Concept Note — Seoul National University as a modelling and Korean-context partner for a DUT Call 2026 PED Topic 3 consortium

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Topic — PED Topic 3, Sustainable PEDs, flexibility in energy systems, and integrated technologies

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1. The gap we want to help close

PED plans routinely assume large flexibility from storage, heat pumps, EV charging and district heating, yet the delivered flexibility often falls short. Uncertainty from weather, occupants, incomplete data and modelling assumptions propagates through energy systems and controls and causes "poor realisation of building energy flexibility" (Dawes et al., 2025, review of 140+ studies). Coordination becomes harder still in multi-carrier systems and depends on reliable two-way communication and cross-domain data standards that are still largely missing (IEA EBC Annex 82, 2025). Lessons from eleven EU PED projects show real districts coping with grid congestion through batteries, aquifer thermal storage and energy management systems, but also that the metering data needed to design and verify smart operation are often absent or too coarse (Alpagut et al., 2025), and DUT's own synthesis notes that monitoring usually stops when a project ends (DUT PED Deep-Dive #4, 2025). The 2022 DUT flexibility projects, DigiTwins4PEDs and FLEdge, advanced planning-stage digital twins (Energy ADE 2.0, OGC-based workflows) and building-level edge control, but their published results do not yet close the loop between planned capacity and realised, measured performance across electricity, heat, cooling and mobility. Part of this gap is a modelling-fidelity problem. Our work on long-duration storage shows that simplified operational constraints make models overly optimistic about the flexibility a technology can deliver (Heo & Macdonald, 2024). PED Topic 3 asks for exactly this evidence, namely a comparison of planned versus realised flexibility, and proof that local flexibility eases grid congestion and supports the resilience and balancing of the wider energy system (PED Framework 3.0, 2025).

2. What SNU brings

(a) Multi-carrier flexibility design and model fidelity. District-scale optimisation models that co-design and schedule electricity, heat/cooling, storage and EV assets under realistic non-linear operating constraints, building on the integrated design-and-scheduling framework and decomposition algorithm we developed for grid-interactive, sector-coupled facilities at 8760-hour resolution (Heo, Mallapragada & Macdonald, *Computers & Chemical Engineering*, 2025). Applied to the consortium's living labs, this quantifies which part of the planned-versus-realised gap is caused by model simplification, which by physical limits, and which by data access, institutional or user factors.

(b) Uncertainty-aware validation against measured data. Probabilistic spatio-temporal learning methods we developed for sparse, heterogeneous sensor data with calibrated uncertainty (Bayesian Neural Fields, Liu, Tsao, Manuel & Heo, *Applied Ocean Research*, 2026; sample-efficient tensor-field embeddings, Heo & Bajaj, AISTATS 2024) reconstruct missing metering data, propagate weather- and occupancy-driven (aleatory) and model-driven (epistemic) uncertainty into flexibility estimates, and deliver confidence bounds on the flexibility a district can actually offer. Together with SNU colleagues in system reliability and infrastructure resilience, we define resilience- and congestion-relief indicators for PED flexibility that can feed national flexibility-needs assessments.

(c) A nested district-to-national perspective. We are building a Korean macro-energy-system model in PyPSA and MacroEnergy (in development, first results 2027). Aggregating district flexibility into system-level models lets the consortium show quantitatively how PEDs contribute to regional and national balancing and resilience, the first role the PED Framework 3.0 assigns to flexibility.

(d) A non-European validation node. Korean districts combine high-rise collective housing, large summer cooling loads, extensive district heating and binding distribution-grid connection limits, under a single-buyer market now being opened by the Distributed Energy Act (2024) and the Jeju real-time market pilot. Testing the consortium's methods against this contrasting context strengthens the transferability claims the call asks for.

All SNU outputs will be interoperability-compliant, with model inputs and outputs following CityGML Energy ADE 2.0 / OGC conventions that plug into the coordinator's digital twin and the DUT Knowledge Hub without a separate data layer.

3. Why this is attractive for the consortium

- **No cost to European partners.** SNU is eligible for direct funding from KAIA (up to EUR 200,000, 100% rate for universities); our participation adds budget and a country without diluting anyone's share.
- **Country coverage and international dimension.** Korea takes part in DUT Call 2026 through KAIA, so a Korean partner broadens the consortium's country coverage and adds a non-European perspective in line with the Mission Innovation dimension of this call.
- **Complementarity, not overlap.** We do not propose to lead the digital platform, city engagement or demonstrations. We add the quantitative validation layer and the outside-Europe test case.

4. Practicalities

- We seek a Co-applicant role, leading one task or work-package segment (modelling and validation) of about 2 person-years, aligned with the KAIA cap of EUR 200,000 and a 24-month Korean funding period (Sept 2027 – Aug 2029). We schedule our tasks in months 1–24 and keep a light in-kind role in the final year.
- SNU is eligible under KAIA rules for all PED topics (TRL 1–8); no Korean national submission is needed at the pre-proposal stage.
- We are ready to move quickly and can provide PIC, PI CV, budget table and partner text on short notice; the DUT pre-proposal deadline is 17 November 2026, 13.00 CET.

5. Team

Taemin Heo (PI) — Assistant Professor, Department of Civil, Urban and Environmental Engineering, SNU. PhD, The University of Texas at Austin (stochastic processes, reliability); postdoctoral associate, MIT Energy Initiative (macro-energy-system and storage modelling, GenX). Energy-systems optimisation, storage and sector-coupling models, scientific machine learning. The SNU team includes colleagues in system reliability and infrastructure resilience and dedicated research staff for proposal preparation.

References

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