Renewable Integration and Transmission Planning

2022-10-24 ESIG CEM Workshop

Hitachi Energy USA Inc. - Power Consulting

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Renewable Development Potentials

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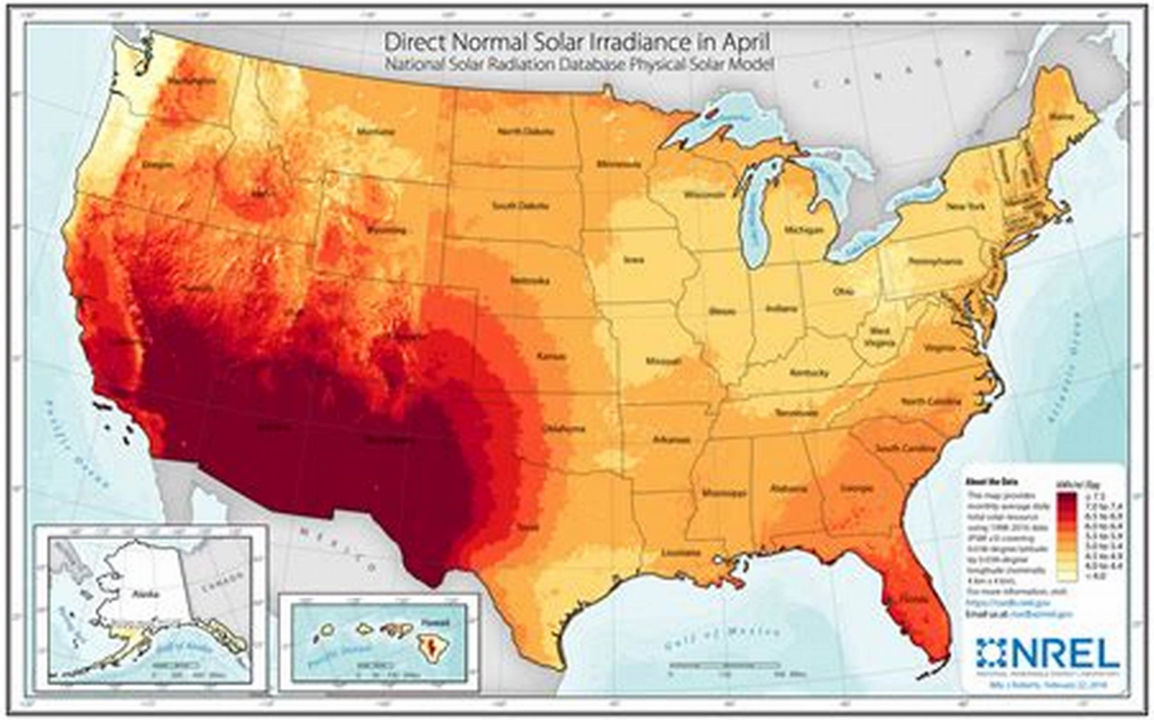
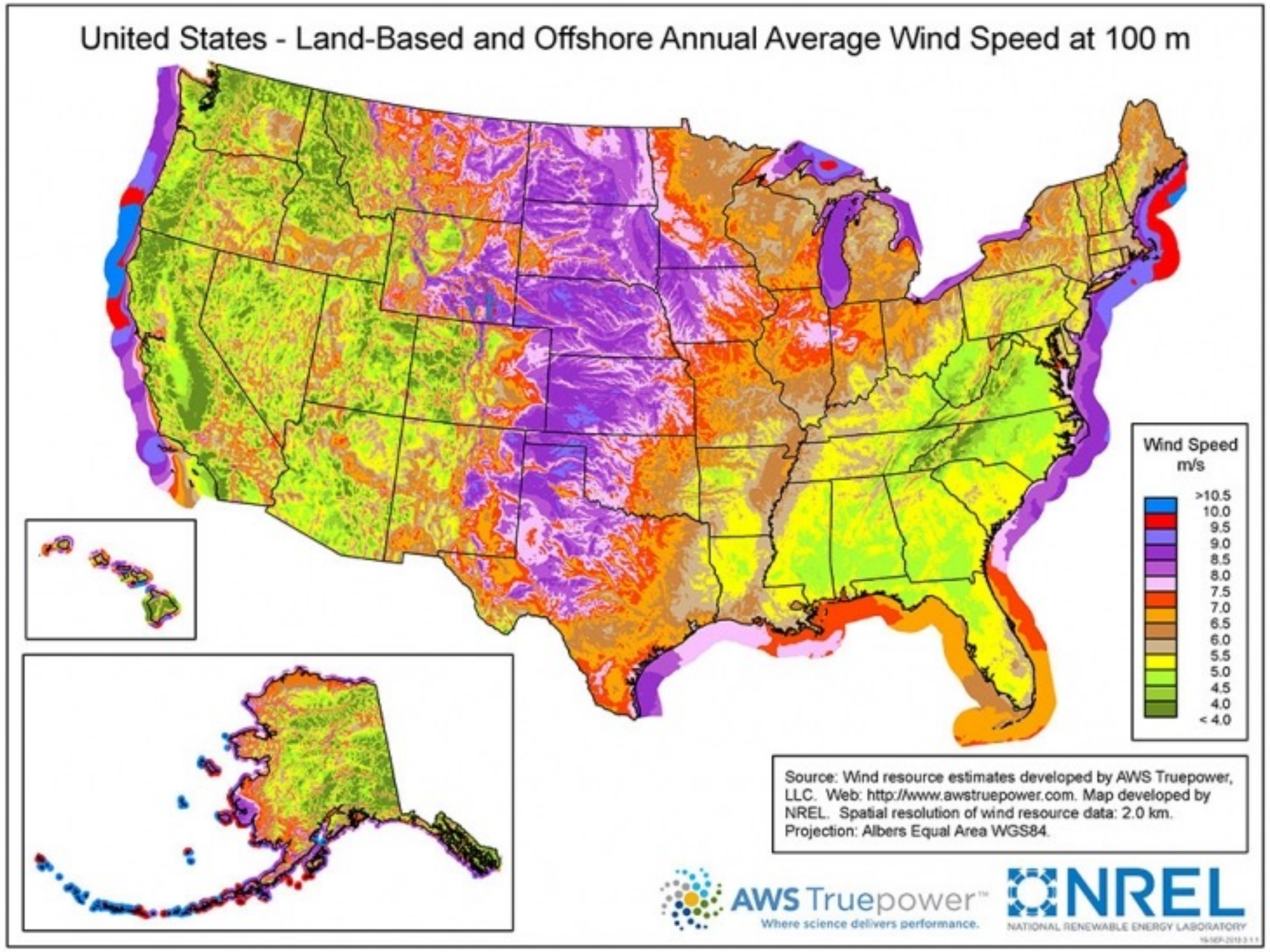
Solar Radiation



