Residential Energy Efficiency Technical Update Meeting

Denver, Colorado. August 9-11, 2011

Hydronic Controls Retrofits for Low-Rise Multi-Family Buildings

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Advanced Residential Integrated Energy Solutions

Research Objective

- Determine the impact of control strategies that use apartment temperatures for central boiler control on energy consumption, comfort and cost.
- Compare energy performance, comfort and cost to individual radiator valve controls in each apartment.

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Background

- Most multi-family boiler systems have:
  - No zone/apartment level control, or
  - Non-electric thermostats on radiator valves
- Central boiler system resets hot water based on outdoor temperature
- Problem:
  - apartments are often too hot or too cold.
  - Occupants often open windows to “control” temperature

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Concept

- New wireless temperature sensors offer the potential to cost-effectively retrofit poorly-controlled heating systems to reduce energy use
- More intelligent boiler plant “reset” control strategies may be more cost effective than full scale retrofits that put zone controls in each apartment.

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Test Site - Project Participants

- The ARIES Collaborative, a Department of Energy Building America research team
  - The Levy Partnership, Inc.
  - CDH Energy Corp.
- Homeowners' Rehab Inc., a non-profit housing developer in Cambridge, MA.
- Massachusetts Low Income Multi-Family Retrofit Program (LEAN), a utility program proving funding for the retrofit
- EnerSpective, Inc., assessing the project for the utility program

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Test Site

- 42-unit complex of three, three-story masonry buildings in Cambridge, MA
- Each building has two or three 87% eff space heating boilers (+one boiler for DHW)

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Technical Approach

- **PHASE I**: Replace boiler controls with wireless system that supplies heat based on both apartment and outdoor temperatures. Rigorously quantify the effectiveness of this strategy.
- **PHASE II** (tentative, TO3): Install radiator zone valves centrally controlled wirelessly using space temperature data.

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PHASE I: Indoor Temperature Based Boiler Control

- Wireless temperature sensors in apartments - data used to adjust building supply water temperature
- Web-enabled. Off-site server stores data and makes it available on a website
- Adaptive and intelligent reset and night setback approaches
- Where required, maintain boiler return water temperatures above 140°F with new 3-way mixing valve
- Goals:
  - Reduce spacing heating energy by 15% to 20%
  - Maintain space temperatures closer to the required set points (reduce overheating)

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PHASE II: Local Radiator Controls

- Central control of individual radiator risers
- Remove existing, mostly failed, non-electric radiator zone valves
- Install new valves in the basement risers,
- Goal:
  - Obtain additional heating energy savings
  - Distribute only the amount of heat needed at each riser in order to maintain the minimum heat needed in the apartment(s) served by that riser

