IAEA
International Atomic Energy Agency
Atoms for Peace and Development

IAEA RTA Key Element 2: Grid Integration

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OUTLINE

- Grid
- RTA Key Element 2: Grid Integration
- **RTA TABLE FOR KEY ELEMENT 2**
  - **How to complete?**
  - **Examples**

Day 2: Tuesday, 11 June 2019		
11:45	**IAEA RTA Key Elements 2:** Grid Integration [IAEA NP-T-1.10, Pg. 30] **Case Study**	Mr Matthias Krause IAEA Teams

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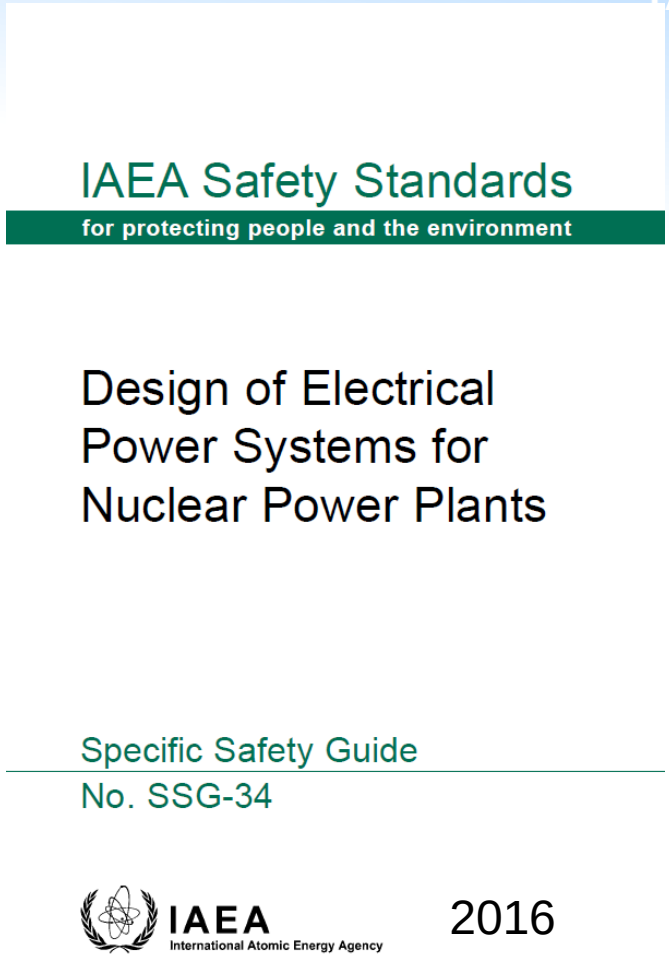
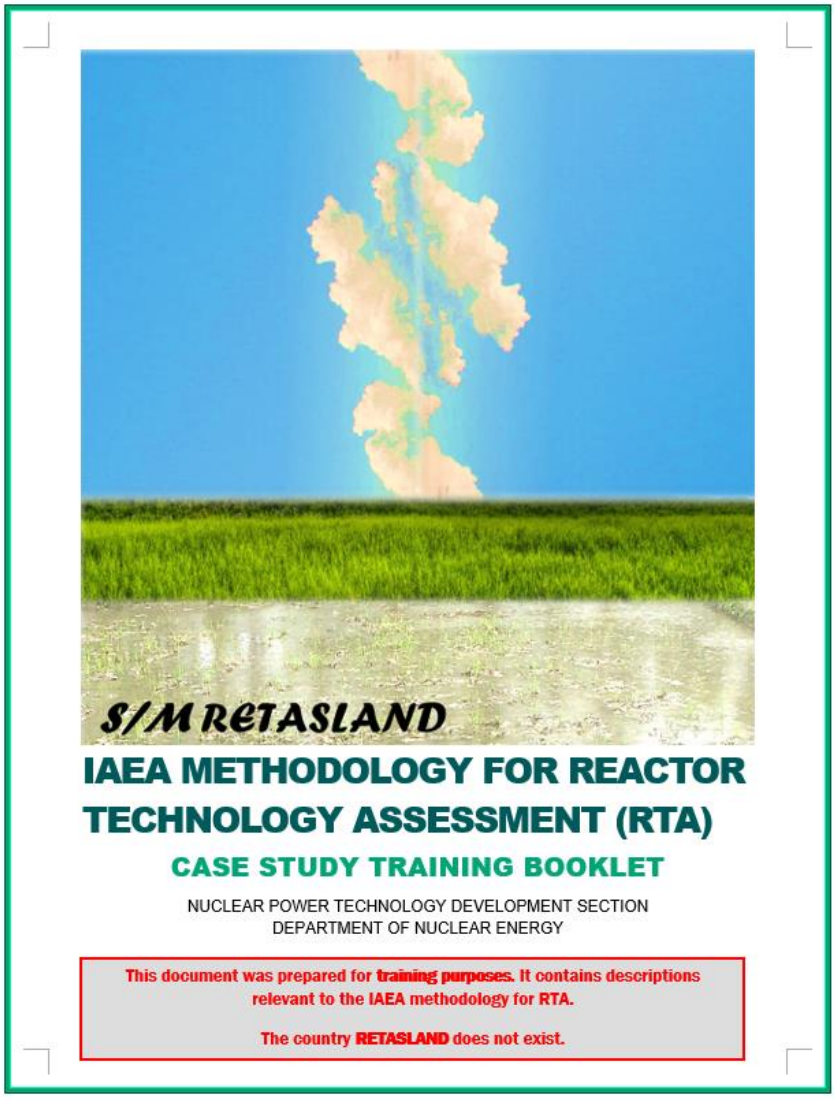
Grid Considerations

