THERMAL GENERATION TO SOLAR-PLUS-STORAGE

FRAMEWORK FOR HYBRID PROJECTS PPA DESIGN AND PROCUREMENT

- Overall Progress Update
- Thermal to Hybrid Generation
- Global Experiences of Hybrid PPAs
- Hybrid PPA Design and Procurement

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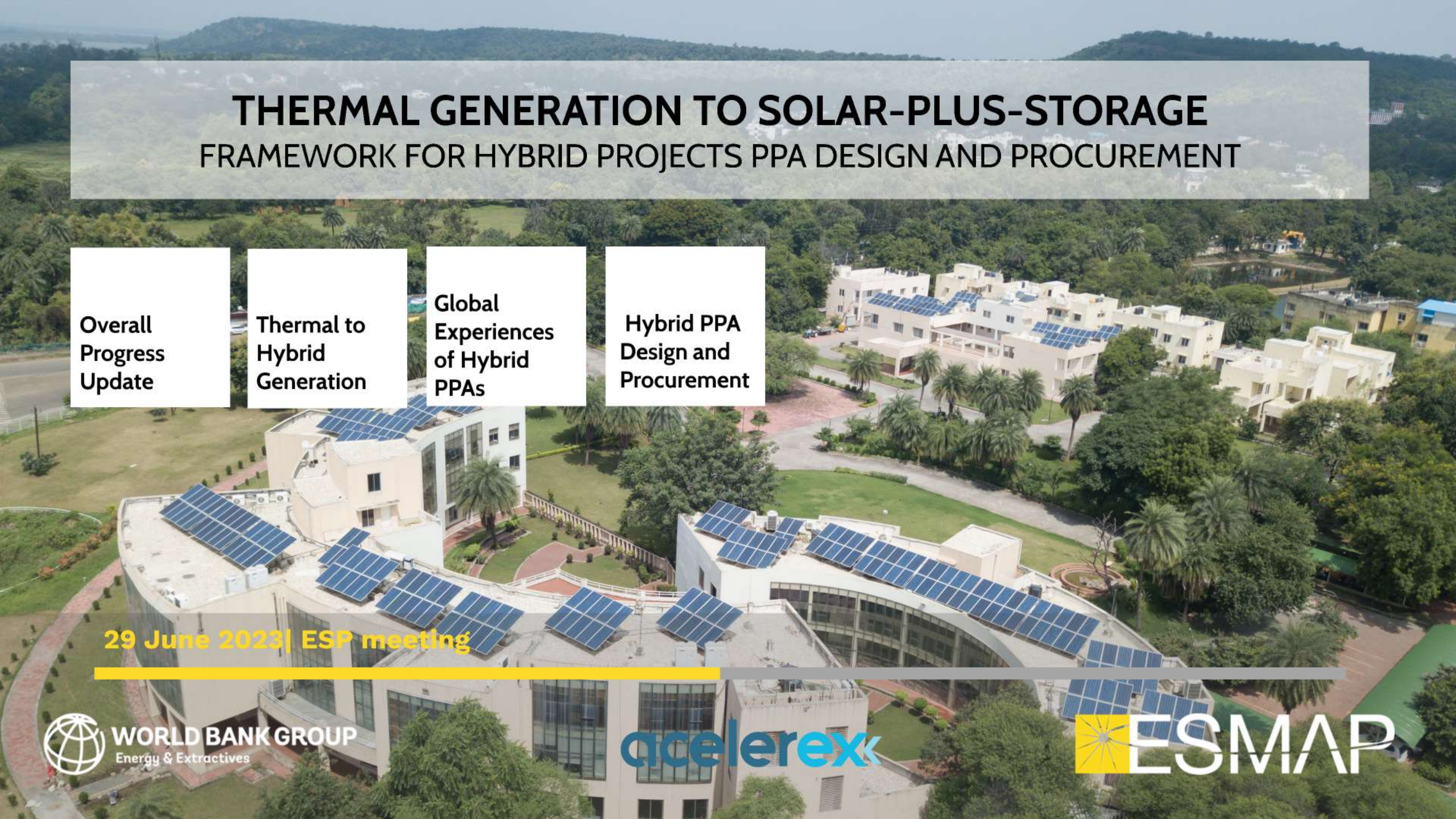

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PROGRESS TO DATE

COMPLETED

Task 1: Desk Research

- Mapping **Contracting Modalities**
- Thermal **PPA transition**
- Global experiences

Task 2: Business Model Review

- **Model Characteristics**
- Advantages & Disadvantages
- Contrasting Characteristics
- Determining **Best Practices**
- **Variations in PPA models**

COMPLETED

Task 3: Expert Interviews

- Survey **Questionnaire**
- Contacting Orgs and Experts
- **Interviews with experts**
- Analysis of PPAs
- Learnings synthesis

Task 4: Hybrid PPA Framework Development

- **Framework for PPA** models
- Decision Making Model
- **Buyer Seller Matrix**
- Core PPA Contract Clauses
- **PPA templates development**

Task 5: Procurement Guidelines Formulation

- **Competitive procurement** and **auction model**
- **LCOE** with Target IRR
- Price **Calculator**
- Key Values and PPA Parameters
- **Warranties**

Task 6: Forecasting Global Trends

- **Trends in VRE** contracting
- Use cases
- Commercial **experience in hybrids**
- **Market share** & growth

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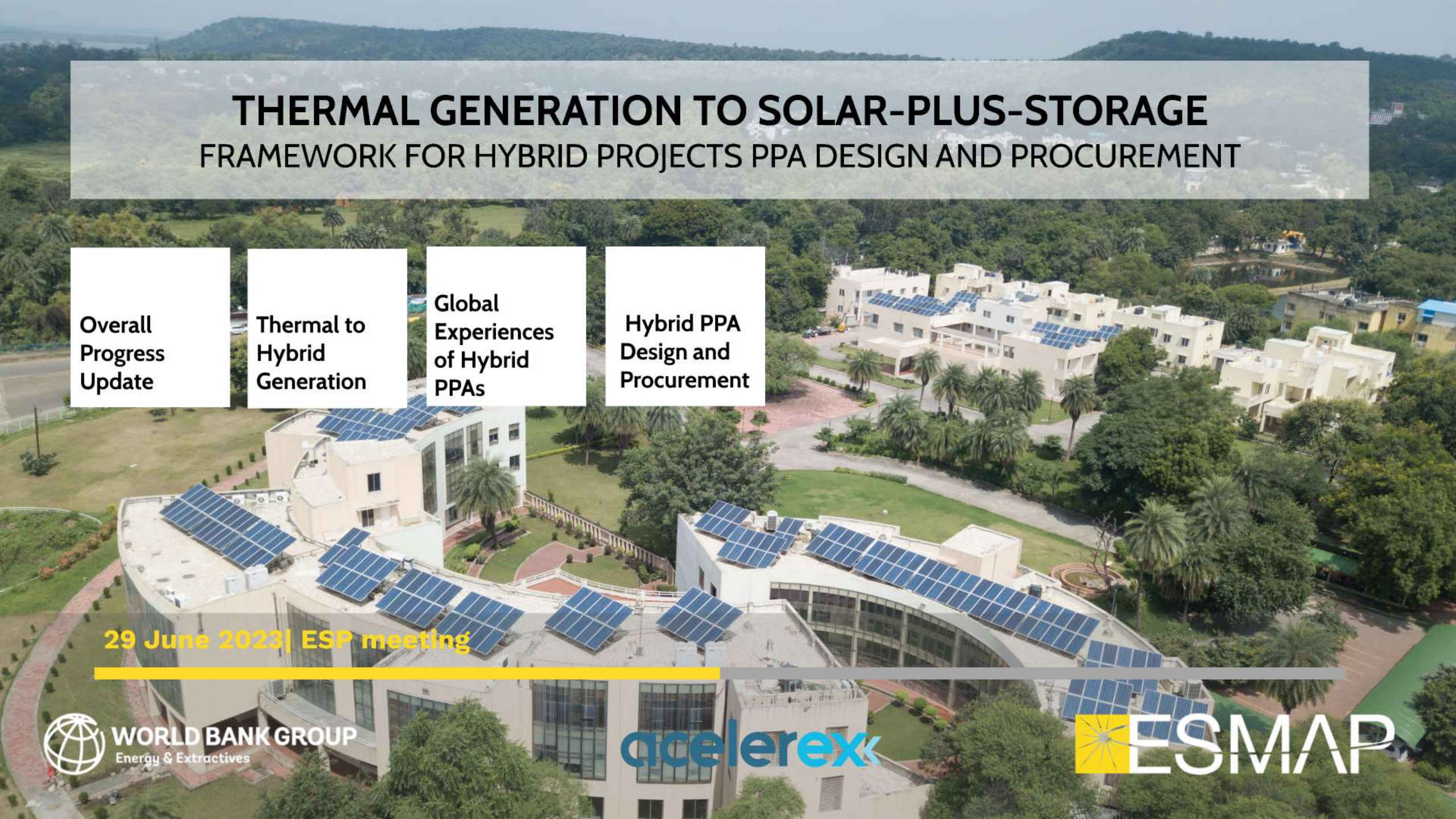

