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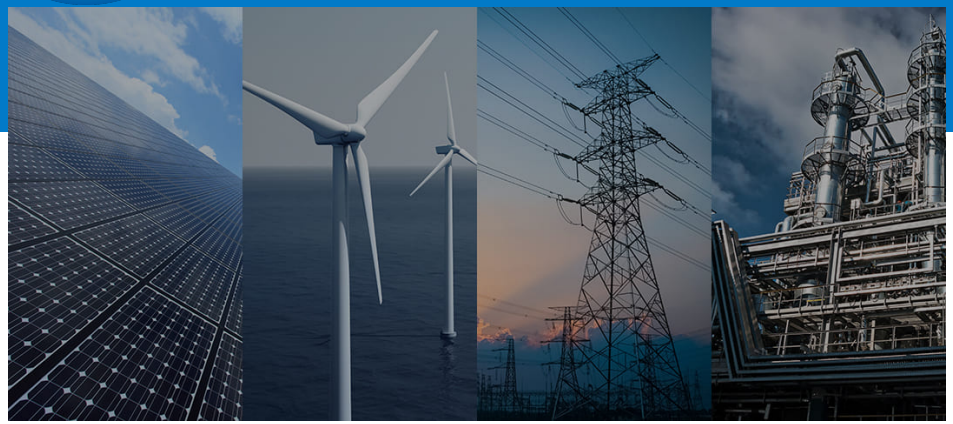

PV plus storage opportunity globally

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Agenda of today's webinar

1. Introduction to PV plus storage

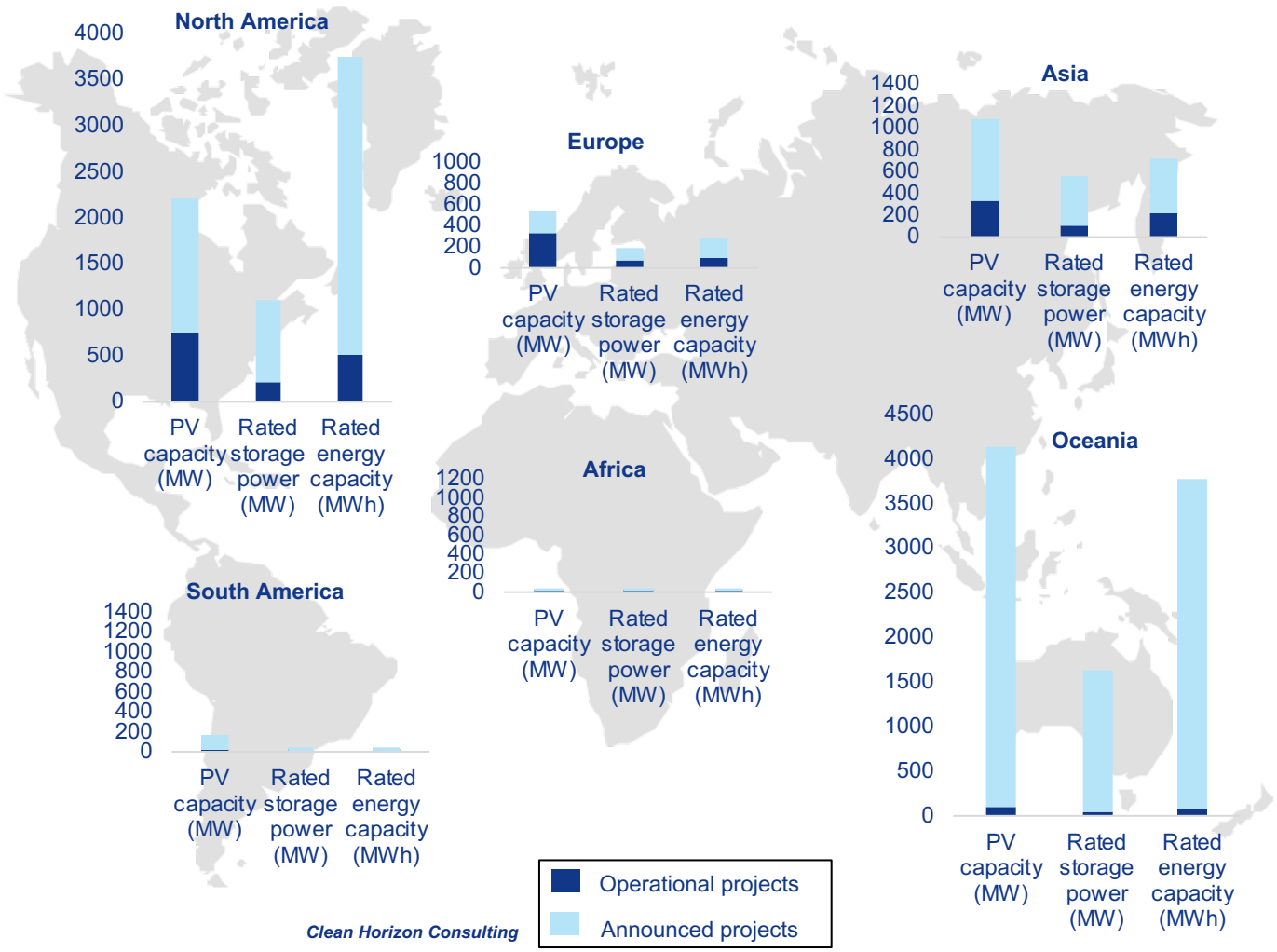
2. Incentives drive PV plus storage deployment in the US