Wind Speed



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Power from the Prairie Concept Development Study (CDS)

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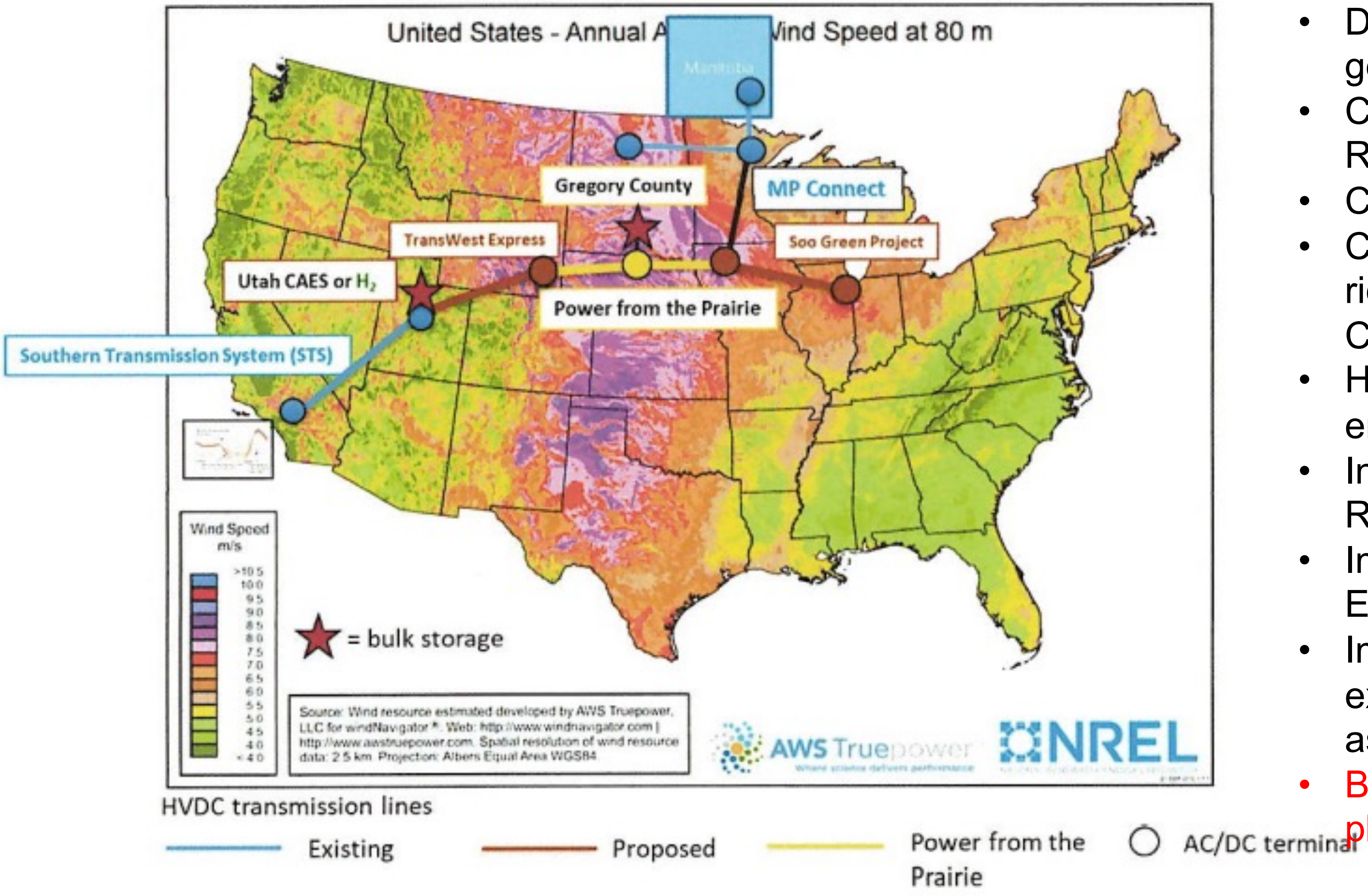

- Diversified Load, Wind and Solar generation
- Connect CAISO, SPP, MISO,PJM RTO markets
- Cross 4 time zones
- Connect solar rich zones and wind rich zones and large storages and Canada Hydro resources
- HVDC projects for long distance energy transfer
- Integrate Renewable resources and Reduce GHG Emission
- Improve System Reliability and Economics
- Improve System Resilience under extreme weather conditions, such as, winter storms, heat waves, etc.
- Based on the Capacity Expansion plan from WECC, SPP, MISO, PJM

