Unraveling the Paradox: The Economics of Using Otherwise Wasted Heat for Chilling

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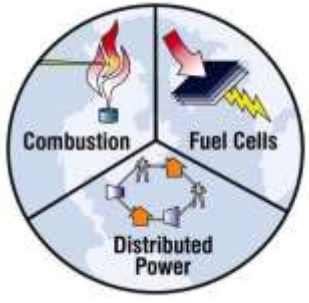
37th IAEE International Conference
New York, New York
June 2014



Advanced Power and Energy Program
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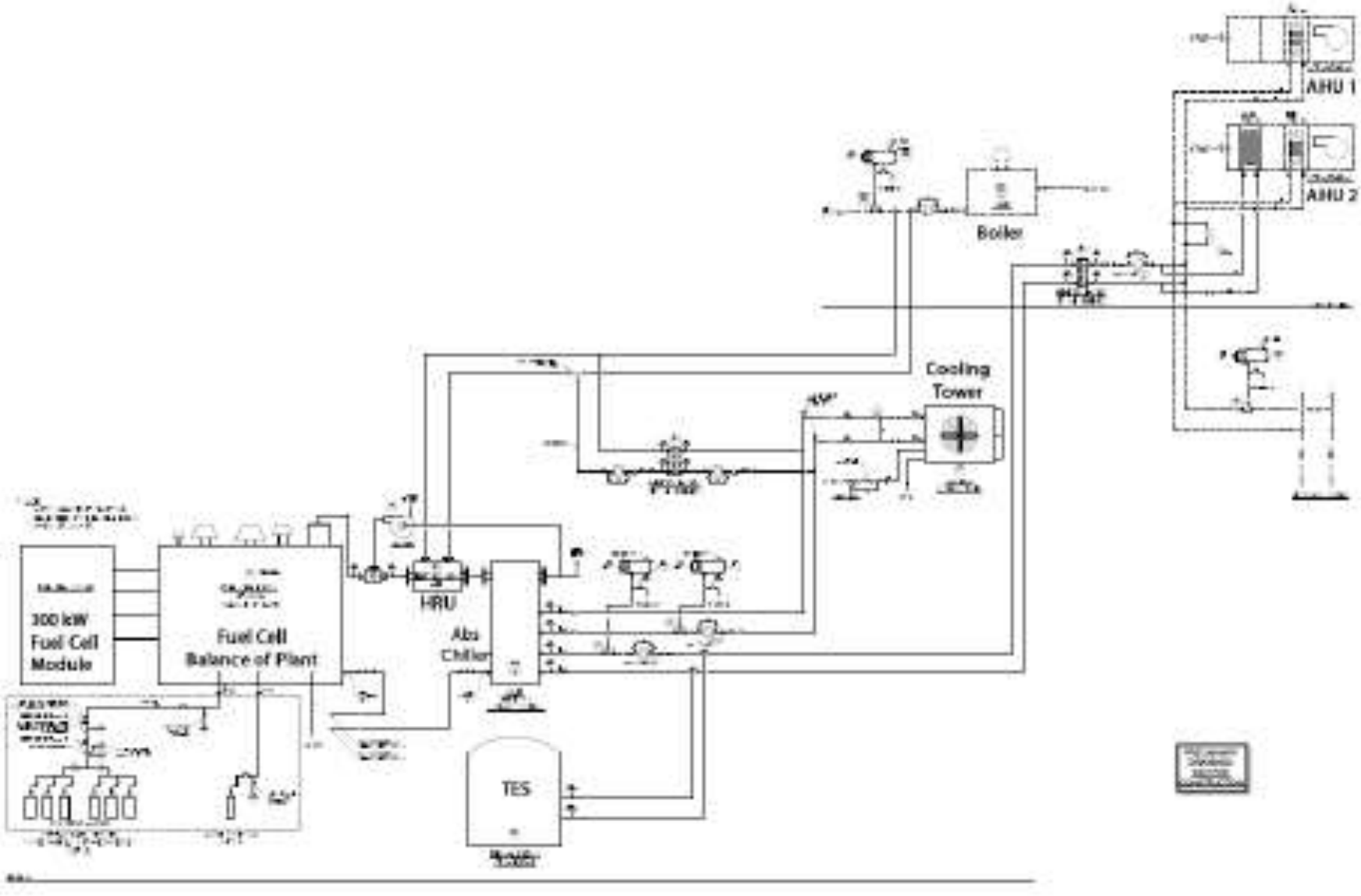
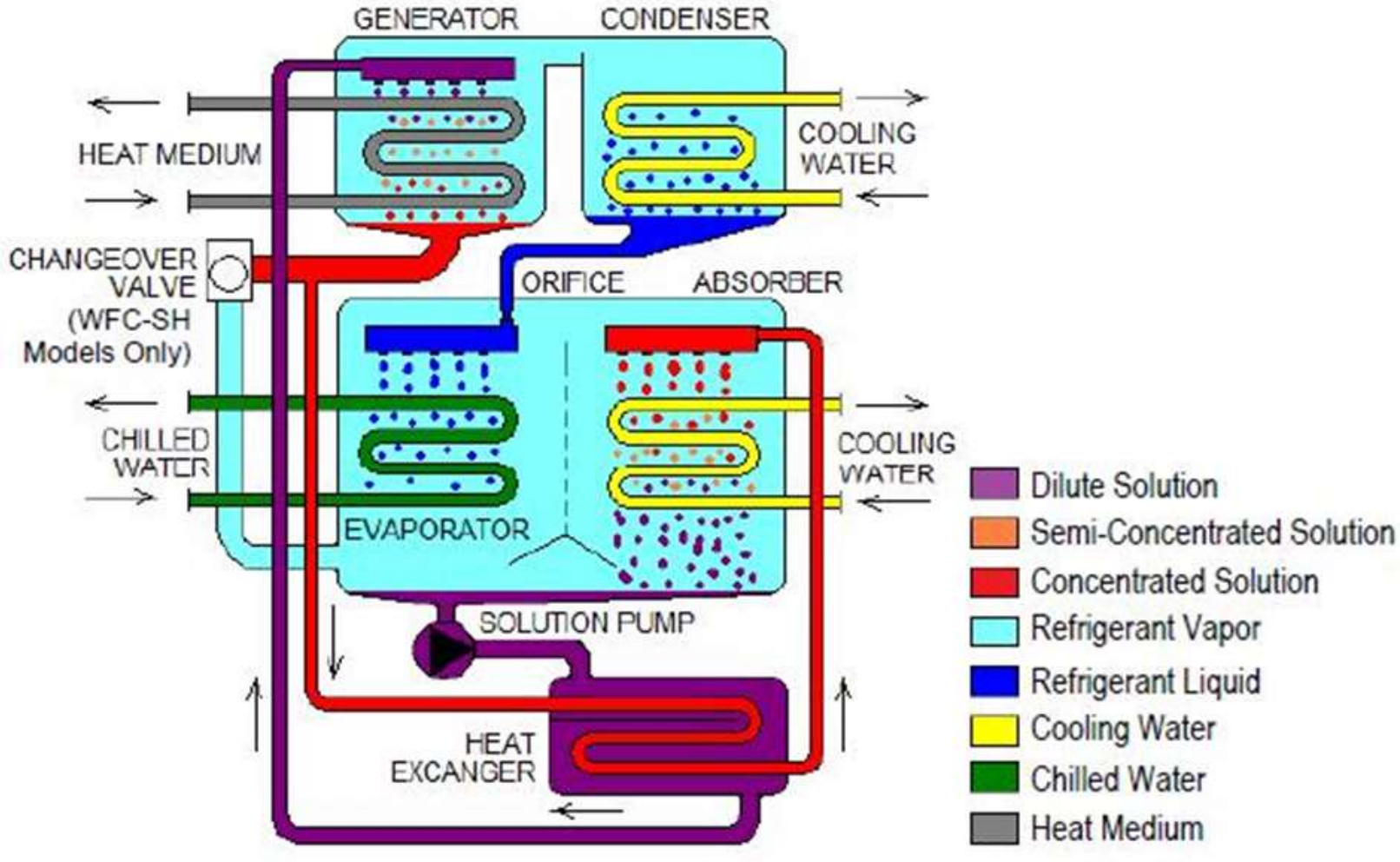
Motivation

