

# Combined Heat and Power (CHP) for Hospitals

*An Energy Efficiency  
Education and Implementation Program*

Module #2

## CHP: The Business Case

*Why Hospitals?*

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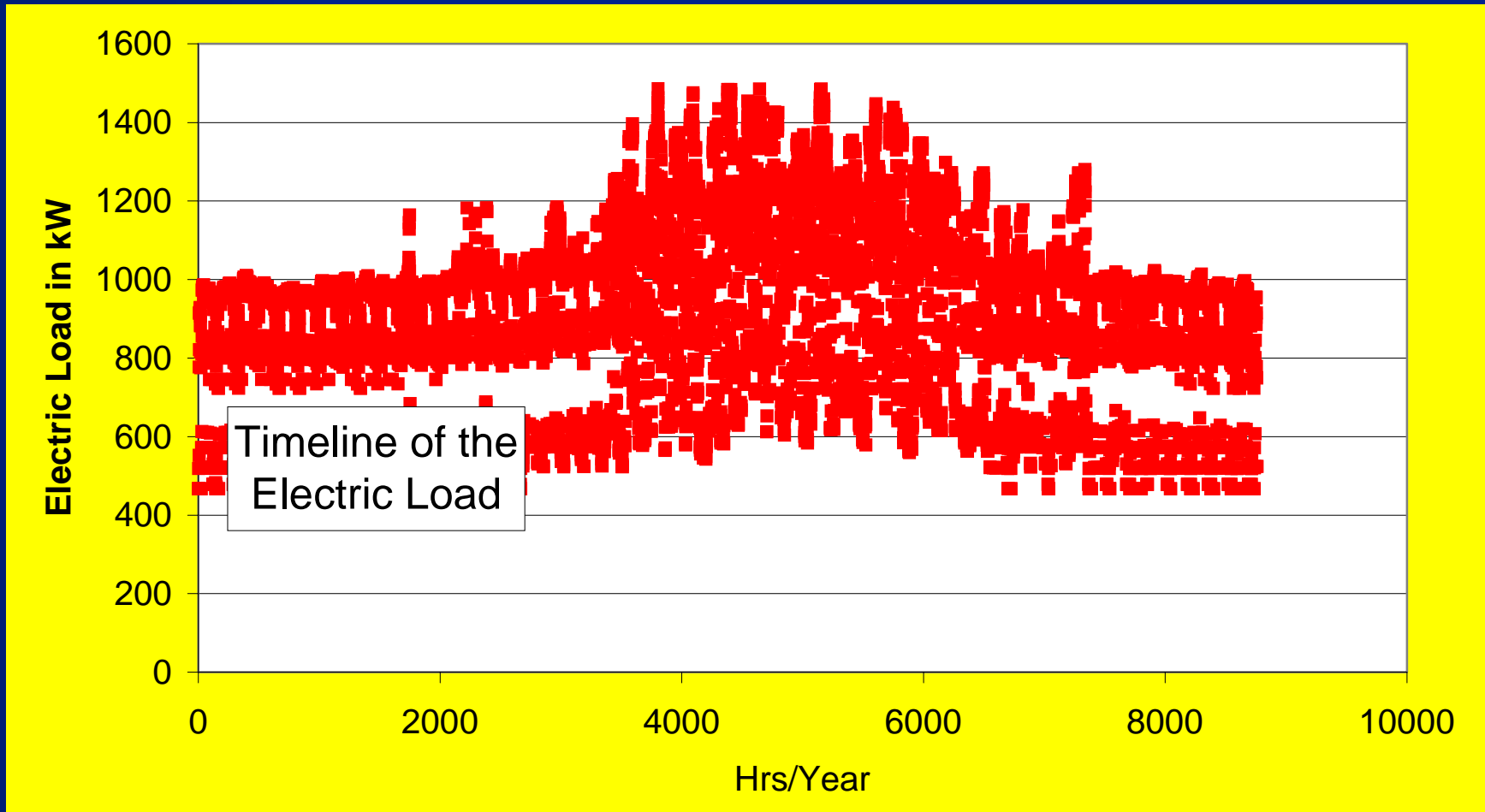
March 18, 2003