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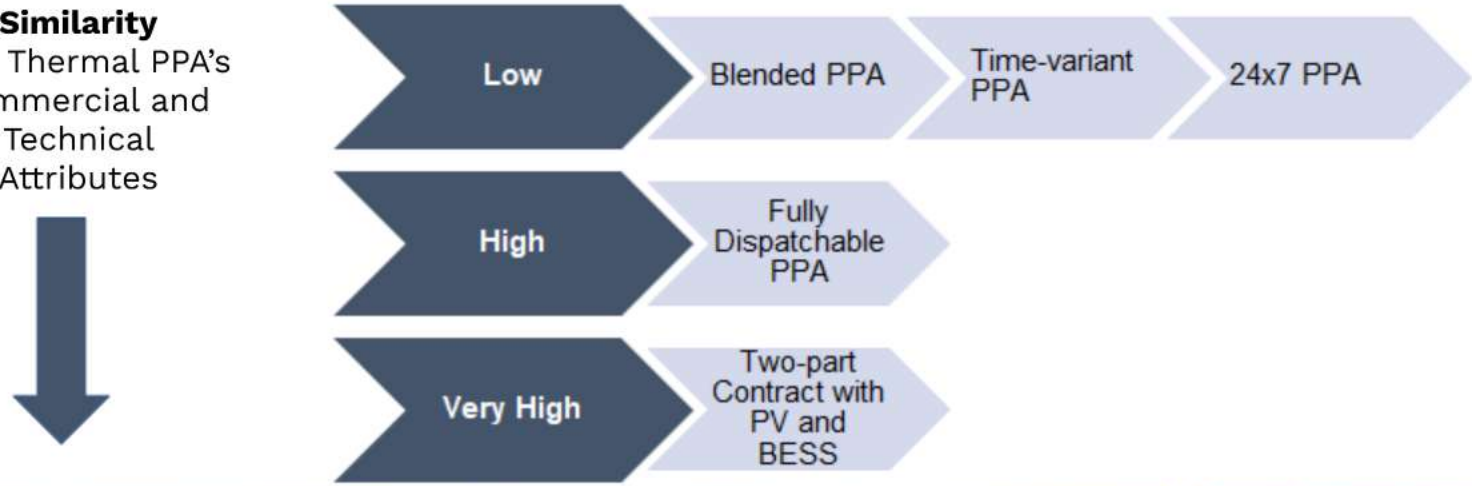
TYPICAL ATTRIBUTES OF A THERMAL GENERATION CONTRACT

SEVEN ATTRIBUTES DEFINE THE **THERMAL GENERATION CONTRACTUAL MODEL** THAT CAN BE COMPLEMENTED BY **SOLAR-PLUS-STORAGE BUSINESS MODEL ALTERNATIVES**

- **Flexibility**
- **Physical Contract**
- **Two-Part Tariff**
- **Dispatchability control**
- **Market Risks**
- **Guarantees Availability**
- **Energy Firmness Obligation**

Similarity with Thermal PPA's Commercial and Technical Attributes



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MAPPING BUSINESS MODEL

	Model 1 Two-Part Contract for PV and BESS	Model 2 Fully Dispatchable PPA	Model 3 Blended PPA	Model 4 *Time-Variant PPA*	Model 5 *24x7 PPA*
VRE and Storage remuneration	*Single contract , 2 Payments*: $/MWh for PV – Pay as produced $/MW for BESS – Capacity	*Single contract, 1 payment*: $/MW - fixed on available capacity	*Single contract 1 payment*: $/MWh - fixed (no capacity payment)	*Single contract 1 payment:* $/MWh - varies by time blocks (no capacity payment)	*Single contract . multiple forms of payment*: a) $/MW – for VRE + Storage plus Thermal generation (India RTC) b) $/MWh (green contract)
Level of Firmness by the seller	Low		High		Very High
Dispatchability Control	High	Very High	Low (modest)		
Storage Services Suitability	High		Low		
Risk Allocation	*Buyer bears **more** risks*		*Seller bears **some** risks (e.g. variability, curtailment)*		*Seller bears **most** risks*
Commercial and Technical Similarities with Thermal PPAs	Very High	High	Low		
Procurement Selection Award	***Bidding:*** Separate bids for energy and capacity (same auction) ***Award:*** *Lowest levelized $/MWh*	***Bidding:*** Bid for total capacity ***Award:*** *Lowest $/MW*	***Bidding:*** Bid for price per MWh ***Award:*** *Lowest $/MWh*	***Bidding:*** Different bids ($/MWh) for time blocks ***Award options*** (i) Lowest price per MWh (fixed off-peak tariffs or (ii) lowest $/MWh for the system	***Bidding:*** Bid for total capacity or energy ***Award:*** *Lowest levelized $/MWh*
Example Project	Nevada (USA) - Six VRE projects with a total capacity of 1,000 MW, including 100 MW of BESS (400 MWh). Maldives: BESS only, separate contract	Hawaii (USA) (2021) - Two projects at Barbers Point and Kahana solar PV. Total of 35 MW PV and 4-hour (140 MWh) of BESS	SECI Project, India (variations reflected in other models)	India (2020) - 600 MW of firm power for peak hours at $0.086/kWh for 6- hour and 300 MW of firm power at $0.096/kWh for a 11-hour period.	India Round the Clock (RTC II) - 2.5 GW – prices ranging from US$ 40 to 46 per MWh for 80% average guaranteed capacity utilization

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BUSINESS MODELS

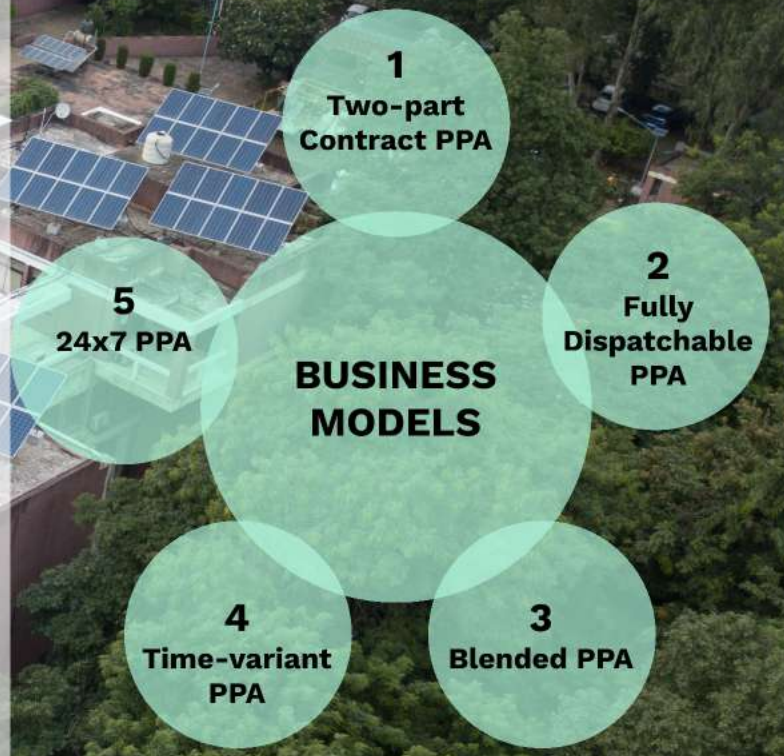
Model-1: Two-part contract for PV and BESS
Two separate contracts for power generation by the Solar PV Panels and available capacity by the BESS.

Model-2: Fully Dispatchable PPAs
Evolution of Model-1 but with all the dispatch rights are with the grid operator.

Model-3: Blended PPA
Model blends the power generation by the PV panels and power injection by the BESS into a single contract with a fixed $/MWh remuneration.

Model-4: Time-variant PPA
The time-variant PPA business model is a version of the blended PPA business model with a fixed $/MWh remuneration that varies by time block.

Model-5: 24x7 PPA
The 24x7 PPA business model with its variations has the highest level of firmness among the business models with multiple forms of payments.