- Air conditioning in commercial buildings accounts for 16% of California's electricity consumption
  - Estimated to grow at 1.30% p.a. through 2024
- Dominant technology: Electric Chillers, which contribute to peak electricity consumption
- A high-temperature fuel cell ("HTFC") generates significant amounts of high quality exhaust heat
- Exhaust heat is wasted in electricity-only fuel cell operations
- If captured, otherwise-wasted exhaust heat can be fed to an absorption chiller for air conditioning.

Piping & Instrumentation Diagram

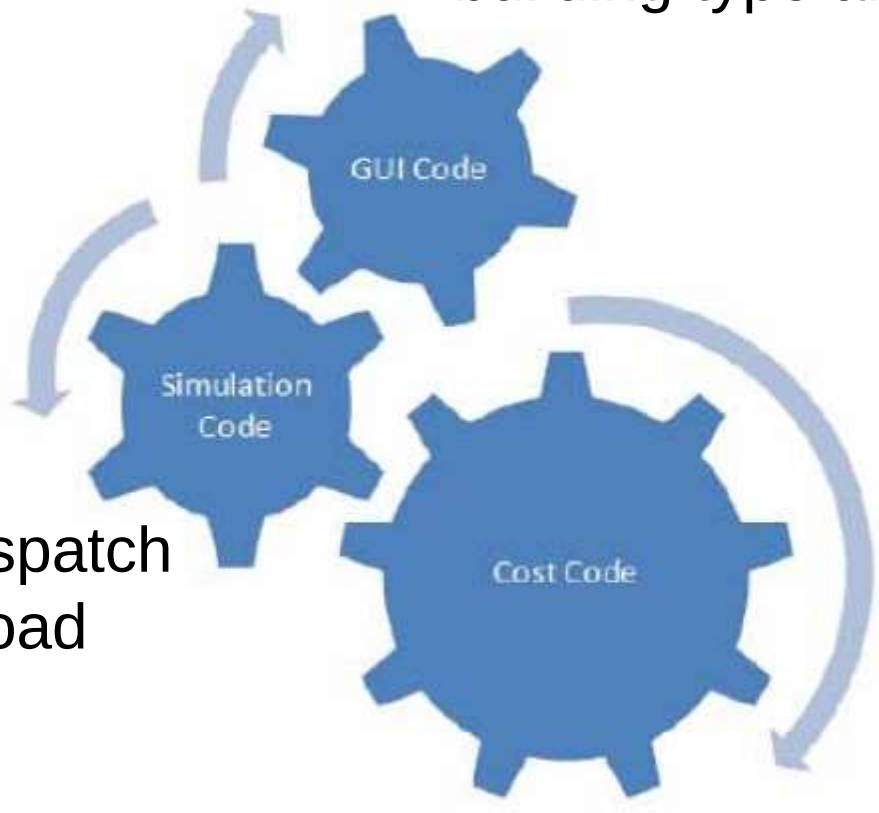


Absorption Chiller: How It Works



HTFC/Chiller Model: Major Components

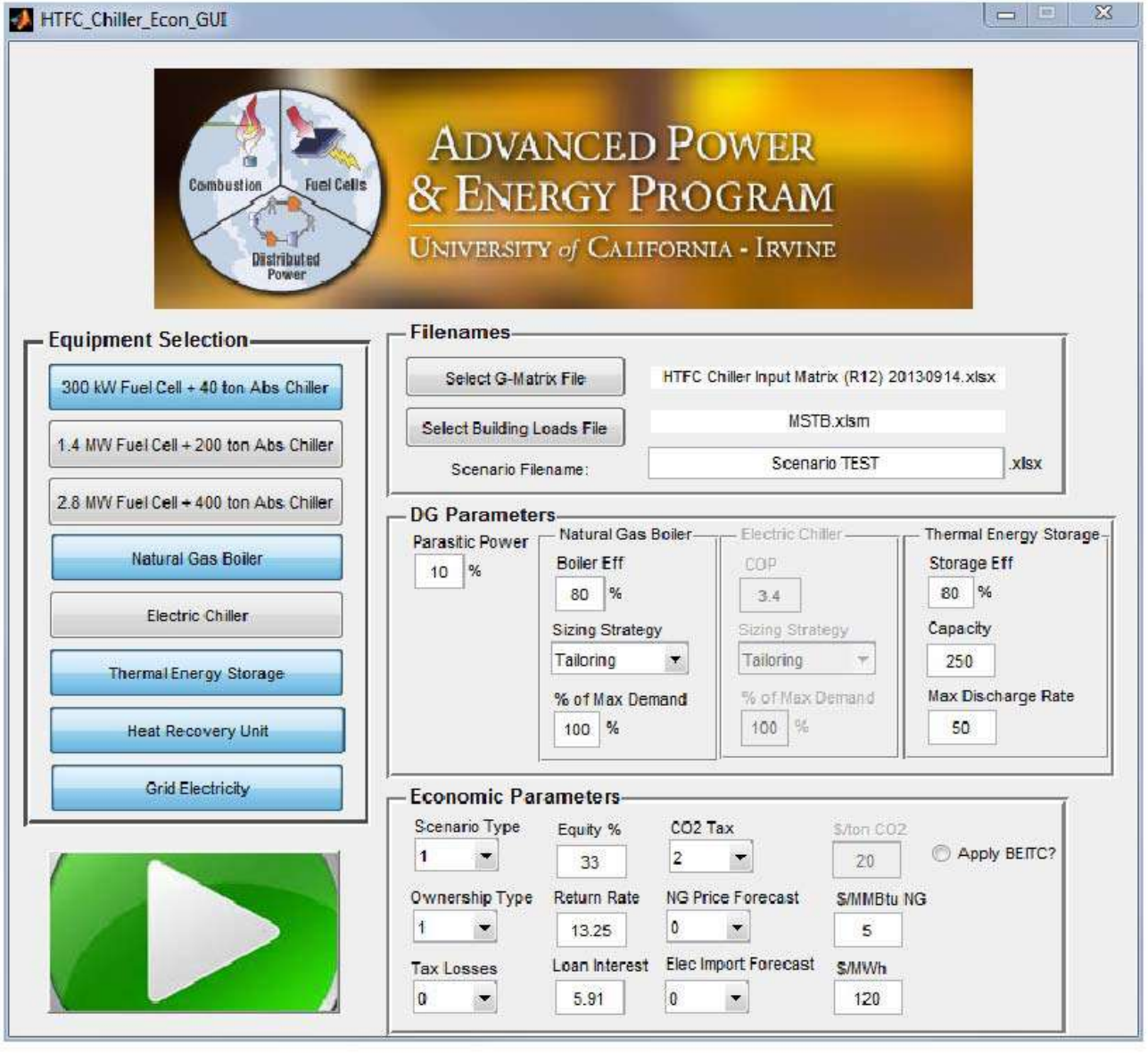
(1) User Interface to specify building type and select equipment