3. PV plus storage deployment outside the US

4. Factors influencing the cost of solar plus storage

Utility scale PV plus storage deployment globally is increasing, the USA and Australia represent the largest opportunity to date

PV plus storage projects are announced worldwide at increasing pace



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- **The United States and Australia lead the charge in terms of PV plus storage adoption**
- **Most projects are announced, proving that the uptake of these projects is justified by the recent decrease in storage costs**

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At the federal level, the investment tax credit drives PV plus storage deployment in the US

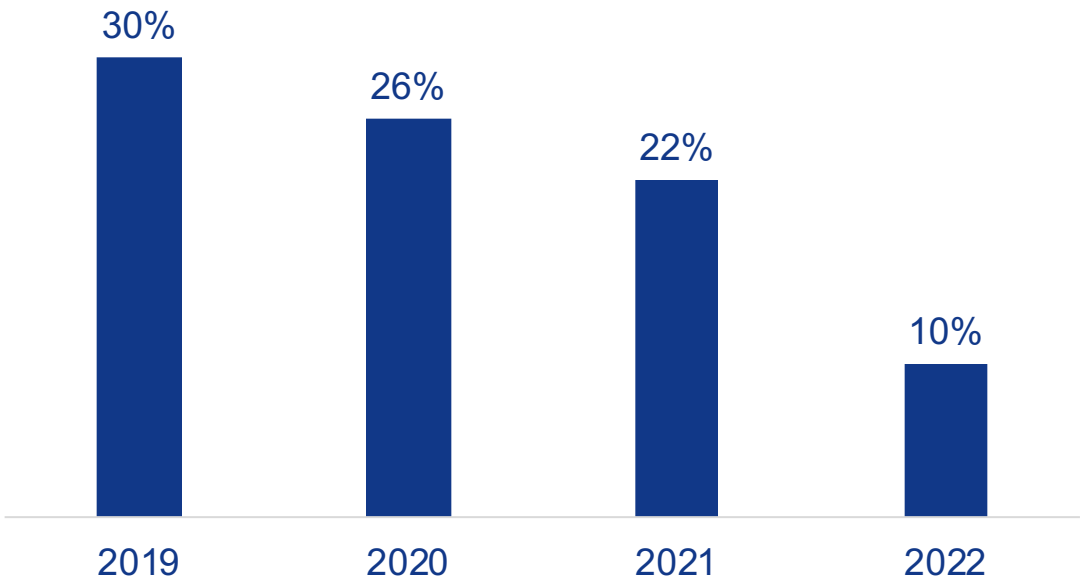
The investement tax credit is gradually phased out from end 2019

Requirement to benefit from the ITC:

- The ITC is awarded to the investor
- For utility scale solar plus storage, at least 75% of the energy charged in the battery needs to be provided by solar panels

