

Intelligent Software Agents For Control and Scheduling of Distributed Generation

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Presentation Agenda

- ◆ ***What is:***
 - *a Distributed Energy Resource?*
 - *an Intelligent Software Agent?*
- ◆ ***CEC-PIER Project(s) Background***
- ◆ ***Agent-Based Approach to DER Asset Scheduling***
- ◆ ***Demonstration Software***
- ◆ ***Summary***

Distributed Energy Resource (DER)?

CADER (California Alliance for Distributed Energy Resources) defines a Distributed Energy Resource (DER) as:

“... low or zero polluting, highly efficient electrical generation and storage technologies...often remotely located, they can be installed near or on a customer’s site. “

We have expanded this definition to include any asset that can be “dispatched” so long as it directly or indirectly affects site electric load. Thus DER can include:

- distributed generation,
- curtailable loads,
- various demand-side management technologies

Intelligent Software Agents?

An *agent* acts on behalf of another....

An *Intelligent Agent*

- Executes autonomously & operates in real-time
- Communicates with other agents or users
- Able to exploit domain knowledge
- Exhibits goal-oriented behavior

An *Agency*:

- Multi-agent systems (a.k.a. Agency)
- Communication and collaboration amongst agents enables distributed processing
- Agent complexity is kept low while agency intelligence is high
- Agent-based solutions are more open and extensible

CEC-PIER Project(s) Background

Circa 1997, the California Energy Commission (CEC) recognized that:

- Distributed Energy Resources (DER) could play a significant role in the impending CA competitive energy markets.
- Making use of DER technology on a large scale requires control and scheduling of large numbers of distributed assets -- yet the centralized decision and control paradigm employed in the electric power industry was ill-suited to this task.
- Distributed processing/decision-making provided by intelligent software agent technology was a potential solution.

CEC-PIER Project(s) Background

California Energy Commission (CEC) - Two Public Interest Energy Research (PIER) Program Projects

- “Intelligent Software Agents for Control and Scheduling of Distributed Generation” (CEC-PIER 500-98-040)
 - ★ started in July 1998, completed February 2001
 - ★ demonstrated viability of the agent-based approach
 - ★ developed demonstration software
- Follow-on contract (500-00-016) is currently underway and provides for refinement in response to marketplace changes and a demonstration field test.

Why Use Intelligent Software Agents?

DER scheduling / aggregation is amenable to an agent-based solution because:

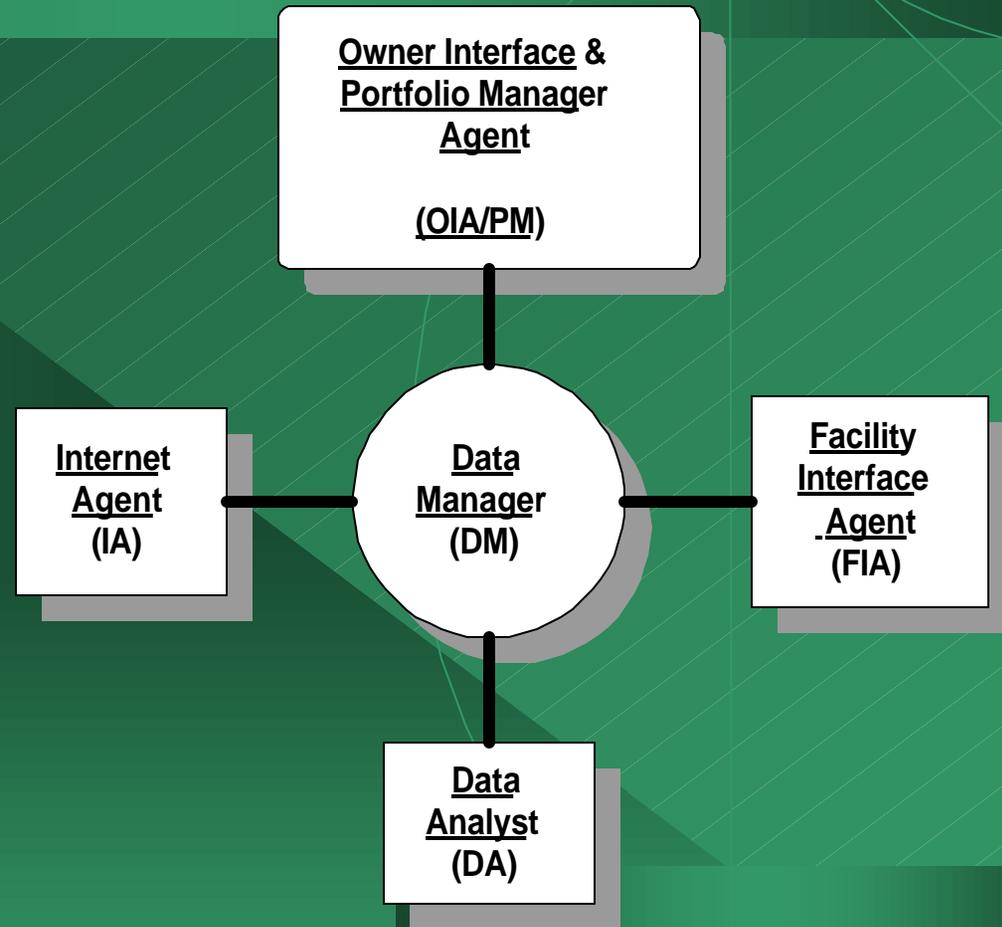
- DER benefits are application & location specific requiring local knowledge and decision-making
- An open / extensible solution is needed
- Aggregation of loads/supplies requires communication / collaboration between sites
- Information comes from a variety of disparate sources
- A dynamic distributed decision-making environment exists but in most instances there is insufficient local expertise consistently available for day-to-day decision making