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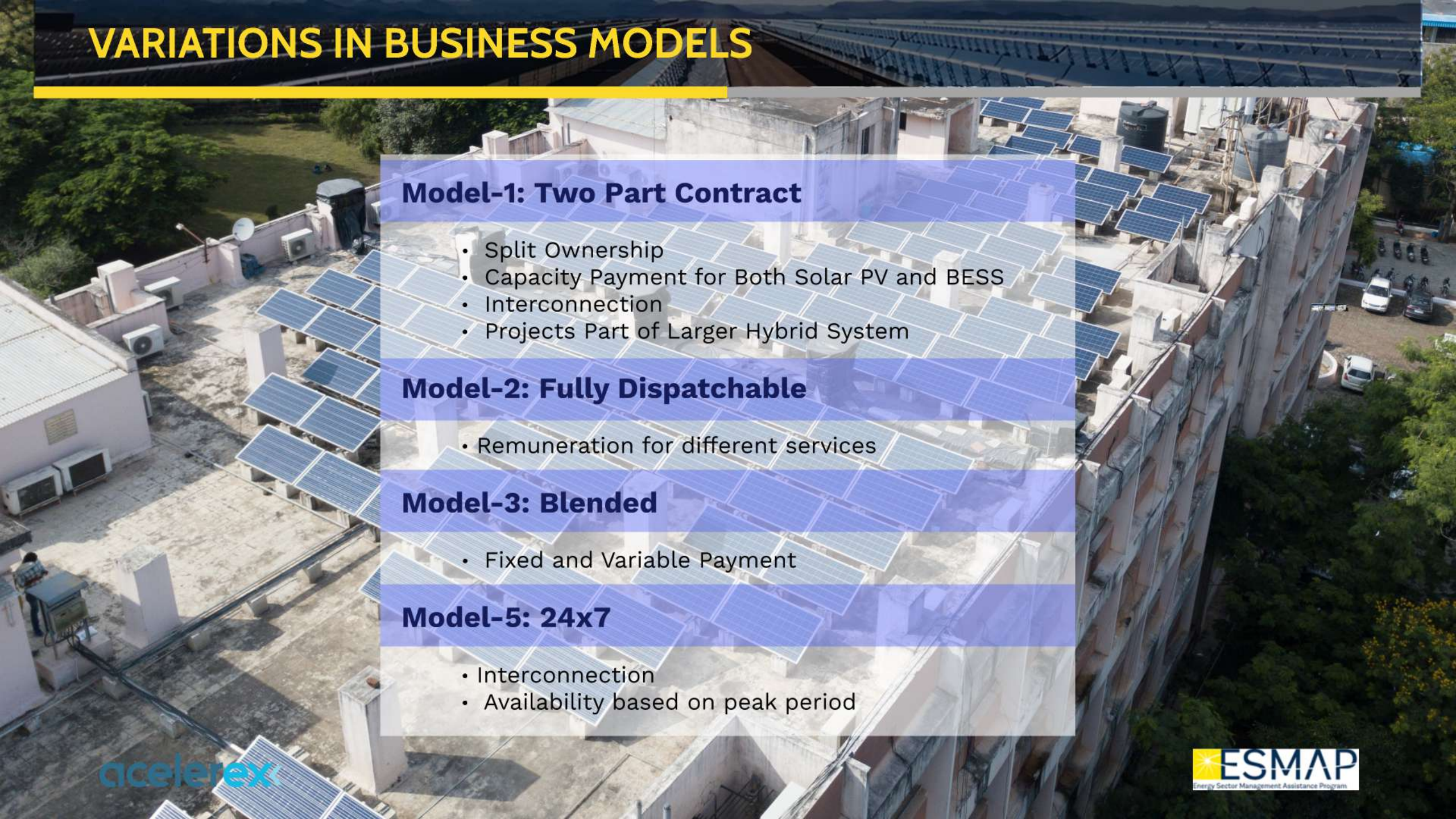
VARIATIONS IN BUSINESS MODELS



Model-1: Two Part Contract

- Split Ownership
- Capacity Payment for Both Solar PV and BESS
- Interconnection
- Projects Part of Larger Hybrid System

Model-2: Fully Dispatchable

- Remuneration for different services

Model-3: Blended

- Fixed and Variable Payment

Model-5: 24x7

- Interconnection
- Availability based on peak period

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UPDATE TO THE TAXONOMY AND CATEGORIZATION OF HYBRID PROJECTS

	Initial Taxonomy	New Taxonomy
Hybrid construction	PPA itself is the hybrid solution	PPA is part of a broader hybrid solution combined with existing technologies
Technologies	Jointly PV+BESS	PV and BESS may be contracted separately
Ownership	Joint ownership for PV+BESS	Split ownership (including BESS owned by utilities)

Model 1 (Prevalent)	
Model 1A = PV + BESS	Model 1B = BESS only

53-Cases Analysis*

- Large **PV capacity not accompanied** with reliable **system management** (e.g. Senegal)
- **PV + thermal capacity is not enough** to meditate PV volatility (e.g. Malawi)
- Some **concessional finance for BESS is only available to government entities**, leading to split ownership between the public and private sectors
- Despite Model 1 prevalence, **16 cases were two-part contracts** (16 for 1A and 10 for 1B models) and **10 were BESS only**

*Projects and engagement at various stages of design and implementation (in many cases, models still undefined)

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BESS ANCILLARY SERVICES

Models 1 (two-part contract PPA) + Model 2 (fully dispatchable PPA)

Buyer wants to have full control of the assets

Allows buyer to maximize value stacking

Leaves seller with no alternatives to monetize BESS services

Since grid operator and PPA off-taker are likely the same entity, it makes sense that the PPA included the entire value stacking

Models 3 (blended PPA)

The PPA may include ancillary services, if the grid operator and the off-taker are the same entity. However, other factors need to be considered

Provision of ancillary services may be governed by grid codes and interconnection agreements

Seller could find other markets to monetize ancillary services (seldom the case among our client countries)

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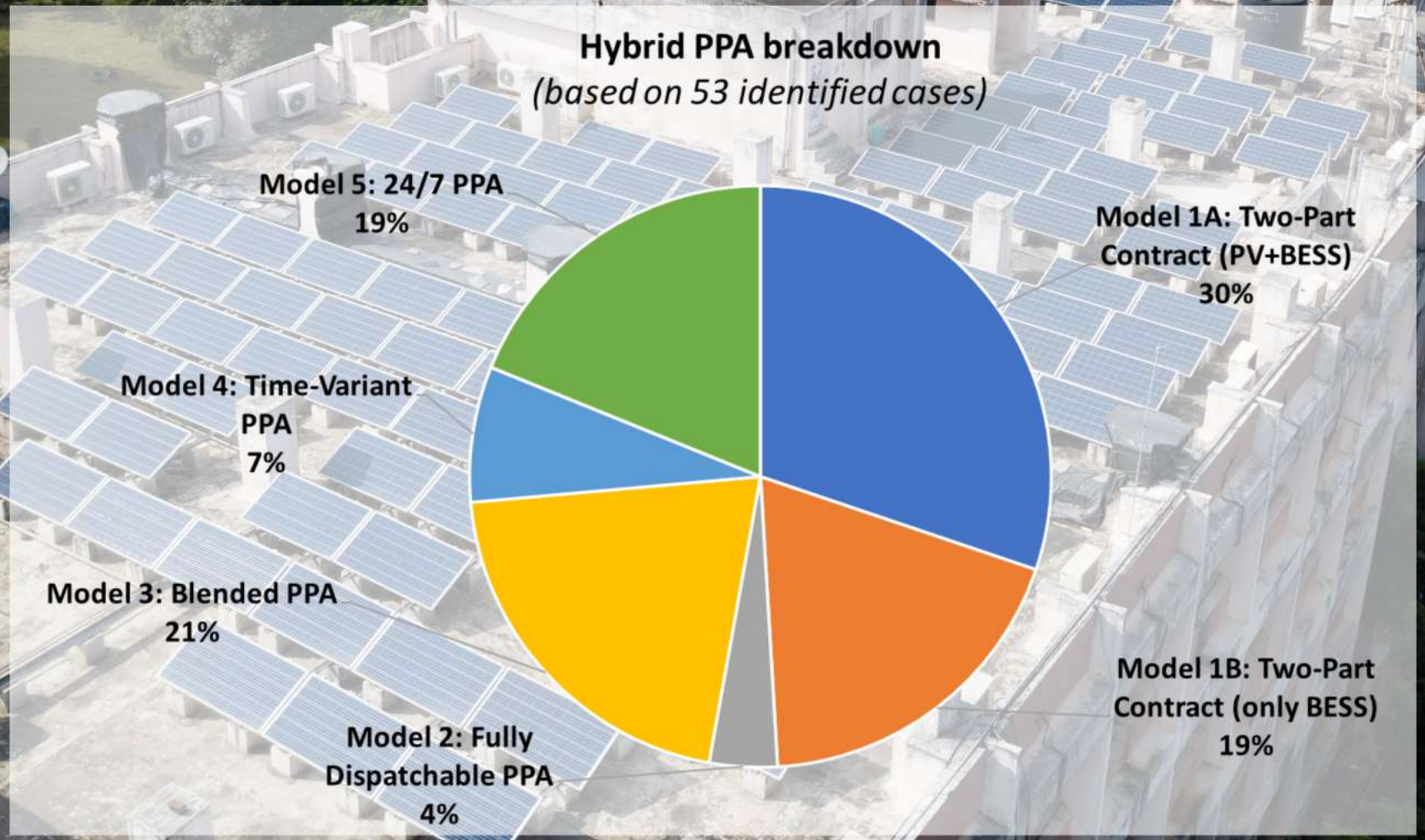
BUSINESS MODELS APPLICATION GLOBALLY



