

An Analysis of Contracts and Relationships between Supercomputing Centers and Electricity Service Providers

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Grid Integration Team

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Background

- Electricity Service Providers (ESPs) face challenges from grid transitions that are currently taking place
 - Electricity production is transitioning to renewable energy sources
 - Peak power demands are growing due to infrastructure electrification
- To address these challenges, ESPs could increase production capacity
 - Low investment efficiency
- Alternatively, options also include influencing consumption behavior
 - Demand charges, variable tariffs, Demand Response approaches
 - Does not require grid investment
 - Building-to-grid integration (B2G)

Supercomputing Centers in B2G

- Supercomputing Centers (SCs) have significant electricity consumption
 - Four centers in the U.S have loads above 10 MW (2013)
 - Same centers have a theoretical peak load of 60 MW (!)
- Larger centers
 - Influence local grid operation and stability
 - Are expected to increase their consumption in pursuit of exascale computing
- Interesting in a B2G context

Related Research

- Demand Response and Demand-Side Management
 - Concepts
 - Potential
 - Programs
 - Adaptation
- Demand Response in the context of Data Centers
 - Energy-aware scheduling
 - Virtual machine placement
 - Capacity planning
 - Interdisciplinary approaches
- Contracts between SCs and ESPs
 - Programs and initiatives for B2G of SCs

Our Approach

- To date, very little is known about details of power procurement contracts in larger SCs
- Accordingly, our approach focuses on the relationship between SCs and ESPs
- Goals of our work
 - Alleviate ESP challenges
 - Address grid evolution from an SC perspective
 - Reduce cost of operation with respect to electricity consumption in SCs
- We use a qualitative survey approach
 - Addresses the assumed heterogeneous nature of power procurement contracts
 - Questions in a quantitative study might hide specific sub-details

Survey

- Target was large SCs (Top 50) in Europe and United States
- The survey also included one smaller site
 - #167 on the TOP 500 List (2015 numbers)
 - To capture characteristics unique to smaller sites
- Participation from 10 sites
 - 30% coverage of the Top 50 SCs in Europe and the United States

Survey Questions

- We asked SCs questions covering the following topics
 - Contract negotiation responsibility
 - Pricing structure
 - Mandatory obligations towards the ESP
 - Voluntary services provided towards the ESP
 - Perspective on future relationship
- The full questionnaire will be available when paper is published

Analysis

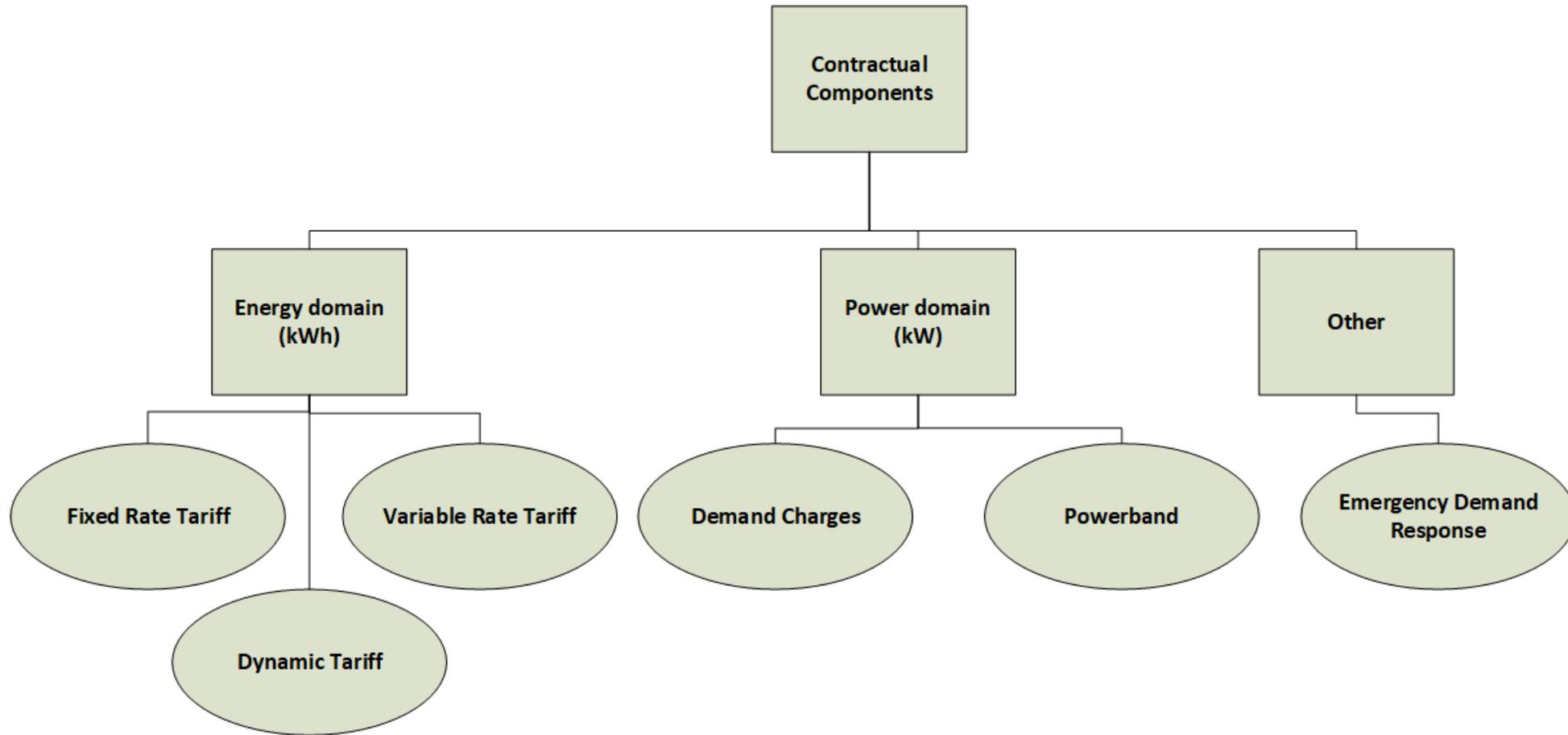
- Survey results were used to conduct analysis on
 - Contract typologies
 - Parties responsible for contract negotiation
 - Interaction between SCs and ESPs
- Results of the analysis used to present suggestions for future directions of SCs in the context of power procurement and ESP involvement

