Improving Integrated Control and Adopting New Approaches for Managing Complexity

- **Motivation**
  - Increase interconnections of advanced energy systems
  - More computations are performed at sensor and actuation level
    - How do we control and coordinate such systems?
    - Adopt and adapt new approaches to decision science for coordinated control to occur at large scale

- **Objectives**
  - Derive criteria for assessing sensor effectiveness and system impact
  - Demonstrate effectiveness and reconfigurability of sensors
  - Extend work in sensors to actuation and control system architecture

- **Concept**
  - Focus on what to control, what to optimize (not how to control)
    - Correct and accurate objective functions for each subsystem
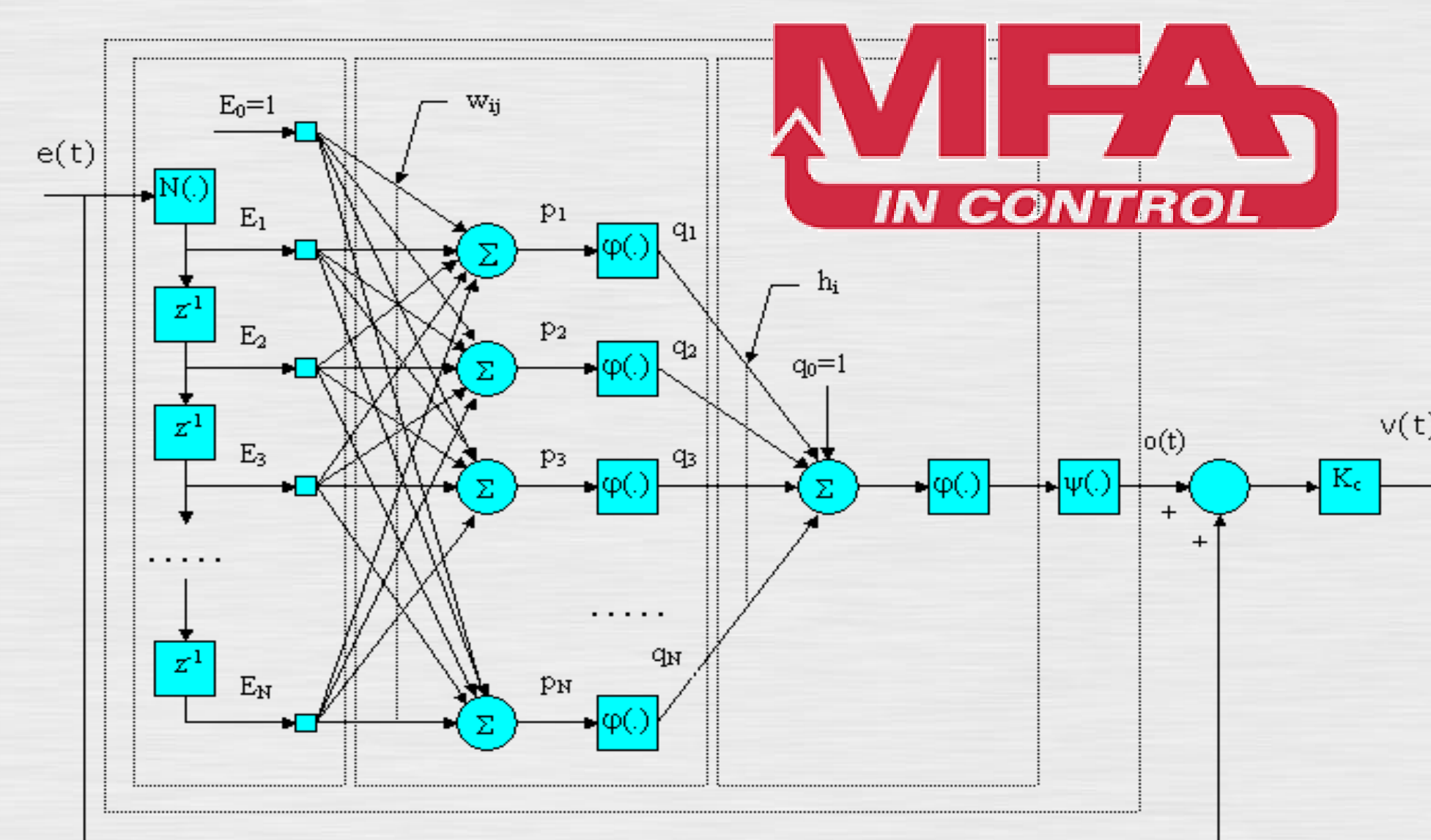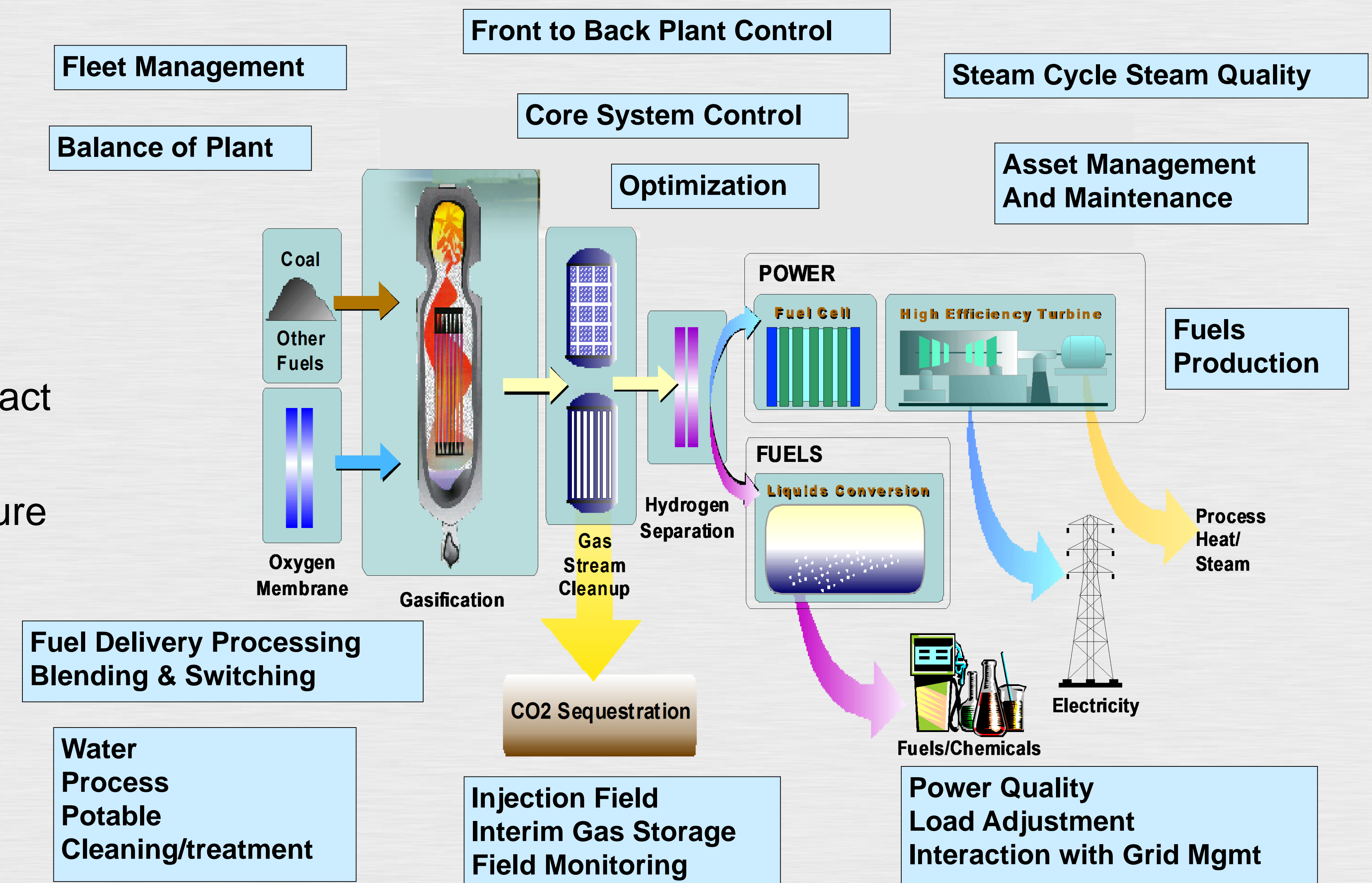   - Better system decomposition

