The Potential for Demand Response to Integrate Variable Energy Resources with the Grid

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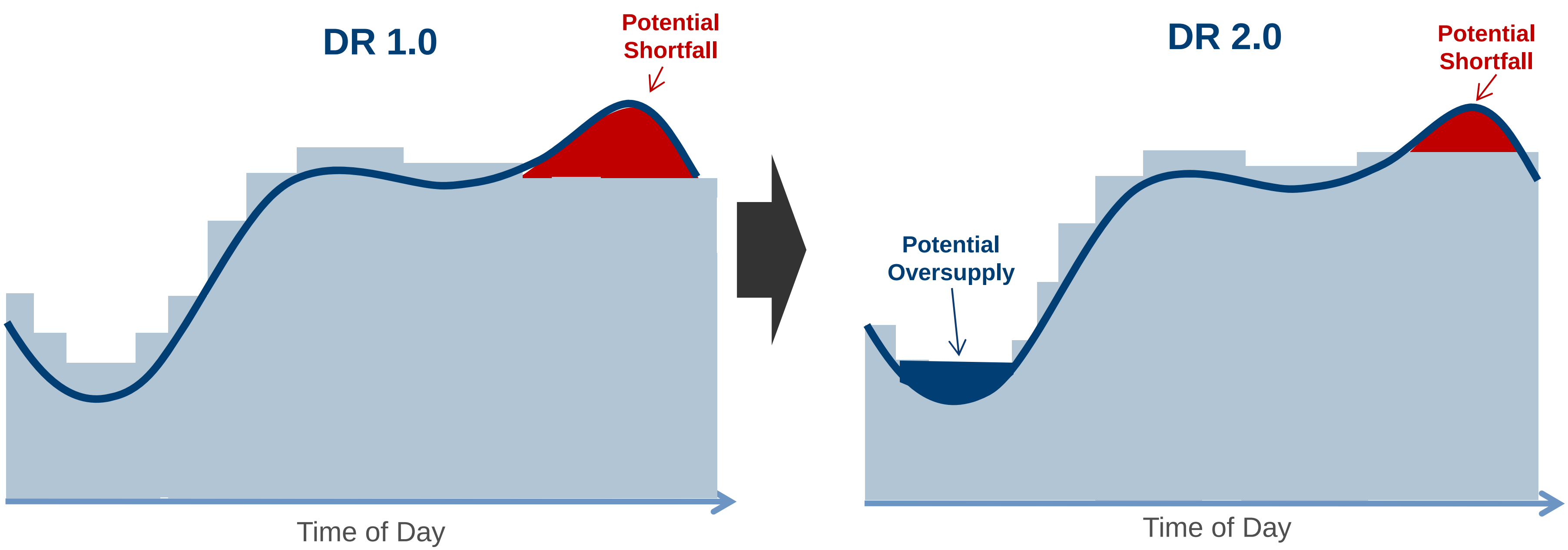
Presentation Overview

- Demand response summary
- Discuss project objectives and task activities
- Identify variable energy resource (VER) growth in the West, highlight associated challenges, and introduce mitigation options (including demand response)
- Demand response resource assessment
  - Potential results
  - Program options
  - Economic assessment framework
- Findings and recommendations

Demand Response: It is a transforming resource

- Historically, demand response (DR) was used to clip peaks in order to ensure system reliability and mitigate price spikes that occurred on an in-frequent and predictable basis
- Now DR is being considered for a wide variety of applications to balance reliability as a result of grid conditions (shortfall, oversupply, frequency) that are increasingly occurring on a frequent and un-predictable basis



Project Objectives

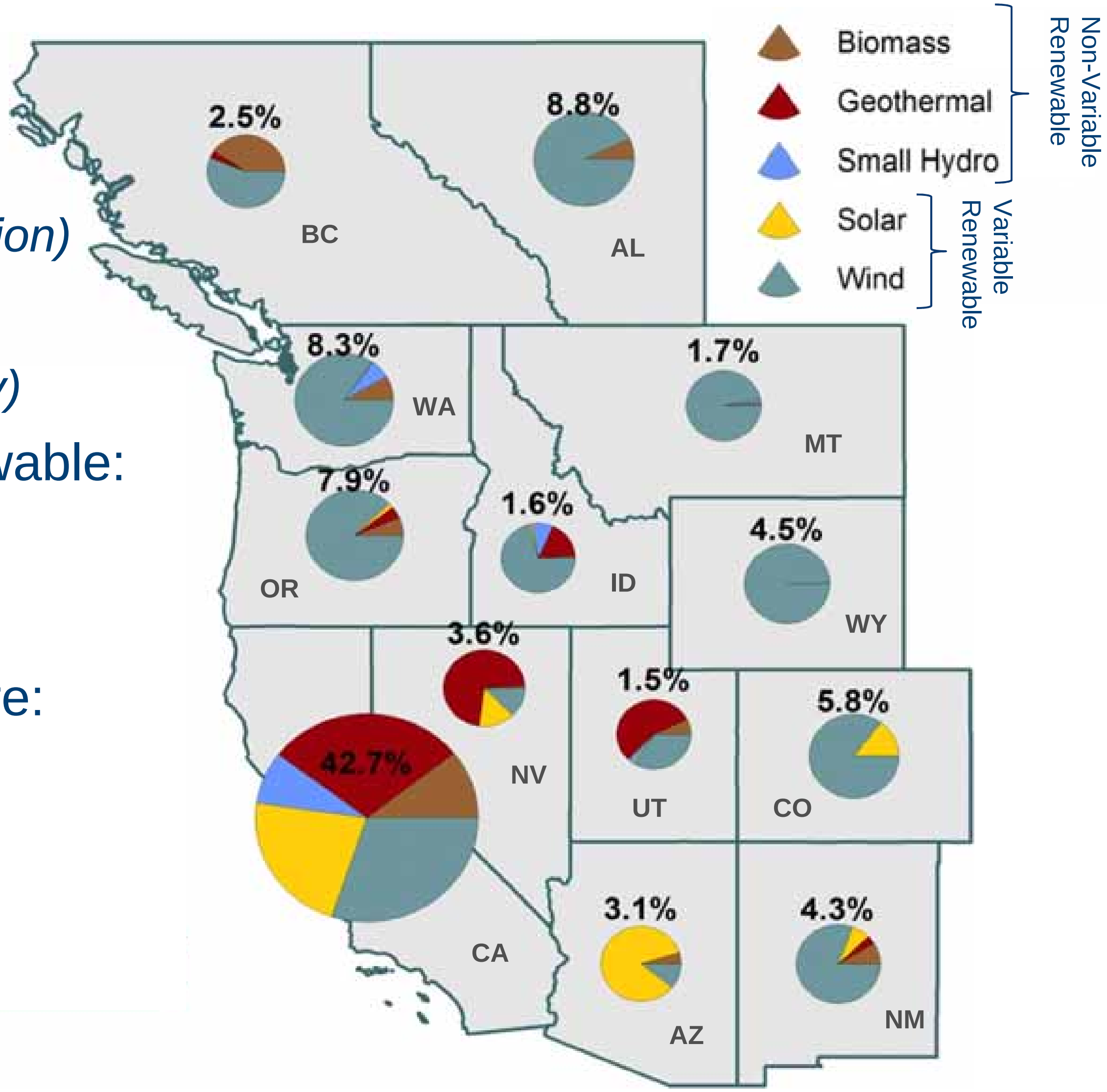
- Identify the role that Demand Response (DR) can contribute to mitigate the challenges associated with a growing VER in the Western Interconnection
- Identify DR programs that can meet the needs of VERs
  - Describe the various market constructs for which these programs serve
  - Define how these programs would be administered
- Develop a framework that will enable more state/province-specific assessments of DR potential for 11 states and 2 provinces
  - Different market environments will require different implementation approaches
  - This is a planning study and is not intended to be an implementation guide

Major Contributors to VER: Solar and Wind Resources

Renewable Energy Shares in the Western Interconnection by 2022

- Overall Renewable:
  168,987 GWh
  (16.6% of total generation)
  61.25 GW
  (22.4% of total capacity)
- Wind Share in Renewable:
  91,253 GWh (54%)
  34.7 GW (57%)
- Estimated Solar Share:
  23,658 GWh (14%)
  19.7 GW (32%)

Assumed capacity factors by resource type:
- Wind-30%
- Solar-13.7%



Source: WECC 2022 PC1 Common Case document; July 25, 2013

Challenges with a Growing VER Portfolio

Variability in VER production	Aggregate output form renewable energy resources is drastically changing system load availability
Forecast uncertainties	All types of forecasts (wind and solar) are subject to inaccuracies
Ramping characteristics	VERs tend to have large and very steep and rapid ramps that are difficult to forecast
Over generation from VERs	Wind resources are likely to be more abundant at night (particularly in wind-rich-rich regions such as PNW and mountain states) during times of limited demand, leading to over-generation and thus grid reliability challenges

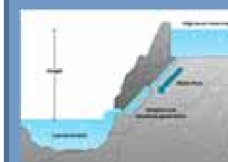
These challenges are typically addressed by "backfilling" the renewable resource with different types of generation or storage options, including Demand Response

There are several options to mitigate the effects of VER but no one “silver bullet” solution

Traditional Generation
gas turbines, coal plants



Centralized Storage
pump storage hydro, compressed air, battery



Distributed Storage
water heaters, thermal storage, process loads, EVs




- The magnitude and economic viability of all options should be assessed
- Interstate transfers should also be assessed to correct load imbalances caused by VERs
- Demand Response works within the Distributed Storage set of options

DR 2.0 has the potential to mitigate the effects of VER

- But DR needs to be fast, swift and predictable
  - Customer loads must be equipped with automation equipment
  - Customer loads must be available 24x7 year round
  - Customer loads must be measured on a frequent basis
  - Customer loads must be capable of moving in both directions
- Different DR product types are needed to address VER integration challenges
  - Contingency
  - Regulation
  - Load following
- Existing DR programs can be repurposed to meet the new challenges
  - Legacy utility DR programs (DLC, Interruptible, Load Aggregator)
  - Ancillary services with RTOs (ERCOT, PJM)
  - Fast DR and load following pilots (PG&E, BPA, Hawaiian Electric)

