Supporting Cold Load Pickup with Demand Response

National Town Hall Meeting on Demand Response and Smart Grid

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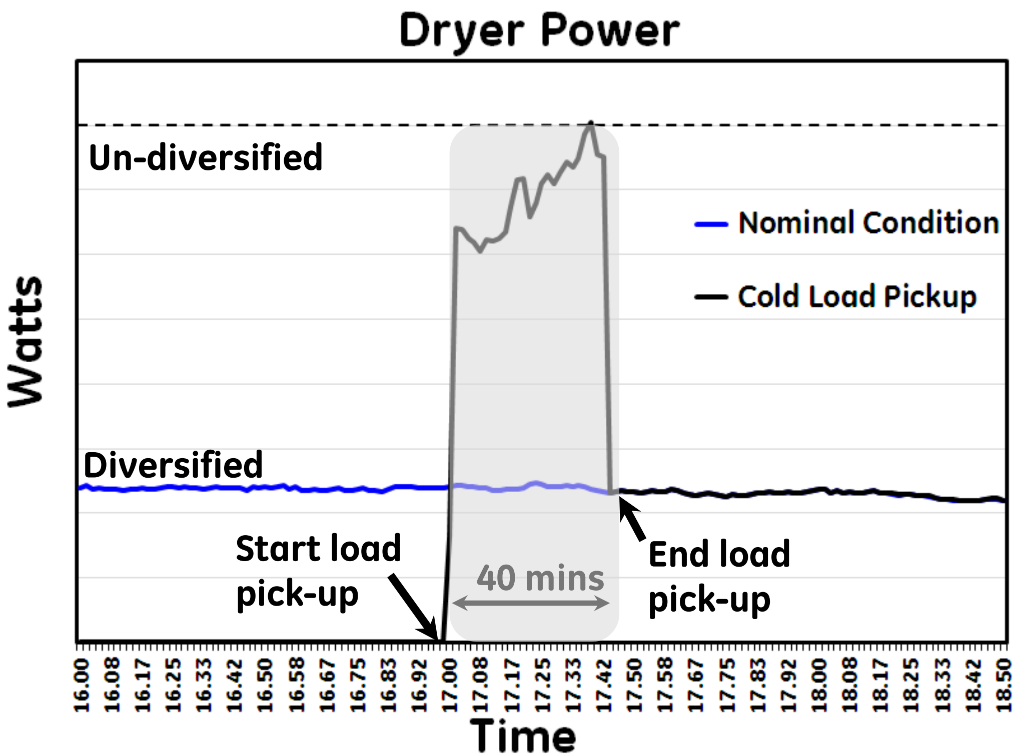
What happens under Cold Load Pickup?

Under normal operating conditions:

- Peak power demand is 20-50% of the undiversified peak demand

After an extended period of outage:

- Load diversity is lost, and peak demand increases



Uncontrolled peak demand results in:

- Degradation of equipment life
- Higher system losses
- Delays in circuit pickup

How is it done today?

Possibility 1: All the load is brought online at the same time

Drawback: Results in high peak power demand for an extended period of time

Possibility 2: Sectionalize the load into different pockets and restore power to one pocket at a time

Drawback: Results in delayed restoration for multiple load groups

How can Demand Response Support?

With Demand Responsive loads:

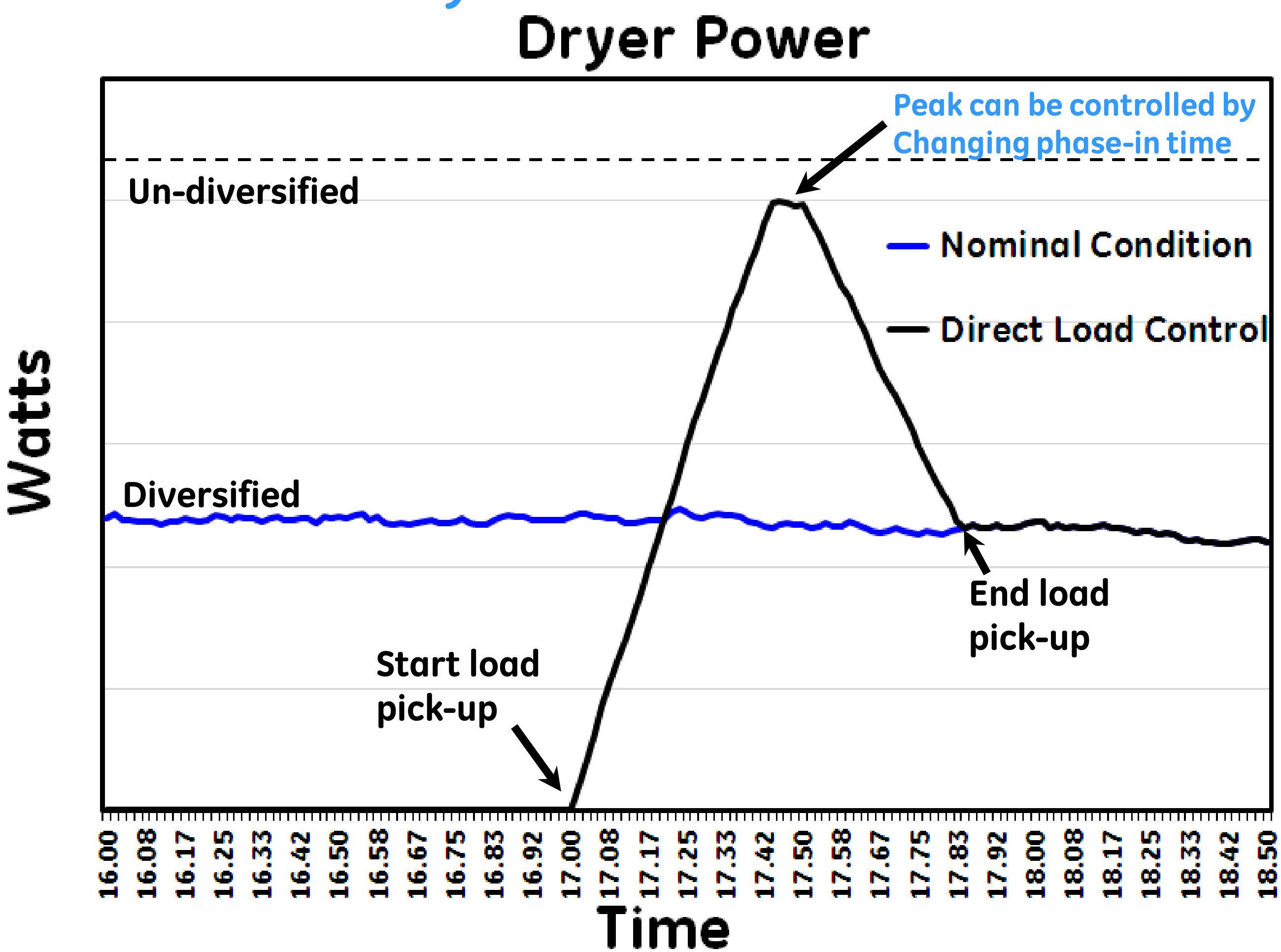
- ✓ Peak power drawn by the system can be reduced
- ✓ Power can be restored simultaneously to more consumers
  - All critical appliances are restored immediately
  - Non critical appliances are restored using one of the methods below

1. **Direct Load Control:** Loads are divided into groups and turned on in phases over time to maintain diversity
2. **PWM control:** Loads are turned on by modulating the input power demand
3. **Voltage control:** Loads are turned on at reduced voltages. Not applicable to voltage critical appliances.

Cold Load Pickup with Direct Load Control

Controlled Pick-up of load:

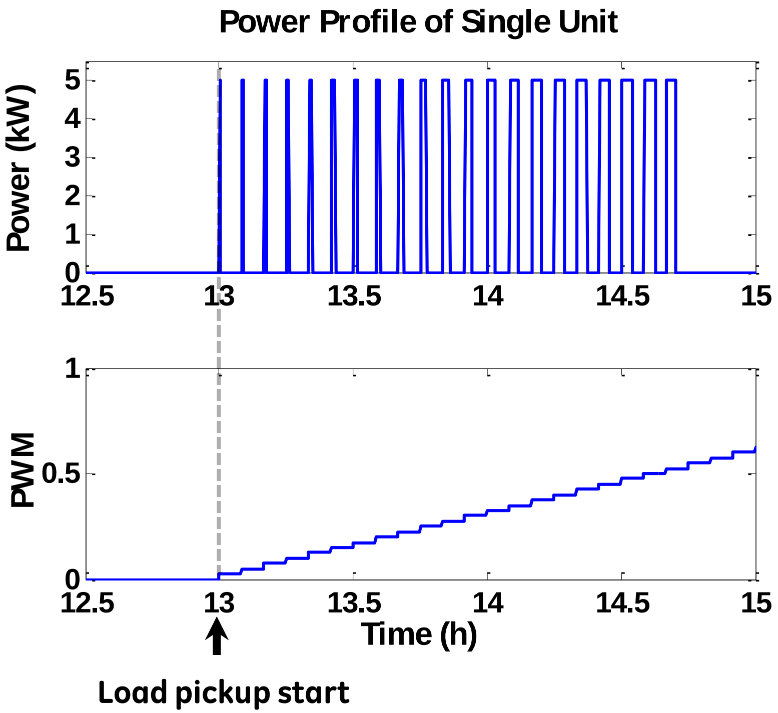
- Limits peak power demand on the circuit
- Phases in non-critical loads
- Maintains load diversity