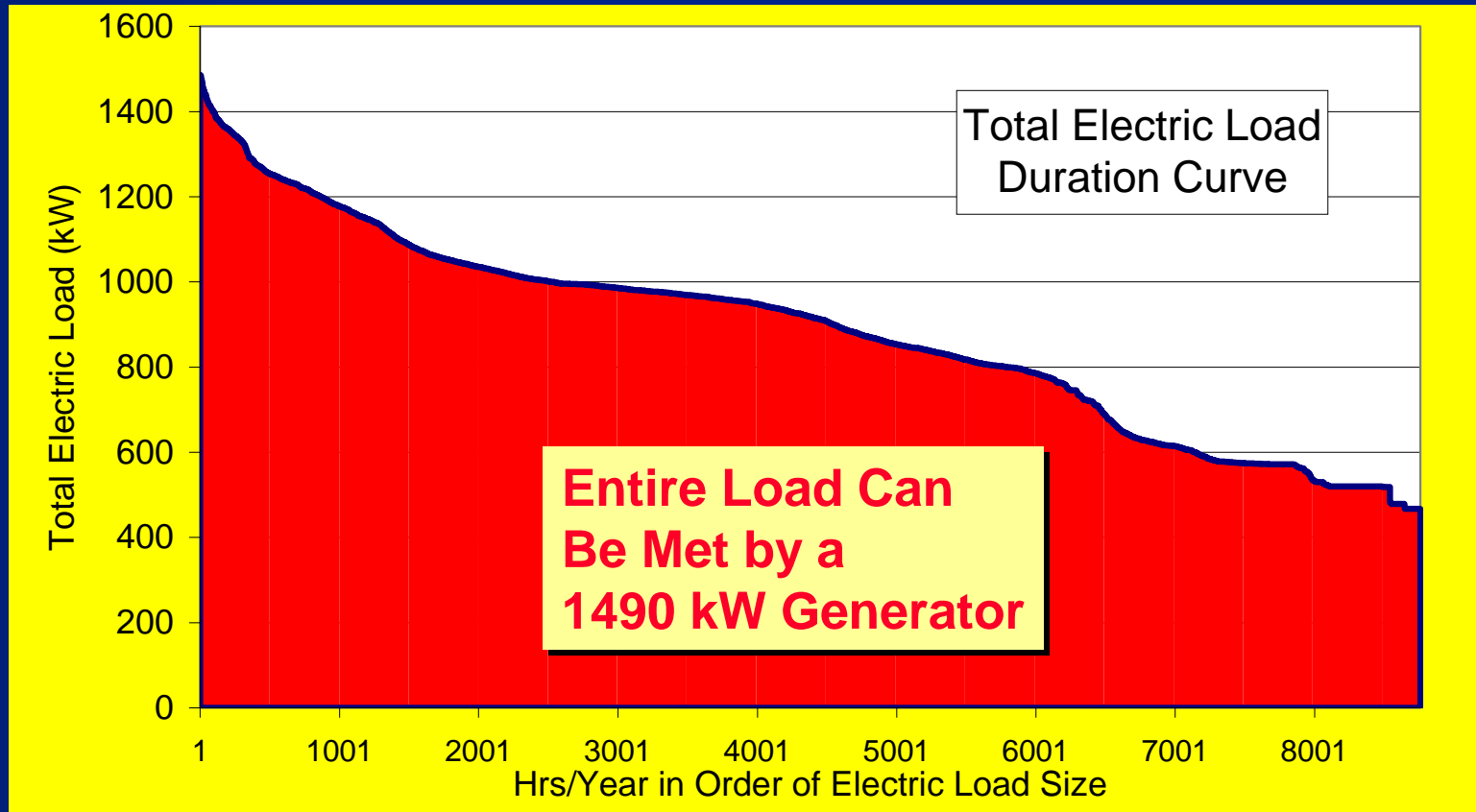
# Overview

- Quick Background on CHP Systems and Heat Recovery
- Energy Analysis Process and Example
- Chicago Area Market Generalization
- Items to Look for in the Energy and Financial Analysis
- Items to Look for in a Concept Design

# Quick Background on CHP System Operation - Hospital Example

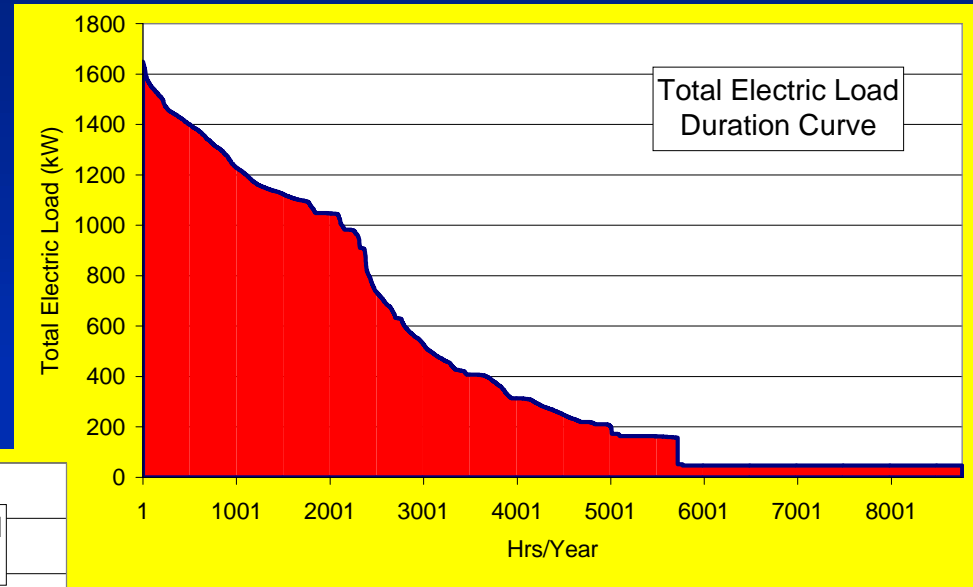
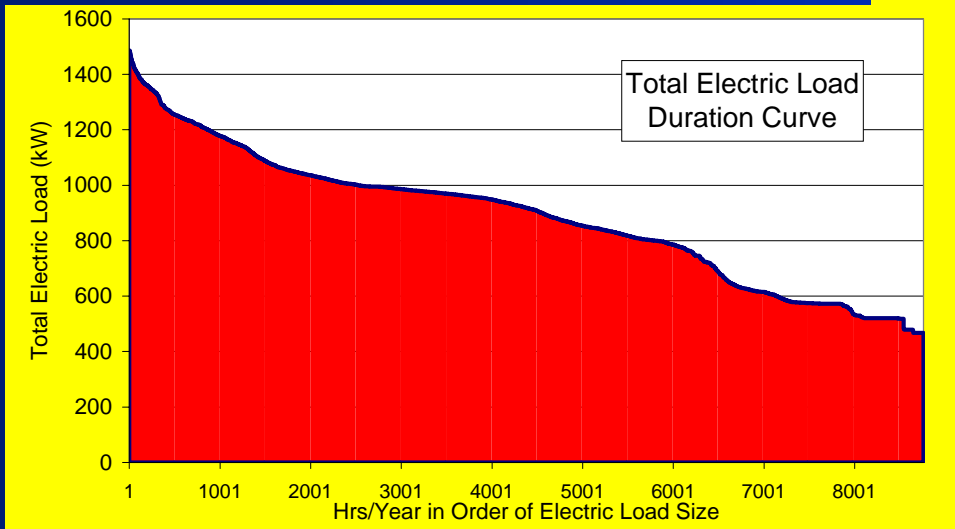


