORAGE AND SMART ENERGY

Dr. Per Lindberg

Per holds a PhD in semiconductor physics with focus on next generation high efficiency solar cells. He combines his fundamental solar cell competence with “hands on experience” from PV-system design, tendering and construction as he been responsible for the design of construction of several PV-plants. Per is also a frequently used lecturer for solar PV training.

Øystein Holm

Øystein is a Senior Advisor with more than 20 years experience in research, product development, design and evaluation of various renewable energy systems, feasibility studies, innovation processes, technical due diligence, project management and administration. He has previously worked for REC and is a leading solar advisor in the Norwegian market.

Håkon Duus

Håkon is a smart grid and solar power adviser. He holds a MSc in Energy and Environmental engineering from NTNU. Håkon is the newest member in our team. Before joining Multiconsult he was a senior researcher at Smart Innovation Norway focusing on future power grid solutions and smart energy market models

Stanislas Merlet

Stanislas is a Solar Energy Advisor with focus on international markets. He started to work with Solar Energy in 2008. He is also board member of the Norwegian Solar Energy Association since 2015 and was awarded “Young Consultant of the Year” by RIF in 2017. He has previously worked for solar power plants in France, as well as for the French Embassy in Norway. His solar energy competence is matched by his language skills in French, English, Spanish and Norwegian.

OUR TEAM

SOLAR, STORAGE AND SMART ENERGY

Hanne Bottolfsen

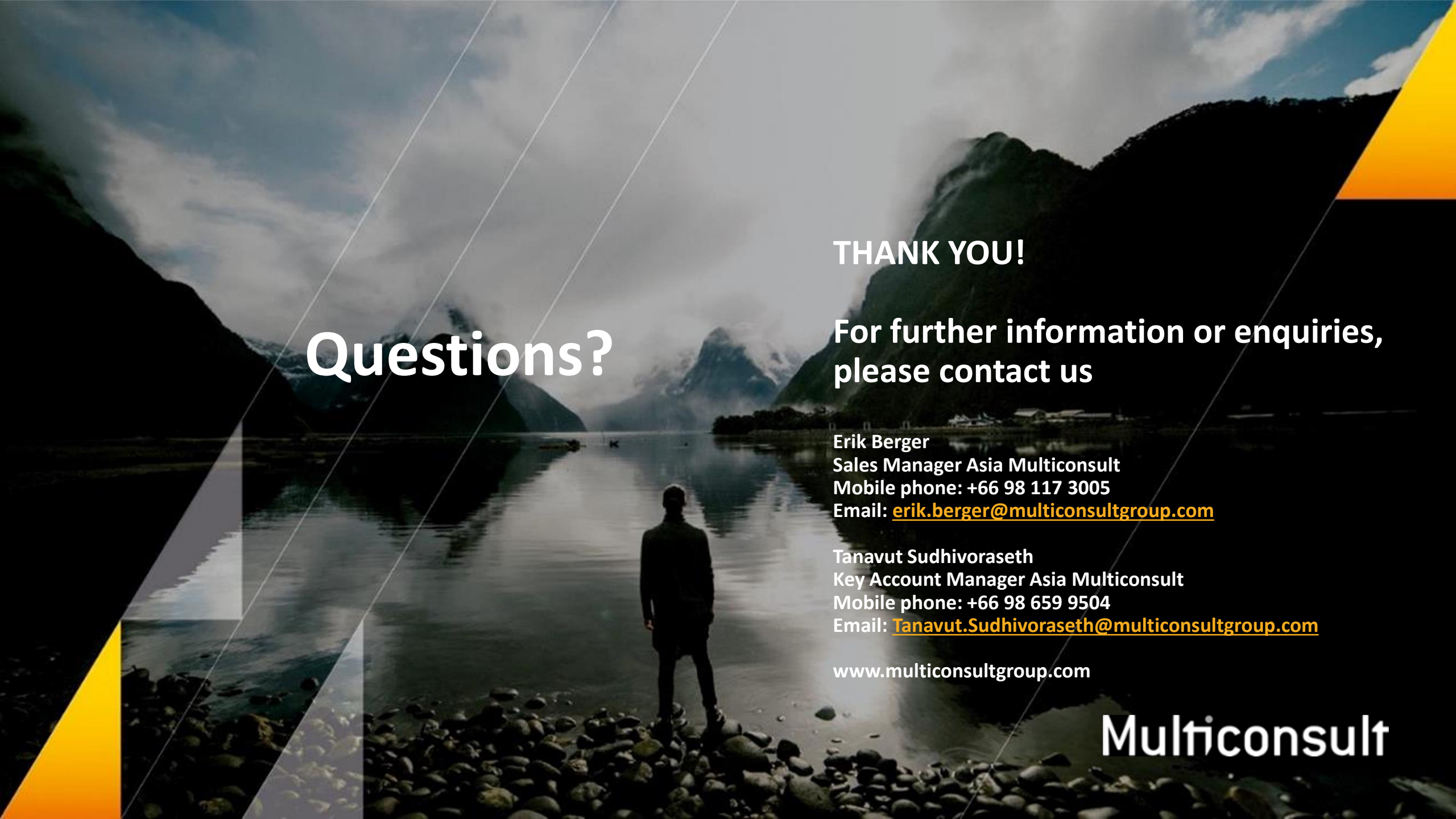
Hanne is a solar and energy advisor and holds a MSc in energy supply and climatization of buildings from NTNU. She is focused on how solar energy can best be utilized in energy efficient buildings in combination with other energy sources and has carried out several feasibility studies for solar PV systems.

Bjørn-Yngve Eriksen

Bjørn-Yngve holds a MSc in Industrial Ecology from NTNU. He has been responsible for energy and environmental consulting and engineering for Hjellnes Consult for five years, until Hjellnes was acquired by Multiconsult. Prior to this, he has worked eight years in the solar thermal industry in Norway, where he was involved in technical sales, engineering, research, project management and installation of solar energy systems.

Marte Nilsson

Marte is an energy advisor with a MSc in Energy and environmental engineering from NTNU. She has extensive experience implementing solar energy in buildings with high environmental goals and is very familiar with building codes, regulations and classification systems regarding buildings and energy. Her knowledge on building physics and HVAC- systems enables her to design complete and holistic energy strategies for buildings, consisting of solar energy. She works with both solar thermal- and PV technology.



THANK YOU!

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