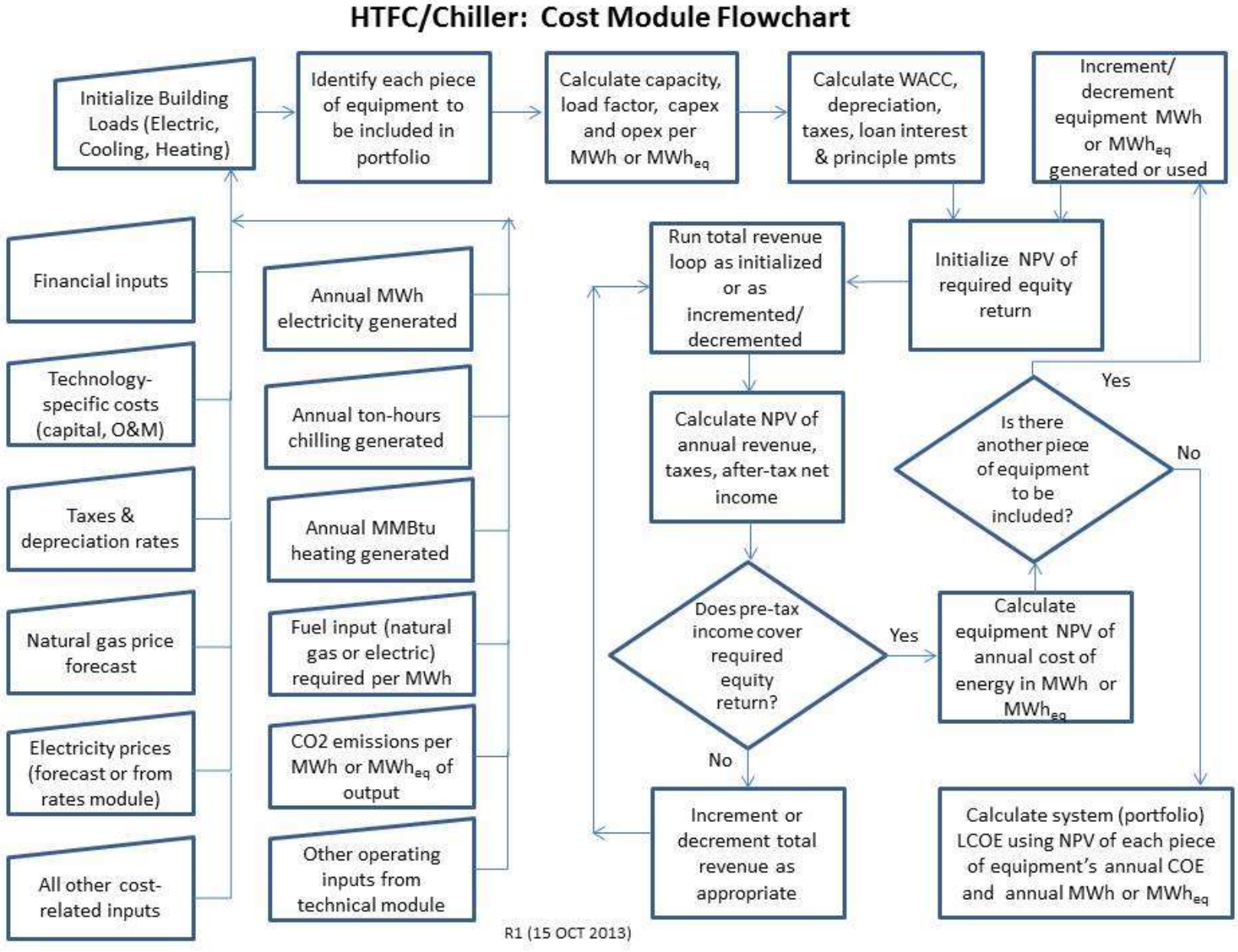
(2) Equipment dispatch to meet building load