- The off-site power supply should have adequate capacity and capability to power plant loads in all modes of the NPP's operation.
- The transmission system is the source of power to the on-site power system.
- The transmission system is also a significant contributor to defence in depth for the NPP safety design.
- As a minimum, each off-site power supply should have the capacity and capability to power all electrical loads required to mitigate the consequences of all design basis accidents and anticipated operational occurrences.

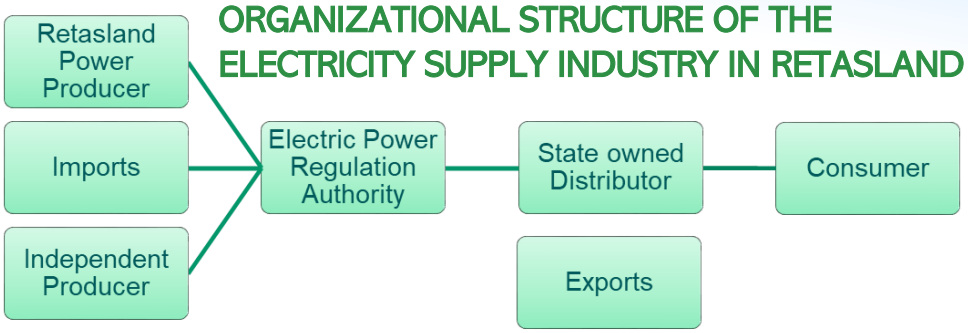


The existing electric grid in Retasland is stable

Retasland Grid Development



Retasland has an integrated electrical grid system with transmission lines.



Retasland is made up of three geographical regions: Northern, Central, and Southern regions.

There are three major transmission lines of 300 MWe, 230 MWe, and 150 MWe that connect the geographical regions. The grid's average number of power supply interruption per year is 2, and the typical duration of an interruption is ½ to about 6 hours.

The frequency of the electric system is 60 Hz.

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RTA Key Element 2: Grid Integration

The interface between the facility design and the grid system in which it is to operate, including normal operation, off-normal operation at the plant, upset conditions on the grid and combinations thereof:

- **Importance factor range suggested: High for WCRs and Medium for SMRs**

- Unique or challenging **features of the grid arrangement** for the facility interface in both **initial and lifetime operation** is critical to the **facility's safe, economic and reliable operation**:
  - *For example*, design features that have been included in the standard NPP for external events (seismic, tsunami, sand storms, human-induced hazards)

- The **capacity and capability of the off-site power supply** to power plant loads in **all modes of the nuclear power plant's operation** shall be evaluated

RTA Key Element 2: Grid Integration

The interface between the facility design and the grid system in which it is to operate, including normal operation, off-normal operation at the plant, upset conditions on the grid and combinations thereof:

- ***Evaluation expectations and relative comparisons*:**
  - Evaluate the technology holder proposals and analyses associated with the grid–plant interface.
  - This must consider the necessary scenarios to ensure safe and reliable operation of the plant under normal, off-normal, accident and severe accident conditions.
  - Technology evaluation and relative comparisons is to ensure that each NPP design and site configuration and characteristics are consistent with the offsite grid characteristics

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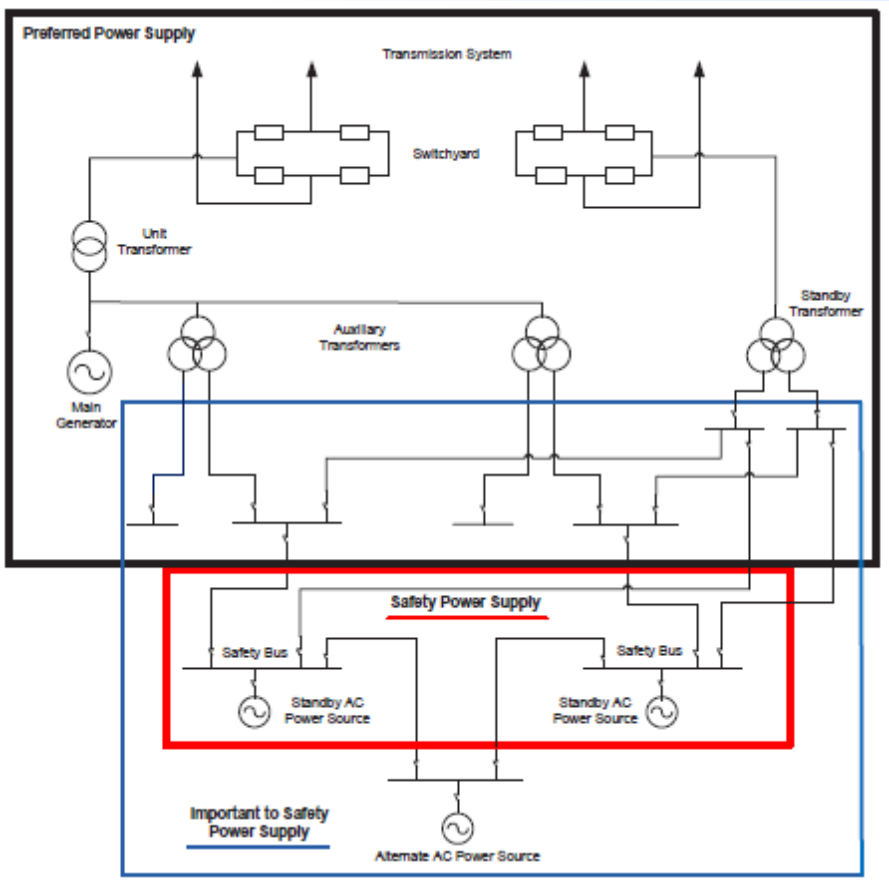
Grid breaker switching capability under blackout transitions