Demand Response Potential Methodological Approach

Establish baseline end-use load characteristics

↓

Determine technical potential

↓

Determine achievable potential

↓

Develop DR programs and approaches for VER integration

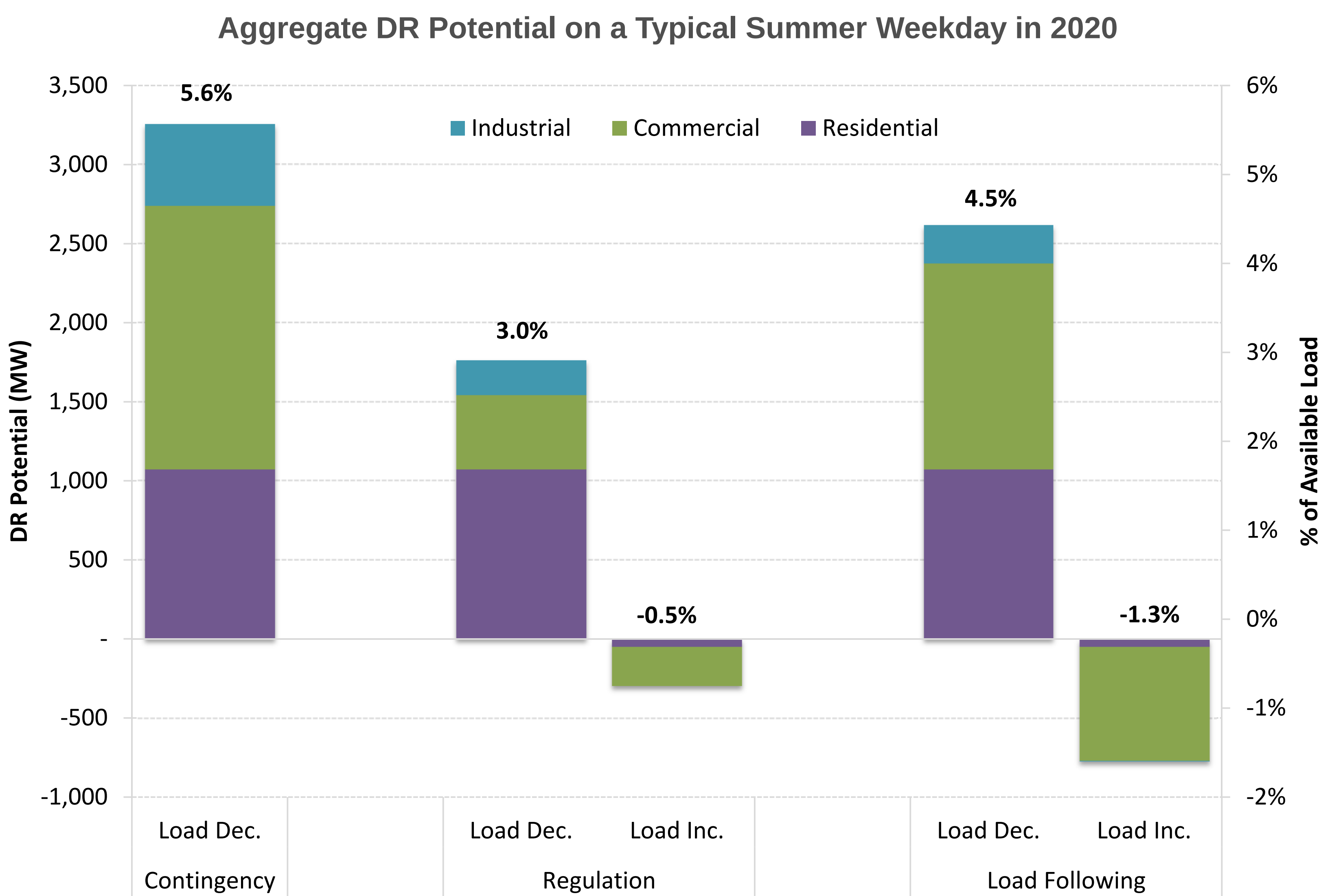
↓

Determine economic potential of the DR programs

DR Potential Analysis Framework

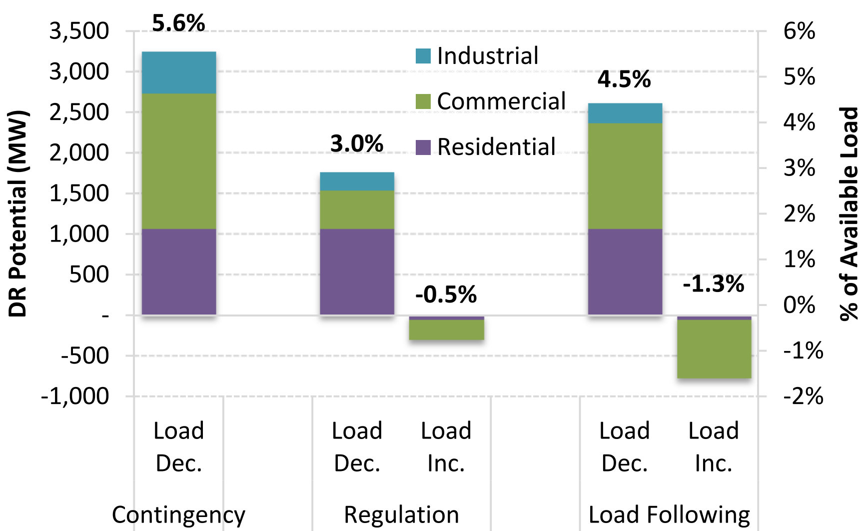
Foundation: End-Use Data	Develop 8760 (weather normal) End-Use Load shapes by segment, building-type, end-use, and census region
Step 1: Customize Load Shapes	Create state/province level segment and end-use level shapes based on mix of building-types in that state/province
Step 2: Develop Baseline Forecast	Unitize all 8760 shapes by state/province, sector, segment and end use; scale appropriately using control totals over the forecast horizon
Step 3: Apply Factors	Apply multiple factors (technical & achievable) to estimate the portion of load available for DR by end-use and segment. *These factors are based on available literature on the topic*
Step 4: Estimate Technical and Achievable Potentials	Estimate total potential MW by day-type, state/province, sector, segment, and end-use

Commercial and Residential Sectors Dominate in Potential DR Resource Availability

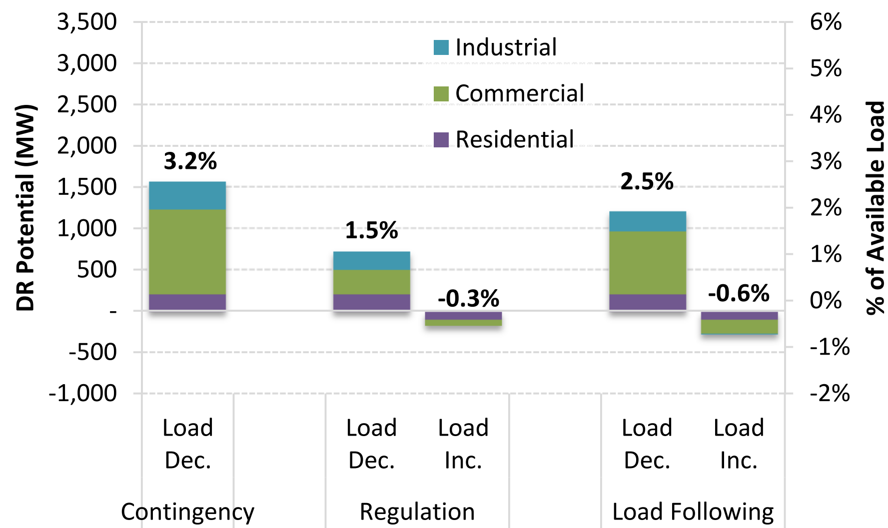


Seasonal Variations in DR Potential Availability

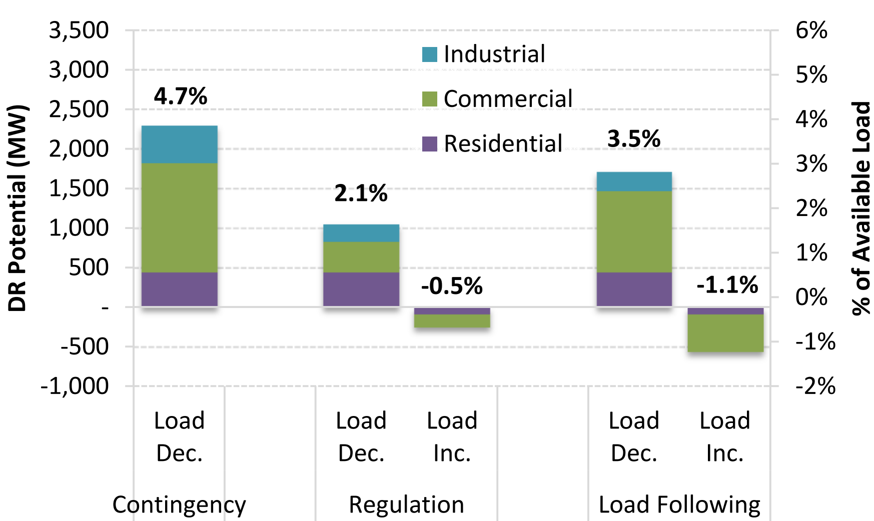
Typical Summer Weekday Potential in 2020



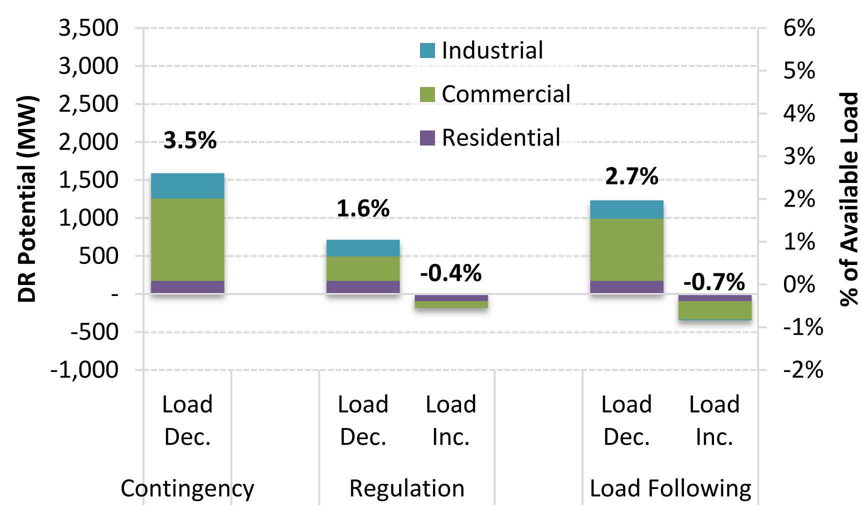
Typical Winter Weekday Potential in 2020



