

STATION BLACKOUT COPING CAPABILITY OF CO-LOCATED REACTOR TECHNOLOGIES WITH ACTIVE AND PASSIVE SAFETY ARCHITECTURES: A COMPARATIVE FRAMEWORK FOR THE JIZZAKH NUCLEAR POWER PLANT

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Annotation: This article proposes a framework for comparing the station blackout coping capability of the two reactor technologies to be co-located at Uzbekistan's first nuclear power plant, the VVER-1000 and the RITM-200N. The two differ principally in how far decay heat removal depends on alternating-current power. Because a single grid event will reach all four units at once while their capacity to withstand it differs by design, site-level risk at such a plant cannot be treated as the sum of independent unit risks.

Keywords: station blackout, coping capability, VVER-1000, RITM-200N, passive safety, co-located units, nuclear power plant, Uzbekistan.

Introduction: Uzbekistan's first nuclear power plant will place two reactor technologies of markedly different design on a single site. Two VVER-1000 units and two RITM-200N small modular reactors are to be commissioned in phases between 2029 and 2035 [1], [2]. Very few sites anywhere combine a large four-loop pressurized-water reactor with an integral small modular reactor. The pairing creates a comparative opportunity a single-technology site cannot offer, because both technologies will experience identical grid conditions, identical site hazards and identical initiating events. Whatever difference appears in their response is attributable to design rather than to circumstance.

The main part: The two differ in the respect that matters most under station blackout: how far decay heat removal depends on alternating-current power [3]. The VVER-1000's engineered safety architecture is built around active systems, among them high- and low-pressure emergency core cooling and independent emergency boron injection, supplemented by passive hydraulic accumulators and passive catalytic hydrogen recombiners [4]. The active portion requires AC power. That is why emergency diesel generators exist, and why their failure defines the station blackout condition. The RITM-200N is built on a different principle. It has an integral primary circuit, two independent shutdown mechanisms, a passive heat removal system and passive autocatalytic recombiners, intended to manage accident conditions without continuous operator action or off-site power [5], [6].

Coping capability is the interval over which a unit can maintain core cooling with no alternating-current power and no intervention from outside the site. Three quantities set it. The first is the stored energy available from direct-current supplies, which sustains instrumentation, control and valve actuation. The second is the period for which any passive heat removal path continues to function unaided. The third is the point at which operator action or off-site equipment becomes necessary to avoid core damage. For neither technology at Jizzakh is any of the three available as a published figure, and establishing them is the object of the framework proposed here.

Table 1 sets out the comparison as it currently stands. The attributes in the upper rows follow from published design descriptions and can be stated now. The coping intervals in the final two rows cannot, and they are precisely what the framework is built to determine.

Attribute	VVER-1000	RITM-200N
Primary circuit	Four loops, external steam generators	Integral; steam generators and pumps inside the vessel
Decay heat removal	Active emergency core cooling	Passive heat removal system
Dependence on emergency AC	High	Reduced
Shutdown provision	Control rods with emergency boron injection	Two independent shutdown mechanisms
Hydrogen control	Passive catalytic recombiners	Passive autocatalytic recombiners
Refuelling interval	12 to 18 months	6 years
Design life	40 years	60 years
DC autonomy	To be established	To be established
Unaided coping time	To be established	To be established

Table 1: Comparison of the two co-located reactor technologies against station blackout coping.

This work therefore proposes a comparative coping-capability framework for the two technologies under identical loss-of-off-site-power conditions, built on the design provisions established internationally for withstanding station blackout [7]. For each technology the framework establishes the AC dependence of the decay heat removal path, the autonomy provided by direct-current supplies, the duration over which passive systems sustain heat removal unaided, and the resulting coping time before external intervention becomes necessary. The two profiles are then compared under a common initiating event, and the comparison is repeated across a range of assumed off-site power recovery times.

Conclusion: The practical significance is that site-level station blackout risk at Jizzakh will not be the sum of two independent unit risks. One grid event will affect all four units at once, while their capacity to withstand it differs by design. Emergency response resources, staff and connections will also be shared, so demand on them arrives simultaneously rather than in sequence. A framework treating the site as a heterogeneous whole rather than as separate units is therefore a precondition for any meaningful site-level assessment, and the phased commissioning between 2029 and 2035 means the site's composition, and its aggregate coping capability, changes several times before the plant is complete.

The comparison is developed from published design characteristics and international safety standards. No plant-specific probabilistic safety assessment is publicly available for either technology, so the analysis is framed as a methodological foundation rather than a quantified risk result.

References

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