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DOE GMLC Project 1.4.18 “Computational Science for Grid Management”

Computational Framework for Grid Applications

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The future grid needs holistic high-performance analytics

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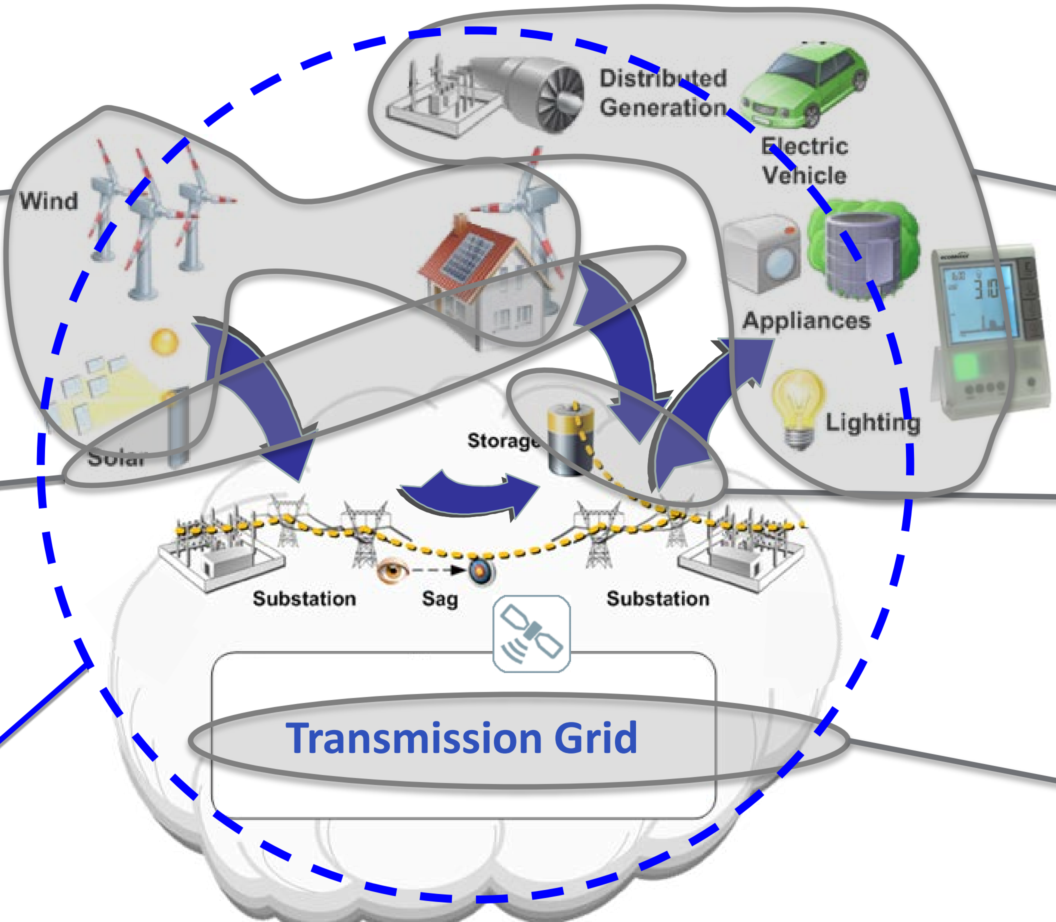
Renewable
(Renewable energy technology, interconnection standards)

Renewable Integration
(Renewable Integration Modeling)



Smart Grid
(Deployment of smart devices, empowering customer involvement and innovation)

Storage and Storage Integration
(Deployment of cost-effective storage)

Transmission Reliability
(Advanced measurement and control technology, e.g., synchrophasors)

Holistic High Performance Analytics

With end-to-end grid in mind, address questions:

- What can we use the data for (what data network is required)?
- How will we address the complexity in order to understand the grid?
- How will we run and control such a complex grid?