- **Approaches for Control**
  - Centralized
  - Distributed
  - Self-Organizing
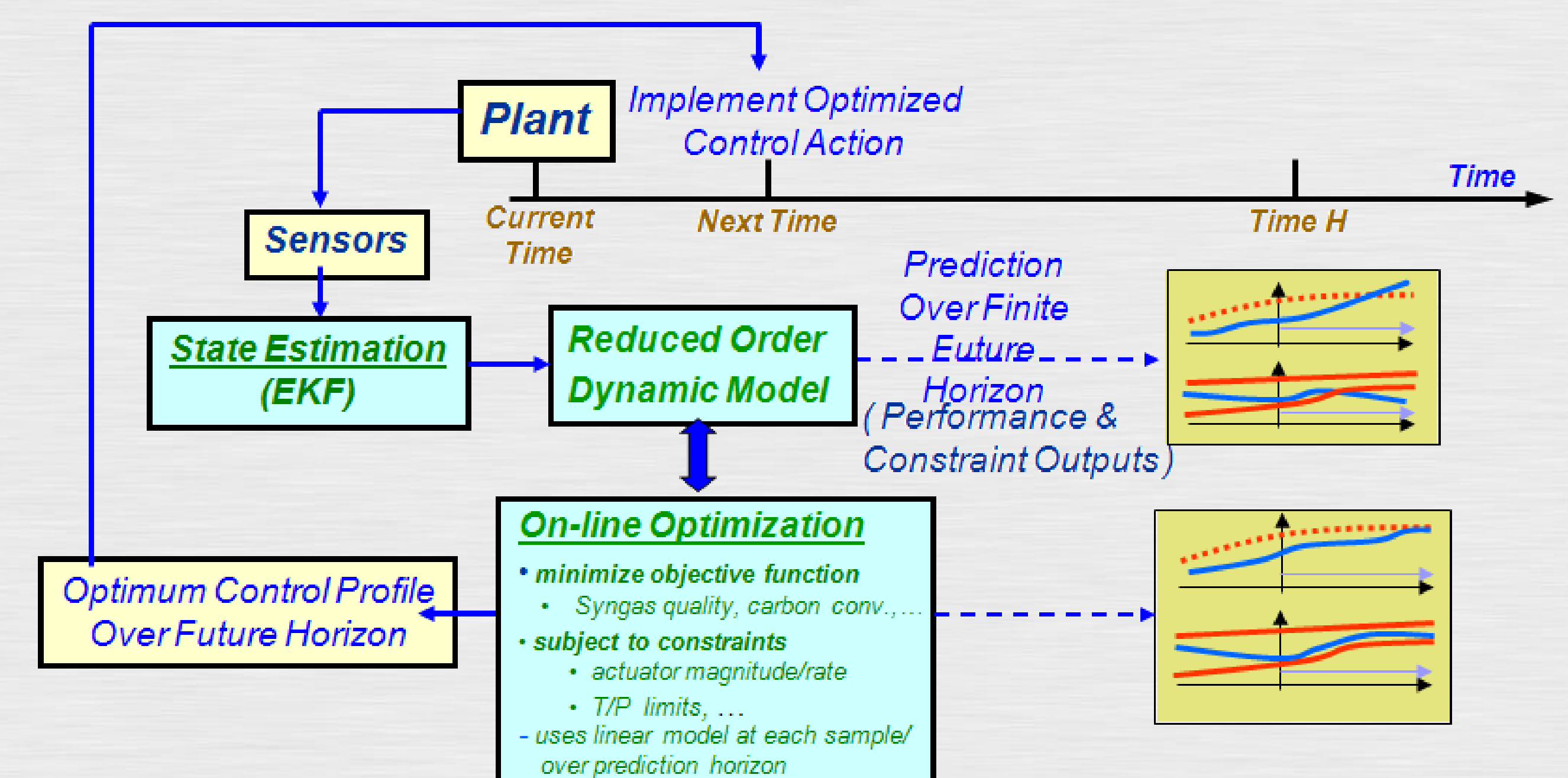
- **Goals for Advanced Process Control are**
  - Seamless
  - Integrated
  - Automated
  - Optimized
  - Intelligent