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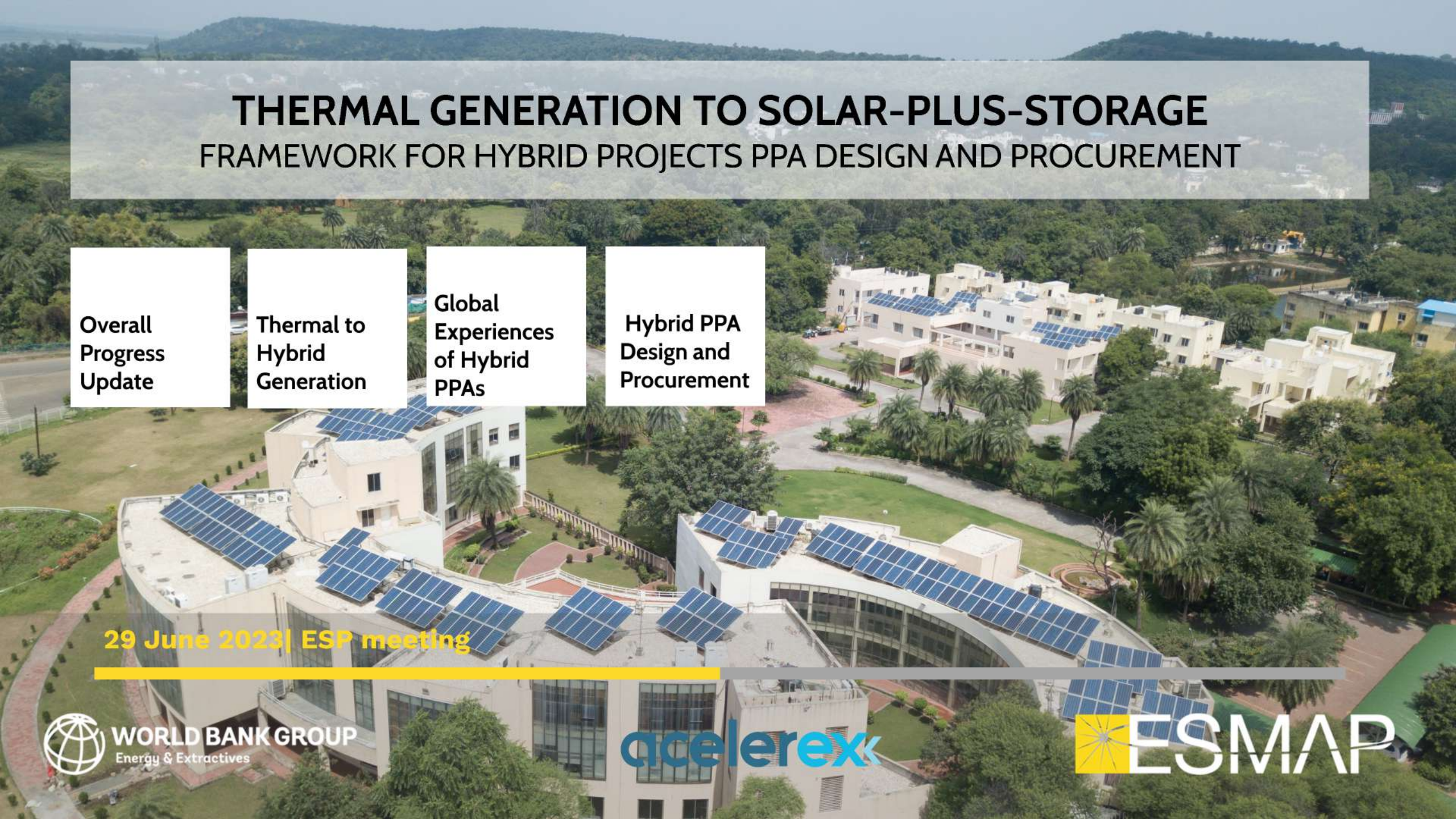

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OBSERVED DIESEL VS. HYBRID TECHNICAL DIFFERENCES

Advantages of Hybrid System

Electrical Characteristics
1. No minimum load requirements with Hybrid
2. Virtual inertia response in milliseconds

Flexibility
1. Hybrid systems can remain synced without generating
2. Hybrid systems can provide grid forming functions

Resiliency
1. Hybrids can provide fast response frequency regulation
2. Hybrids can provide voltage control with minimal costs

Reliability
1. Hybrids has sub second synchronization time
2. 4Q Inverters can provide reactive power compensation

Efficiency
1. Same efficiency on different output levels unlike diesel generators.

Emissions
1. No CO2 emissions with Hybrid systems

Challenges with Hybrid System

Electrical Characteristics
1. Hybrids feed less fault current which may not get picked up by grid relays to clear fault
2. Can possibly have Harmonics – mitigated with filters

Resiliency
1. Hybrid systems require grid forming inverter with fault ride-through function

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OBSERVED DIESEL VS. HYBRID TECHNICAL DIFFERENCES

RFP Risk

- Price Risk with absence of *Reserve Price*
- Value Paid for Storage
- Project Valuation gaps
- Technology Obsolescence

Buyer Risk

- Financial justification with additional services
- Default PPA Payments
- BESS and Solar Technical Life matching

Seller Risk

- Grid Control Infrastructure
- Output guarantee risk
- Lack of suitable smart EMS & poor tech capabilities
- Complex EMS with multiple technologies

Hybrid PPAs

- Stacked benefits essential for Project Feasibility
- Fully dispatchable PPAs – suitable to Island Grids
- Technical Solution Adaptation

Hybrid vs Diesel

- Upgradation of Grid Protection
- Sizing up to get same capacity as diesel
- Require capacity building

Hybrid Services

- Lack of clarity on BESS Services
- Monetization for normal and emergency operation
- Challenges with single pricing models

Hybrid Performance

- Dispatch Software
- Compensation model with fading, augmentation, SoC, etc.

Hybrid Augmentation

- Degradation and Augmentation
- Technology agnostic PPA
- Upgrade or allow fade?

Warranties

- Monitoring of asset use
- Honoring of BESS supplier warranties
- Changes in use-case mid-contract
- Changes in market rules, tariffs, policies