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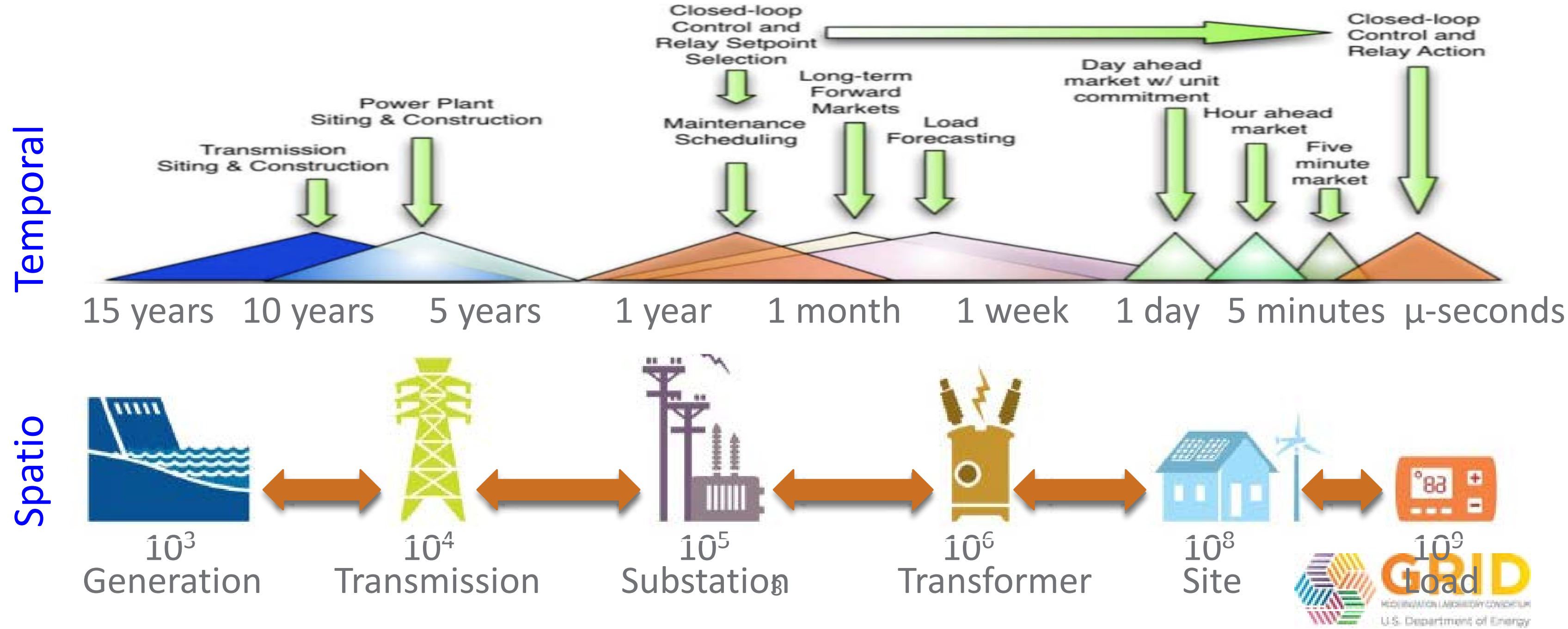
Math and computing challenges in modeling and simulation of the future grid

- Multi-scale spatio-temporal modeling and simulation with stochasticity
  - From micro-second to decades
  - From 10^3 generators nodes to 10^9 end-use devices
- Large-scale data assimilation for state and parameter calibration
  - Petabyte data/year from high-speed sensors and smart meters.
- Modeling of multi-system dynamics and dependency
  - Grid, buildings, communication, gas pipelines, weather/wind/solar, water