# Power Needs are More Easily Viewed by Ordering into a Duration Curve



# Hospital Power Consumption is More Constant than Other Commercial Loads

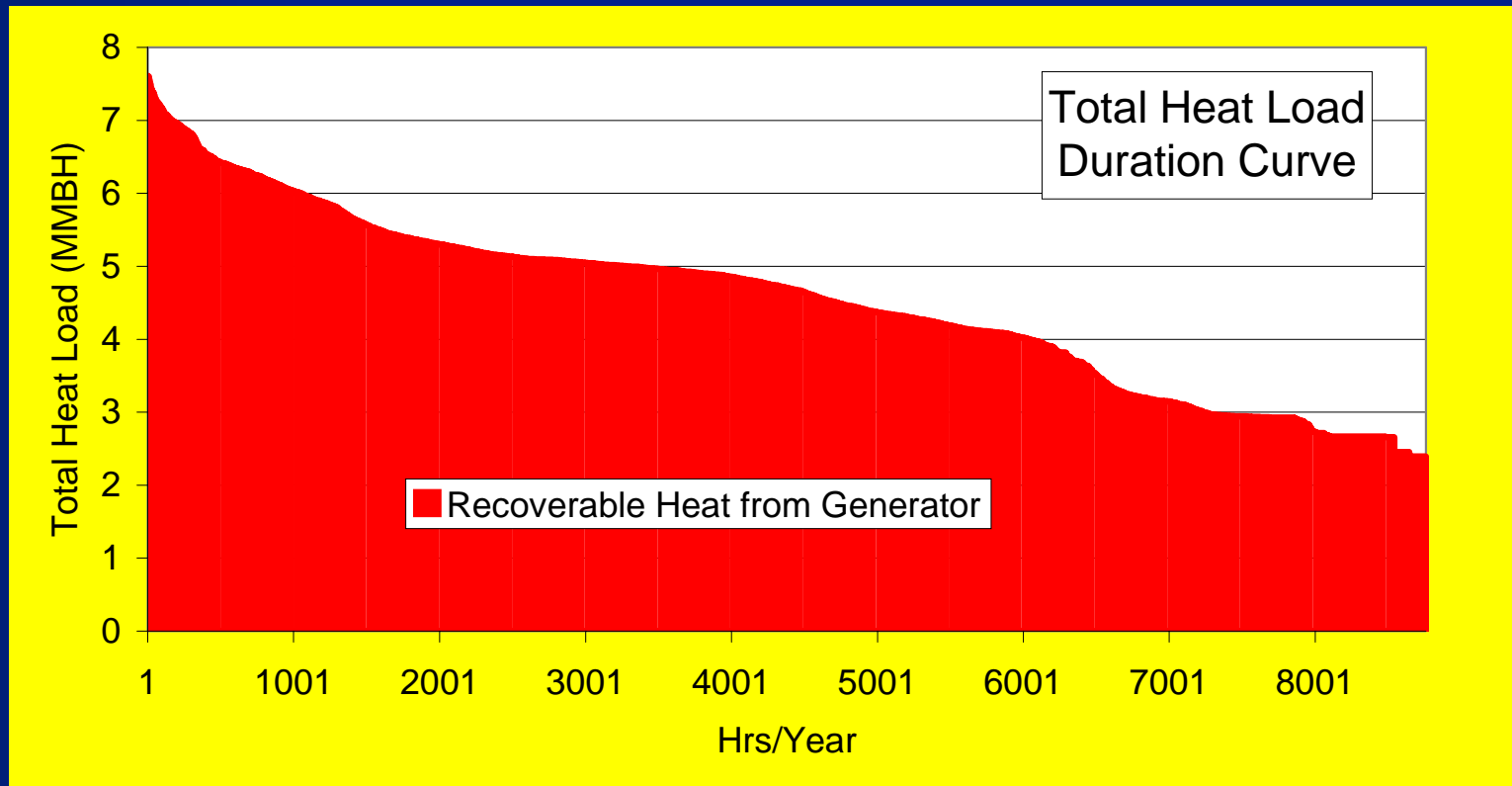
## Hospital 300,000 SF



## Office Bldg 300,000 SF



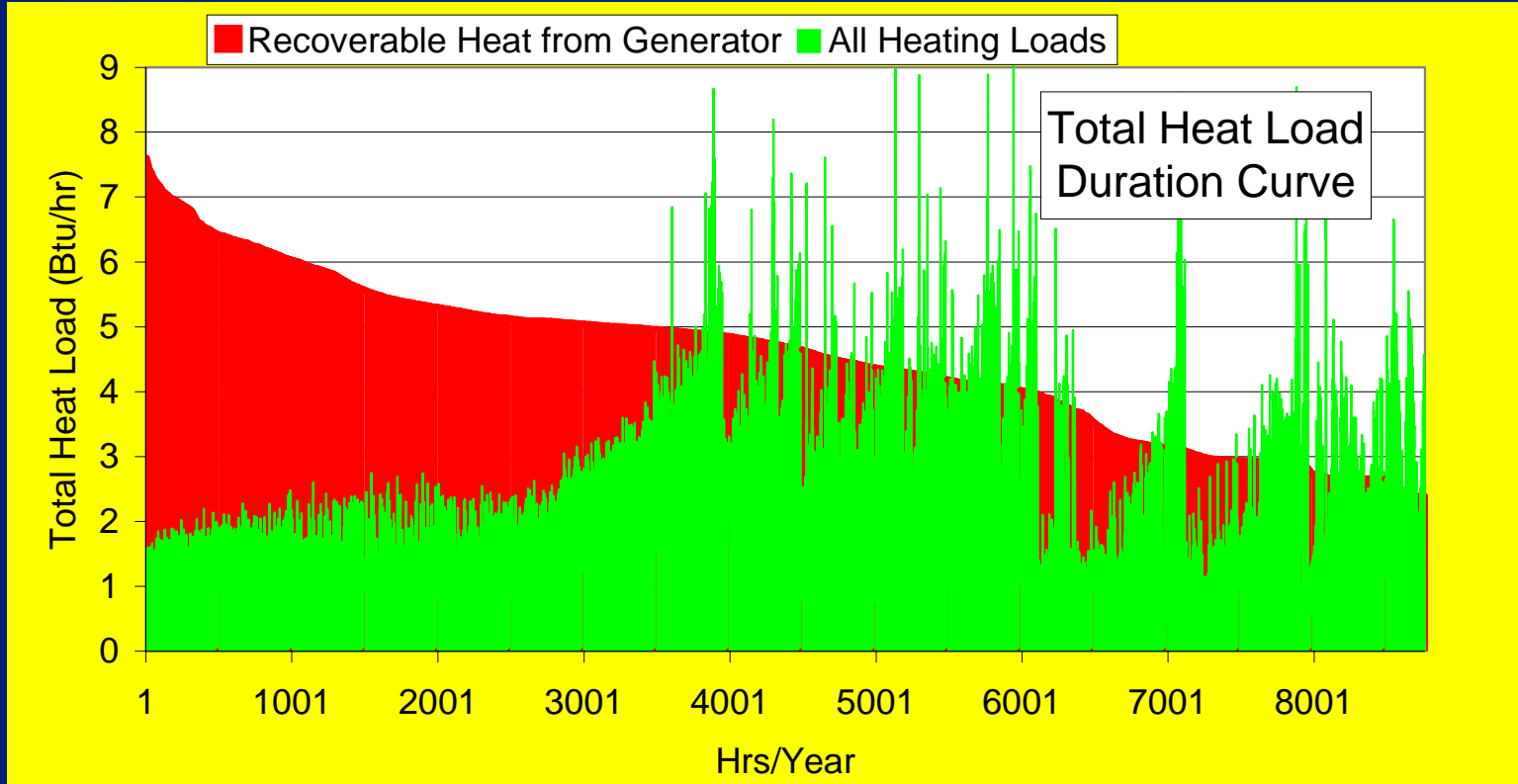