Typical Spring Weekday Potential in 2020

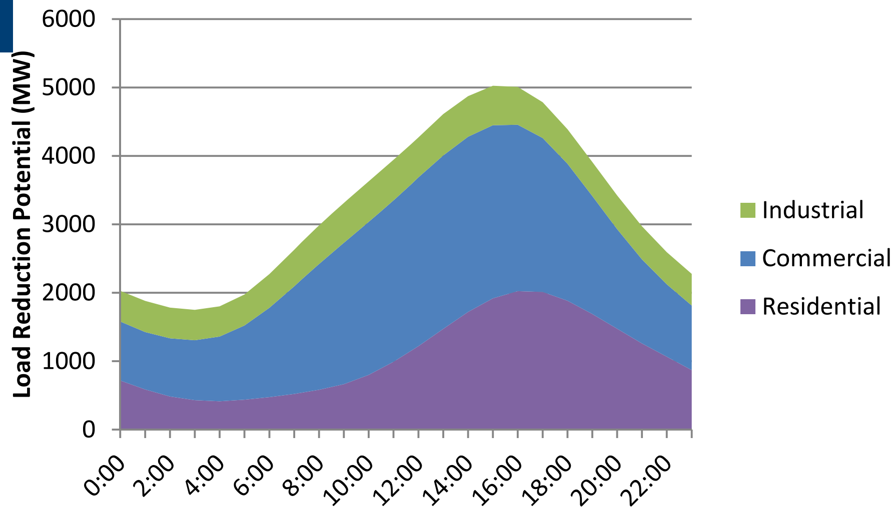


Typical Fall Weekday Potential in 2020

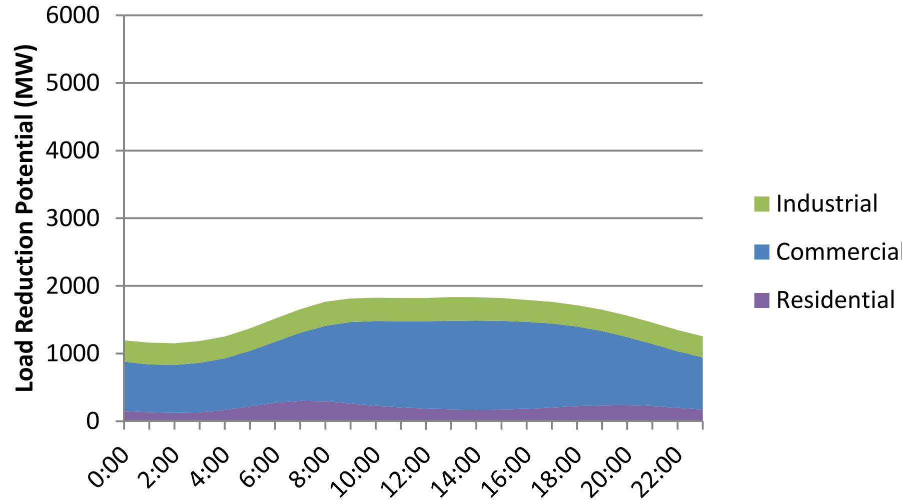


Average Hourly Load Reduction Profiles for Contingency Services

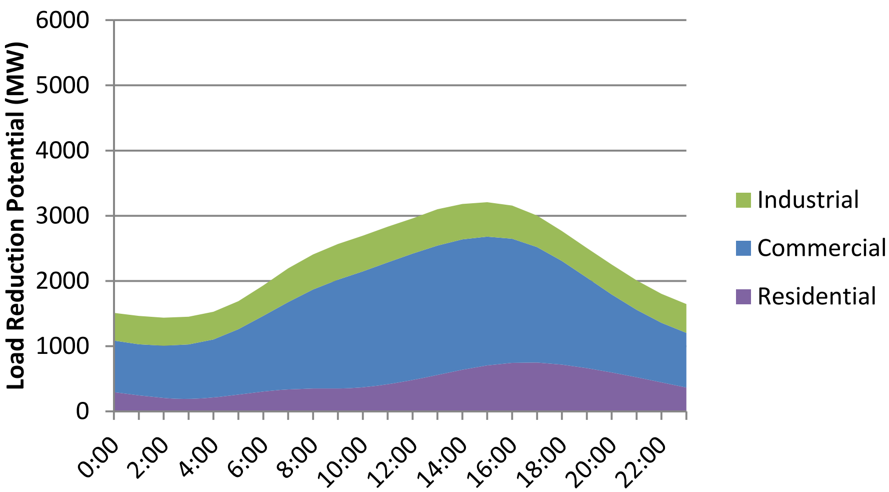
Typical Summer Weekday in 2020



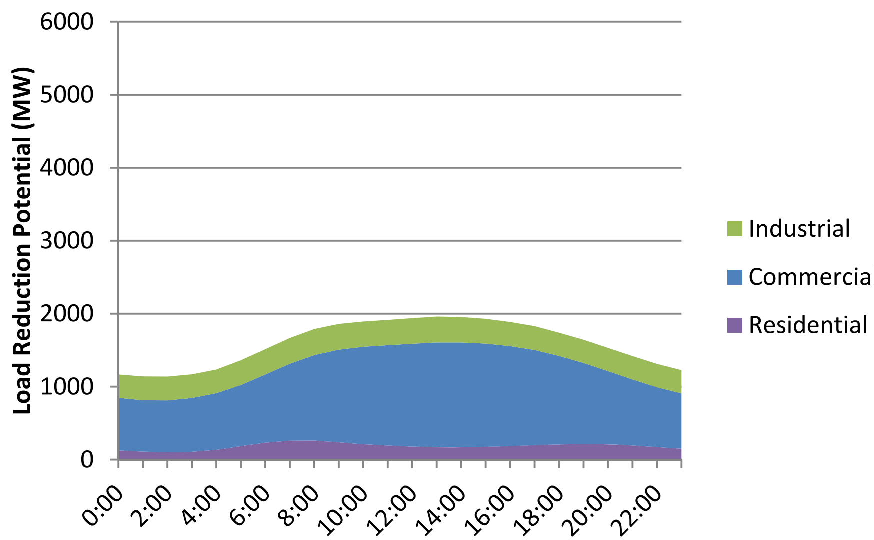
Typical Winter Weekday in 2020



Typical Spring Weekday in 2020

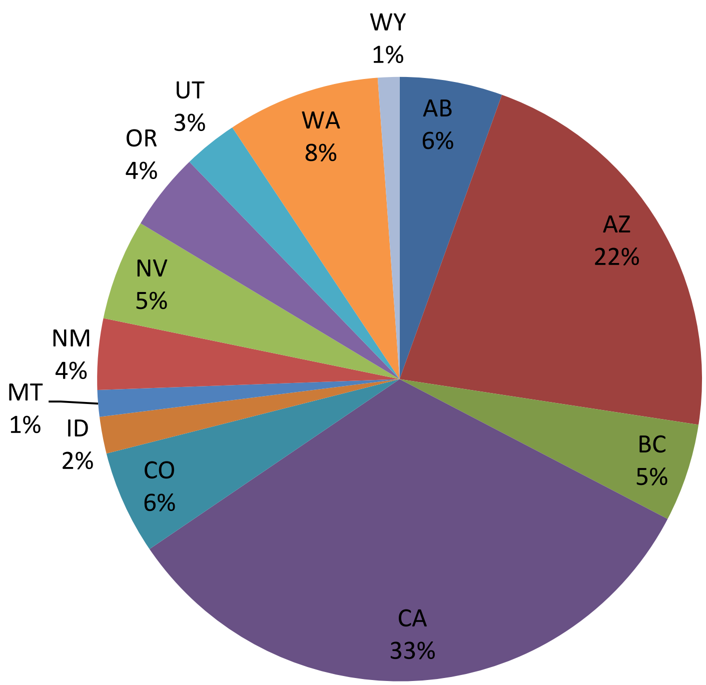


Typical Fall Weekday in 2020

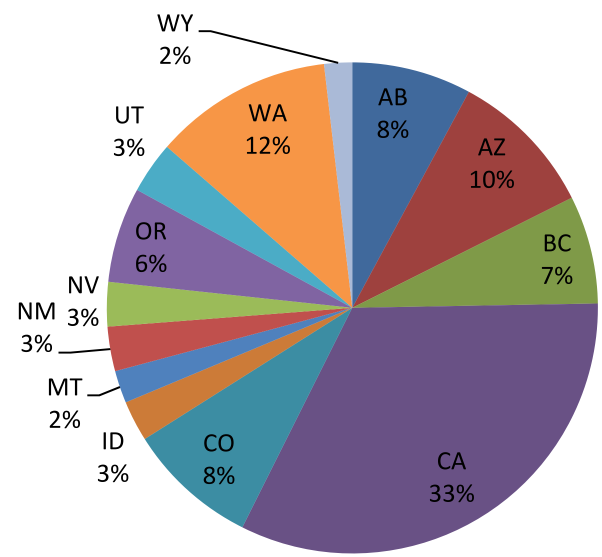


Aggregate DR Potential by State/Province in 2020

Typical Summer Weekday 'Load Following' Potential



Total Load Decrease Potential- 2,619 MW



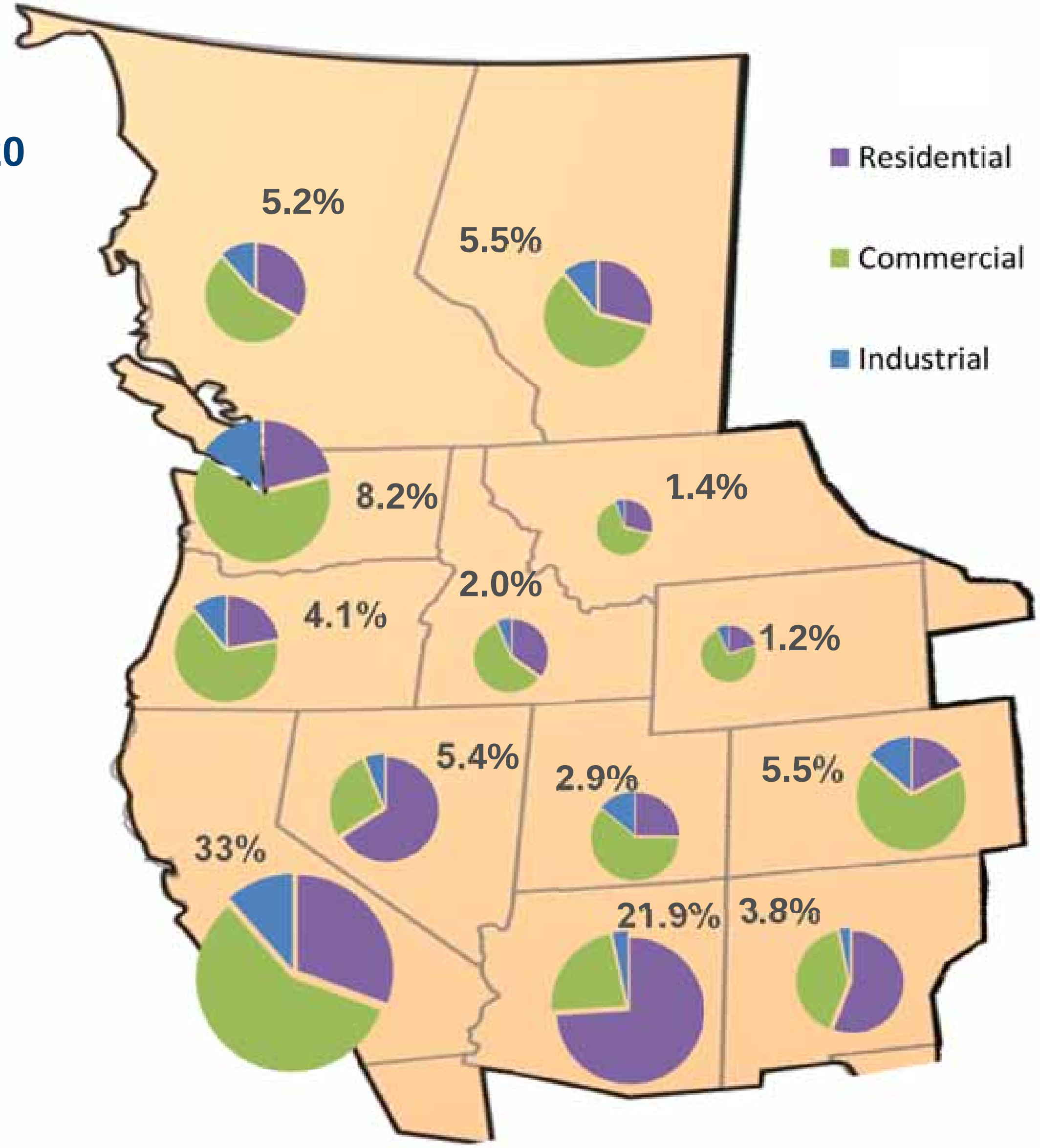
Total Load Increase Potential- 770 MW

DR Potential Load Decrease by State/Province

Shares in the Western Interconnection Potential

"Load Following" Potential for a Typical Summer Weekday in 2020

- Total Load Decrease Potential- 2,619 MW
  - Residential: 1,071 MW
  - Commercial: 1,304 MW
  - Industrial: 243 MW