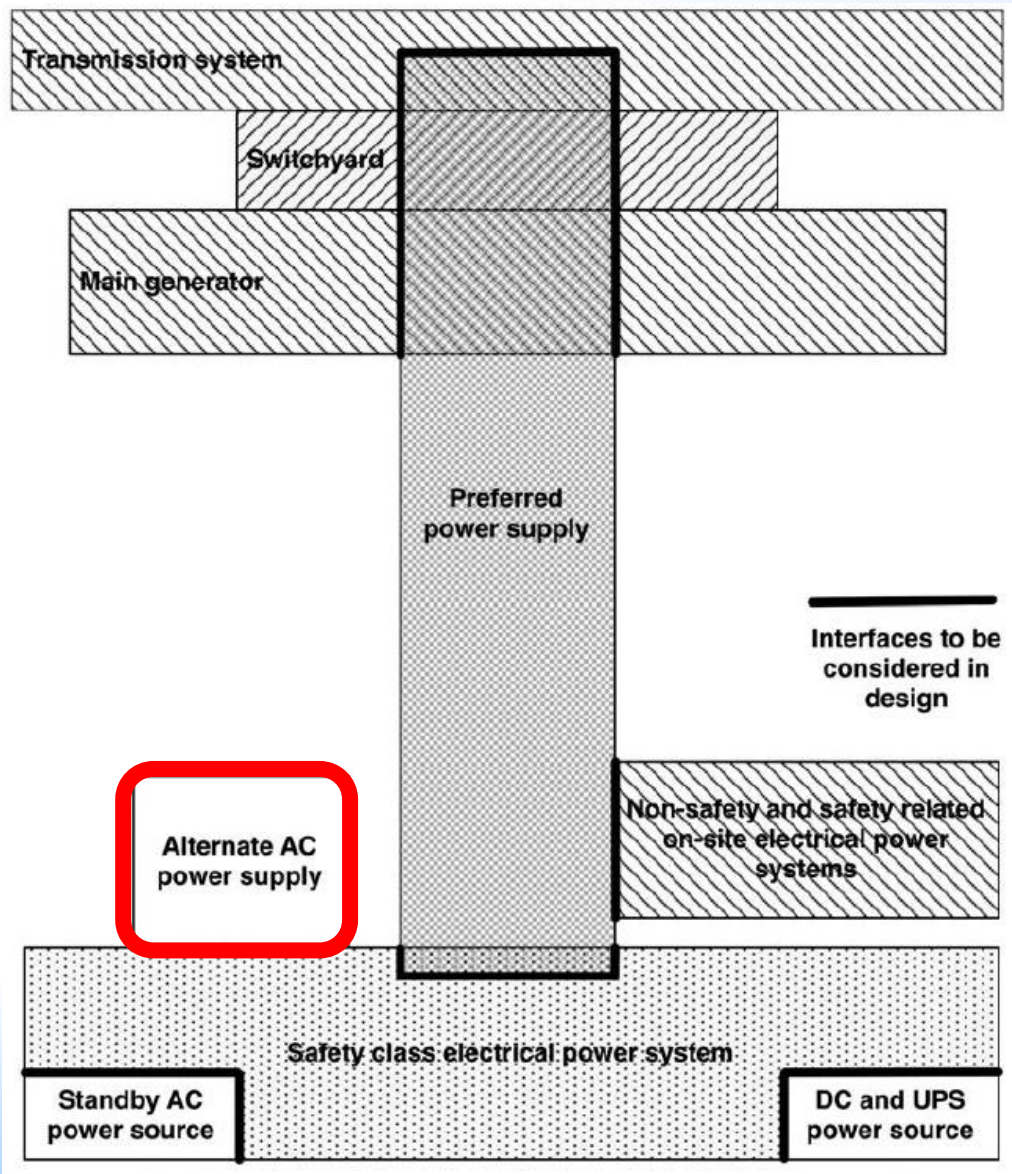
- For a NPP, the **priority in a station blackout (SBO)** is to have the **off-site supplies restored as soon as possible**
- **Generator circuit breaker** may be used to **power the on-site AC power systems from the off-site circuits following an SBO** (generator load break switches can be used)



Example of Offsite and Onsite AC Power

Design of Electrical Power Systems for Nuclear Power Plants, IAEA No. SSG-34
Electric Grid Reliability and Interface with Nuclear Power Plants, IAEA No. NG-T-3.8

Relationship between preferred power supply and other elements of electrical power system