# If the Facility has a Generator that Supplies ALL Power Needs, How Much Waste Heat is Available ?



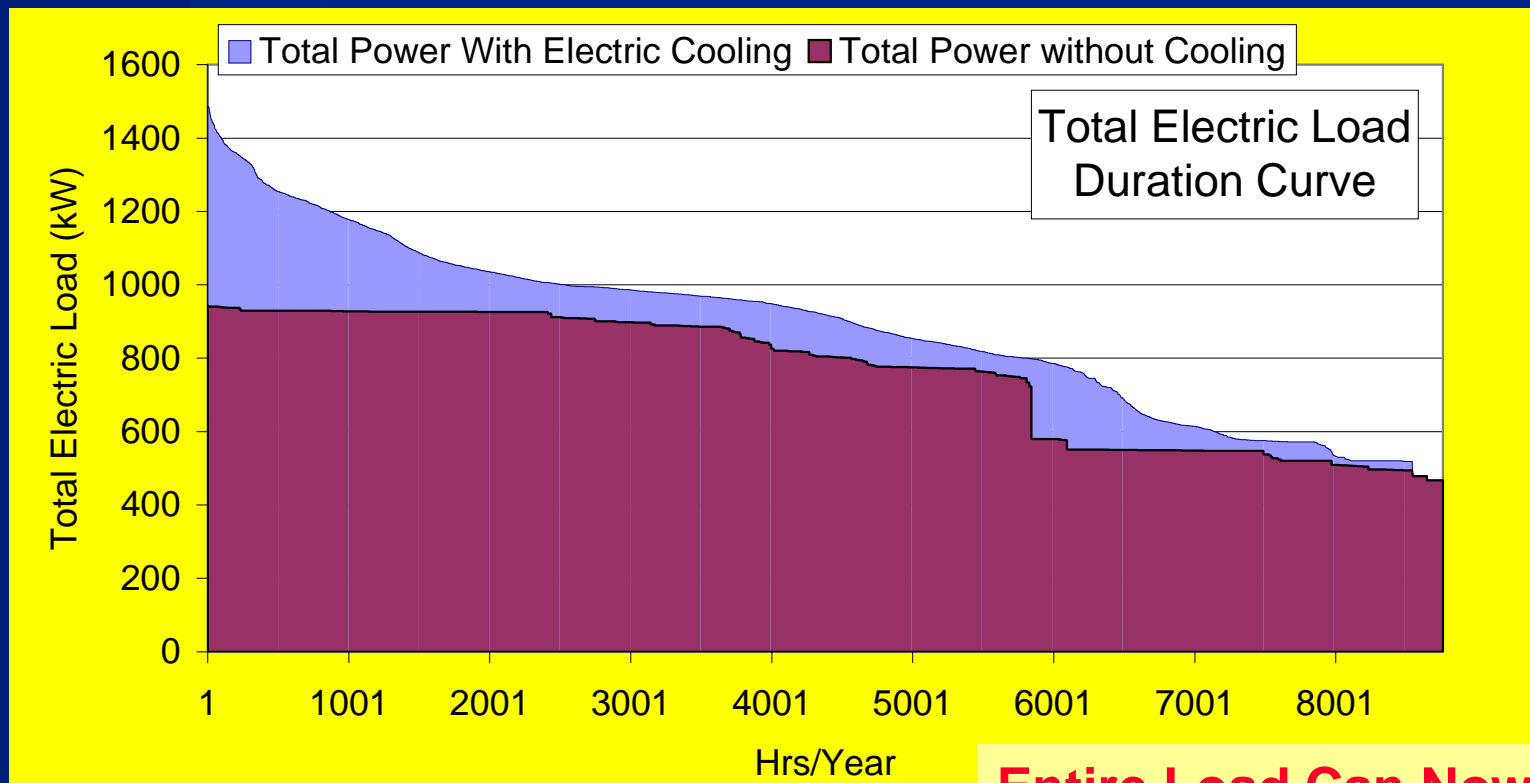
*Note: For Simplicity, the Engine is Assumed to Be Capable of Running Down to Zero Load at a Constant Efficiency and Heat Rejection Rate. This is Not True of Actual Engines*