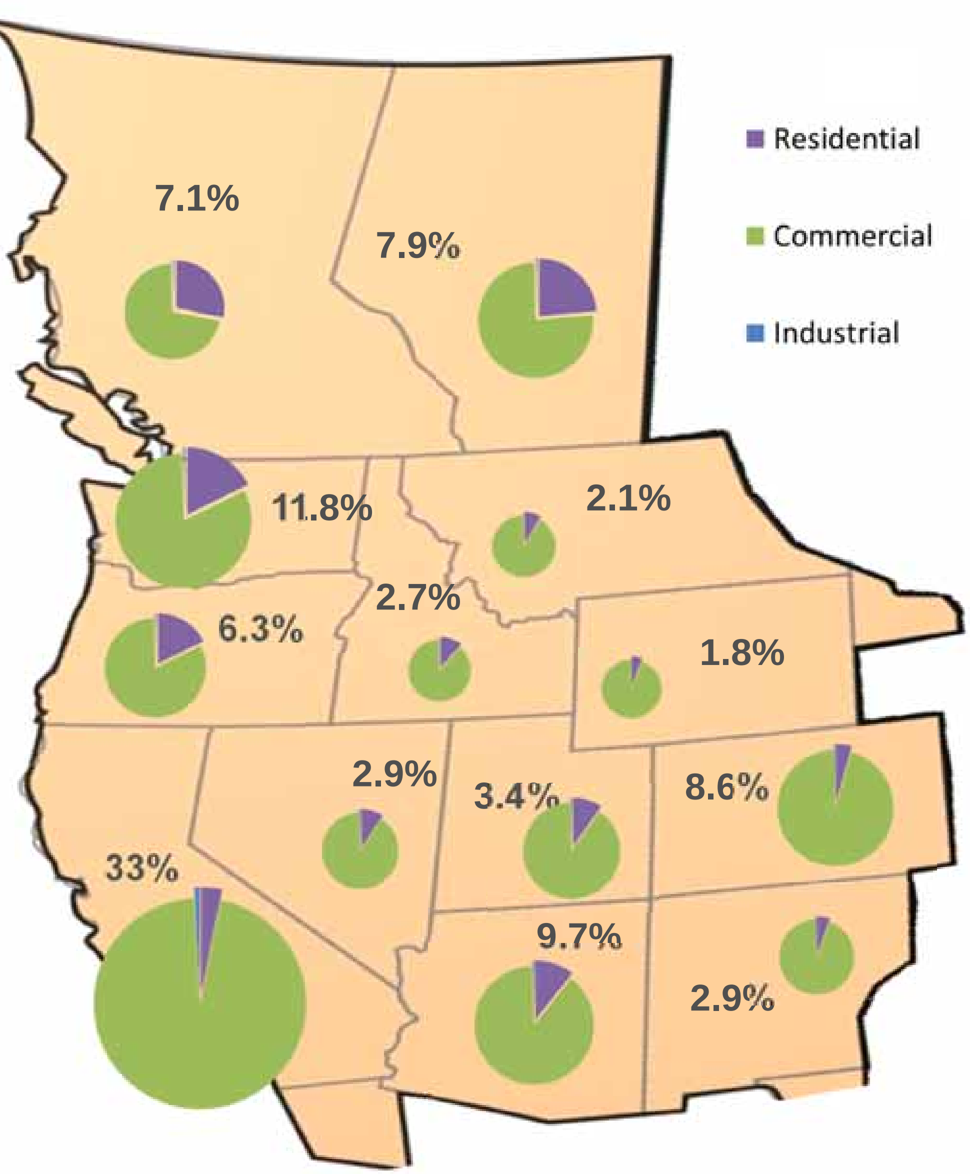


DR Potential Load Increase by State/Province

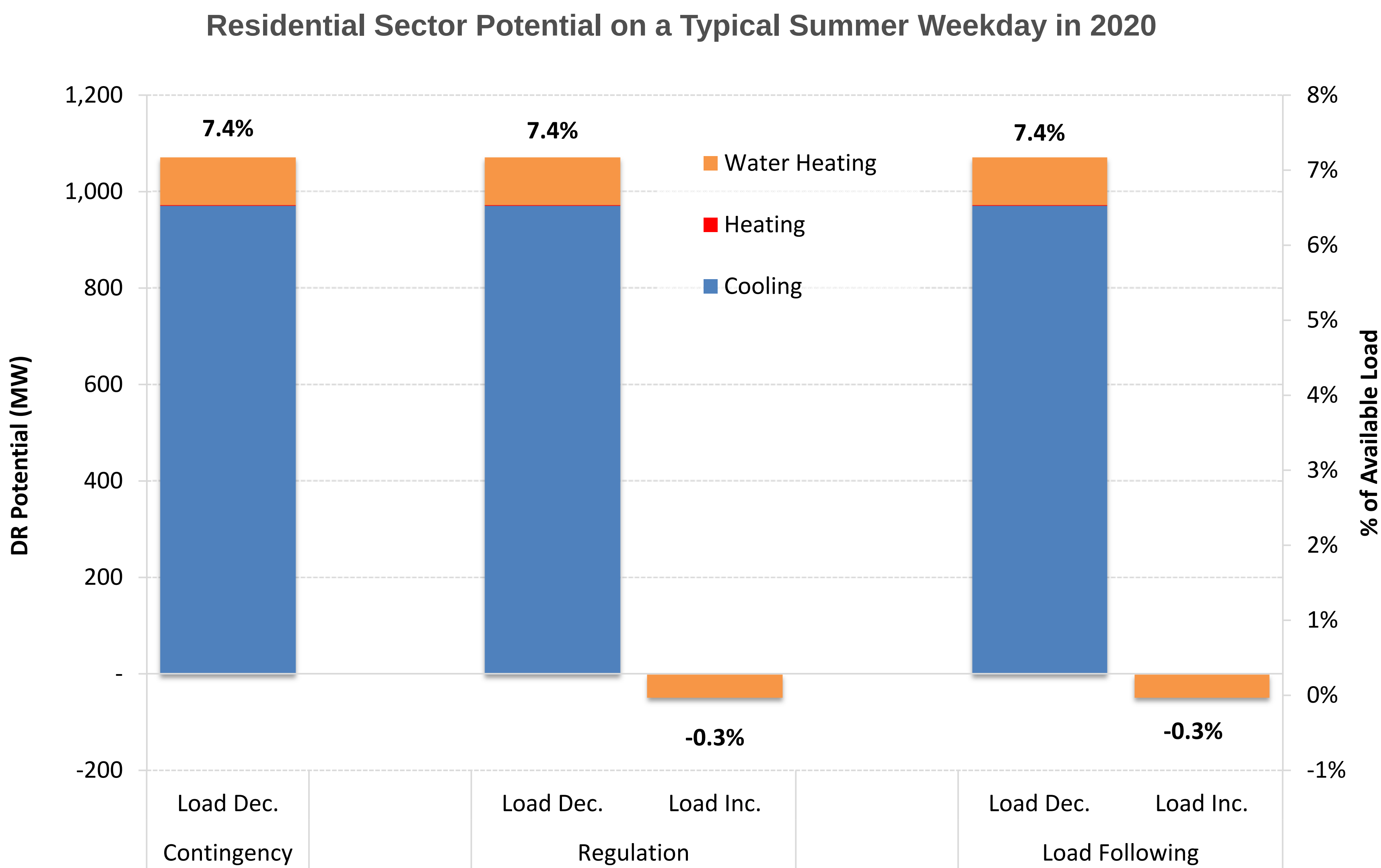
Shares in the Western Interconnection Potential

"Load Following" Potential for a Typical Summer Weekday in 2020

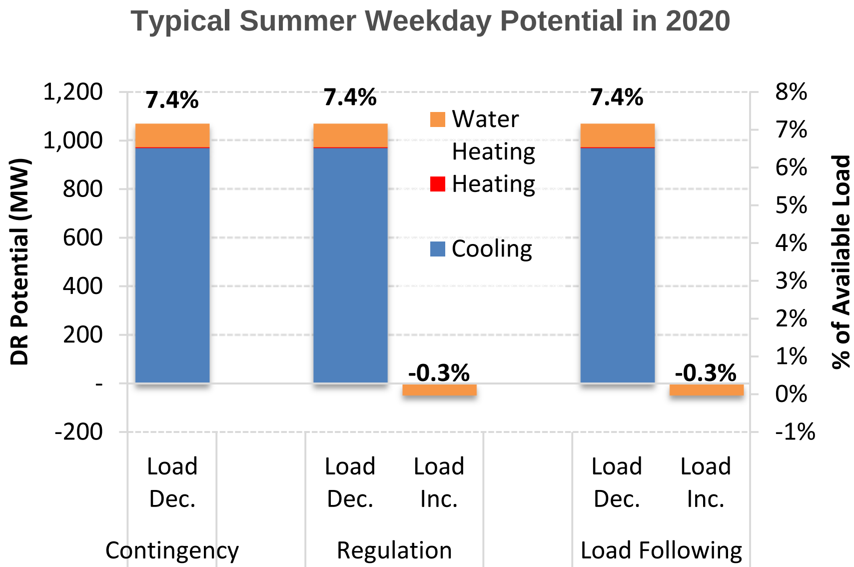
- Total Load Increase Potential- 770 MW
  - Residential: 48 MW
  - Commercial: 718 MW
  - Industrial: 5 MW

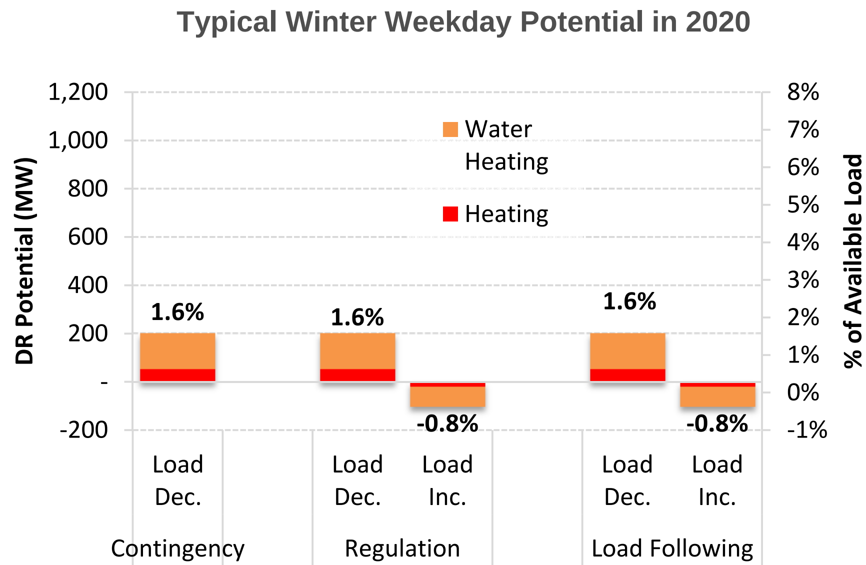


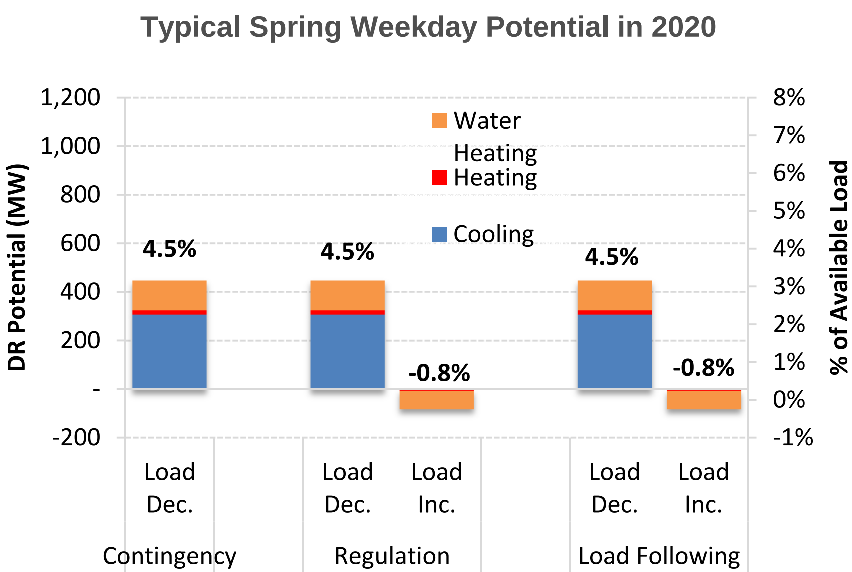
Residential Sector Potential is Dominated by Cooling Load