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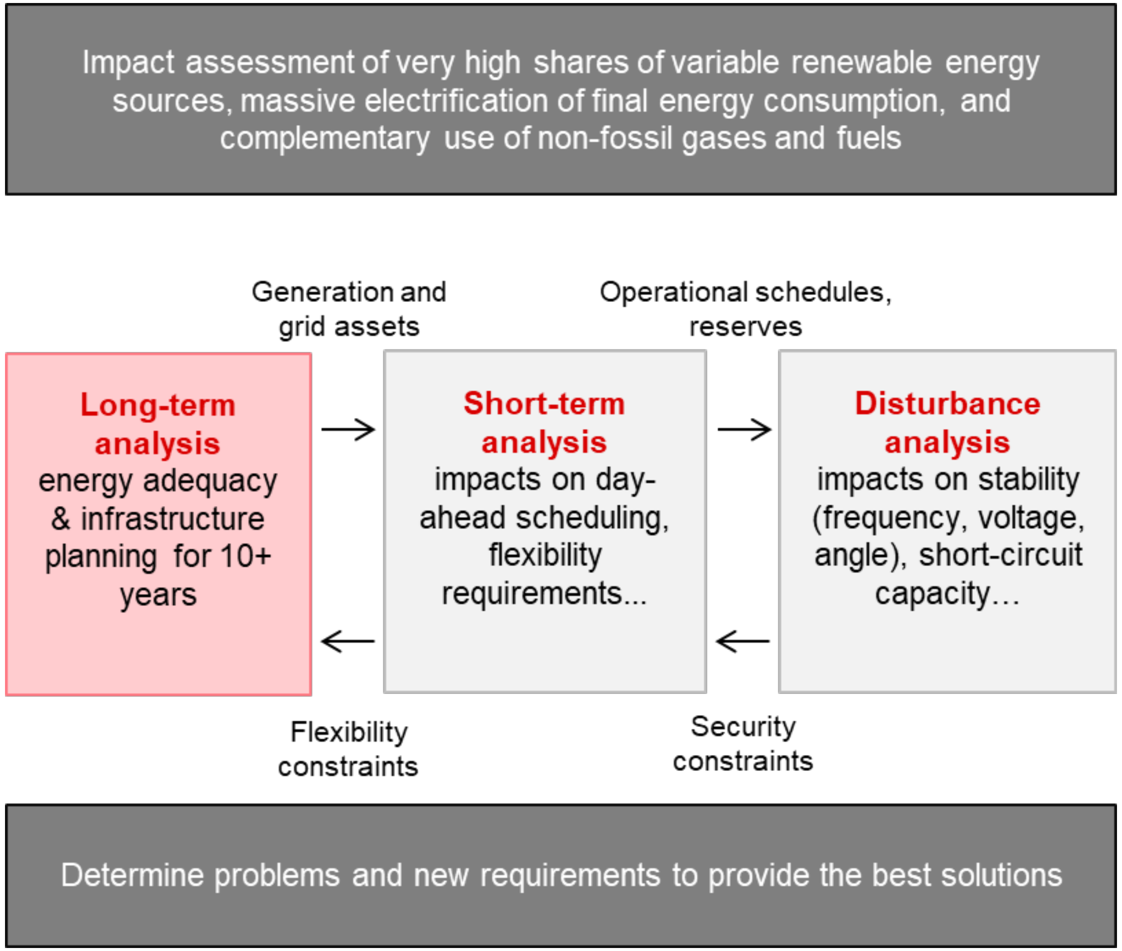
Multi-Energy Vector simulation framework

In the process of strategic multi energy vector system development we identify when, where and what kind of energy infrastructure must be deployed to deliver a vision of 100% renewable energy system:

- co-optimize generation, storage and grid expansion in one shot over a complete mid-/long-term simulation period,
- divide a geographic area into a number of zones/bubbles representing major demand and renewable generation centers,
- taking holistic energy system planning approach to leverage complementarities of energy sectors (electricity, hydrogen).

References (public):

- *GEIDCO: “Global Green Grid - role of grid interconnectors and energy storage in the future power systems”.*
- *Renewable Grid Initiative: “Accelerating full decarbonization in Europe: Resource optimization in energy infrastructure planning”.*



Note: This diagram is a generic illustration of the system planning process.