# How Much Can be Used for All Heating?

42% of the Waste Heat Can Be Used for Space and Water Heating

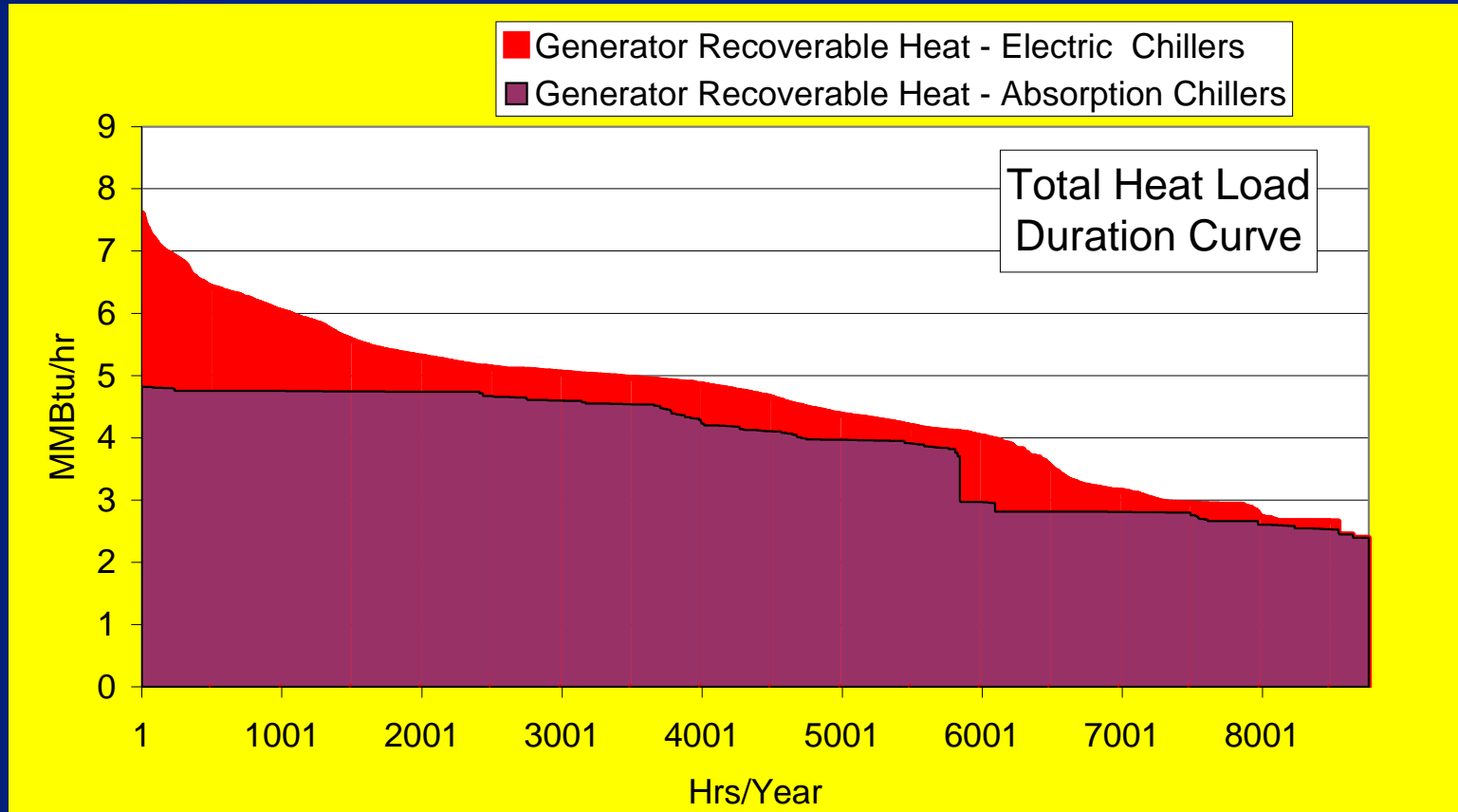


# If the Cooling Load is Now Also Operated by Waste Heat – The Electric Load is Changed

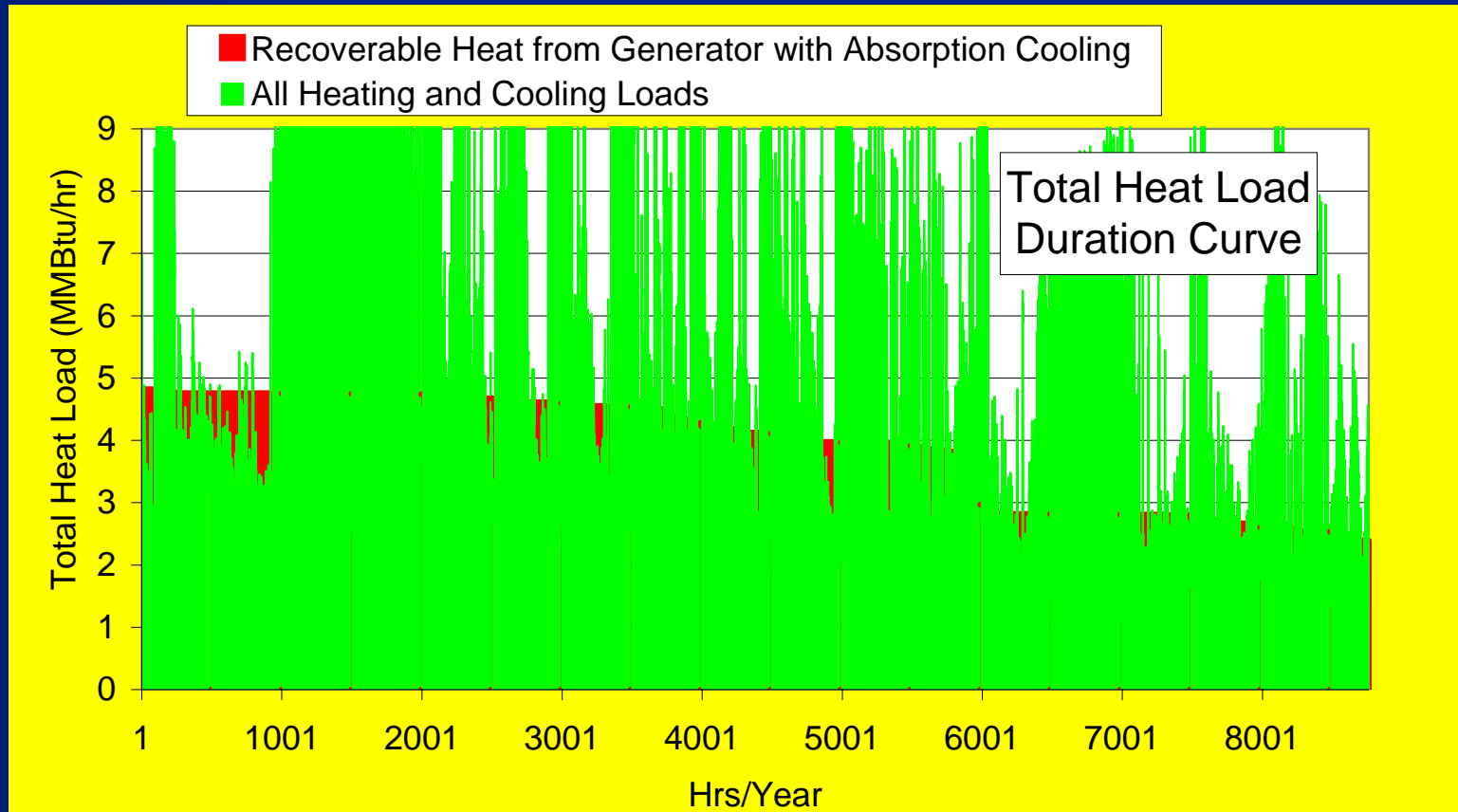


**Entire Load Can Now  
Be Met by a  
940 kW Generator**

# After Downsizing the Load and the Generator The Recoverable Heat is Lower and More Constant



# How Much Waste Heat Can be Used for Space Heating AND Cooling?



- 85% of the Waste Heat Can Be Used for Heating/Cooling
- To Avoid Excessive Boiler Operation – a Mix of Electric and Absorption Chillers is Generally Used

# Importance

- Heat Rejected by the Generator is Only Useful to the Extent that It Coincides with a Load Capable of Using It.
- Hospitals Have a Greater Opportunity to Due to the More Consistent Electric and Thermal Loads



# Analysis Example

## Three Chicago Hospital Load Sizes

<b>Floor Space</b>	<b>100,000</b>	<b>300,000</b>	<b>800,000</b>
<b>Optimal System Size:</b>	<b>275 kW</b>	<b>900 kW</b>	<b>2,500 kW</b>
<b>Installed First Cost:</b>	<b>\$460,000</b>	<b>\$1,043,000</b>	<b>\$2,120,000</b>
<b>Gas Price Per Therm:</b>	<b>\$0.40</b>	<b>\$0.40</b>	<b>\$0.40</b>
<b>Annual Savings:</b>	<b>\$64,000</b>	<b>\$200,000</b>	<b>\$540,000</b>
<b>Simple Payback:</b>	<b>7.2 Years</b>	<b>5.3 Years</b>	<b>3.9 Years</b>

*Going to Three Times Larger Building  
Savings have Tripled (as Expected)  
Installed Costs have a Little over DOUBLED*