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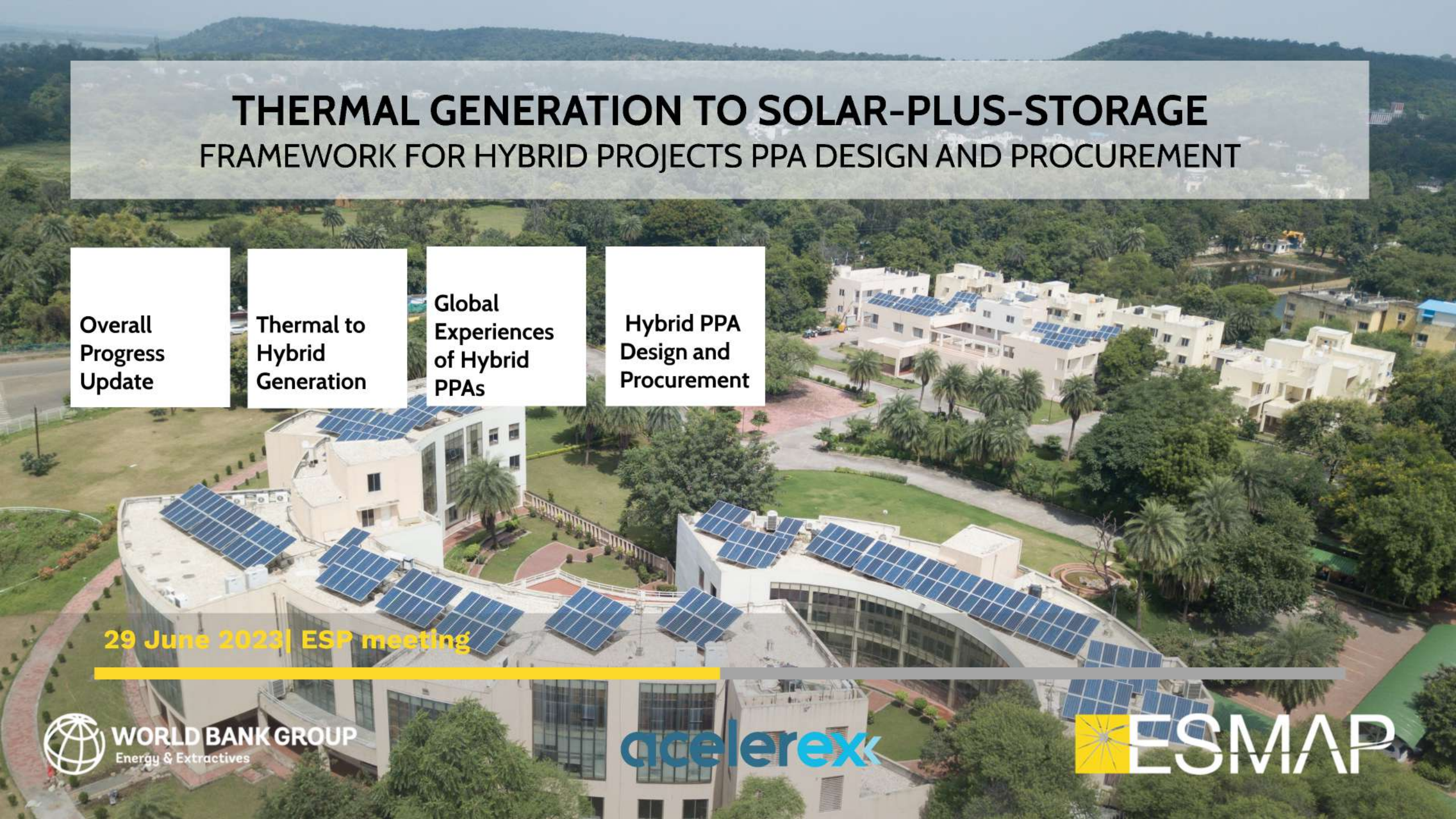

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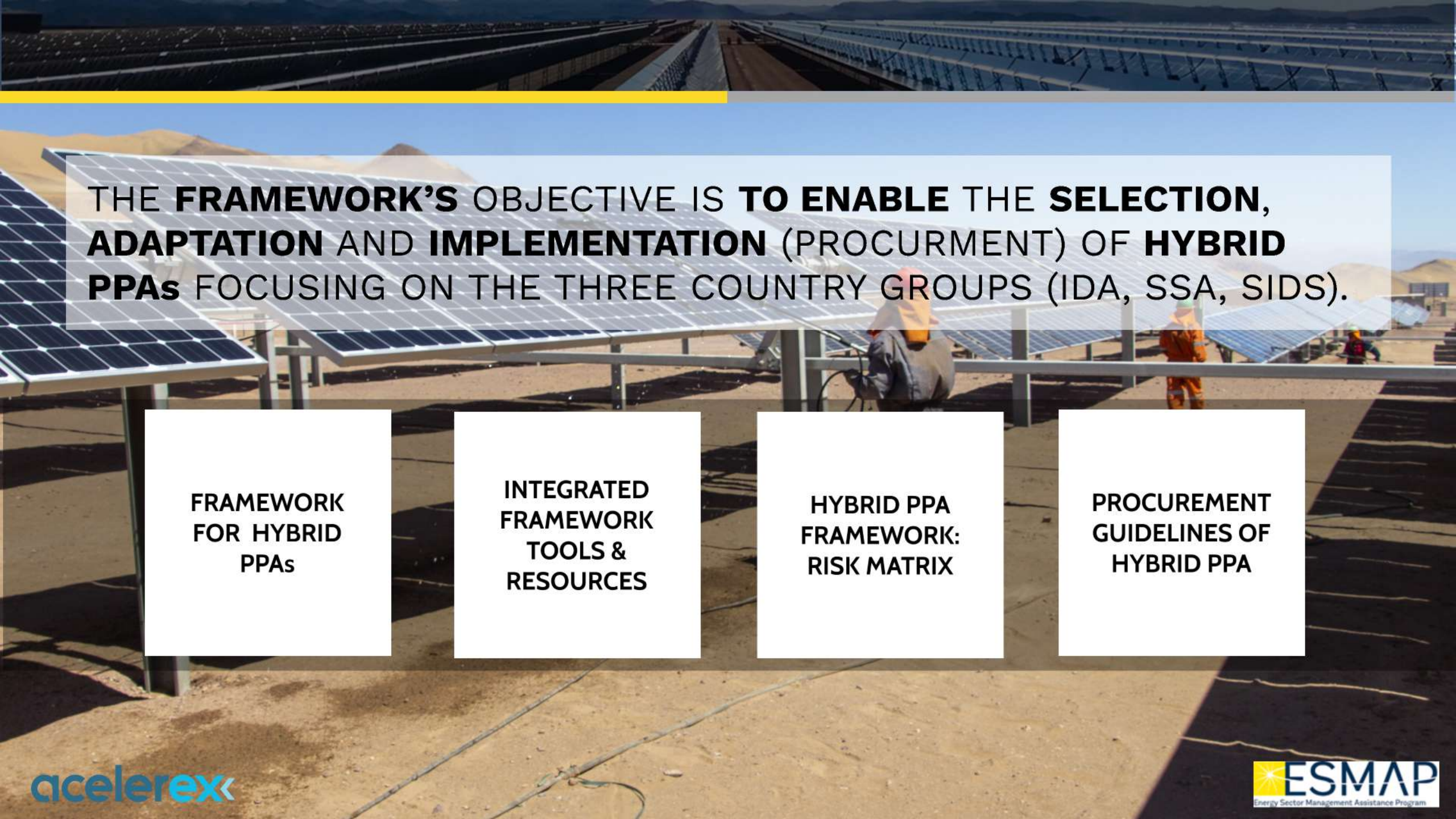

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FRAMEWORK FOR HYBRID PPAs

INTEGRATED FRAMEWORK TOOLS & RESOURCES

HYBRID PPA FRAMEWORK: RISK MATRIX

PROCUREMENT GUIDELINES OF HYBRID PPA

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FRAMEWORK FOR SELECTING, ADAPTING AND IMPLEMENTING HYBRID PPAs

THE **FRAMEWORK'S OBJECTIVE IS TO FACILITATE** THE **SELECTION** AND **ADAPTATION** OF **HYBRID PPAs** FOCUSING ON VARIOUS COUNTRY GROUPS

Five Primary Phases	Defining Project Architecture	Selection of Business Models	Adaptation of PPA Template	PPA Key Parameters	Procurement and Implementation
Activity	Determine detailed requirements of the project such as: • Project Type (new hybrid, addition of BESS to Solar, Replacement of Diesel) • Use Cases and Supply Requirements • Required Level of Firmness • Control Requirements (Local, Central) • Electrical Arrangement • Payment Terms (two term, blended, single term) • Metering Requirements	Determine the most suitable Hybrid Project Business Model out of the 5 PPA templates • Match the remuneration method • Match the use cases • Match the level of firmness • Match dispatchability control • Match Risk allocations • Match Buyer and Seller risks • Select the template PPA	Adapt the template PPA to the Hybrid Project Business Model • Review **Buyer Seller Matrix** • Determine and adapt **Relevant Core PPA Clauses** • Determine the key **parameters that needs to be defined** • Identify Additional Risks	Set and quantify **the initial parameters of the PPA and determine the PPA value** (amongst others): • Solar PV Parameters • Energy Storage Parameters • Project Parameters • Financial Parameters • PPA Key Values	• Define competitive procurement/ auction model • LCOE with Target IRR • Price Calculator • Key Values and PPA Parameters • Warranties • Negotiate the PPA terms with the Buyer and Seller
Framework Tools / Resources	○ Risk Matrix ○ Decision Making Model	○ Guided PPA Templates	○ Guided PPA Templates ○ PPA Parameters Calculator and Guidelines	○ Procurement Guidelines ○ PPA Parameters Calculator	