Math and computing challenges in optimization and control of the future grid

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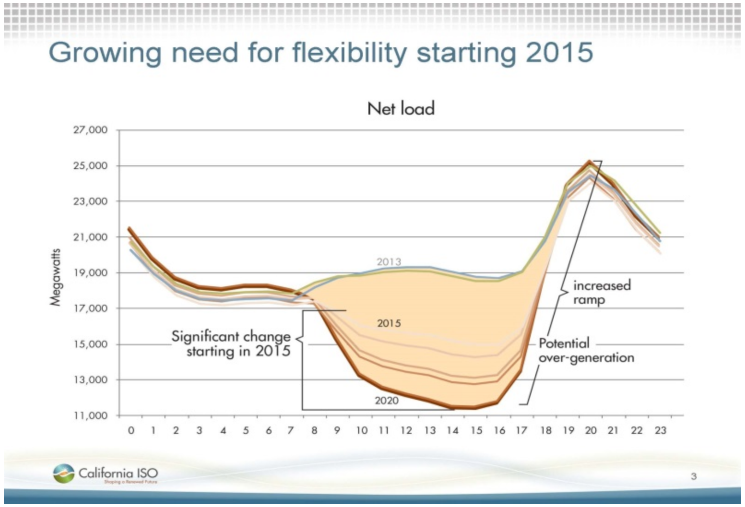
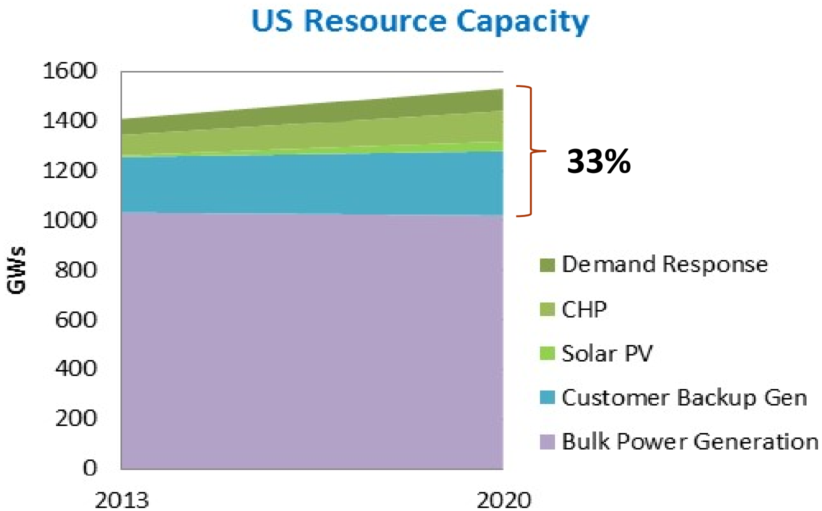
- Dynamic security assessment with uncertainty from renewable and DERs
- Decision support with actionable information from big data from both large-volume measurements and large-scale simulation
- Optimal planning and operation with uncertainty and dynamics
  - Short time horizon for economic dispatch and unit commitment (5 minutes)
  - Long time horizon for transmission planning (>10 years)
- Optimization and control of million devices in a hierarchical architecture