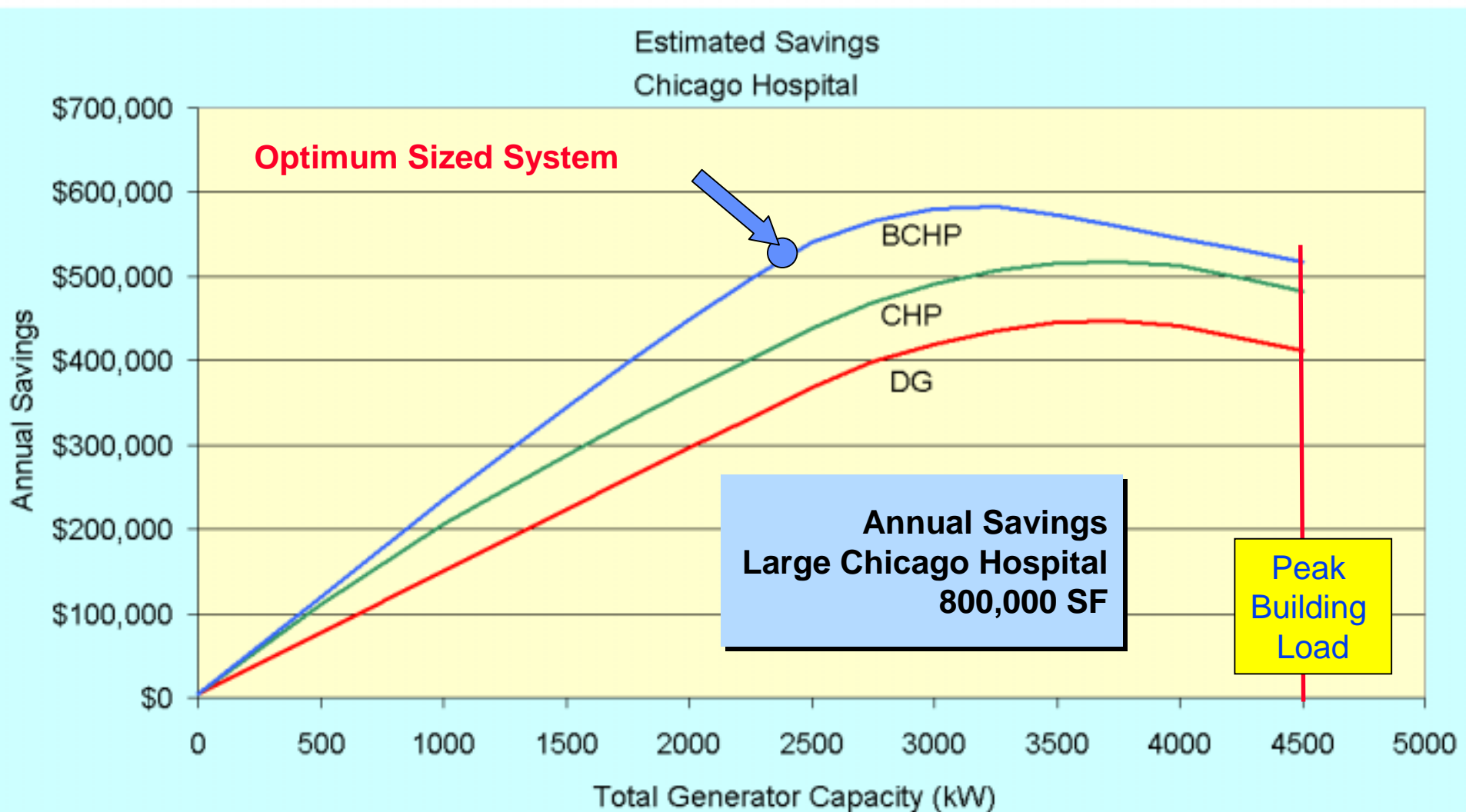
# Load Size Dictates the Best Cogeneration Size

Too Large and the Savings/Unit Size Fall

**DG = Generation Only (No Heat Recovery)**

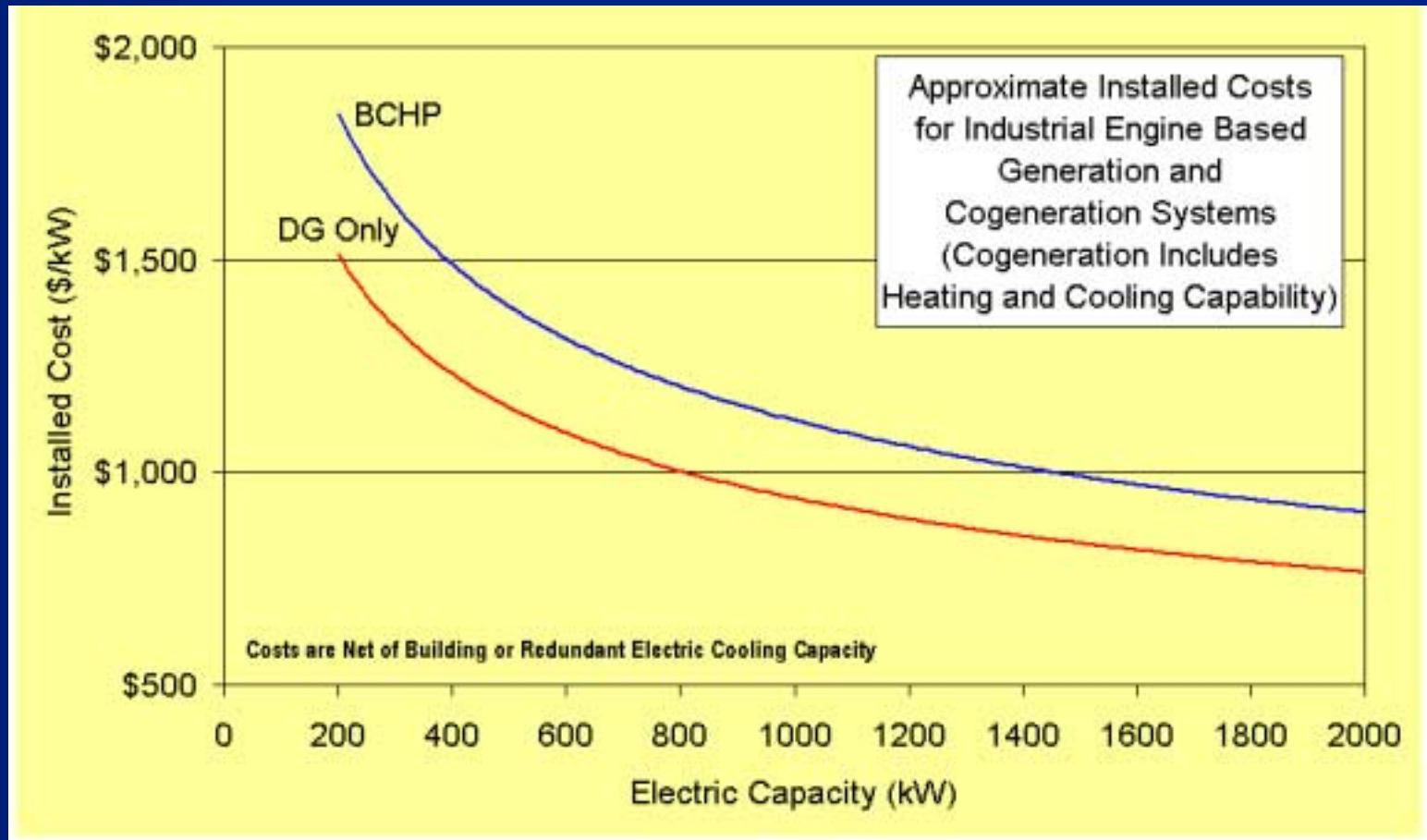
**CHP = Generation with Heat Recovery for Heating**