Agent/Agency Market Opportunities

- ◆ **Conventional tariffs**
 - Local utility bill reduction in campus environments
- ◆ **Conventional interruptible tariffs (UDC)**
 - Automate notification and implementation processes.
 - Single site and campus environments
- ◆ **Customer demand bidding programs (UDC)**
 - Internet-based bidding and notification (CA utilities)
 - Automate notification and implementation processes.
 - Single site and campus environments
- ◆ **“Re-regulated” marketplaces (ISO)**
 - Energy markets (day-ahead, hour-ahead)
 - Ancillary services markets (day-ahead, hour-ahead)
 - Aggregation of DER across multiple sites or multiple facilities in a campus.

Intelligent Agency

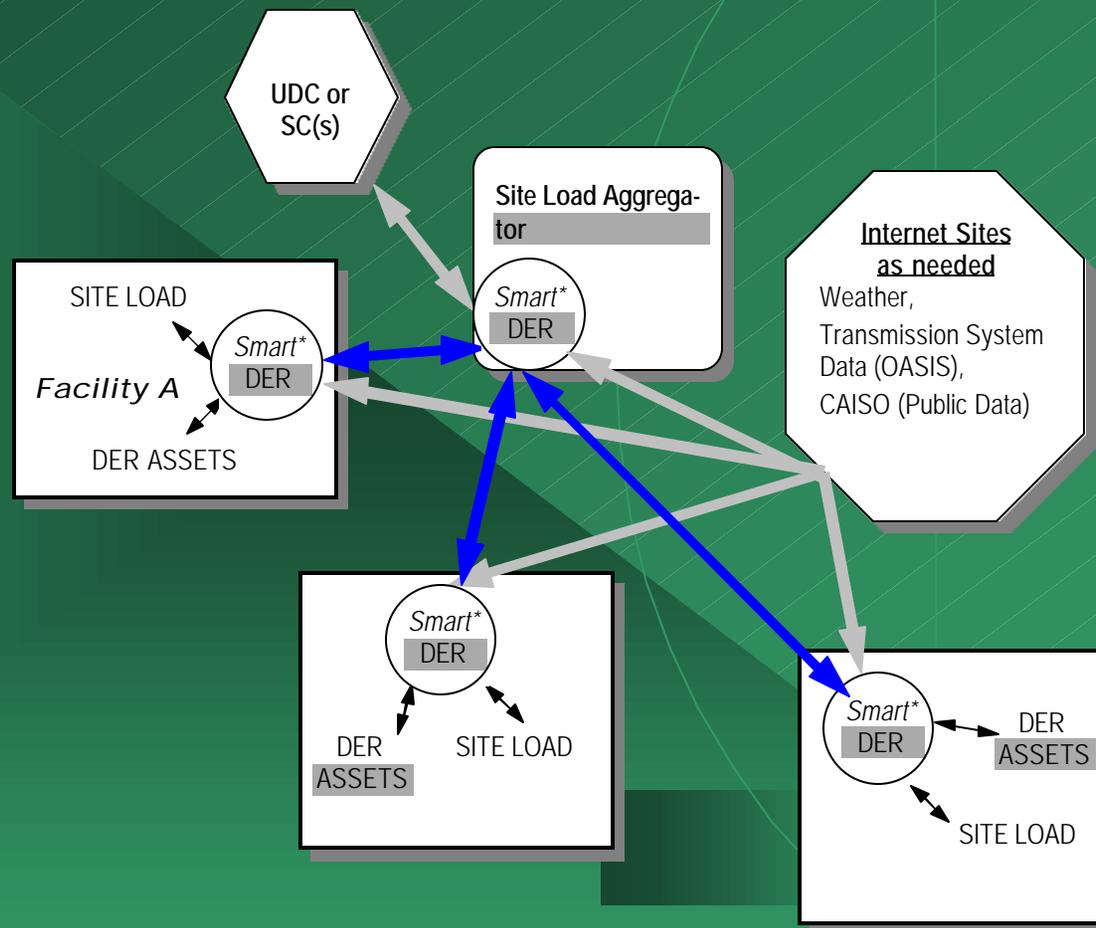
- ◆ Our task analysis yielded five independent & collaborating agents, each devoted to an aspect of the scheduling / aggregation process
- ◆ Java based code & Internet-based communications
- ◆ Individual agents can be located on the same or multiple platforms
- ◆ Individual agent complexity and functionality can vary widely
- ◆ Secure communications between agents