Multi-period/-zonal/-energy vector Modeling Framework

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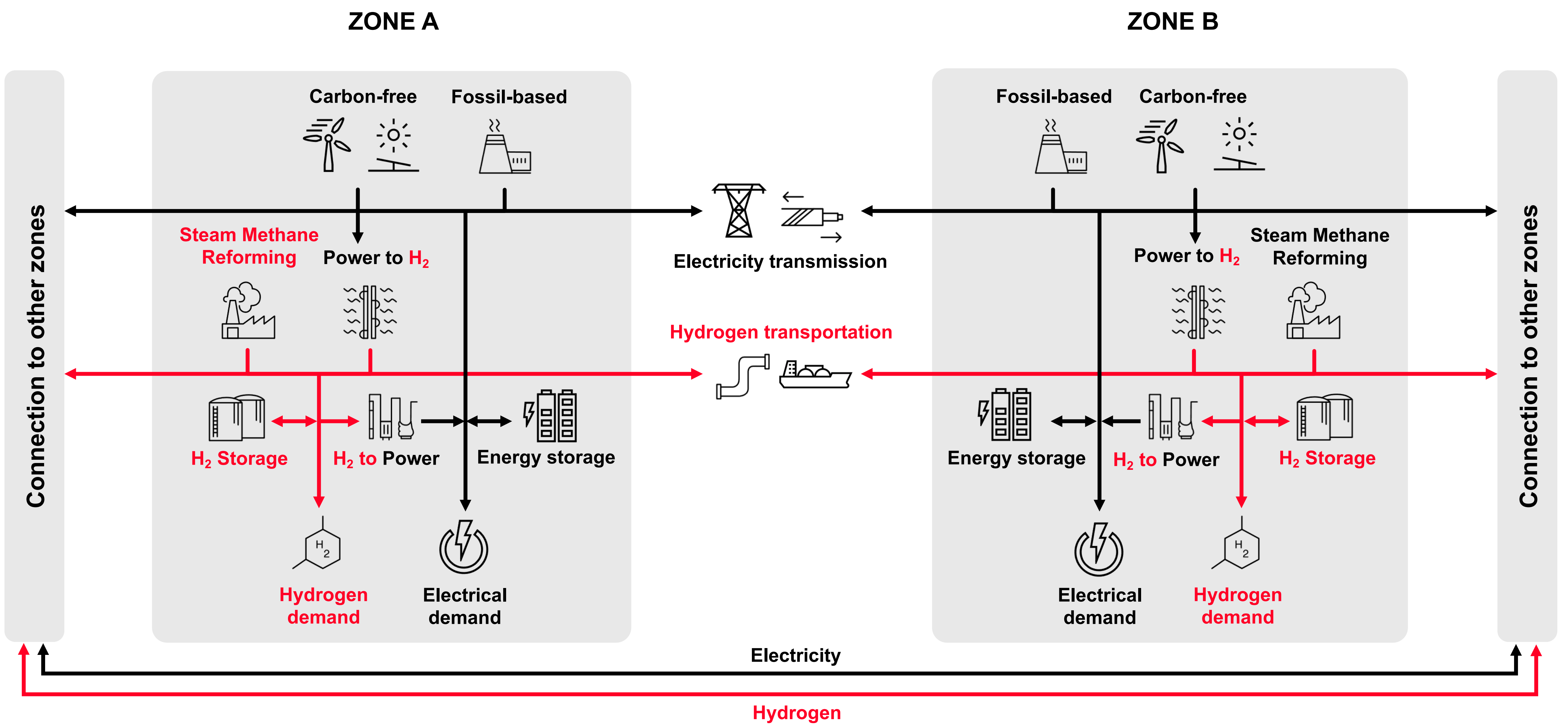

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Model Input Parameters and Outputs

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Variable renewables:
- Initial installed capacity
- Generation profiles (8760) for a climatic year
- Maximum technical potential
- Investment, operation costs
- Lifetime
- Discount rate

Energy storage:
- Initial installed capacity (P and E)
- Investment, operation costs
- Charging, discharging efficiency
- Lifetime
- Charge and discharge rates
- Discount rate

Transmission:
- Zones and topology
- Distances between zones
- Initial installed capacity (NTC)
- Investment, operation costs
- Losses
- Lifetime
- Discount rate