Sources: EIA, EPA, DOE, FERC, Carnegie Mellon, GlobalData

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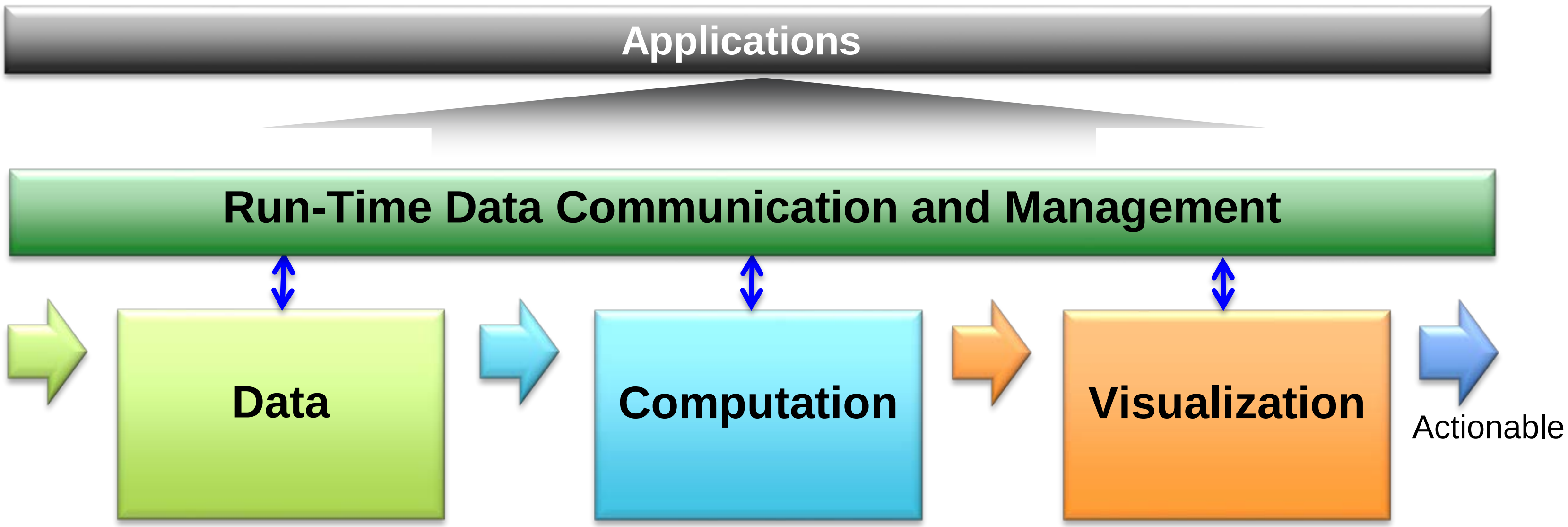
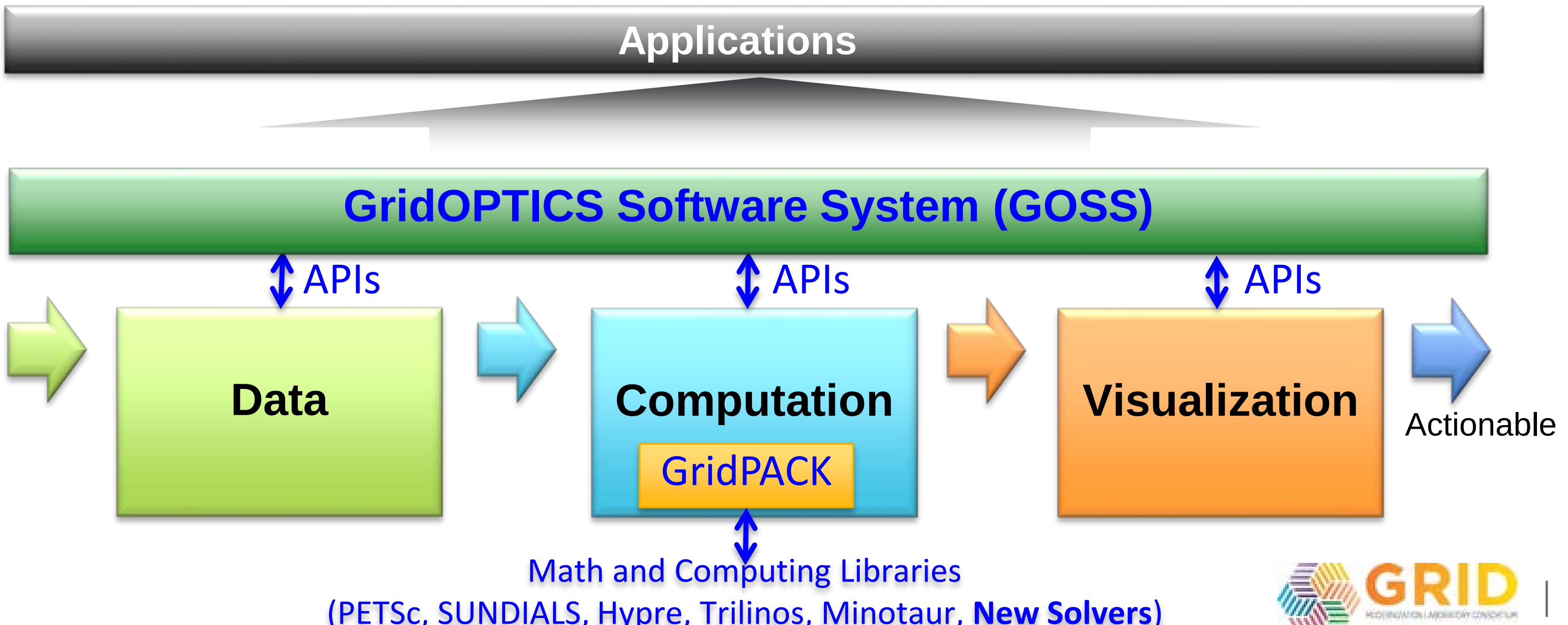
Need for a computational framework and efficient solvers