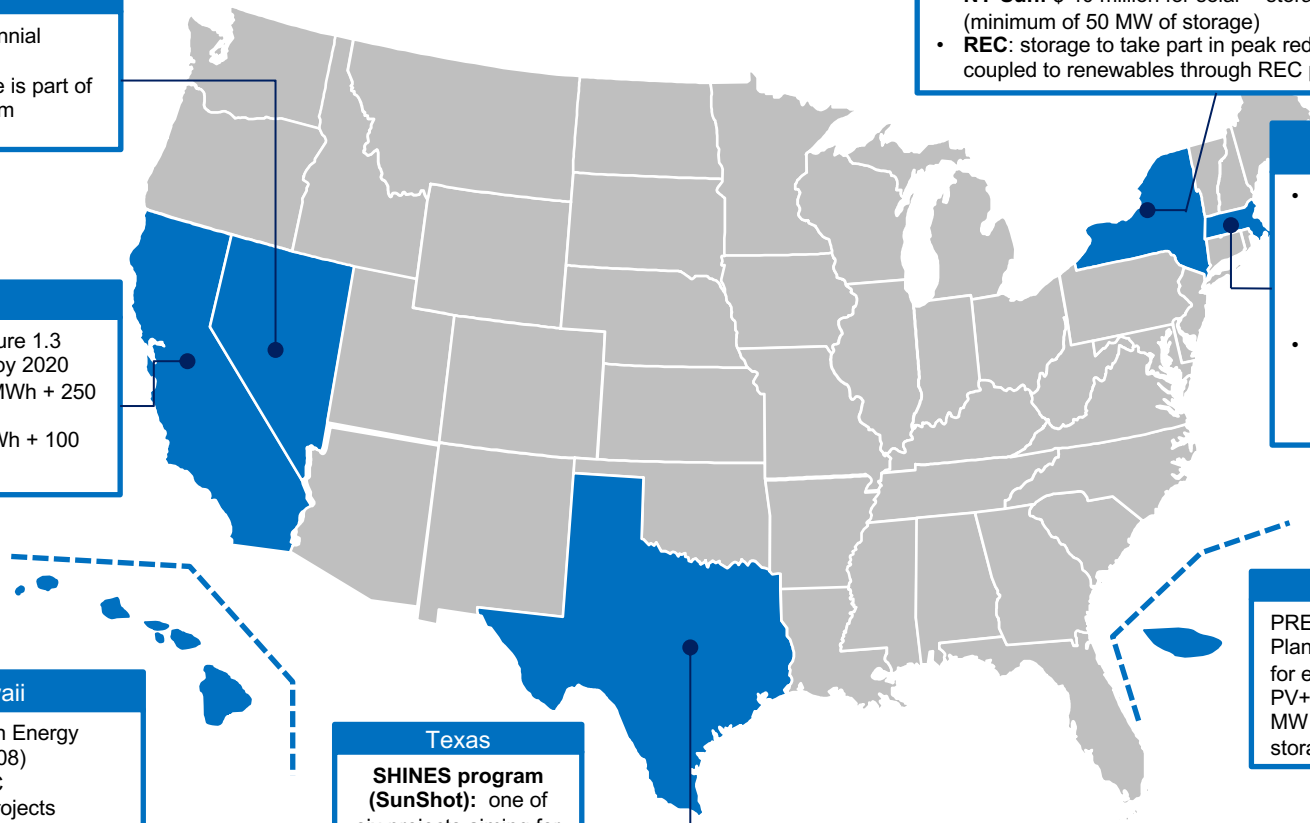
Investment tax credit for utility scale PV + storage in the US

In % capital expenditure depending on commence construction date



- **The ITC is the most lucrative federal incentive for PV plus storage**
- **2019 is the most economically attractive year for solar-plus-storage projects hoping to benefit from the ITC mechanism**
- **The ITC is likely to be extended to standalone energy storage in the future**

At the State levels, incentives for PV + storage are driving development further



Nevada

- **SB 204**: creation of biennial energy storage targets
- **SB 145**: energy storage is part of the state's solar program