Demand:
- Zonal demand profiles (8760) for different population scenarios
- Demand flexibility (%, time shift)

Hydrogen PtH2 and H2tP:
- Initial installed capacity
- Flexibility
- Efficiency
- Investment, operation cost
- Lifetime
- Discount rate

Constraints:
- Electricity balance per zone
- Maximum asset capacity installed per investment step
- CO_2 emission cap
- Deployment lead times

Other parameters:
- Optimization period
- Investment step
- Sampling (hours : days : years)

Objective function:
- Minimize total net present cost (can be tuned)
- Residual investment value is recovered

Linear optimization

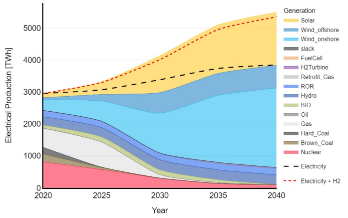
GUROBI OPTIMIZATION

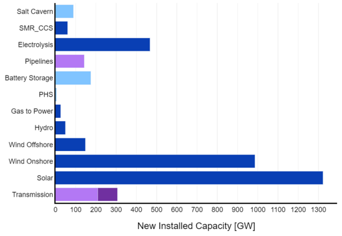
MATLAB

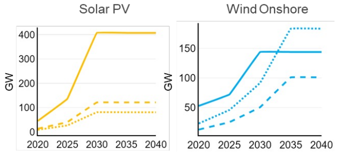
python

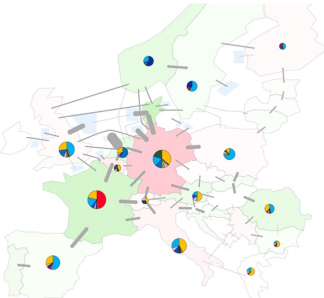
Simulation outputs:
- Optimal capacity expansion per technology, time step, location
- Operational details of all assets (8760) e.g., generation, storage (dis)charge, energy flows, etc.
- Total net present investment and operation cost
- Various sensitivity studies
- N-x security assessment

Graphical outputs:
- Various line, bar and pie charts
- Geographic maps
- Animated time-lapse system operation plots
- Operational details of all assets (8760) e.g., generation, storage (dis)charge, energy flows, etc.









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National CEM Database Development

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Variable renewables:
- Initial installed capacity
- Generation profiles (8760) for a climatic year
- Maximum technical potential
- Investment, operation costs
- Lifetime
- Discount rate

Energy storage:
- Initial installed capacity (P and E)
- Investment, operation costs
- Charging, discharging efficiency
- Lifetime
- Charge and discharge rates
- Discount rate

Transmission:
- Zones and topology
- Distances between zones
- Initial installed capacity (NTC)
- Investment, operation costs
- Losses
- Lifetime
- Discount rate

Demand:
- Zonal demand profiles (8760) for different population scenarios
- Demand flexibility (%, time shift)
- EV charging profile (flexibility)

Weather Year Data:
- Temperature data
- Wind and Solar Data
- Temperature impacts to demands, transmission line rates and generation capacity/profile
- Temperature dependent FOR

Constraints:
- Electricity balance per zone
- Maximum asset capacity installed per investment step
- CO_2 emission cap
- Deployment lead times
- RPS goals by State

Other parameters:
- Optimization period
- Investment step
- Sampling (hours : days : years)

Objective function:
- Minimize total net present cost (can be tuned)
- Residual investment value is recovered

Six principles of resource adequacy for modern power systems

- ✓ Chronological operations must be modeled across many weather years
- ✓ Quantifying size, frequency, duration, and timing of capacity shortfalls is critical to finding the right resource solutions
- ✓ Neighboring grids and transmission are a key part of the RA challenge
- ✓ There is no such thing as perfect capacity.
- ✓ Load participation fundamentally changes the resource adequacy construct.
- ✓ Reliability criterion should not be arbitrary, but transparent and economic.

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