- A computational framework that enables linking data to computation and software compatibility
- Efficient solvers that handle large-scale diverse problems
- Conceptual Design – GridOPTICS™



Reference implementation with GOSS and GridPACK

- **Requirements**: scalable, portable, extensible, fast, compact
- GOSS – hide implementation details from application developers
  - a middleware using publication/subscription mechanism
- GridPACK – expose math to solver developers
  - a software framework and library designed for grid applications on high-performance computing platform



GridOPTICS Software System (GOSS)

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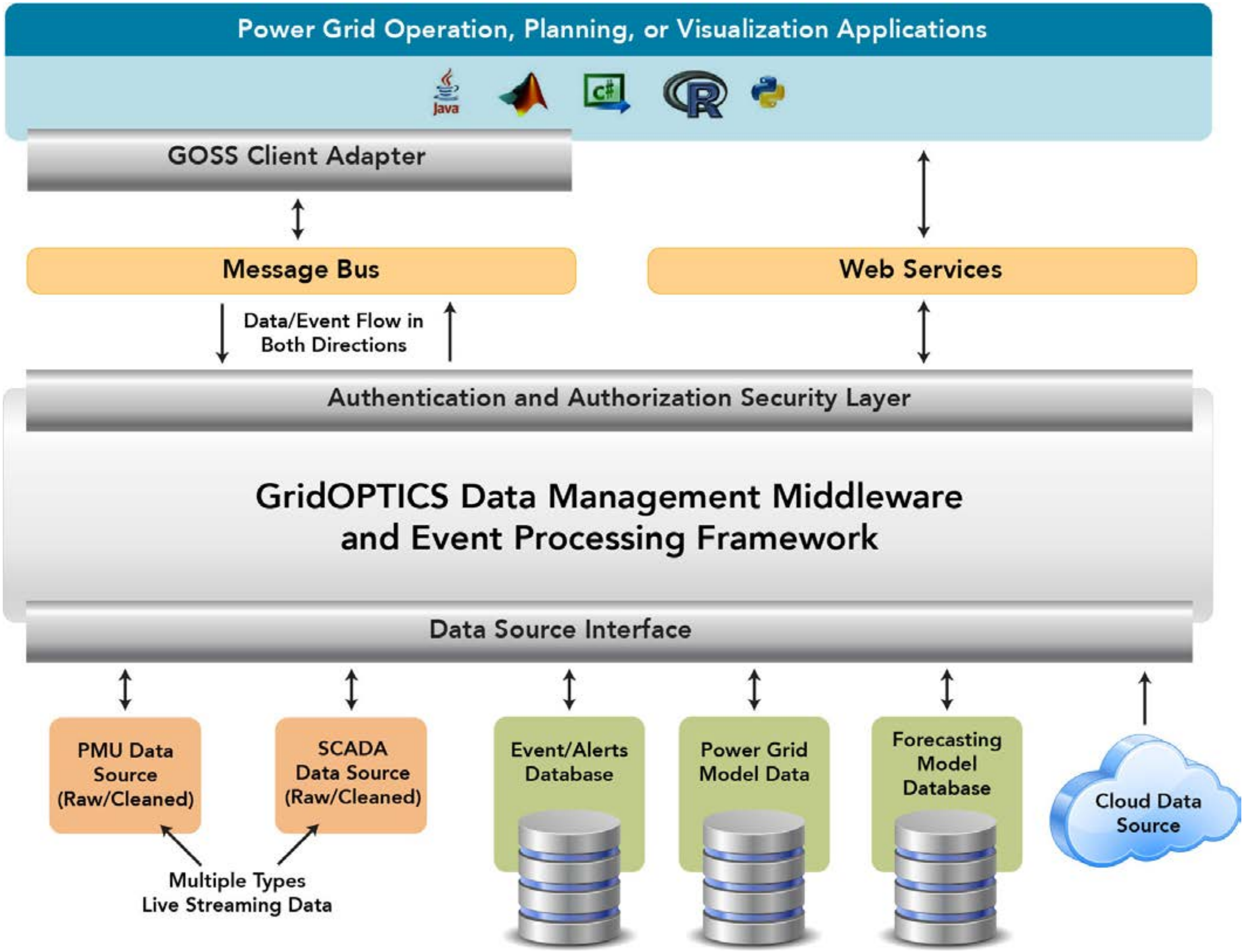

