Flatirons Nexus: AI–Renewables Integration Test Campus

Executive Summary

Project 29 outlines a renewables-focused AI experimental campus idea situated at or adjacent to the National Renewable Energy Laboratory (NREL) Flatirons site. It creates a concise array of adaptable AI campus design patterns and appraises them through solely unclassified stand-in simulations and strategic reviews. Every result consists of relative assessments aimed at aiding initial choices; no functional oversight of power sources, network elements, or computing hubs is suggested or inferred.

The goal is to equip the Department of Energy (DOE) with an organized method to grasp how sophisticated AI tasks might function in tight synergy with wind, solar, batteries, hydrogen, and additional unified energy setups available in the Flatirons setting, as outlined in the March 2025 “AI Infrastructure on DOE Lands” Request for Information (RFI). The framework aids in cultivating future possibilities without binding DOE or NREL to any definite rollout trajectory.

Strategic Goals and RFI Compatibility

Strategic Goals

Project 29 aims to:

- Position NREL Flatirons as a hub for AI-energy fusion trials, rather than just a commercial hosting location.
- Investigate how adaptable and partially adaptable AI operations could adjust to fluctuating renewable output while upholding suitable simulated performance standards.
- Contrast renewables-dominant, grid-equilibrated, and blended functional modes via surrogate simulations.
- Highlight the core location, network, and partner details DOE would require prior to contemplating any upcoming bid or collaboration approach.
- Reveal partnership potentials involving NREL initiatives, power companies, academic institutions, and sector allies.

Compatibility with the DOE RFI

The idea aligns with the RFI through:

- Explaining Flatirons' suitability as a potential spot, drawing on its openly detailed renewable power resources, battery and hydrogen setups, grid connectivity, and experimental purpose.
- Specifying broad AI campus aims and design elements fitting for a renewables-oriented trial space.
- Probing abstract local energy merging and network engagements with situation-driven surrogate simulations.
- Noting ecological, territory utilization, labor force, and local factors pertinent to the Boulder and Front Range area.
- Offering a progression framework that enables DOE to advance from preliminary curiosity to knowledgeable resolution without rushed obligations.

System Design Framework

The AI-Renewables Trial Campus is simulated as a closely linked system featuring four abstract levels.

AI Campus Level

- Flexible AI groupings crafted for trials involving model training, inference, and investigative computations.
- Artificial demand curves depicting a blend of time-critical and timing-malleable processing.
- Supplier-neutral depictions that stay aligned with progressing computational structures.

Renewable and Storage Level

- Hypothetical wind, solar, battery, hydrogen-linked, and other energy elements shown as broad variable and reserve assets based on open efficiency traits.
- Situations stress elevated renewable involvement to assess interplay dynamics over optimizing volume.

Grid Connection Level

- Inflow and outflow channels portraying ties to the area network and local electrical framework from public references.
- Situations vary from network-backed functioning to limited network access where onsite renewables and reserves assume greater prominence.

Oversight and Monitoring Level

- A conceptual structure for appraising adaptability, durability, and adjustability of each design pattern.
- Monitoring emerges solely as simulated surveillance necessities to gauge upcoming visibility requirements.

Inception Phase Framework

Phase 1 – Design Patterns and Premises

Phase 1 sets up a compact group of design patterns shaped by Flatirons' renewable trial ground nature.

Phase 1 tasks encompass:

- Examining open overviews of Flatirons to gather:
- Wind, solar, reserve, hydrogen, and merged energy installations.
- Ground availability for trial setups.
- Closeness to skilled personnel and research bodies.
- Ecological and preservation backdrop.
- Recording limits tied to ground care, water access, natural vulnerability, and harmony with current investigative efforts.

Design patterns encompass:

- R1 – Grid-Equilibrated Trial Campus
- Switches between standard network-dependent running and renewables-following states.
- Serves as a reference for adaptability improvements compared to conventional computing center patterns.

- R2 – Renewables-Optimizing Trial Campus
- Emphasizes maximum use of onsite renewable and reserve assets.
- Arranges malleable AI tasks to match production timing.
- R3 – Durable Blended Campus
- Harmonizes onsite renewable provision, reserves, and network aid.
- Applied to review endurance amid network interruptions and renewable inconsistencies.