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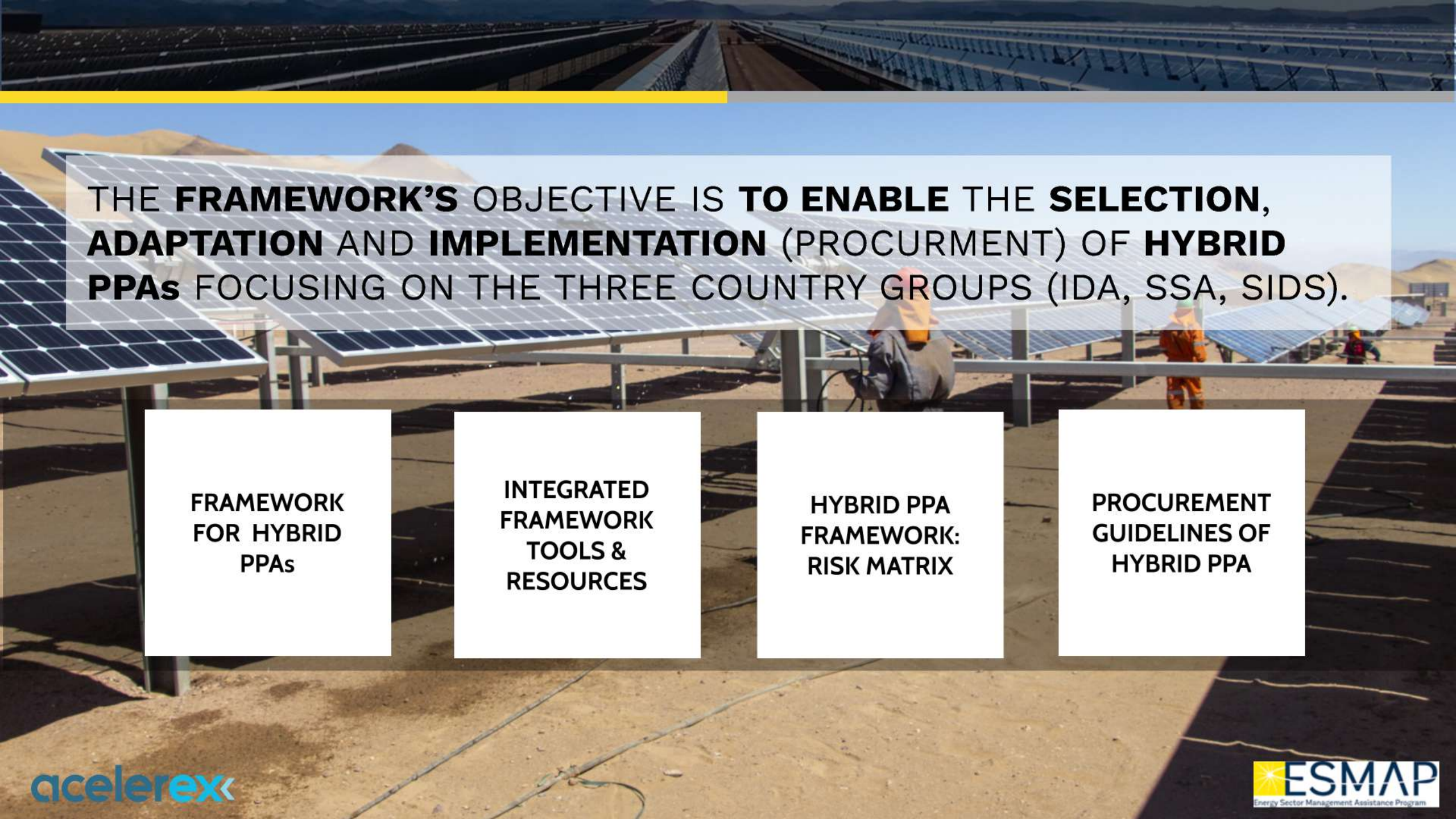

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INTEGRATED FRAMEWORK TOOLS & RESOURCES

THE FRAMEWORK RESOURCES CONSISTS OF **6 COMPONENTS** THE SUPPORT THE FIVE PHASES OF HYBRID PPA DEVELOPMENT

Conceptualization **(Selection)**

Decision Making Model

The **decision making flowchart** will permit users to **select the business model**

Buyer/Seller Matrix

Maps out the risks of various models, outlining **stakeholders responsibilities**

Planning **(Adaptation)**

PPA **Guided Templates** for **5 business models**

A **guided template** would be used and adapted, considering the **core clauses** and the **key parameters**

Core PPA contract clauses

Key values and PPA parameters

The core clauses of each models would be outlined, and **guidance of adaptation** and integration with parameters computed will be provided.
The **calculation methodologies, assumptions, guidance** would be provided for PPA (through Hybrid PPA Calculator)

Implementation **(Procurement)**

PPA Procurement Guidelines

Procurement methods of each model would be outlined, with guidance on integrating plans within broader **Long Term plans** of **Energy Transition**, and maximizing **private sector participation**, and considering longevity (BESS warranties, capacity building, Risk Management)

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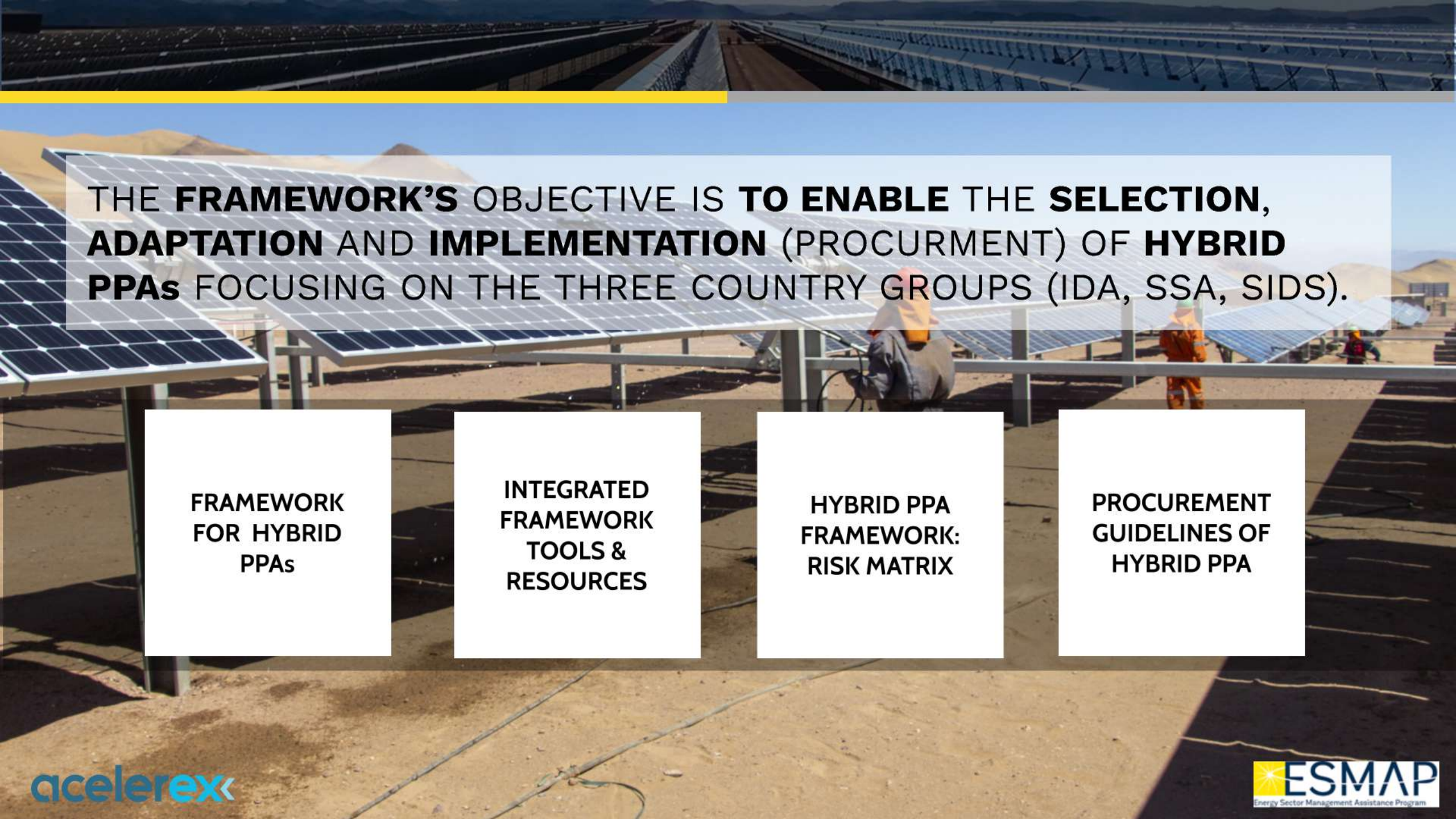

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HYBRID PPA FRAMEWORK: RISK MATRIX

Buyer Risks

The risks that the buyer has but can be mitigated with the clause.