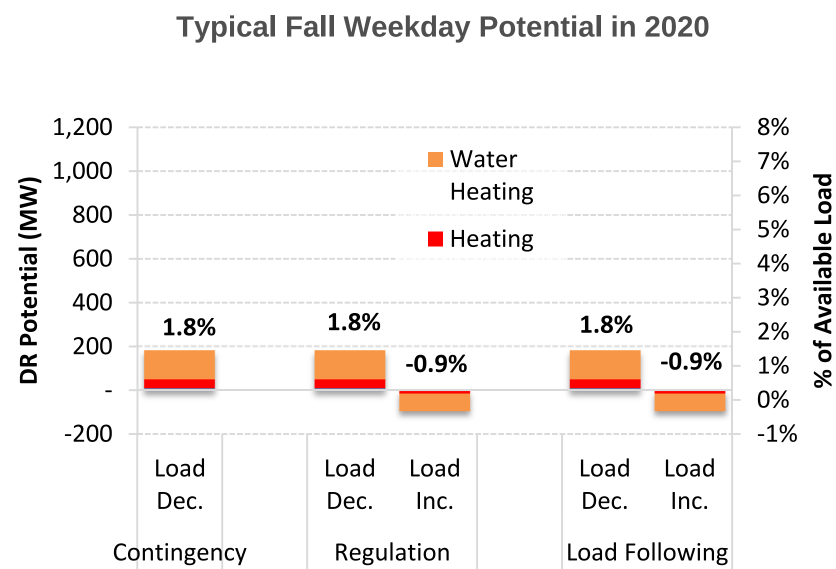


Residential DR Potential Varies by Available End-uses Across Seasons









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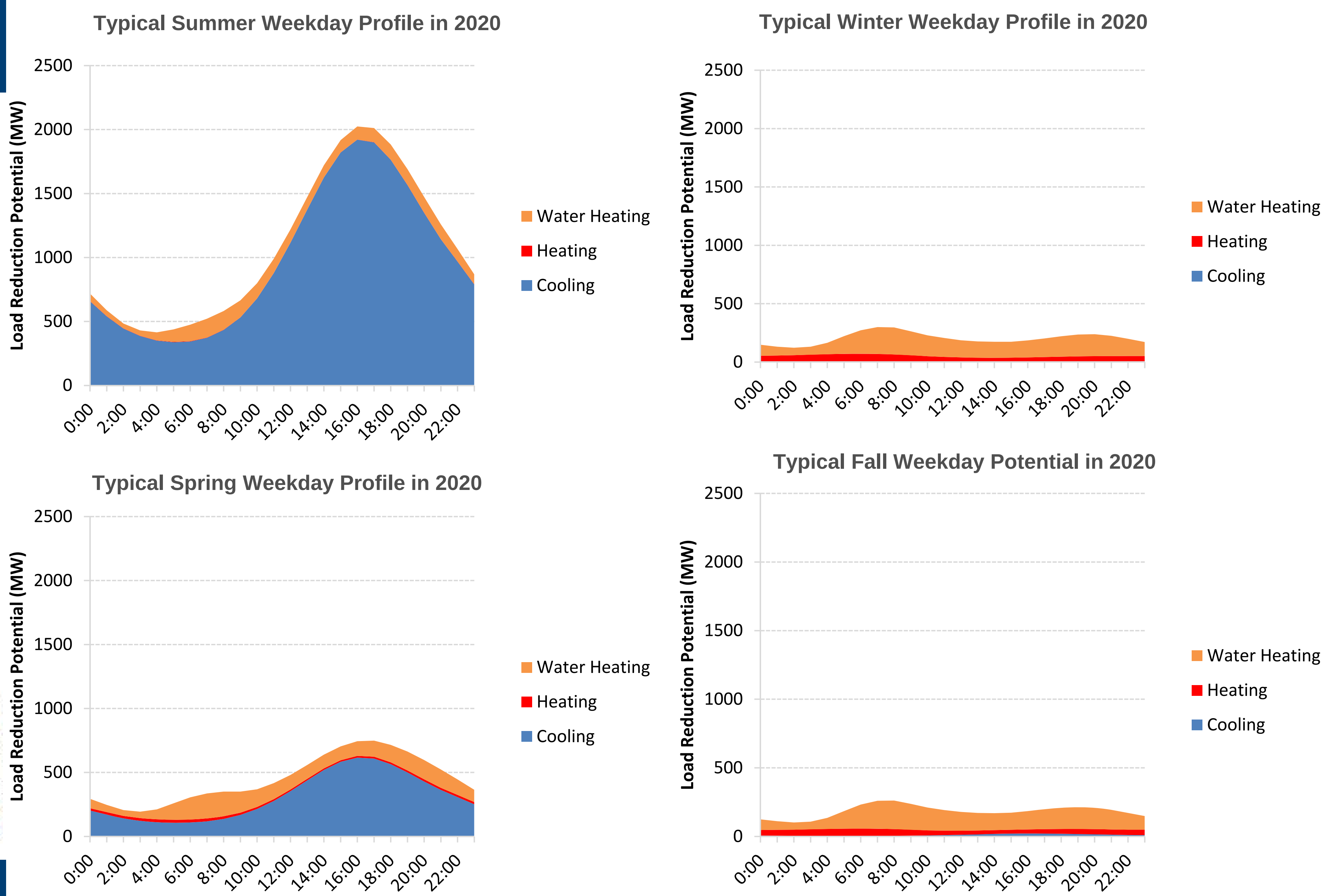
Residential: Hourly Load Reduction Profiles for Contingency Services



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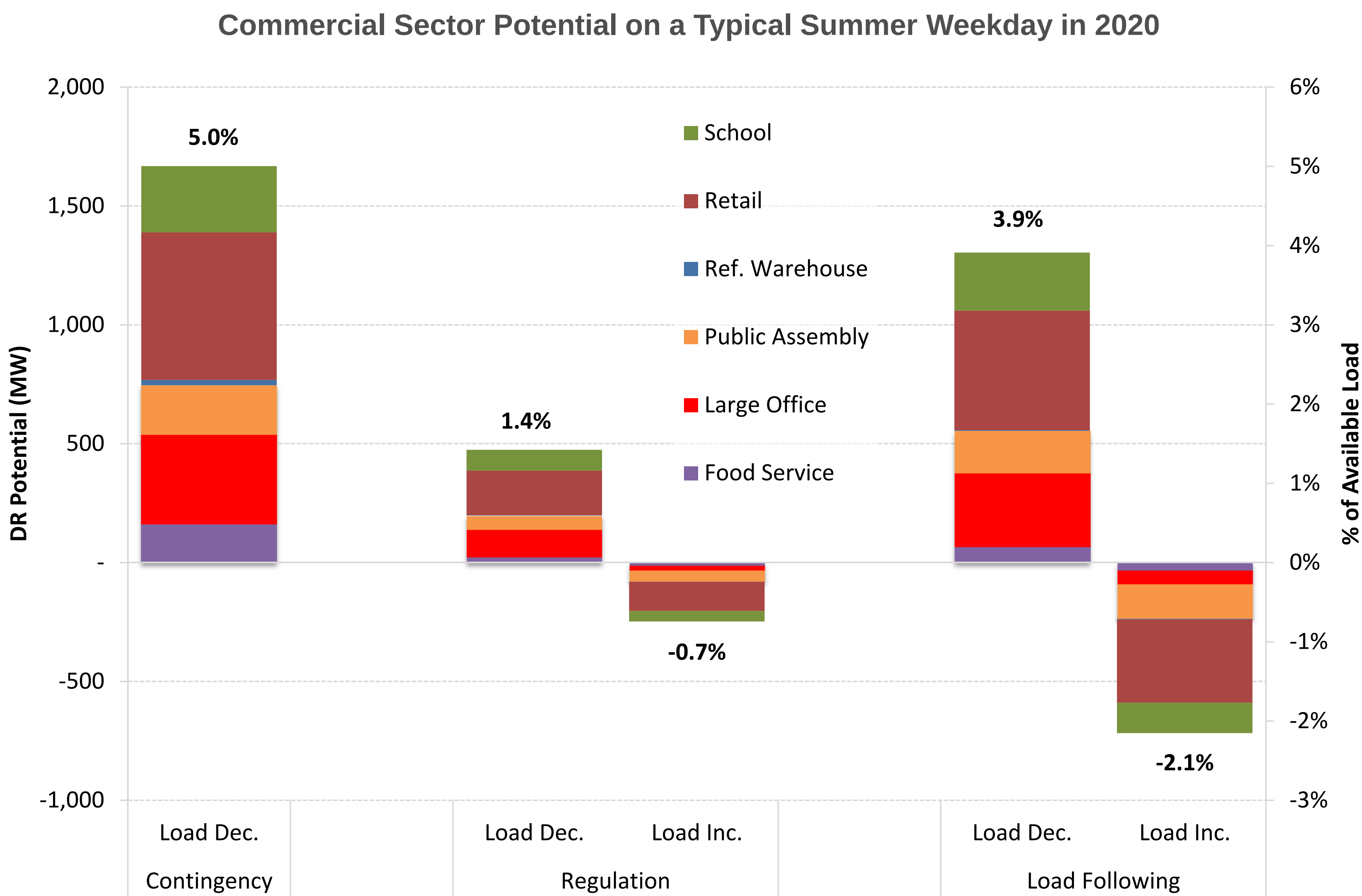
Commercial Sector Potential Availability is Dominated by Retail and Large Office Buildings



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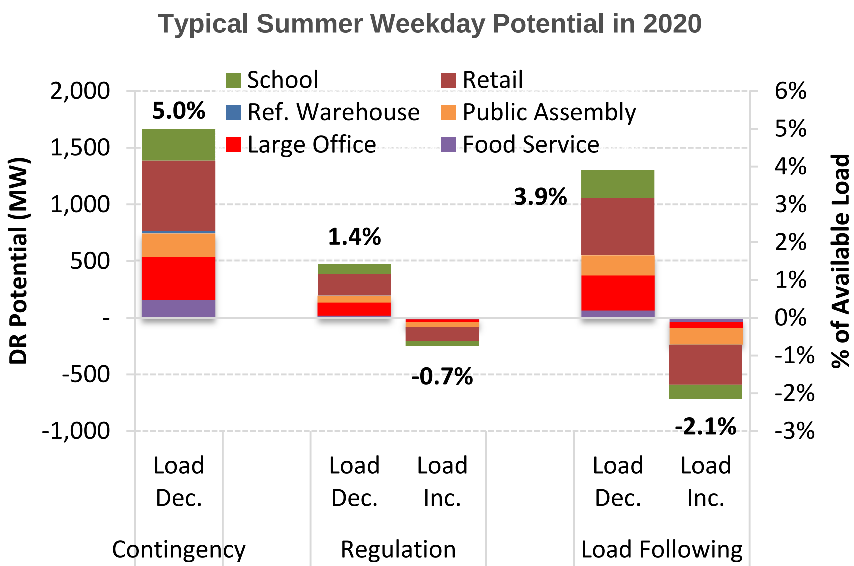
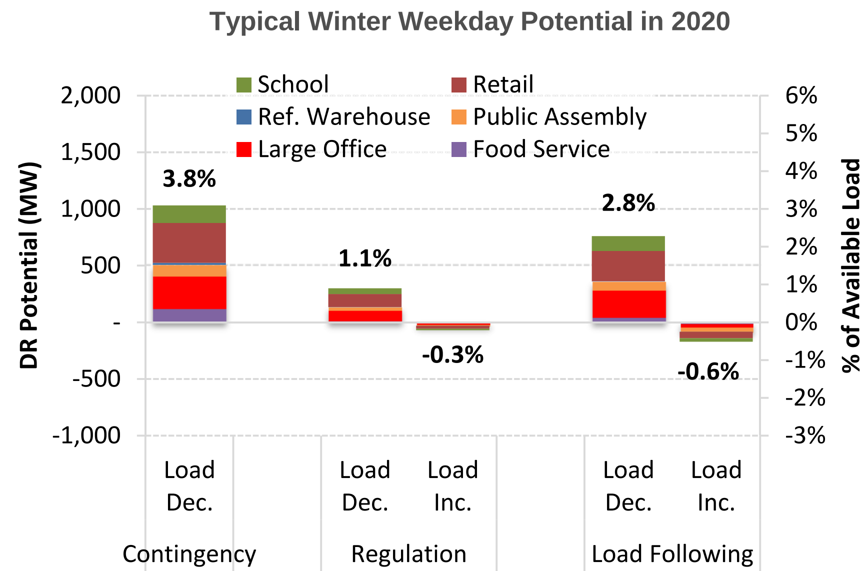
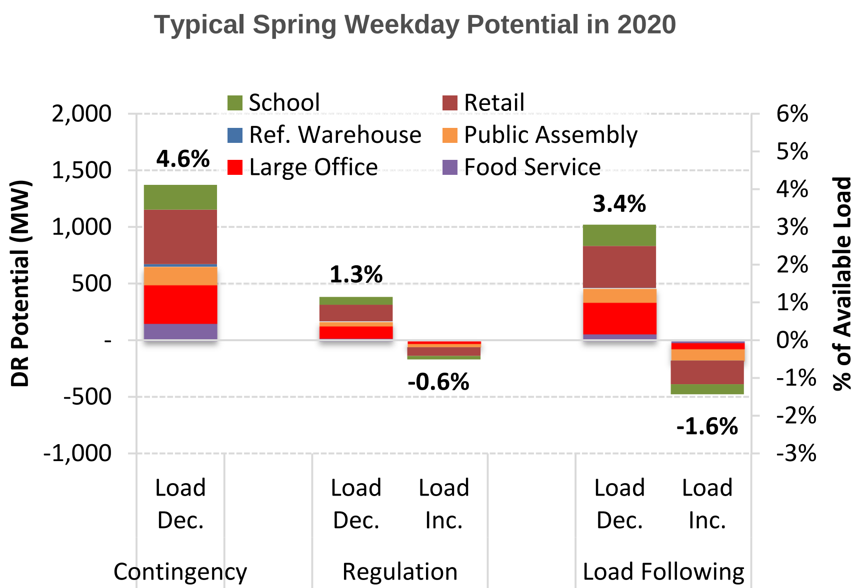
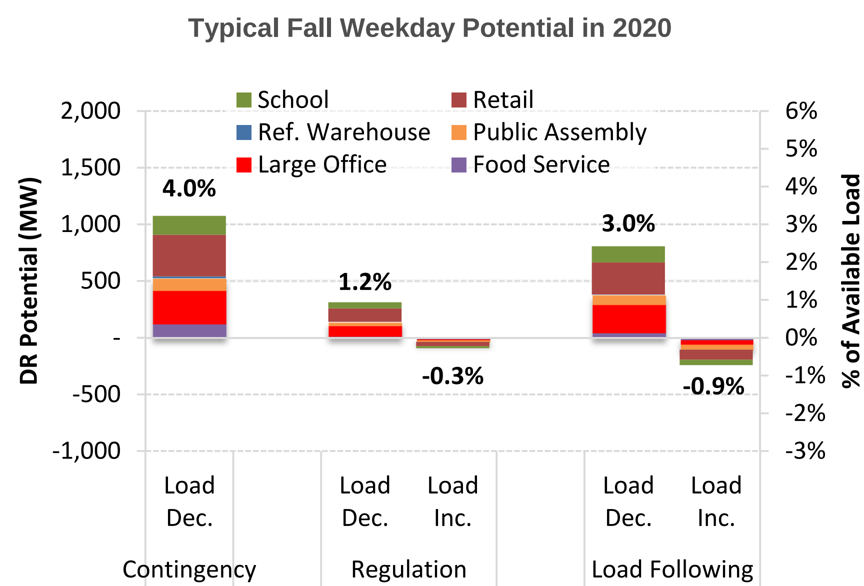
Seasonal Variations in Commercial DR Potential Availability