(3) Levelized Cost of Energy ("LCOE") calculations based on equipment dispatch

HTFC/Chiller Model: User-Friendly Interface



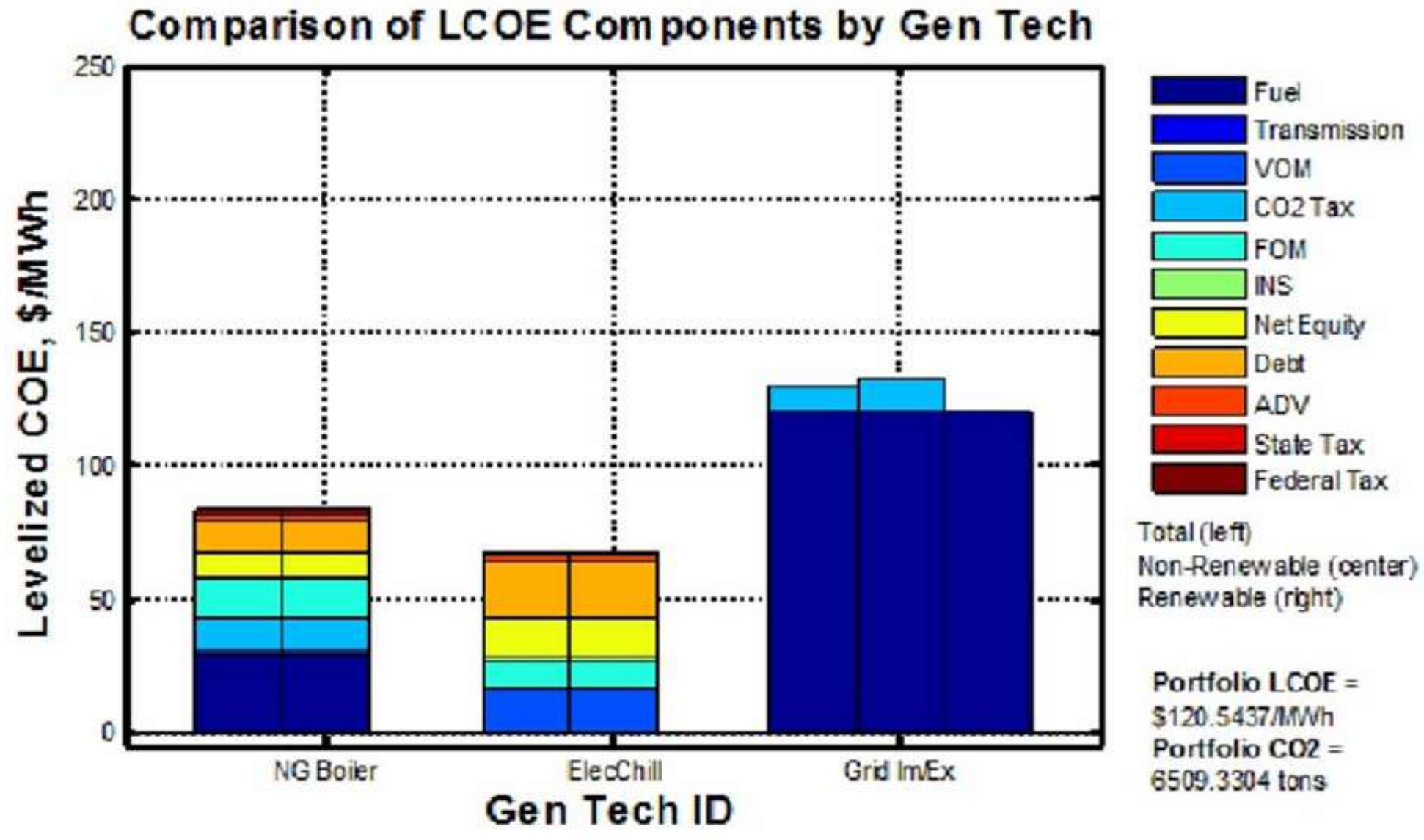
HTFC/Chiller Model: Cost Module



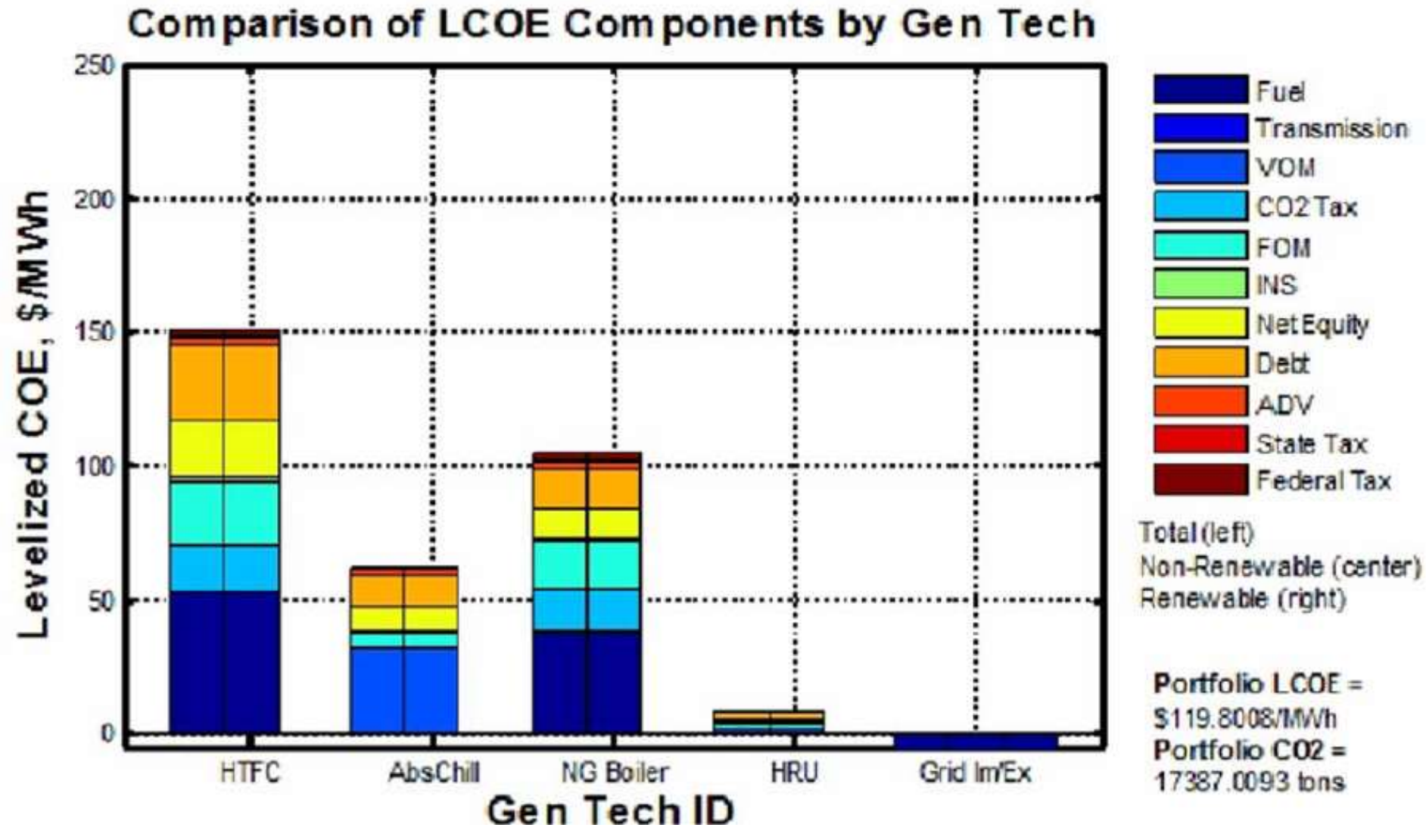
LCOE Changes with Size & Building Load

- **Optimal fuel cell size depends on availability of complementary technologies**
  - **Higher capacity, lower capacity factor**
  - **Lower capacity factor, higher LCOE**
- **Thermal energy storage ("TES") and/or natural gas-fired boiler allow for smaller HTFC capacity and greater efficiencies**
  - **Must balance efficiencies vs. equipment costs**
- **Model an existing building on UCI campus**
  - **Multipurpose Science & Technology Building ("MSTB")**
- **All physical flows converted to MW or MWh electric or thermal, as appropriate**