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GridOPTICS GridPACK™

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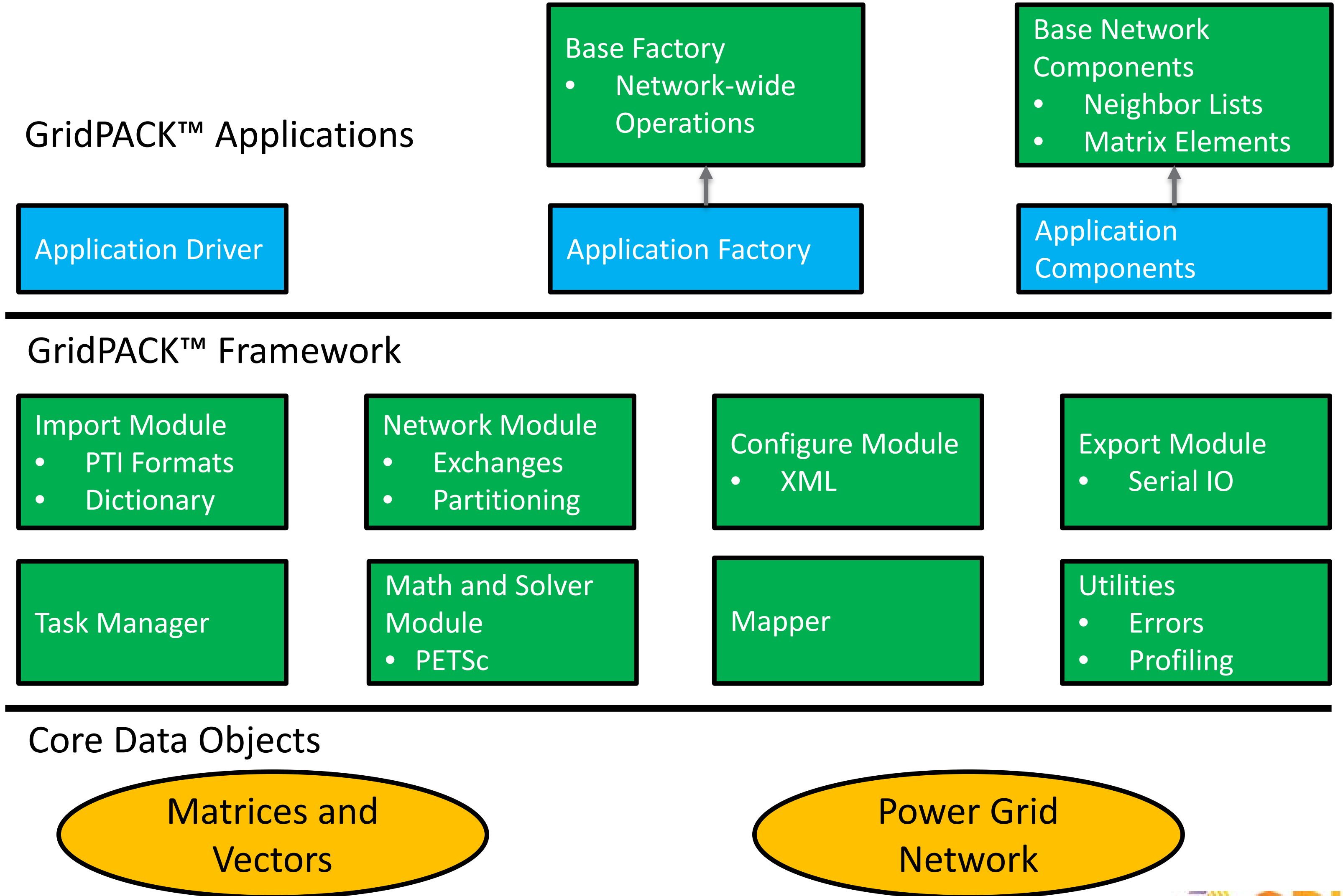