- Metering and measurement
- Reduction in contract capacity
- Periodic capacity tests
- Initial capacity tests
- Curtailment
- Commercial operational date
- Capacity Audits
- Warranty terms

LEGEND

- 1A - Model-1A: Two Part Contract Hybrid
- 1B - Model-1B: Two Part Contract BESS Only
- 2 - Model-2: Fully Dispatchable
- 3 - Model-3: Blended
- 4 - Model-4: Time Variant
- 5 - Model-5: 24x7

Seller Risks

The risks that the seller has but can be mitigated with the clause.

- Warranty terms
- Wear and tear
- Storage losses
- Penalty prices Non-capacity availability
- Construction of Facility
- Commercial operational date
- Delay of achieving commercial operation date
- Contract annual energy output
- Storage capacity maintenance
- Solar capacity maintenance

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PPA Articles Comparison (1/2)

Model 1
Two Part Contract
PPA – Boulder III

#	Articles
1	Definitions
2	Term; termination and survival of obligations
3	Supply service obligations
4	Price of product
5	Portfolio energy credits/renew able energy benefits
6	Right of first offer; right of first refusal; purchase options; end of term purchase option
7	Metering, invoicing and payments
8	Facility construction; operations and modifications
9	Emergency
10	Curtailment
11	Planned outages
12	Planned outages
13	Communications
14	Scheduling notification
15	Compliance
16	Approvals
17	Security
18	Indemnification
19	Limitation of liability
20	Force majeure
21	Disputes
22	Nature of obligations
23	Assignment
24	Default and remedies
25	Representations and warranties of supplier
26	Representations and warranties of buyer
27	Insurance
28	No expectation of confidentiality; public statements
29	Miscellaneous

Model 2
Fully Dispatchable
PPA – Barbers Point

#	Articles
1	Parallel operation
2	Purchase and sale of energy and dispatchability; ratef or purchase and sale ; billing and payment
3	Facility owned and / or operated by seller
4	Company-owned inter connection facilities
5	Maintenance records and scheduling
6	Forecasting
7	Seller payments
8	Company dispatch
9	Personnel and system safety
10	Metering
11	Governmental approvals, land rights and compliance with laws
12	Term of agreement and company's option to purchase at end of term
13	Guaranteed project milestones including commercial operations.
14	Credit assurance and security
15	Events of default
16	Damages in the event of termination by company.
17	Indemnification
18	Insurance
19	Transfers, assignments, and facility debt.
20	Sale of energy to third parties
21	Force majeure
22	Warranties and representation
23	Process for addressing revisions to performance standards.
24	Financial compliance
25	Good engineering and operating practices
26	Equal employment opportunity
27	Set off
28	Dispute resolution
29	Miscellaneous

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PPA Articles Comparison (2/2)

Model 3
Blended PPA – Molokai

#	Articles
1	Parallel operation
2	Purchase and sale of energy and dispatchability; ratef or purchase and sale ; billing and payment
3	Facility owned and / or operated by seller
4	Company-owned inter connection facilities
5	Maintenance records and scheduling
6	Forecasting
7	Seller payments
8	Company dispatch
9	Personnel and system safety
10	Metering
11	Governmental approvals, land rights and compliance with laws
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13	Guaranteed project milestones including commercial operations.
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22	Warranties and representation
23	Process for addressing revisions to performance standards.
24	Financial compliance
25	Good engineering and operating practices
26	Equal employment opportunity
27	Set off
28	Dispute resolution
29	Miscellaneous

Model 5
24x7 PPA – SECI

#	Articles
1	Definitions and interpretation
2	Term of agreement
3	Conditions subsequent
4	Construction & development of the project
5	Synchronisation, commissioning and commercial operation
6	Dispatch and scheduling
7	Metering
8	Insurances
9	Applicable tariff
10	Billing and payment
11	Force majeure
12	Change in law
13	Events of default and termination
14	Liability and indemnification
15	Assignments and charges
16	Governing law and dispute resolution
17	Miscellaneous provisions

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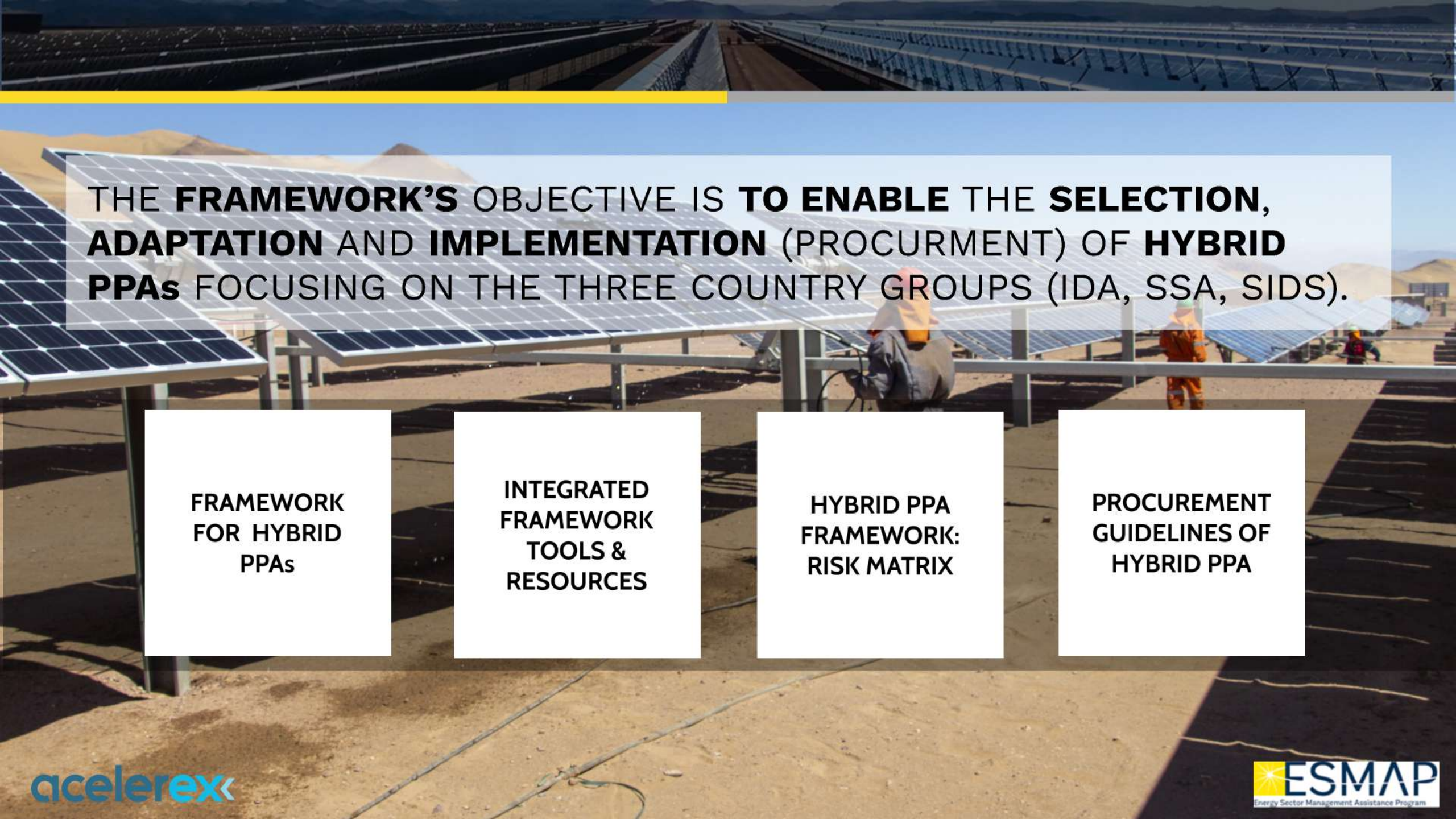

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PROCUREMENT GUIDELINES OF HYBRID PPA