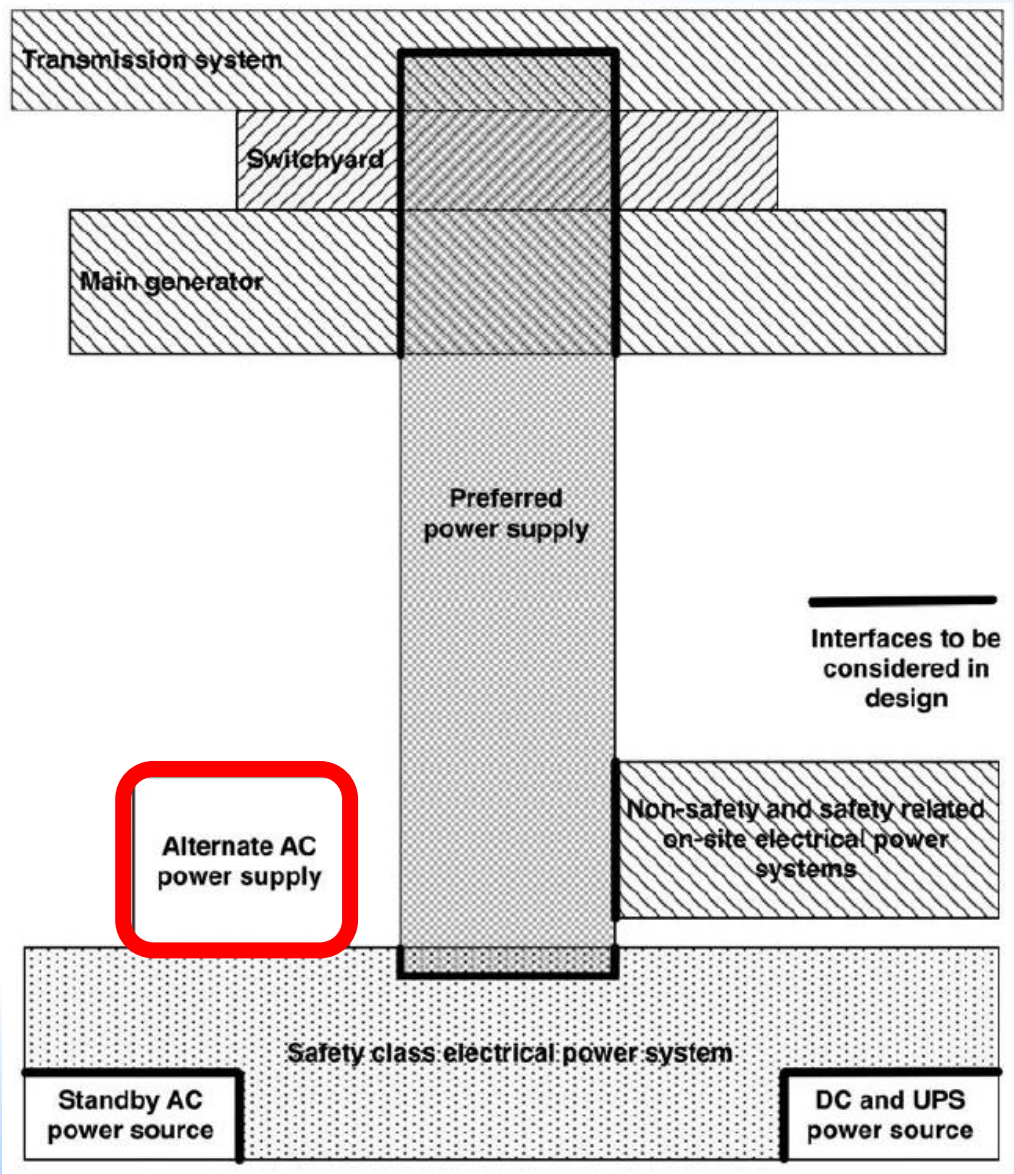
Alternate AC power supply should be provided at or near the NPP **if the plant's design depends on AC power** to bring the plant to a controlled state following loss of off-site power and safety standby power sources

Alternate AC power supplies, including necessary connecting points, are provided to protect electrical power systems against the **simultaneous failure of off-site and emergency AC power supplies**

AC power sources are diverse in design and are not susceptible to the events that caused the loss of on-site and off-site power sources

Design of Electrical Power Systems for Nuclear Power Plants, IAEA No. SSG-34

Relationship between preferred power supply and other elements of electrical power system



Alternate AC power supplies should have sufficient capacity to operate systems necessary for coping with a station blackout for the time required to bring the plant to a controlled state and to maintain it in a controlled state

Ensuring that the alternate AC power supplies can cope with station blackout involves ensuring that the alternate supply is sufficient for simultaneous removal of reactor decay heat, ensuring primary circuit integrity and maintaining the reactor subcritical, and for removing decay heat from spent fuel for all units served for a period of time that is sufficient for reliable restoration of other power sources

Blackout Transitions

- For Retasland:
  - What are the reactor design's features for recovering offsite power after SBO?
  - How fast can recovery of offsite power be expected to take for each design?
  - Does the design offer any alternate AC power supply?
  - Is the alternate AC power supply diverse with respect to the "standard" onsite AC power supplies?