Space, Scale & Scope of Plant Control

Fleet Management

Front to Back Plant Control

Steam Cycle Steam Quality

Balance of Plant

Core System Control

Optimization

Asset Management And Maintenance

Coal

Other Fuels

POWER

Fuel Cell

High Efficiency Turbine

Fuels Production

FUELS

Liquids Conversion

Hydrogen Separation

Oxygen Membrane

Gasification

Gas Stream Cleanup

Process Heat/ Steam

Electricity

Fuel Delivery Processing Blending & Switching

Fuels/Chemicals

CO2 Sequestration

Water Process Potable Cleaning/treatment

Injection Field Interim Gas Storage Field Monitoring

Power Quality Load Adjustment Interaction with Grid Mgmt

MFA IN CONTROL

MFA – Model-Free Adaptive

**Neural Network for nonlinear control
Overlay or replacement for PID
Control at lowest levels**

Model Predictive Control (MPC)

Plant — Implement Optimized Control Action

Sensors

Current Time — Next Time — Time H — *Time*

State Estimation (EKF) — *Reduced Order Dynamic Model* — Prediction Over Finite Future Horizon (Performance & Constraint Outputs)

Optimum Control Profile Over Future Horizon

On-line Optimization
- minimize objective function
  - Syngas quality, carbon conv.,...
- subject to constraints
  - actuator magnitude/rate
  - T/P limits, ...
- uses linear model at each sample/ over prediction horizon

(Extended Kalman Filter) How to Improve?