Aggregation for Competitive Market Response

Agencies --

- Collaborate to aggregates DER assets across multiple sites
- Load aggregator hosts the Portfolio Manager and actively runs the auction process
- Local agencies develop and implement DER operating schedules in response to dynamic pricing or DSM signals.



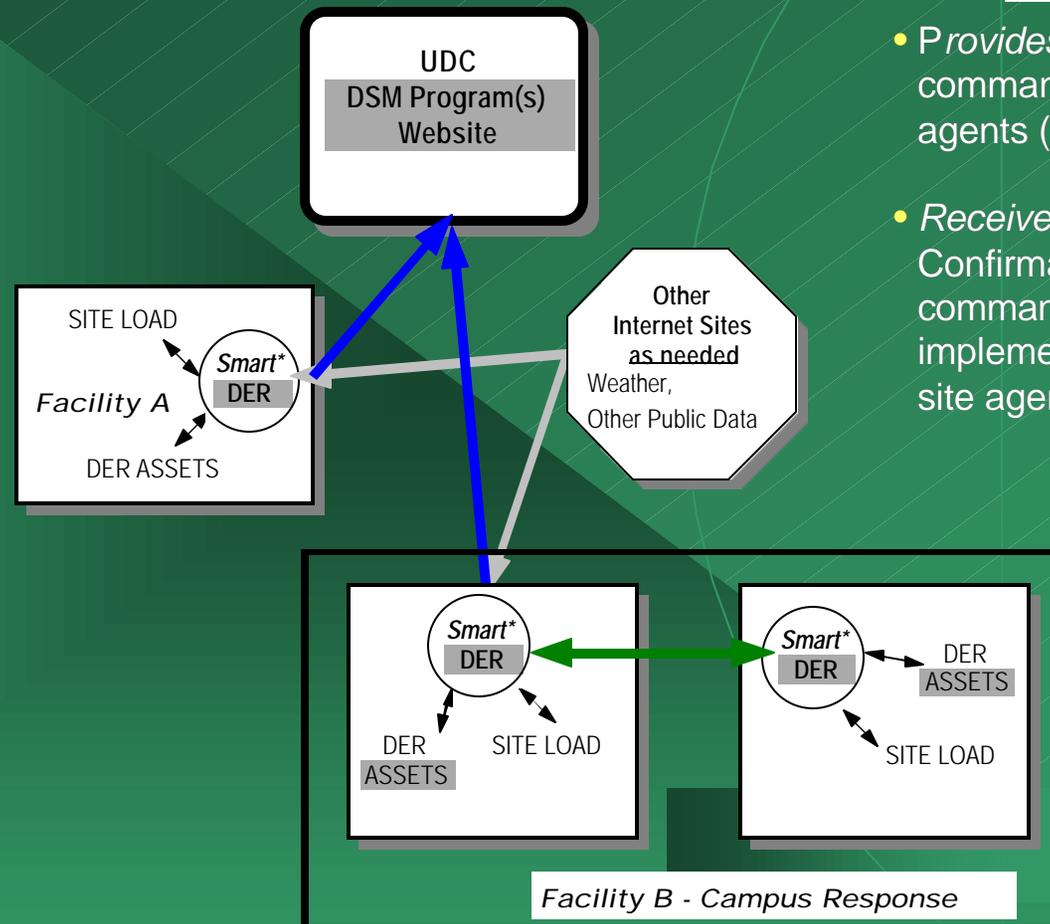
Agent-based Coordination of DSM Program Response

UDC Website

- Provides: Curtailment commands to on-site agents (on-request.)
- Receives: Command Confirmation and command implementation from on-site agents.