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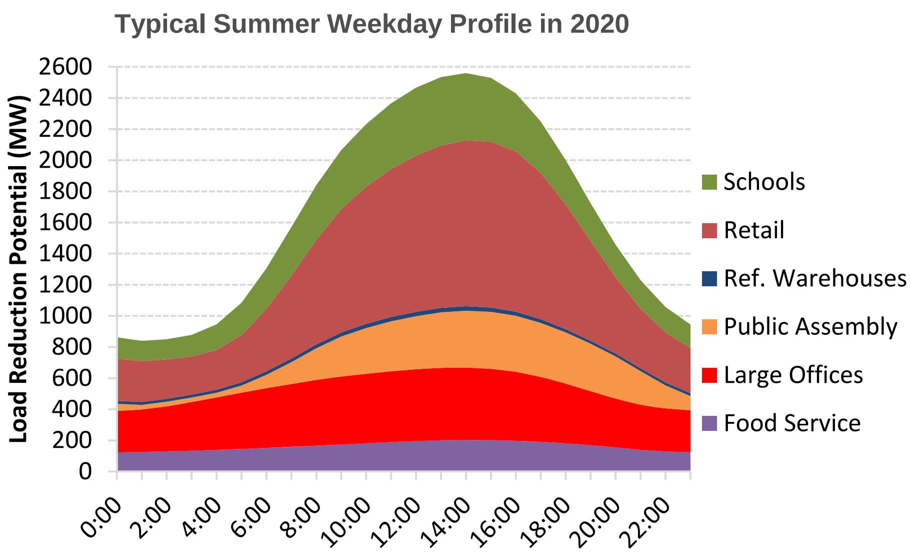
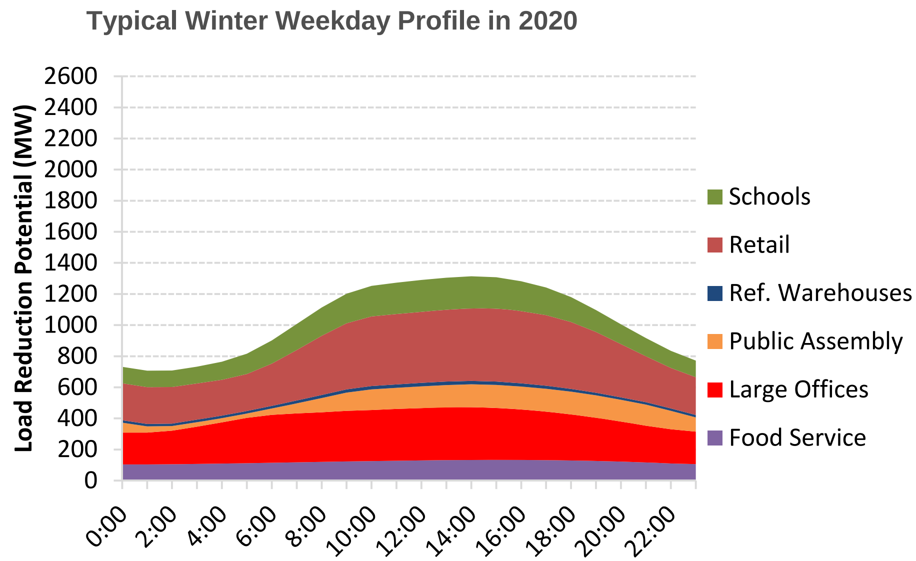
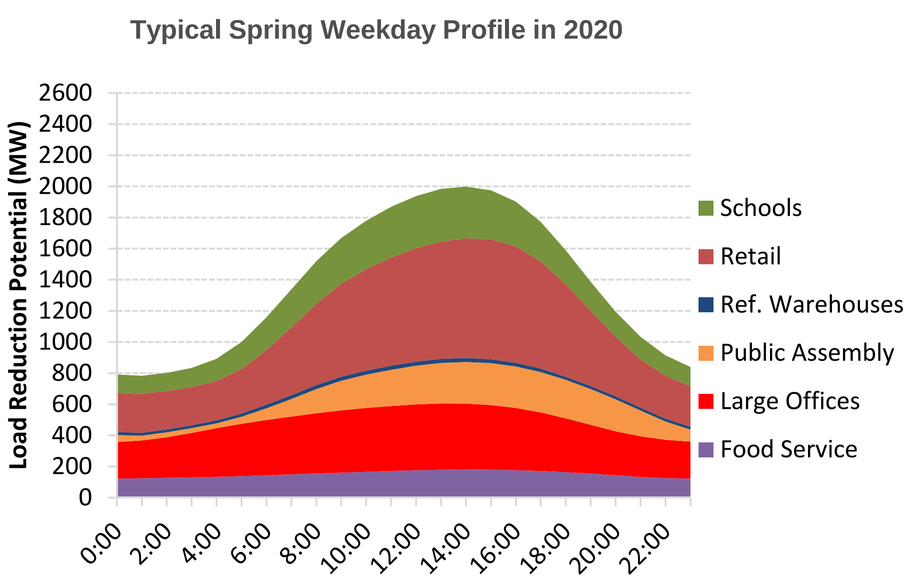
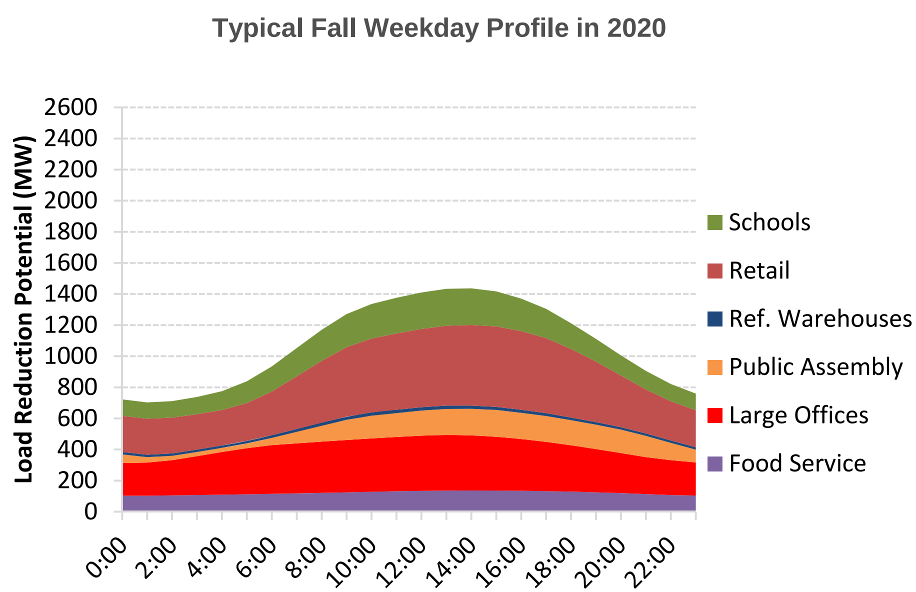
Commercial: Hourly Load Reduction Profiles for Contingency Services