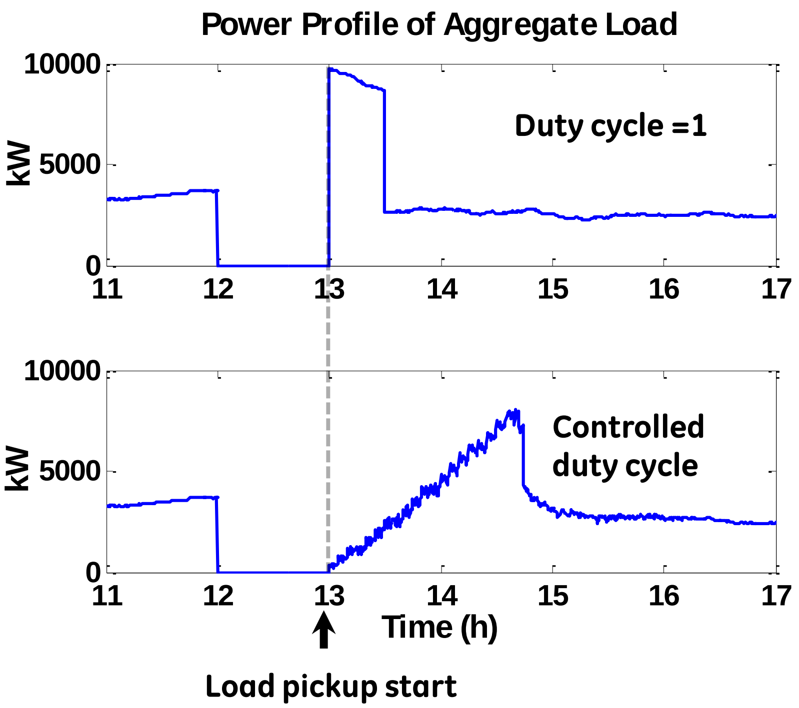


Cold Load Pickup with PWM Control

Power intake is managed through a controlled PWM control of input power to appliances

- Each unit receives identical increasing Duty Cycle command
- Duty Cycle slowly increases back to 1 (full power)
- Rate of increase in duty cycle controls the peak power demand

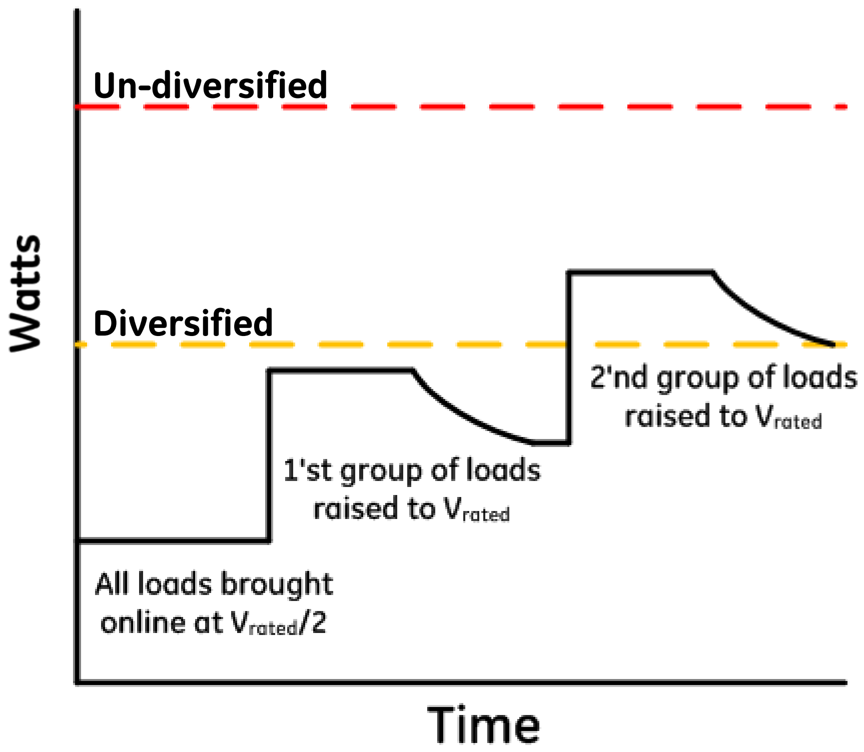




Cold Load Pickup with Voltage Control

Power intake is managed through a controlled input voltage

- All appliances are picked up at reduced power level
- Power intake is controlled by ramp-up of input voltage



Illustrated with an example for water heater ($P = V^2/R$):

1. All water heater loads are brought online at $V_{rated}/2$
   → Power demand = $P_{un\text{-}diversified}$ /4
2. Voltage for the first group is raised to V_{rated}
   → Power demand increases and reaches steady state
3. Voltage for the next group is raised to V_{rated}
   → Power demand increases and reaches steady state
4. As a result, the total peak power is always contained

What infrastructure is required?

Control units: for controlling input power to the appliances

- Step-down transformers: Voltage control
- Relay/switch: Direct load control, low frequency PWM

Communications: for information exchange between utility & appliances

- e.g. Zigbee, Power Line Carrier

Measurement: for monitoring local load status

- e.g. Metering infrastructure (AMI)

Conclusions

Demand Response can improve Cold Load Pickup by:

- Reducing coincident peaks after outages
- Maintaining load diversity
- Allowing for faster restoration of customers
- Prioritizing critical loads over non critical loads within premises

But Needs. . .

- Additional investments in hardware, controls, communications
- Regulatory and rate structures for implementation