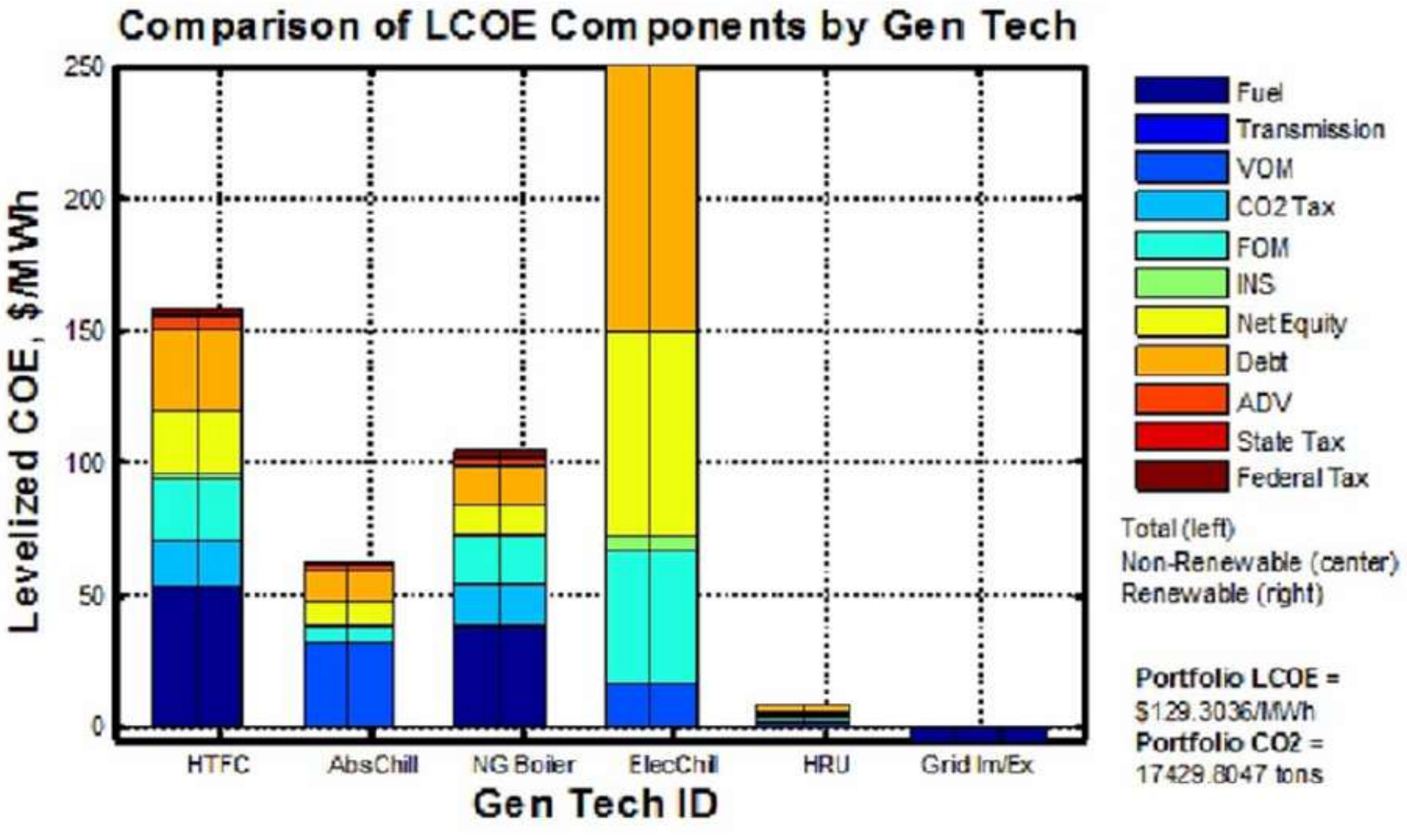
MSTB: Traditional Cooling/Heating



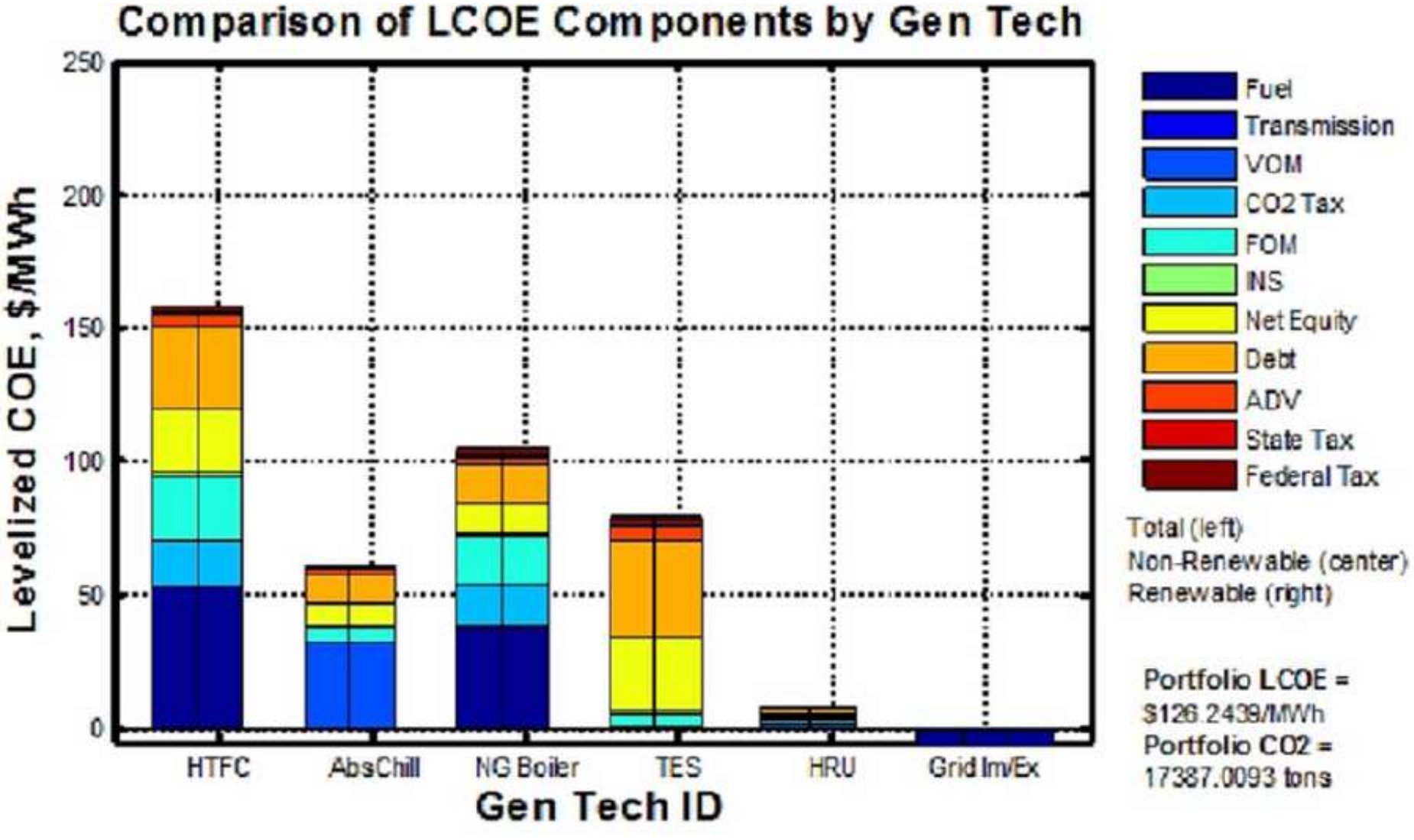
MSTB: 300 kW FC + Abs Chiller + Boiler



MSTB: Add Electric Chiller for Backup



MSTB: TES Instead of Electric Chiller



Conclusions

- A high-temperature fuel cell/absorption chiller unit effectively displaces traditional electric chillers
- Peak and total electricity consumption is reduced
  - Value of peak reduction is not monetized
- LCOE is reduced vs. the traditional technology
  - $119.80/MWh vs. $120.54/MWh
- Backup equipment increases LCOE & reliability
  - Value of increased reliability is not monetized
- Adding complementary technologies increases fuel cell sizing flexibility and operating efficiencies
- Ongoing research
  - What is the potential market size in California?
  - What are the market entry barriers?

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