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RTA Key Element 2: Table

Key element: 2. Grid Integration (Suggested High Importance) →						%
6 Key topics	%	Rationale for percentage	HTR-PM	NuScale	SMART	Rationale for score
Grid stability, size, existing and future capacity, plant connectivity	2	1	4	4	4	3
Plant operation under normal grid, disturbed grid and isolated grid conditions						
Off-site power requirements for the plant						
Ability to house load the power station						
Grid code restrictions applicable to plant						
Grid breaker switching capability under blackout transitions						

%	Represents the importance of the key topic
Rationale for percentage	Requires explanation for quantified importance
Rationale for score	Requires explanation of the scoring range:

5 High achievement of criteria
3 Medium achievement of criteria
1 Low or no achievement of criteria, or no information available

RTA Key Element 2: Table

Key element: 2. Grid Integration (Suggested High Importance)						%
Key topics	%	Rationale for percentage	HTR-PM	NuScale	SMART	Rationale for score
Grid stability, size, existing and future capacity, plant connectivity		NPP should fit well in the current and future grid conditions, and have a good connectivity with the grid				
Plant operation under normal grid, disturbed grid and isolated grid conditions (PONGDGIGC)		NPP should operate safely under any grid condition				
Off-site power requirements for the plant		NPP should not impose excessive requirements on the offsite grid				

RTA Key Element 2: Table

Key element: 2. Grid Integration (Suggested High Importance)						%
Key topics	%	Rationale for percentage	HTR-PM	NuScale	SMART	Rationale for score
Grid stability, size, existing and future capacity, plant connectivity	15	NPP should fit well in the current and future grid conditions, and have a good connectivity with the grid				
Plant operation under normal grid, disturbed grid and isolated grid conditions (PONGDGIGC)	25	NPP should operate safely under any grid condition				
Off-site power requirements for the plant	20	NPP should not impose excessive requirements on the offsite grid				

2 1

RTA Key Element 2: Table

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Key topics	%	Rationale for percentage	HTR-PM	NuScale	SMART	Rationale for score
Grid stability, size, existing and future capacity, plant connectivity	15	NPP should fit well in the current and future grid conditions, and have a good connectivity with the grid				5. Many redundant paths of plant connectivity to offsite grid (PCOG) 3. Some redundant paths of PCOG 1. No info or minimum redundant paths of PCOG
Plant operation under normal grid, disturbed grid and isolated grid conditions (PONGDGIGC)	25	NPP should operate safely under any grid condition				5. PONGDGIGC has ample safety margin 3. PONGDGIGC has fair safety margin 1. No info or PONGDGIGC has minimum safety margin
Off-site power requirements for the plant	20	NPP should not impose excessive requirements on the offsite grid				5. Use of passive features minimize the off-site power requirements for the plant 3. Similar power requirements as currently operating nuclear plants 1. No info or significant power requirements

2 1 3

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Key topics	%	Rationale for percentage	HTR-PM	NuScale	SMART	Rationale for score
Grid stability, size, existing and future capacity, plant connectivity	15	NPP should fit well in the current and future grid conditions, and have a good connectivity with the grid	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	5. Many redundant paths of plant connectivity to offsite grid (PCOG) 3. Some redundant paths of PCOG 1. No info or minimum redundant paths of PCOG
Plant operation under normal grid, disturbed grid and isolated grid conditions (PONGDGIGC)	25	NPP should operate safely under any grid condition	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	5. PONGDGIGC has ample safety margin 3. PONGDGIGC has fair safety margin 1. No info or PONGDGIGC has minimum safety margin
Off-site power requirements for the plant	20	NPP should not impose excessive requirements on the offsite grid	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	Score 1 or 2 or 3 or 4 or 5	5. Use of passive features minimize the off-site power requirements for the plant 3. Similar power requirements as currently operating nuclear plants 1. No info or significant power requirements
	2	1		4		3

Case Study Toolkit

Teams

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Thank you!