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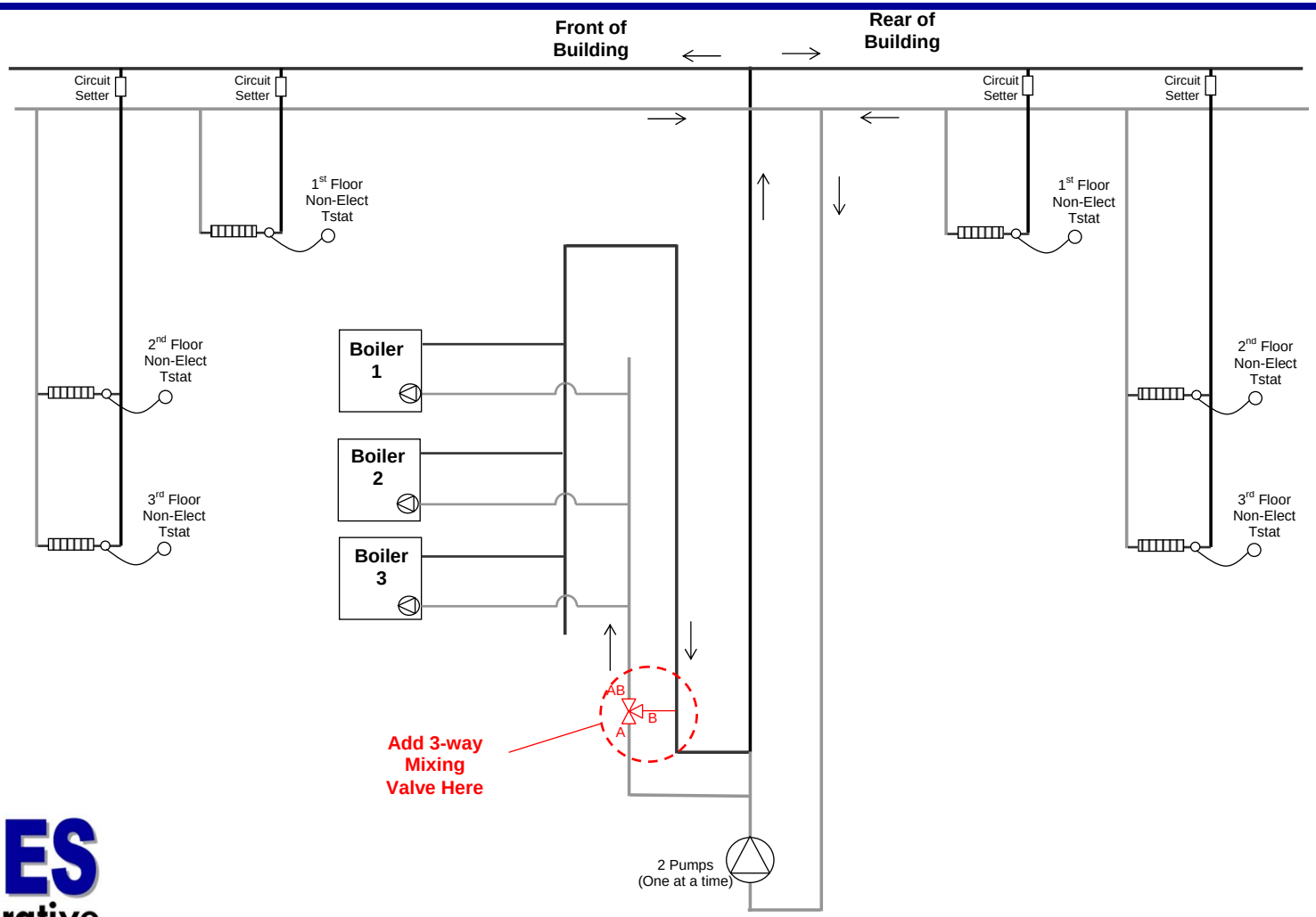
System Configuration