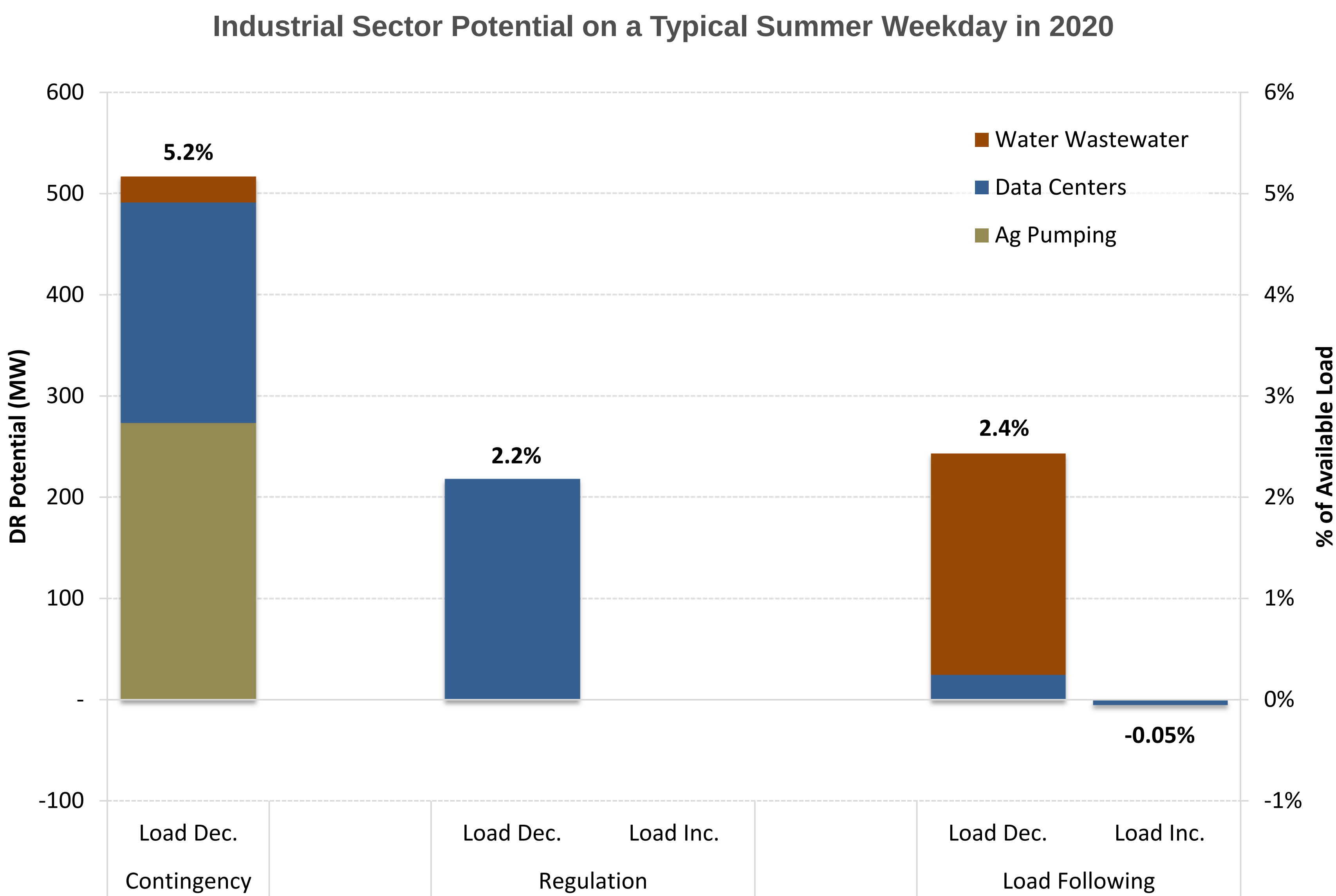




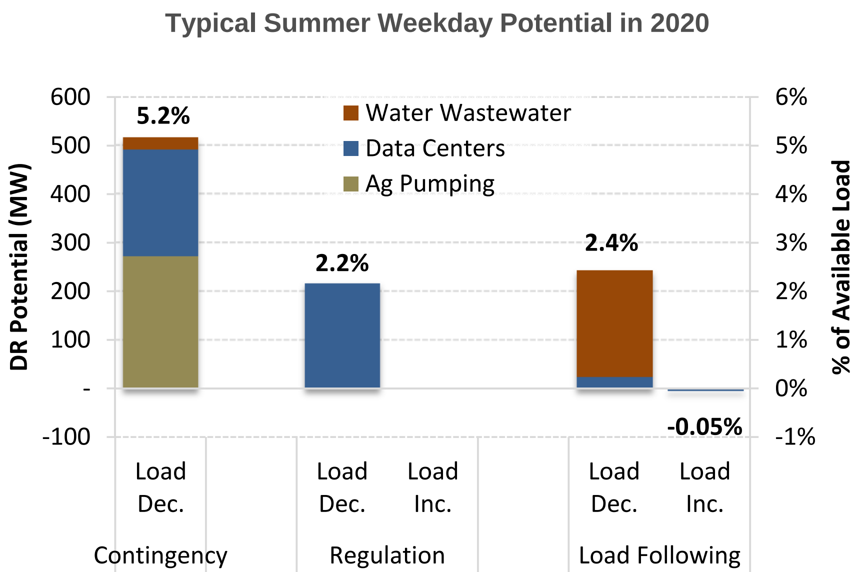


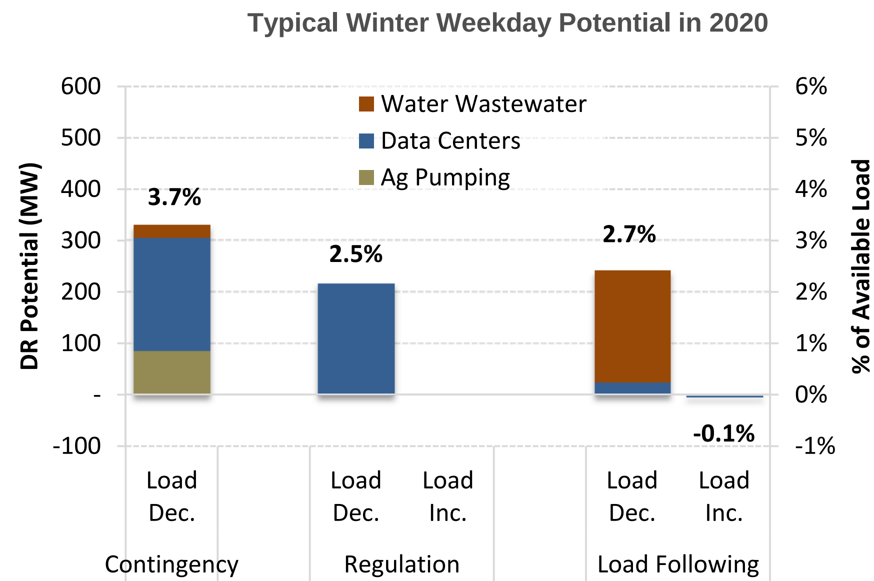


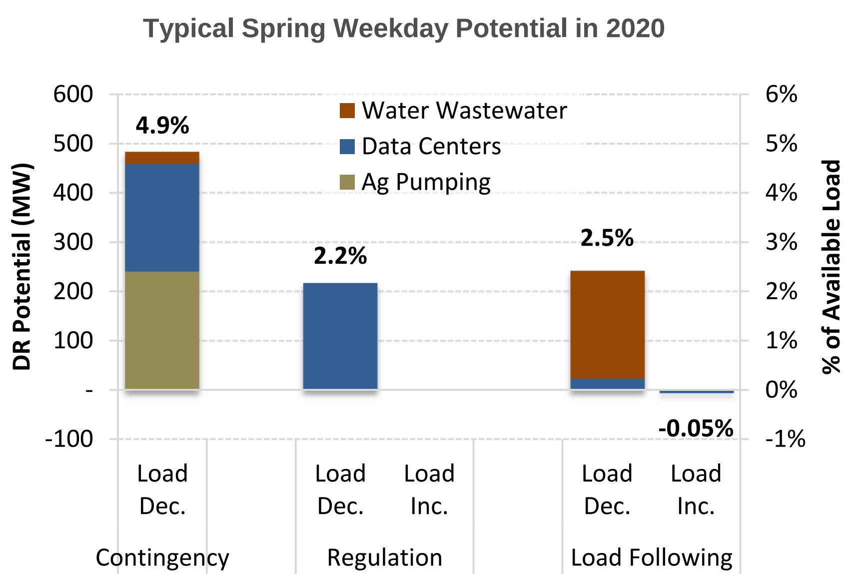
Water/Wastewater Treatment Plants and Ag Pumping Dominate Industrial Potential Availability