California

- **AB 2514**: IOUs to procure 1.3 GW of energy storage by 2020
  - LADWP 20MW/10 MWh + 250 MW PV
  - PG&E 10MW/40 MWh + 100 MW PV

New York

- **NY's REV:** 50% of renewables by 2030
- **NY-Sun:** $ 40 million for solar + storage development (minimum of 50 MW of storage)
- **REC**: storage to take part in peak reduction by being coupled to renewables through REC procurements

Massachusetts

- **SMART**: incentives for solar-plus-storage adoption on small and large scales. Possibility to participate in the Forward Capacity Market (*DPU 17-146-A*).
- **Clean Peak Standards**: energy storage considered as clean peak resource. Other states to follow

Hawaii

- Hawaii Clean Energy Initiative (2008)
- ITC & NMTC
- HECO's 7 projects totalling 262 MW of PV plus 263MW/1055MWh storage

NMTC: New Markets Tax Credit Program

Texas

SHINES program (SunShot): one of six projects aiming for a less-than 0.14$/kWh solar + storage LCOE

Puerto Rico

PREPA's Integrated Resource Plan considers multiple scenarios for eight minigrids, all including PV+ Storage with a total of 2,220 MW of PV plus 1080 MW of storage

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Outside the US, PV plus storage projects use batteries for different applications: ramping, forecasting, shifting

Storage to smooth PV and make it comparable to conventional power plants

Easier integration of intermittent PV in the power grid thanks to storage:

- Respect of a pre-set forecast
- Output smoothing

Region	Installed storage capacity	Battery application	Ratio MW_{batt}/MW_{PV}	Storage duration
Hokkaido	238 MW	▪ Ramp-rate control	0.7	30 min
French Overseas Territories	97 MW	▪ Ramp-rate control ▪ Match a forecast ▪ Shift part of the PV production	0.5	1 hour
South Korea	88 MW	▪ Shift part of the PV production to the evening	0.9	2 h to 3h
Miscellaneous islands	94 MW	▪ Microgrid stabilization[1]	0.44	1.25 hours

- Dispatchable production during peak consumption periods:

Region	Bonus for PV production shifting
French Overseas Territories	200 €/MWh
South Korea	3.8 REC, equivalent to approx. 380 €/MWh

Clean Horizon identifies three typical regions for regulation-driven PV-plus-storage deployment : small islands, South Korea and Overseas French

1. Note: Microgrid stabilization refers to storage systems providing several services to a small grid (typically with less than a 10 MW load). These services always include frequency regulation and can sometimes include production shifting

Development finance institutions drive PV plus storage deployment in emerging countries

Development Finance Institutions are adding storage to their renewable energy projects to ensure a maximum operational profitability

- Integration of intermittent renewables in developing countries with weak power grids is challenging
  - Energy storage is added to solar plants to ensure a maximum benefit of the grid operators

Projects	Main funder	Country	Status
40MWp PV plus storage	USTDA	Kenya	Commissioned
25MW PV plus storage	Scaling Solar	Madagascar	Tendered
20MW PV plus storage	USTDA	Sierra Leone	Planned
2MW PV plus 2MW/0.5MWh storage	Australian federal government	Mauritius	Announced
200MW PV plus 10MW storage	USTDA	South Africa	Operational
13MW PV plus 5MWh storage	AFD	Niger	Tendered

- **The DFI awareness of the advantages of coupling renewables with storage will facilitate the development of such approaches in developing countries with emerging markets**
- **The World Bank has launched a $1 billion battery storage investment program in Sept 2018**

Merchant PV plus storage projects without incentives flourish across the world

Sometimes, it all comes down to a simple choice of the developers to combine these technologies to maximize revenues

- Rationale for PV-plus-storage coupling:
  - Provision of grid services (e.g. frequency regulation):
    - Spatial optimization (existing real estate)
    - Grid connection optimization (when the PV plant doesn't retain the maximum connection capacity)
  - High electricity prices leading to competitive solar-plus storage PPAs