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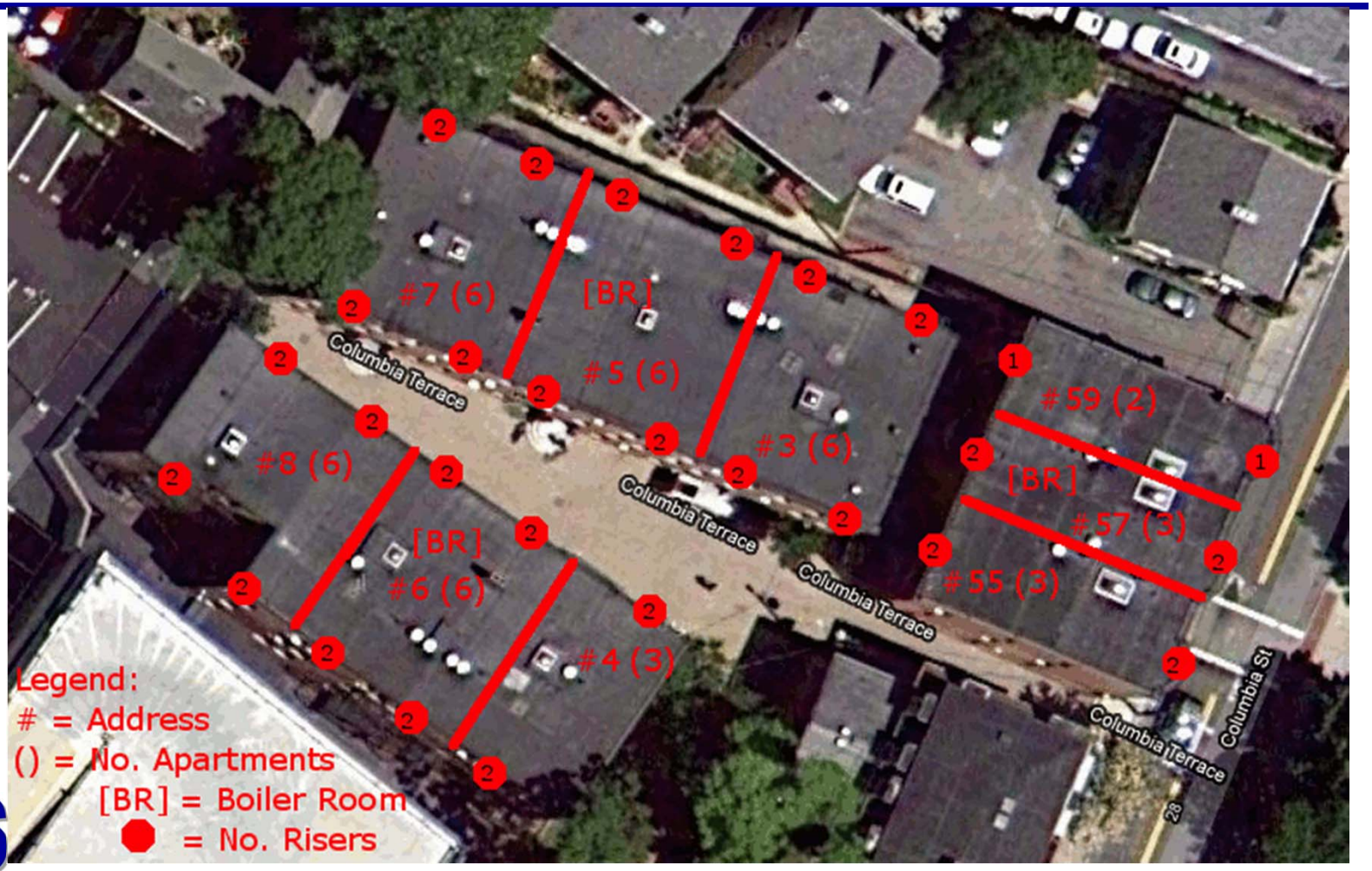
Apt Complex Layout



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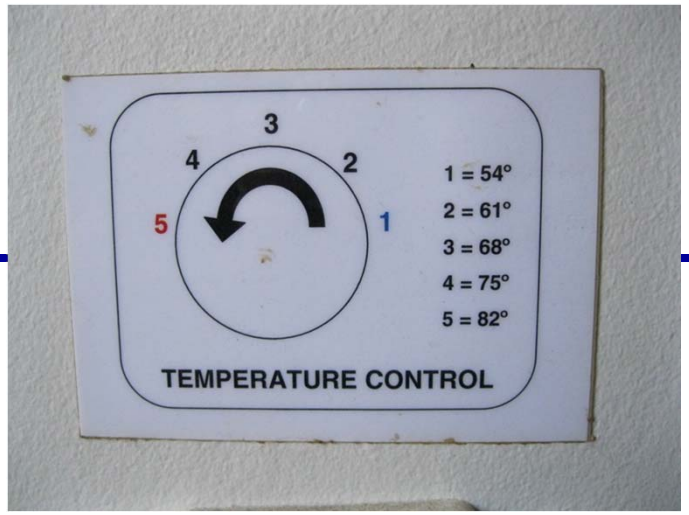
Current Zone Controls



- Each apartment has 1-2 non-electric, remote “thermostats” to regulate baseboard water flow
- Valve calibration is unknown
- Many have failed in open position (resulting in overheating)
- Residents typically disregard municipally mandated set points (68°F day, 64°F night)