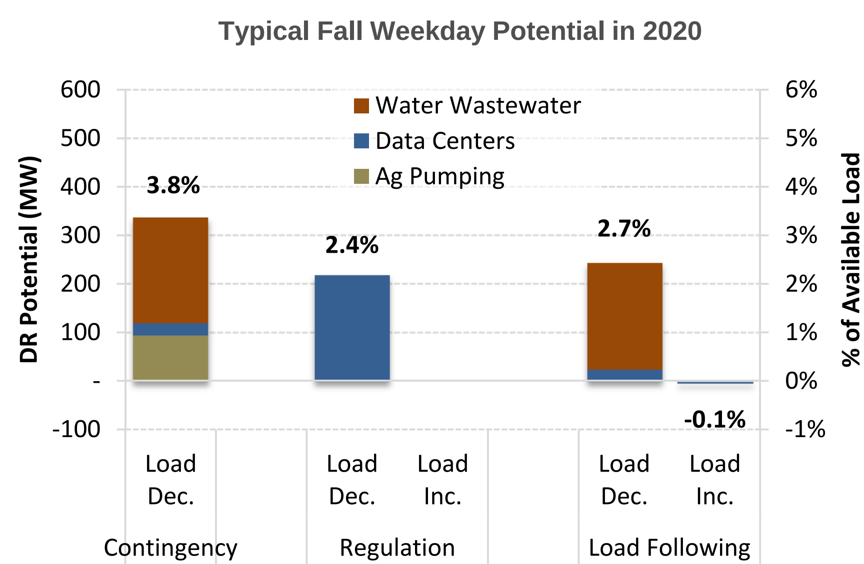


Seasonal Variations in Industrial DR Potential

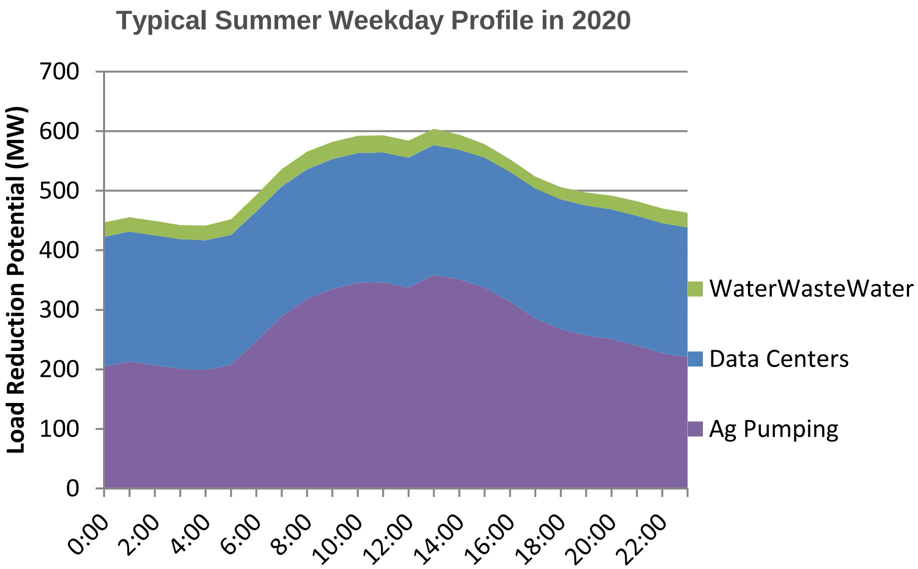


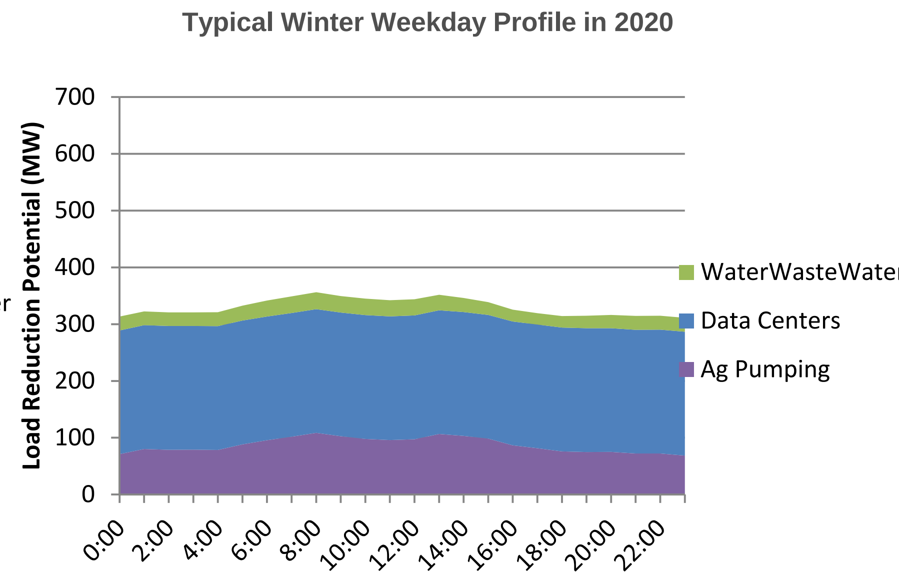


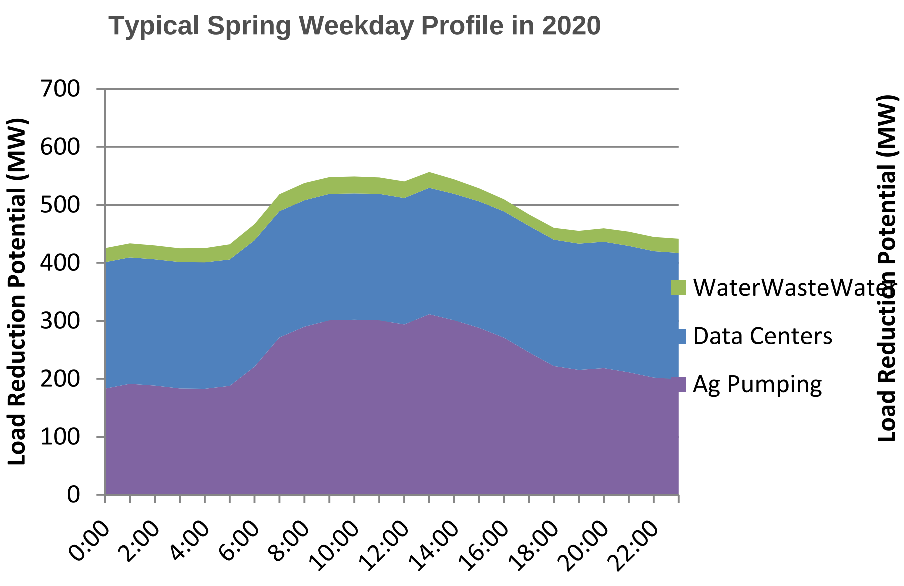


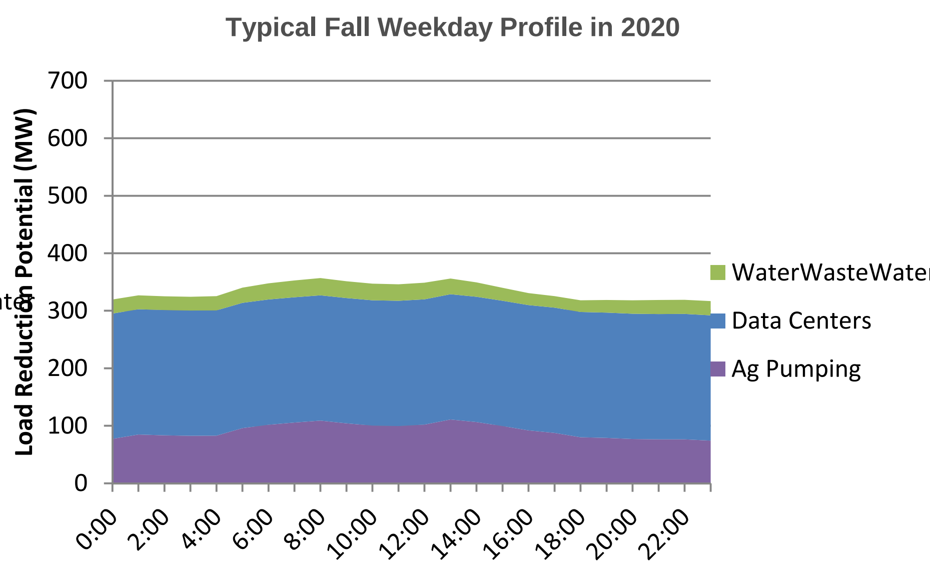


Industrial: Hourly Load Reduction Profiles for Contingency Services









DR 1.0 vs. DR 2.0 Potential Estimates

- Estimated DR 1.0 Potential in 11 WECC states

  13.6 GW in 2022

  Ref: WECC 20-year Demand Response Forecast. Prepared by the Brattle Group for Lawrence Berkeley National Laboratory, June 2012

- Estimated DR 2.0 Potential in 11 WECC states *(Potential Load Decrease in 'Load Following Product')*

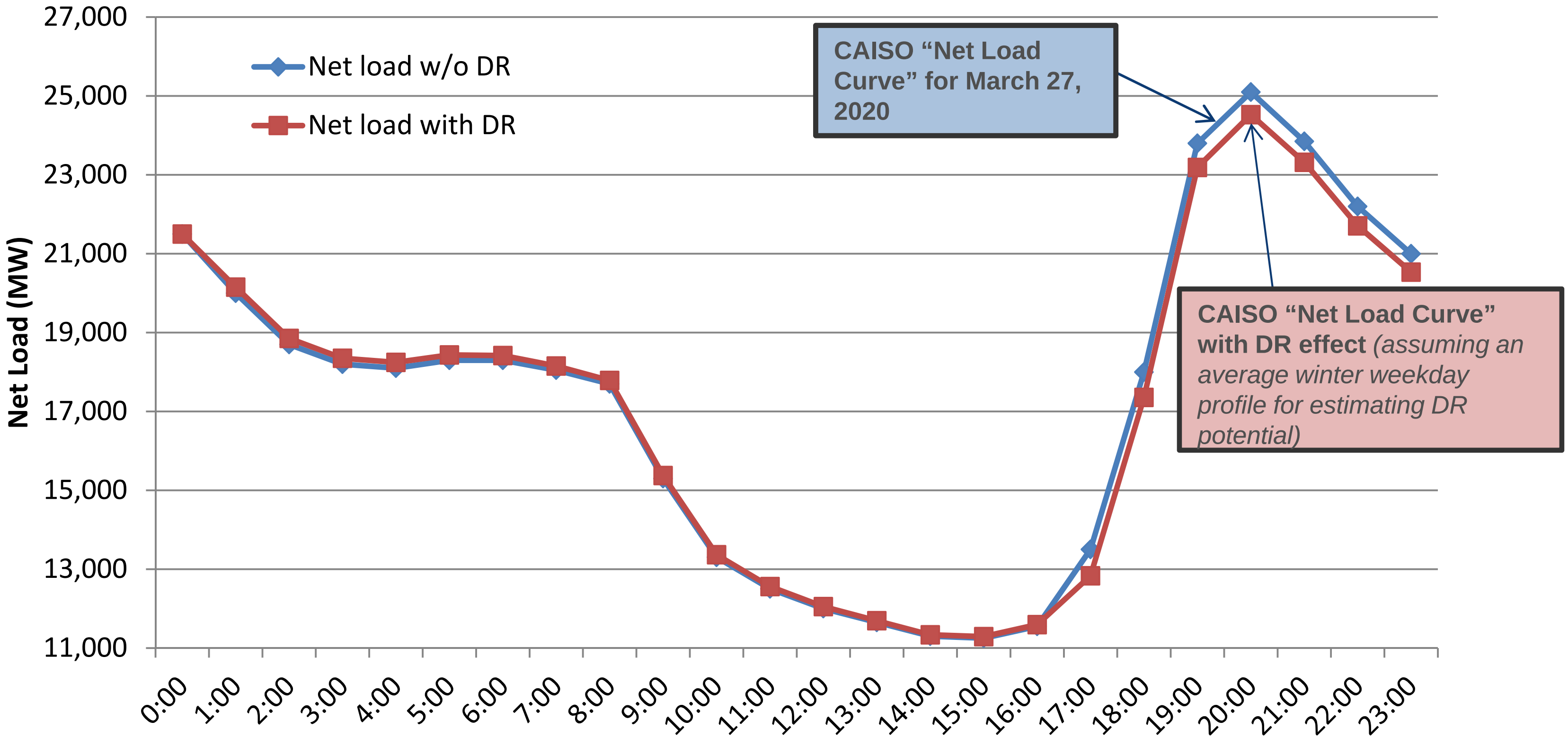
  2.4 GW in 2022 (from current study)

- DR 2.0 Potential as a % of DR 1.0 Potential in 11 WECC states

  ~18%

Reshaping the "Duck Chart" through DR?

Illustration of the Potential Implications of DR Integration on Net Load (CA Example)



Average DR Potential Impacts on Net Load for a Typical Winter Weekday

- Load Decrease Potential (% of "Net Load")~4%
- Load Increase Potential (% of "Net Load")~0.5%

Please note that the "net load" curve with DR is estimated using average winter weekday load profile for CA, and not specifically for the month of March and on the 27th day of the month

This chart is for illustration purposes only, and does not represent the actual CAISO load data. It is meant to illustrate the relative magnitude of the DR potential estimates vis-à-vis the "net load".

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DR Program Considerations

- A new generation of DR programs can possibly help realize the potential opportunities for addressing VER integration challenges
- Additionally, existing DR programs could also be modified and positioned to address VER integration challenges
- These DR programs will need to embody characteristics such as:
  - Responding to events with short notification periods
  - Responding to a relatively high frequency of DR events
  - Capable of providing bi-directional response
  - Sustaining load reductions over relatively long time periods
- Automated response with advanced control and communication capabilities will be a key component of program design
- Program designs will need to take into consideration customer segments and end-uses that are being targeted.
  - Frequent starts and stops will have an impact on processes, maintenance and lifetime of equipment and this will need to be addressed
  - Impacts on customer electricity bills, caused by load increase, will also need to be considered
  - Appropriate incentive levels will need to be designed

DR Program Considerations (continued)

- Opportunities exist to leverage the customer base enrolled in traditional DR program offerings offered by utilities across western states.
- Existing residential and small commercial direct load control (DLC) type programs could serve as a base from which to further build upon
  - Targeted loads include air-conditioning, space heating, and water heating
  - Advanced DLC technologies will enhance performance and include smart appliances
  - Irrigation loads are increasingly becoming an attractive target for advanced DLC applications
  - Western states with significant DLC programs include California, Colorado, Idaho, New Mexico, Nevada, and Utah
- Existing commercial and industrial curtailment type programs could serve as a base from which to further build upon
  - Targeted loads include HVAC, lighting and industrial processes
  - Utilization of automated controls and advanced communication systems will be necessary to ensure performance
  - An aggregated portfolio of customers is likely to help fulfill essential program attributes
  - Western states with sizeable C&I participation base in DR options are- Arizona, California, Colorado, New Mexico, Nevada, Oregon, and Washington

DR Potential: Assessing the Economic Viability

- Data and methodology gaps limit our ability to thoroughly assess the economic potential of the DR options
  - Data about the size and cost of the various VER integration options is limited
  - No cost effectiveness methods currently exist to assess VER options
- Key questions:
  - What are the costs associated with the DR programs?
  - What is the right value for the DR products that are integrated with VER?
  - What is the resource to be avoided for load reductions and load increases?
  - Are the standard practice approaches for DR cost-effectiveness appropriate for VER resource integration?

Cost Effectiveness Framework

- DR program cost elements
  - Program implementation and operations
  - Enablement costs for automation equipment and telemetry
  - Customer incentives (capacity and energy)
- DR program benefit elements
  - Load reductions: Avoid the investment in traditional generation resources, such as a peaking plants
  - Load building: Avoid the investment in special equipment designed to mitigate the effects of overproduction of electricity on the grid
    - Consider potential benefits associated with additional revenue to renewable energy developers

Findings and Recommendations

- Findings:
  - DR 2.0 will play an important role in mitigating the effects of VER in the next decade
  - There are a limited number of customer segments and end-use loads that can accommodate the needs for VER integration
  - Utilities can adapt existing several existing DR programs to meet the technical requirements for VER integration
  - DR is one of many options to mitigate the effects of VER
- Recommendations:
  - Develop the necessary parameters to support a meaningful analysis of DR cost-effectiveness of for VER integration
  - Identify the magnitude and economic viability for all options that can mitigate the effects of VER
  - Utilities and balancing authorities in the Western Interconnection should begin developing their own estimates of DR potential for VER integration
  - Develop pilot programs to improve the quantification of DR potential and test new breakthrough technologies

Appendix Slides

- Definitions of Ancillary Services Product Types
- States and Provinces Included in the Study

Ancillary Services Products Definitions and Attributes

Spinning Reserves- The California ISO defines spinning reserves as follows- "Spinning reserve is the portion of unloaded capacity from units already connected or synchronized to the grid and that can deliver their energy in 10 minutes and run for at least two hours." *(Source- Perlstein et.al., 2012)*

Non-spinning Reserves- The California ISO defines non-spinning reserves as follows- "Non-spinning (or supplemental) reserve is the extra generating capacity that is not currently connected or synchronized to the grid but that can be brought online and ramp up to a specified load within ten minutes." *(Source- Perlstein et.al., 2012)*

Regulation- The California ISO defines regulation as follows- "Regulation energy is used to control system frequency that can vary as generators access the system and must be maintained very narrowly around 60 hertz. Units and system resources providing regulation are certified by the ISO and must respond to 'automatic generation control' (AGC) signals to increase or decrease their operating levels depending upon the service being provided, regulation up or regulation down." *(Source- Perlstein et.al., 2012).*

Load Following- The California ISO defines load following as- "Load following is the ramping capability of a resource to match the maximum megawatts by which the net load is expected to change in either an upward or a downward direction in a given hour in a given month..." (Source- Perlstein et.al., 2012).

DR Program Attributes Required to Provide Products Capable of Supporting Integration of Variable Generation Resources

Attribute	Spinning/non-spinning reserve	Regulation	Continuous ramping/load following
Telemetry	Required	Required	Required
Response time	<10 minute; <10 second to begin ramping is desirable	<1 minute	<1hour
Automated response	Required	Required	Required
Event limitations	Dozens to more than 100 events, lasting at least 1 hour each	Continuous availability desired	10 hours or more duration, minimum of one hour
Daily/seasonal availability	24x7 year round	24x7 year round	24x7 year round, with seasonal variation
Target end uses	Agricultural and municipal water pumping, electric water heating	Temperature controlled warehouses, industrial motor load on Variable Frequency Drives (VFDs)	Commercial Lighting and HVAC

Source: Perlstein et al, "Potential Role of DR Resources in Maintaining Grid Stability and Integrating Variable Renewable Energy", July 2012.

States and Provinces Included in the Study

- States

  Arizona, California, Colorado, Idaho, Montana, New Mexico, Nevada, Oregon, Utah, Washington, and Wyoming.

- Provinces

  Alberta, British Columbia