Agency --

- Retrieves curtailment commands, confirms curtailment command receipt .
- Implements curtailment actions based on local constraints/inputs, weather etc. or directs user to implement using a local GUI.
- Confirms curtailment implementation

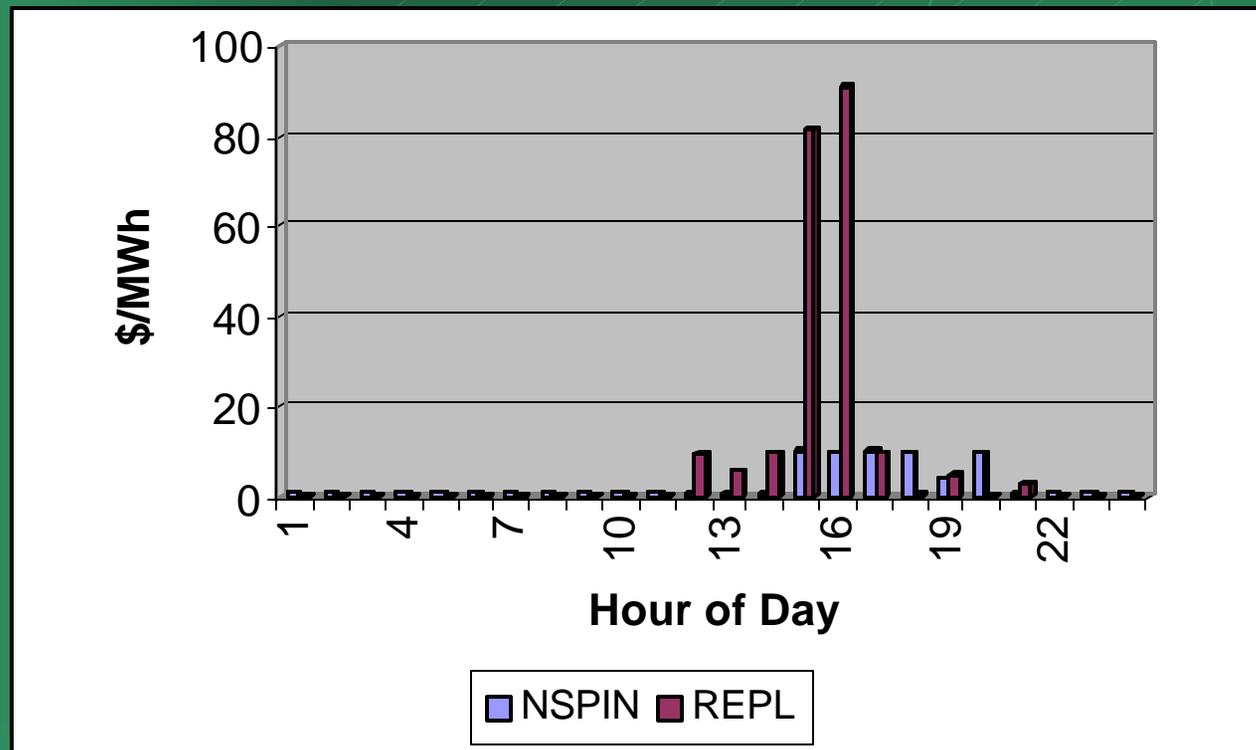


Demonstration Software

- ◆ **Demonstration software was developed to facilitate technology transfer as part of the initial CEC-PIER project.**
- ◆ **Demonstrates the multi-agent auction based resource allocation approach**
- ◆ **Demo Software Uses:**
 - Price data for 1999 calendar year
 - San Diego area weather data & generic commercial, industrial and residential load profiles
 - A single complete agency per PC (demo purposes)
 - Microsoft Access DB, which limits it to the Windows OS