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PROCUREMENT GUIDELINES OF HYBRID PPA PROJECTS

Procurement Methodologies for Each Model

Legal, Commercial, and Operational considerations

Maximizing Private Sector Participation

Integration with Long Term Sector Development

MODEL	AUCTION TYPE	SELECTION
Two-part PPA	Separate bids for energy and capacity (same auction)	Lowest levelized $/MWh
Fully Dispatchable PPA	Bid for total capacity	Lowest bid $/MW
Blended PPA	Bid for price per MWh (for a given firmness level)	Lowest $/MWh
Time-Variant PPA	Different bids ($/MWh) for time blocks (*or bid for peak hours and fixed tariff for off-peak*)	Lowest cost for the system (or lowest $/MWh)
24x7 PPA	Bid for technology types and energy requirements (for a given firmness level)	Lowest levelized energy price ($/MWh)

Key considerations:

- Each model auction types and award method would be outlined
- Potential alternative auction types and selection methods may be outlined where relevant
- Examples and cases studies reflecting successes and failures would be highlighted

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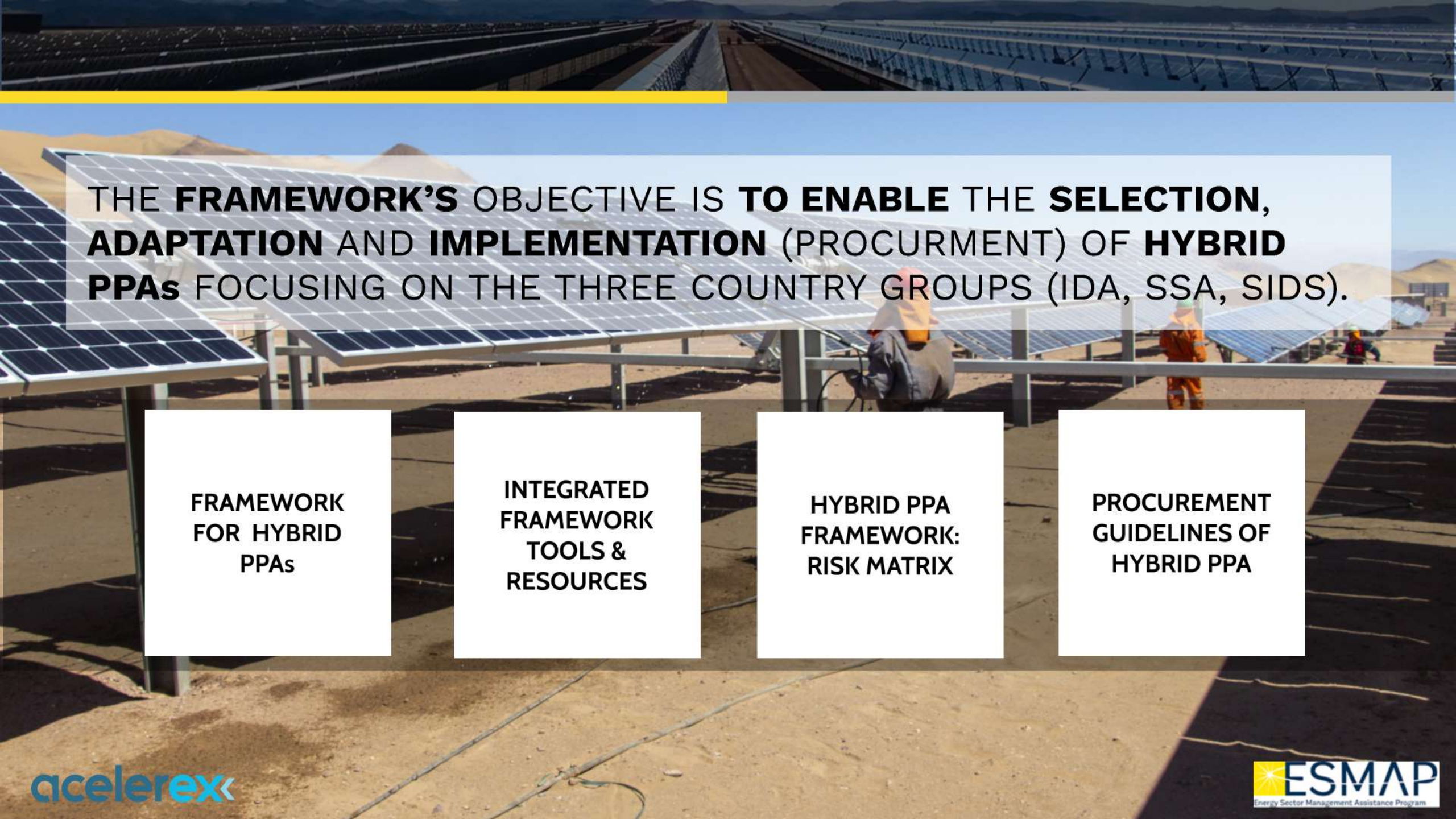

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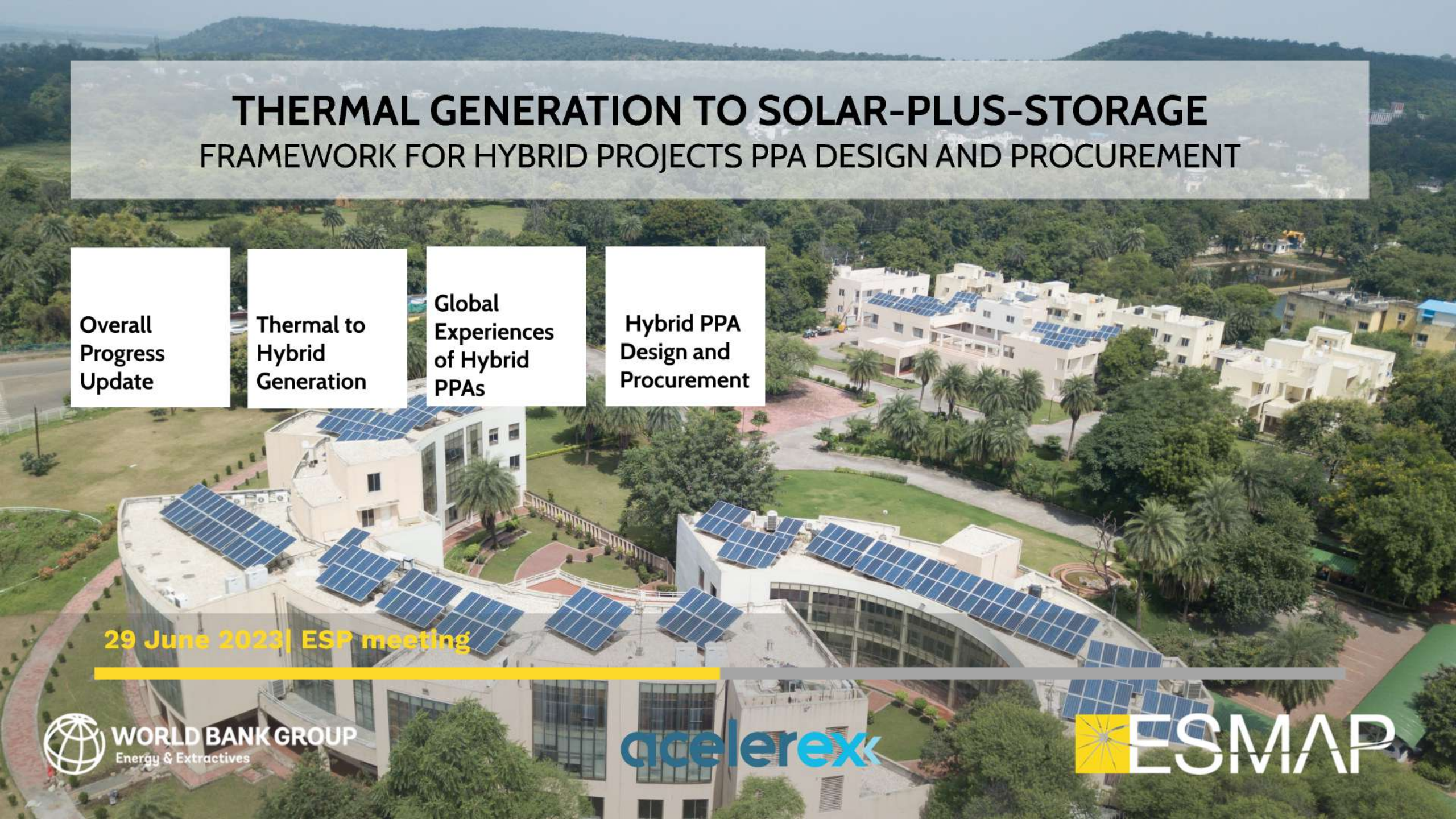

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