Country	Project name	Developer	Installed PV capacity	Installed storage capacity	Energy storage application
Germany	Neuhardenberg	Upside Group	145 MW	5MW / 5 MWh	Frequency regulation
France	Azur	Neoen	9 MW	6 MW / 6MWh	Frequency regulation
Australia	Nowingi solar farm	Lyon Group	250 MW	80 MW / 320 MWh	To be defined
Great Britain	Clayhill	Anesco	10 MW	6 MW / 6MWh	Capacity market & frequency regulation
French Guyana	Centrale Electrique de l'Ouest Guyannais	HDF	60 MW	10 MW / 20 MWh battery 130 MWh hydrogen	20-year PPA signed with EDF SEI
Jordan	Mafraq	Philadelphia Solar	12 MW	4 MW / 12 MWh	20-year PPA signed with Irbid District Electricity Company

Developers co-locate storage with solar where it makes economic sense, i.e. if the right market signals exist such as:
- High electricity prices making solar-plus-storage competitive
- Battery services are valued by the system operator (e.g. frequency regulation)

Data is sourced from the Clean Horizon Energy Storage Source (CHESS), Clean Horizon's own global energy storage project database

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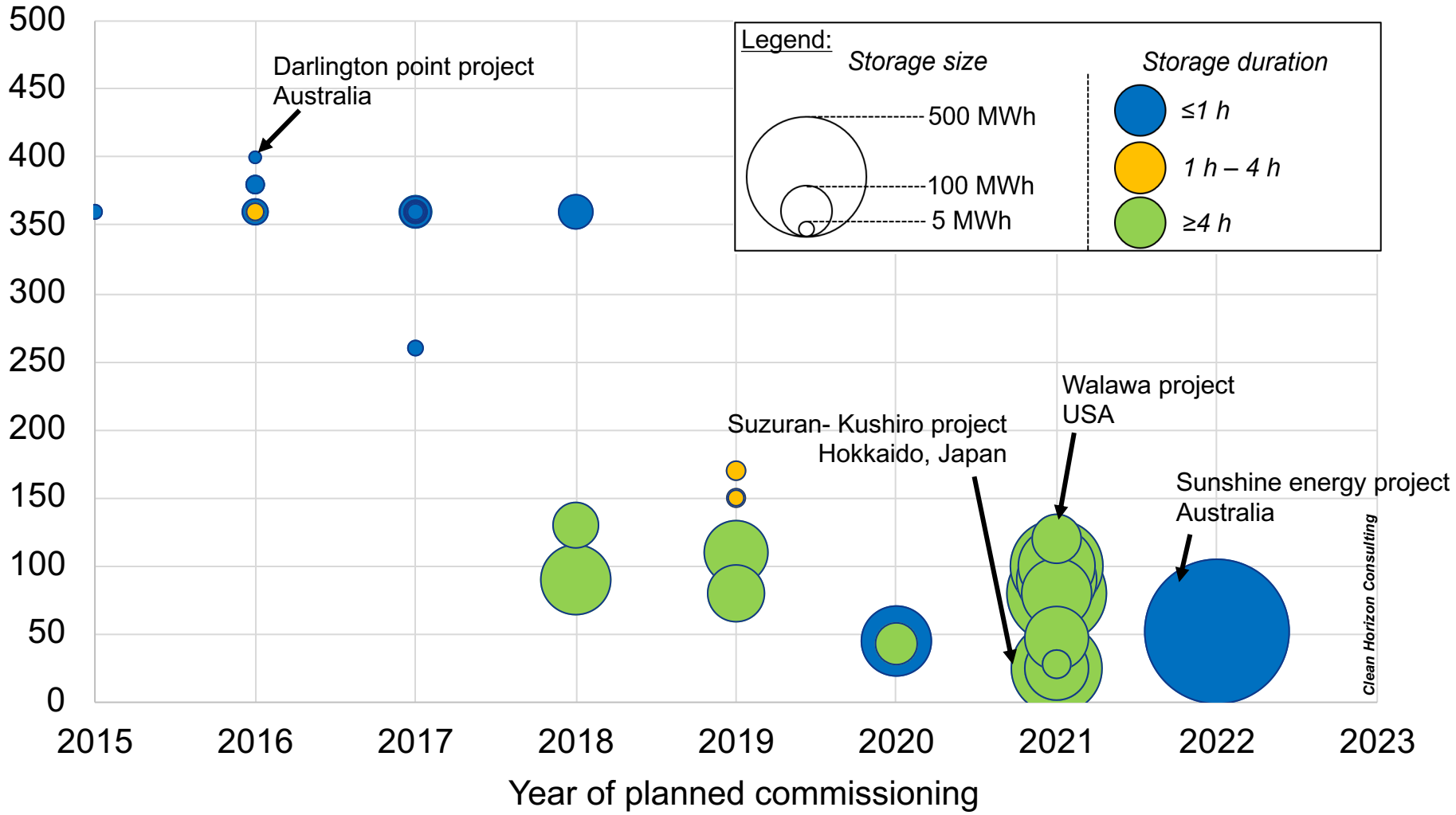
PV plus storage levelised cost has decreased from 350$/MWh in 2015 to less than 100$/MWh today