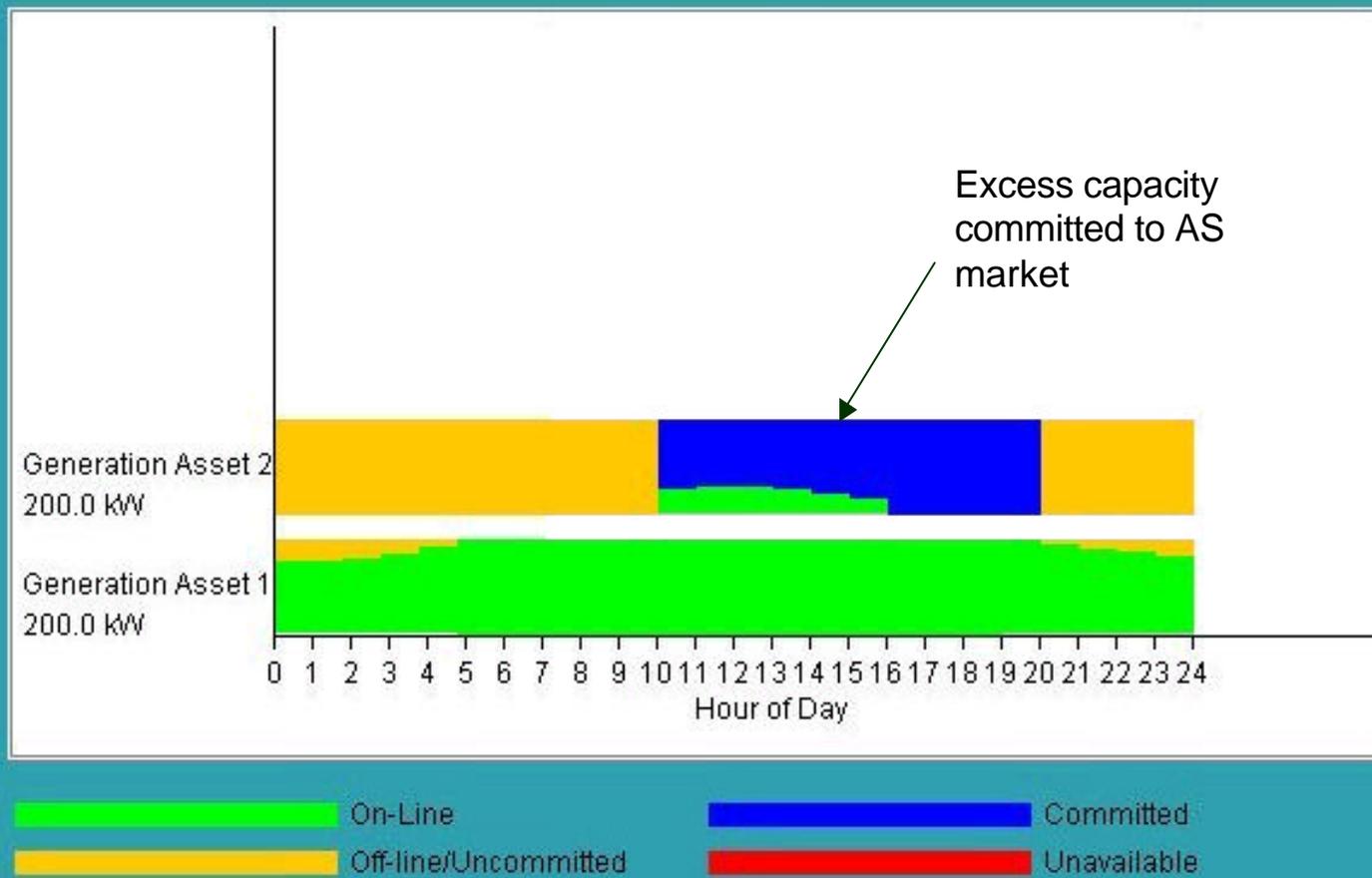
Demonstration Day Pricing - 9/28/99

Ancillary Services Pricing



Asset Status/Schedule - 9/28/99

400 kW Installed Capacity - Large Commercial Load Profile



Agent-based Approach Benefits & Efficiencies

- ◆ Integrates local site knowledge & associated inputs.
- ◆ System is easily expanded - new sites automatically register with the auctioneer agent (Portfolio Manager) - no programming or algorithm changes are needed.
- ◆ Any site can be configured to manage the portfolio
- ◆ Local user provides basic system constraints but once configured there is little in the way of routine decision input from on-site personnel (if allowed).

Summary

- ◆ Opportunities continue to exist for DER involvement in both California and elsewhere.
- ◆ Agent technology provides an open and extensible architecture that can be readily adapted to the changing marketplace.
- ◆ CEC-PIER project results have shown that intelligent agent technology is a viable DER scheduling tool.
- ◆ The demonstration project currently underway will further demonstrate the applicability and benefits of the agent-based approach.
- ◆ The demonstration project is soliciting demonstration site participation both in and out of California.