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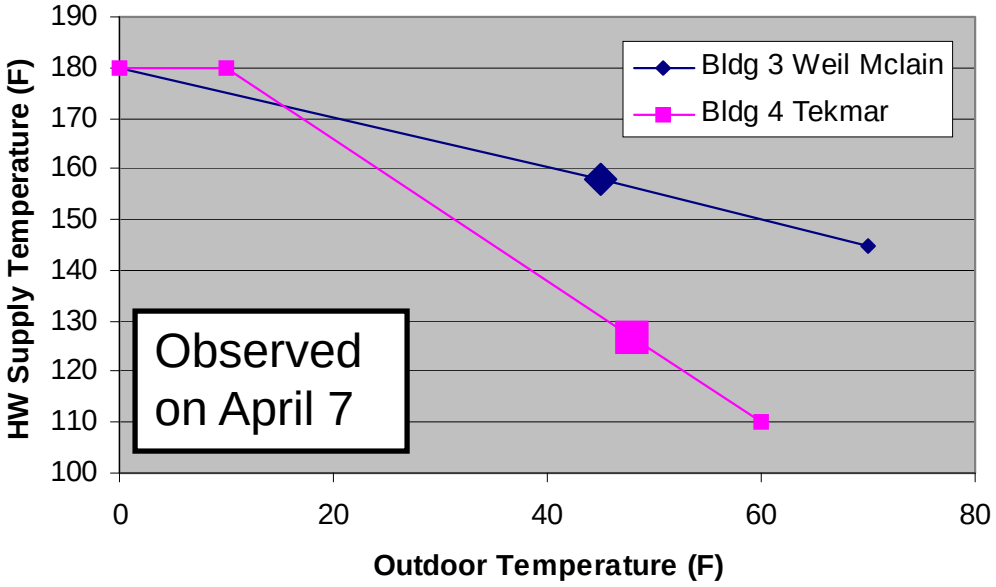
Boiler Controls

- Both Buildings have Outdoor Reset control
- Supply T about 30°F higher in Bldg 3 on April 7, 2011



Savings & Cost-Effectiveness

- Target: Reduce heating costs by 15% to 25%
- 20% savings = 4,539 therms per year ($5,447 at $1.2/therm)
- Initial Assumption: cost to install the control system (PHASE 1) was $25,000
- Simple payback is 4-5 years
- Payback is longer due to small size of building and multiple boiler rooms

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Adjusted Test Plan

- BUILDING 3: Wireless, Web-enabled system (Intech 21)
  - Full functionality
  - Web-based data collection
- BUILDING 4: Updated Baseline system (tekmar)
  - Standard controls, boiler protection valve
  - Data collection capabilities

