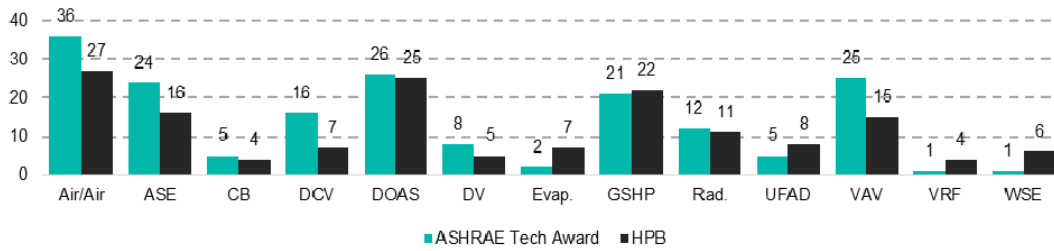


## Systems Approaches to High Performance Buildings

Evaluation of Factors Impacting EUI from High Performing Building Case Studies

<b>Air/Air = Air-to-Air Energy Recovery</b>	<b>GSHP = Geothermal/Ground-Source Heat Pump</b>
<b>ASE = Air-Side Economizer</b>	<b>Rad. = Radiant Heating/Cooling</b>
<b>CB = Chilled Beams</b>	<b>UFAD = Underfloor Air Distribution</b>
<b>DCV = Demand-Controlled Ventilation</b>	<b>VAV = Variable Air Volume</b>
<b>DOAS = Dedicated-Outdoor Air System</b>	<b>VRF = Variable Refrigerant Flow</b>
<b>DV = Displacement Ventilation</b>	<b>WSE = Water-Side Economizer</b>
<b>Evap. = Evaporative Cooling</b>	

Number of Case Studies with Each System Type by Data Source

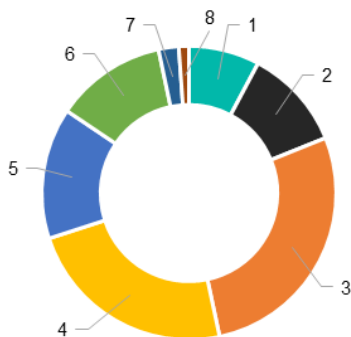


Source: <http://www.hpbmagazine.org/Case-Studies/Evaluation-of-Factors-Impacting-EUI/>

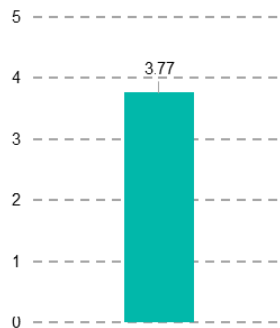
## High Performance Buildings = Hybrid Buildings

82% of case studies include more than one HVAC system

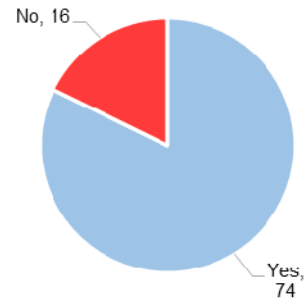
Number of HVAC Technologies per Case Study



Average No. of HVAC Technologies per Case Study



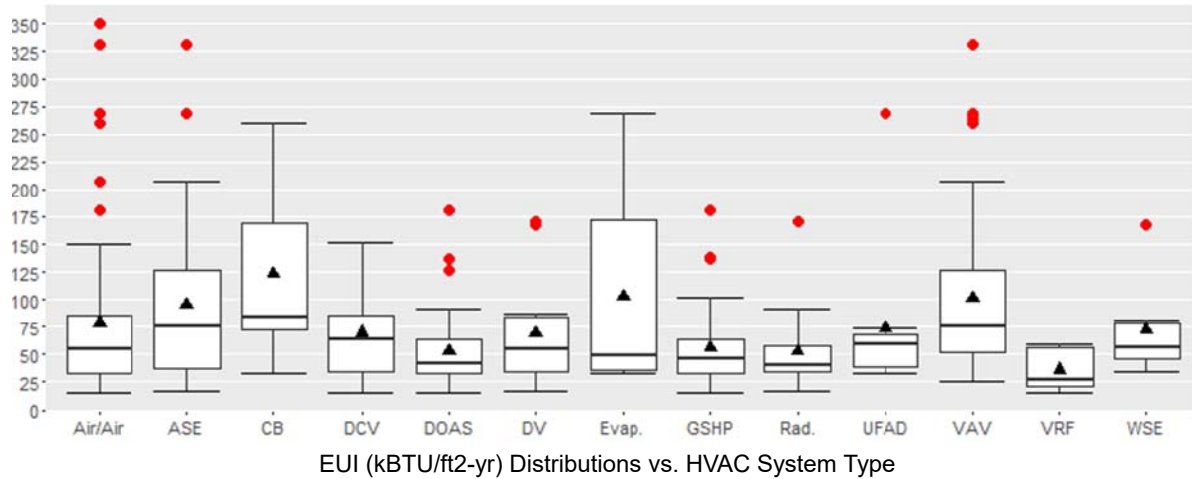
Does Case Study Have a Hybrid HVAC Solution?



Source: <http://www.hpbmagazine.org/Case-Studies/Evaluation-of-Factors-Impacting-EUI/>

## EUI Distributions: No Single System Type Outperforms

A systems-based approach is needed which considers building geometry, lighting, plug loads, schedules, weather conditions and different HVAC system configurations



Source: <http://www.hpbmagazine.org/Case-Studies/Evaluation-of-Factors-Impacting-EUI/>

## Powerhouse Brattøra Trondheim, Norway

- Entra Eiendom ASA
- Office building: 18,000 sq. meters
- Central BMS across 25 sites
- Smart Equipment
- Smart Room Control
- Smart Lighting Controls
- Smart Security System
- Visitor Kiosk
- Geothermal Heat Pump with Natural Refrigerant for Central Heating/Cooling
- Energy Positive - solar panels will produce 500,000 kWh, more than twice yearly consumption

<http://www.powerhouse.no/en/>