Cost of energy for PV + storage projects worldwide

In USD/MWh

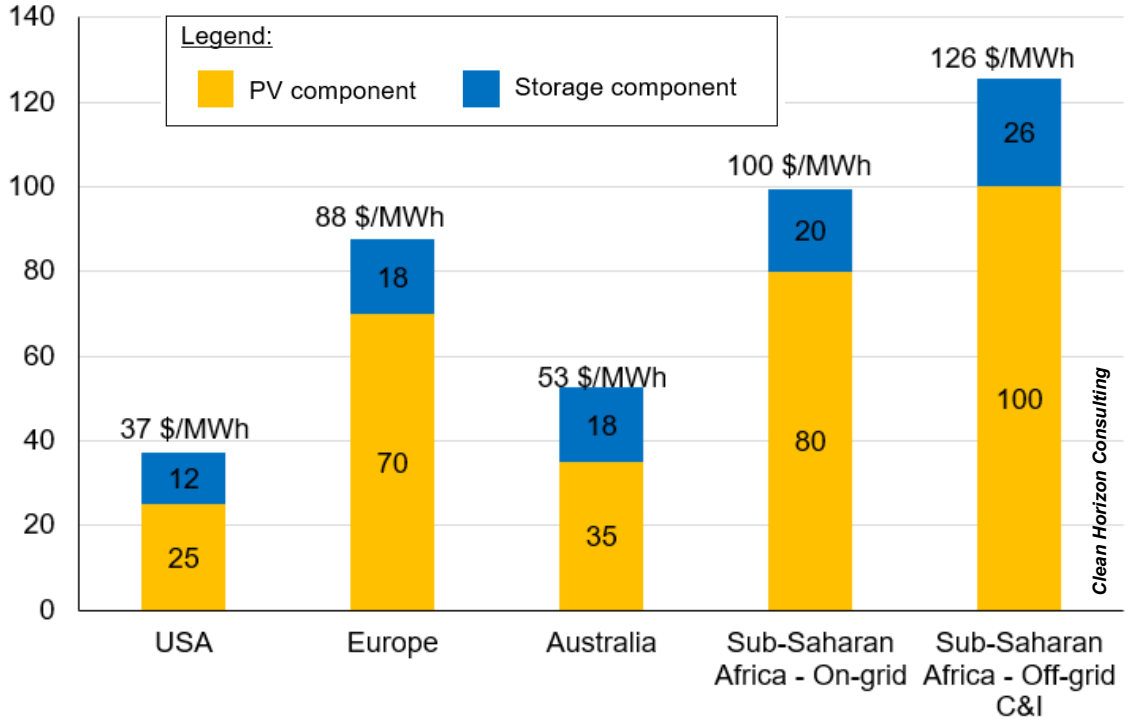


Business opportunities: Factors influencing the cost of solar plus storage

Cost of PV plus storage can vary extensively from one location to another

- The cost of energy can vary extensively from one project to another depending on its location:
  - Solar irradiance
  - System costs
  - Cost of financing and project risks
  - Project valuation duration
  - Available subsidies

Levelized cost of energy of a typical 100 MWp / 25 MW / 100 MWh PV + storage project in various geographies
(in USD/MWh)



- **Energy and project costs have a great dependency on multiple locale-related variables**
- **A specific region cant be necessarily taken as a benchmark for any PV-plus-storage project**

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Thanks for your attention!

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