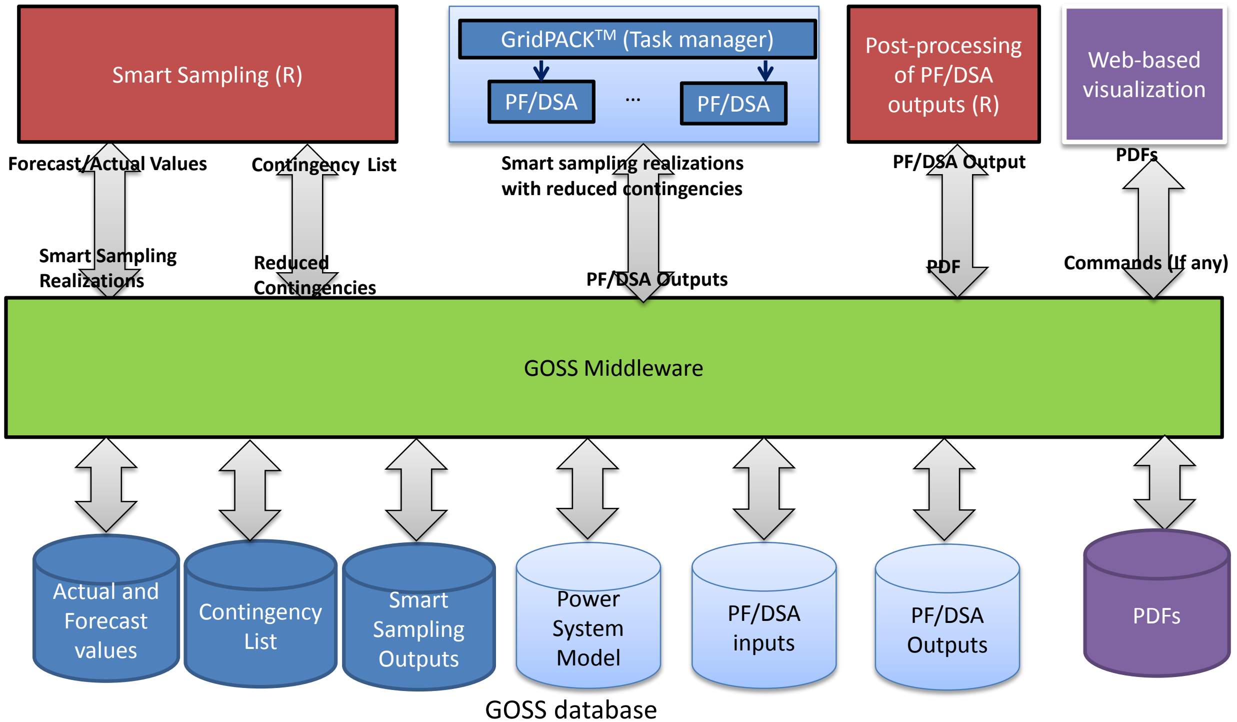
Example use cases to drive the development of the framework and solvers

- Domain drivers:
  - Uncertainty: Renewable, DERs, EVs
  - Dynamics: physical behaviors (e.g. power electronics), market dynamics
  - Optimization: transmission + distribution + …

- Use Case 1: Security-Constrained AC OPF under Uncertainty
- Use Case 2: Dynamic Security Assessment with Uncertainties
- Use Case 3: Optimization under Uncertainty with Transient Security Constraints

Example: Use Case 2 – Dynamic Security Assessment with Uncertainties

- Impact of increasing penetration of renewable generation on stability
- Impact of DERs & consumer participation on system operation & planning
- Optimization of DERs for multiple value streams for the power system



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Questions?