Analysis

Contract Typology

- Contracts where found to be (very!) heterogeneous
 - Not immediately comparable
- We proposed a contract typology to provide
 - Common terminology
 - Classification of contractual components

Contract Typology



Contract Typology

- Applied to survey results:

	Demand Charges		Tariffs (kWh-domain)			Other
	Demand Charges	Powerband	Fixed	Variable	Dynamic	Emergency DR
Site 1	✓		✓	✓		
Site 2	✓	✓	✓			
Site 3	✓		✓			✓
Site 4	✓				✓	
Site 5	✓	✓	✓			
Site 6		✓	✓			
Site 7	✓	✓			✓	✓
Site 8					✓	
Site 9	✓	✓	✓	✓		
Site 10			✓			

- Many sites subject to Demand Charges and Powerband
 - Both impose economic penalties on power fluctuations (kw-based)
- Variable and Dynamic Tariffs present in 50% of the sites
 - Time-varying electricity prices (kWh)
 - No measures implemented to take advantage
- Emergency DR implemented in 20% of the sites
 - Due to legislation

Responsible Negotiating Parties

- Survey results used to identify parties responsible for negotiating electricity procurement
- Purpose is to map roles into actions for SCs
 - Direct negotiation responsibility
 - Indirect negotiation responsibility
 - No negotiation responsibility

Responsible Negotiating Parties

- Survey identified three types of negotiation responsible parties on the consumption side
 - Supercomputing Centers
 - Internal actors
 - When Supercomputing Centers are part of a larger facility
 - Contracts negotiated for entire facility
 - Supercomputing Center representatives might be involved in this negotiation.
 - External actors
 - Typically public procurement
 - An example is the United States Department of Energy
 - Negotiates power procurement contracts across a wide range of (public) facilities
 - Supercomputing Center representatives not involved

Observations

- Survey used to shed light on the interaction between SCs and their ESP
- Demand charges and powerbands influence operation to a degree
 - General awareness post survey
- Impact from variable/dynamic tariffs and demand response minimal
 - Economic incentive small compared to facility investment
 - Not sufficient to compromise operation
- Survey found that “being good neighbors” has an effect
 - Notify ESP of events with significant influence on power consumption
 - Maintenance, benchmarks...
 - Communicated manually (by phone)
 - Some by contract – others as part of a good business relationship or societal concerns

Recommendations

- Generally: Know your contract and adjust operations to comply
 - Job scheduling (CPU/memory intensive)
 - Facility planning (offices, cooling)
 - Energy efficiency
- Direct negotiation responsibility actions
 - Active involvement with ESP
 - Proactive contract specification to mitigate economic impact on operation
- Indirect negotiation responsibility
 - Get involved!
- No negotiation responsibility
 - Engage ESP – Learn impact

Conclusion

- Economic incentives do not animate SCs
 - Investment in SC requires full output
- Consequently, variable/dynamic tariffs and Demand Charges have limited potential
- Focus on power – demand charges and powerbands
- Focus on energy efficiency – reduce operational costs
- We are seeing results from ESP interaction
 - Ability to influence contracts
 - Consumption data used in negotiation
- Consider contingency planning
 - Collaboration with ESP
 - Especially true for direct/indirect negotiation parties