Premises address:

- AI operation adaptability spreads.
- Broad renewable and reserve efficiency spans.
- Conceptual network engagement traits.
    - Thermal viability and abstract water boundaries.
    - Territory application and ecological edges.

Phase 1 results:

- Descriptive accounts of R1–R3.
- A premises and ambiguities ledger.

Phase 2 – Surrogate Simulations and Relative Results

Phase 2 activates stand-in simulations of the patterns and establishes result creation and analysis methods. Simulations stay purely for conceptual contrasts.

Simulation components include:

- AI groupings depicted by malleable and rigid demand parts.
- Renewable and reserve stand-ins employing open fluctuation trends.
- Network channels simulated as restricted inflow/outflow paths.

Situation array includes:

- Core functioning situation
- Balanced renewable engagement and network backing.
- Renewables-pressure situation
- Elevated renewable usage with reduced network dependence.
- Network-pressure situation
- Diminished network aid, heightened focus on onsite assets.

Relative results feature abstract measures like:

- Extent of renewable synchronization.
- Occurrence of simulated excess trimming or unsatisfied demand.
- Strain on reserve and hydrogen stand-ins.
- Thermal and water tension across various running states.

Phase 2 results:

- Simulation guideline.
- Relative account spanning patterns and situations.

Phase 3 – Durability, Variability, and Adjustability

Phase 3 appraises pattern performance under ambiguity and how setups can be readily modified.

Durability appraisal probes:

- Renewable fluctuation outliers.
- Alterations in AI operation composition and expansion.
- Variations in network aid scenarios.

Variability review assesses:

- Share of malleable AI operations.
- Comparative scale of renewable and reserve collections.

- Intensity and schedule of network boundaries.
- Ecological and water boundary strictness.

Adjustability charting outlines:

- Shift routes among patterns.
- Functional reductions if boundaries intensify.
- Initiative effects of expansion or contraction.

Phase 3 results:

- Durability account.
- Variability overview.
- Adjustability chart.

Phase 4 – Preparedness Inventory and Progression Route

Phase 4 specifies prerequisites before DOE weighs moving to a bid process.

Preparedness areas include:

- Location info development.
- Energy setup transparency.
- Network linkage comprehension.
- Thermal and water suitability.
- Harmony with NREL objectives.
- Local and partner involvement level.
- Policy and oversight recognition.

Progression route encompasses:

- Planning finalization.
- Location and partner enhancement.

- DOE resolution stage.
- Ally-guided planning and appraisal if advanced.

Phase 4 results:

- Preparedness inventory.
- Progression account maintaining flexibility.

Practical Viability and Hazard Review

Viability

The initiative draws on routine strategic approaches: situation simulations, artificial operations, and broad renewable generalizations. It keeps entirely non-sensitive and free from confidential inputs.

Primary Hazards

- Restricted asset-specific open info.
- Ambiguous AI operation development.
- Policy and oversight changes.
- Ecological and ground care boundaries.

Hazard Mitigation

- Abstract results over specific predictions.
- Clear premise monitoring.
- Segmented and adjustable structures.

Partnership Framework

- DOE establishes boundaries and choice focuses.
- NREL supplies general location and objective perspectives.
- Network parties offer broad linkage insights.

- Educational and lab collaborators assist simulation techniques.
- Sector allies provide general layout and running perspectives.

Anticipated Outputs and Choice Benefits

Outputs

- Design patterns bundle.
- Surrogate simulations and relative review account.
- Preparedness inventory and progression summary.
- Partnership and outreach idea.

Choice Benefits

- Illuminates AI-renewables merging dynamics in a trial setting.
- Delivers adaptable strategic approach for additional DOE locations.
- Aids knowledgeable ranking without obligations.

Moral, Ecological, and Local Factors

- Firm divide between simulations and implementation.
- Natural vulnerability integrated into situation layouts.
- Preliminary outreach stressed as a necessity.
- Preservation focuses upheld.

Achievement Benchmarks (12 / 24 / 36 Months)

12 Months

- Patterns outlined and recorded.
- Starting relative simulations finished.

24 Months

- Durability and variability finished.
- Refreshed premises integrated.

36 Months

- Preparedness bundle concluded.
- DOE ready to evaluate subsequent actions.

  View Implementation Link (Planning) (Manual link: https://ucdpforge.com/pdfs/NLIG/NREL_Flatirons_AI_Impl_Guide.pdf)