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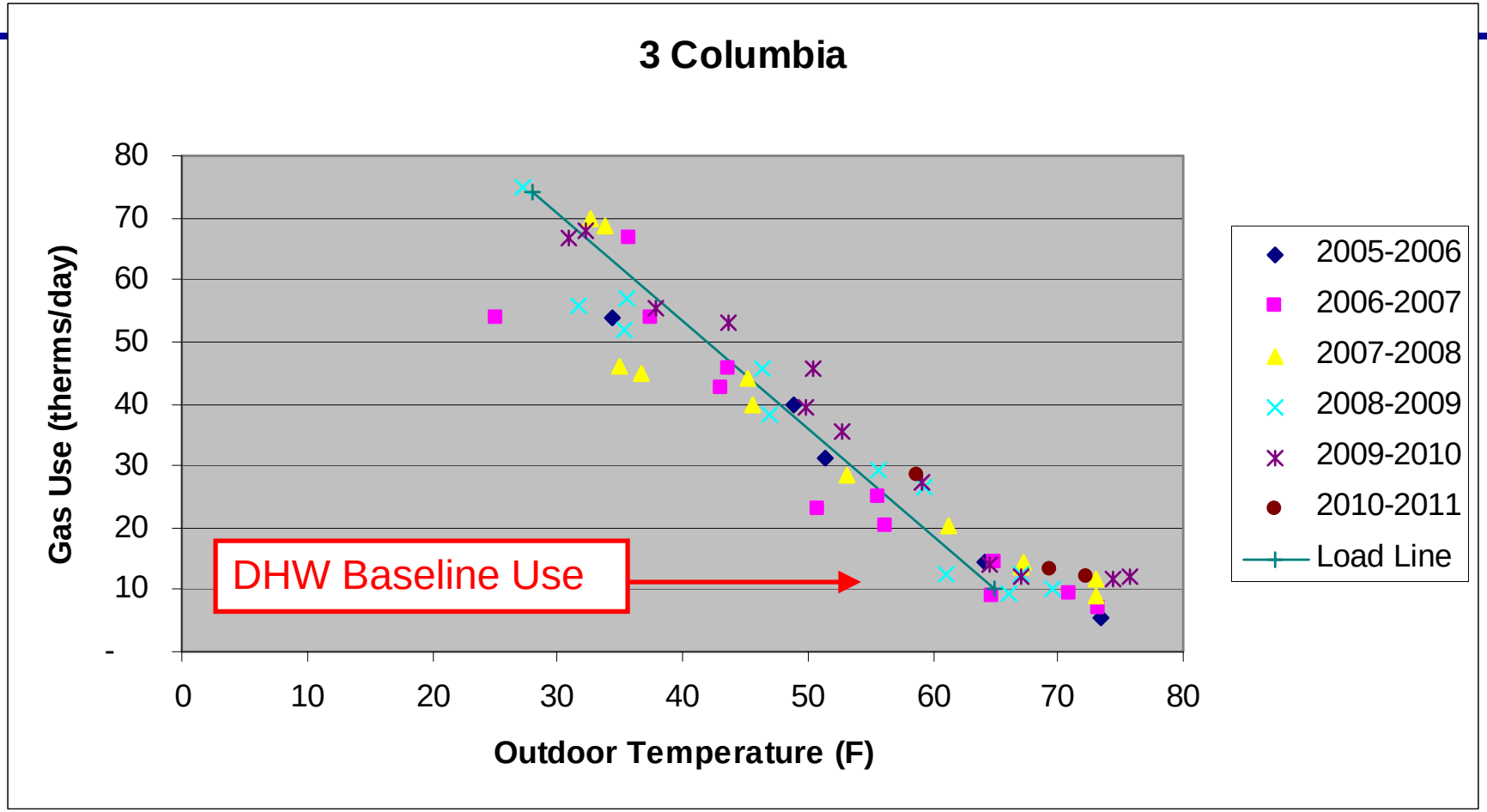
Baseline Performance



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Load line of monthly gas use vs. temperature 2005-2011

Data Collection (Intech 21)

- Web-enabled control will be used to collect data at 15-minute intervals:
  - Apartment temperatures
  - Outdoor temperature
  - Hot water supply temperature
  - Hot water return temperature
  - Hot water return temp (entering boilers)
  - Cumulative boiler run time (each boiler)
  - Mixing valve position
  - Cumulative runtime of hot water pump

- Also…
  - Comfort will be gauged by heat complaint reports, surveys and observations of open windows
  - Monthly gas consumption from fuel bills

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Test in Various Modes

- Control Modes:
  1. Existing conditions (baseline outdoor reset)
  2. Indoor temperature-based control
  3. Indoor temperature-based control with one-time manual balancing of system using riser valves (one building)
- Spend several weeks in each mode
- Directly compare energy performance and comfort impacts after normalizing for weather

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Analysis Approach

- Daily load line analysis relating total boiler runtime to outdoor temperature for each day
- Compare resulting linear trends for different performance periods / control modes to discern impacts
  - Multi-linear regression analysis with dummy variables to determine if the differences are statistically significant
  - Relate monthly runtimes to billed gas use to discern impact on fuel use

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Project Status

- Hardware installation is underway
- Expect system (and data collection) to be operational and commissioned for late September
- Switch between operating modes throughout fall-winter season

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Summary

- Seek to document that new control strategies are viable and cost-effective in affordable low-rise multifamily buildings in cold climates
- Test program designed to gather quantitative data to verify energy efficiency and occupant comfort

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