**BCHP = Generation with Heat Recovery for Heating and Cooling**



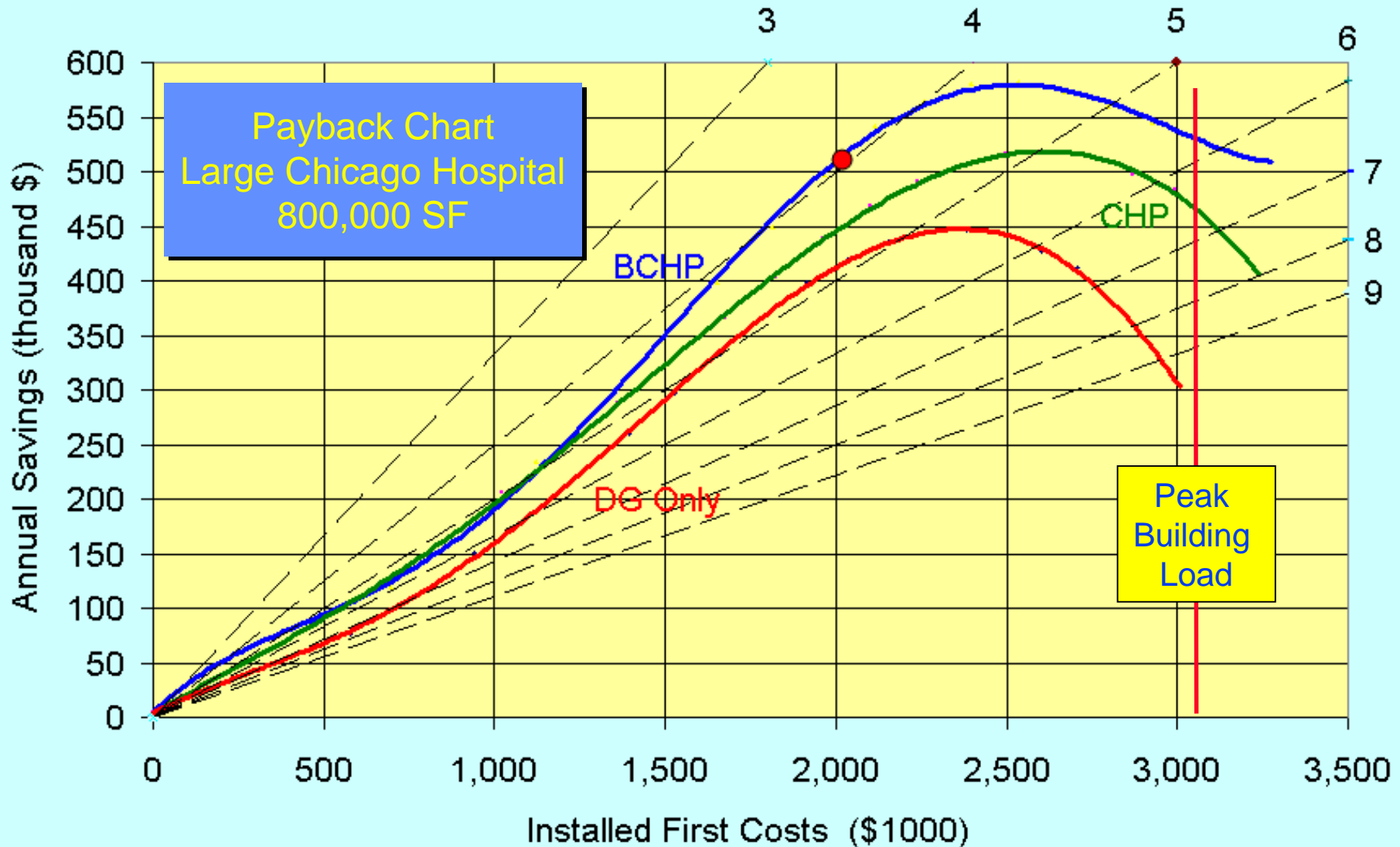
# Load Size Dictates the Best Cogeneration Size

## Too Small and the Cost per Unit of Equipment Rises

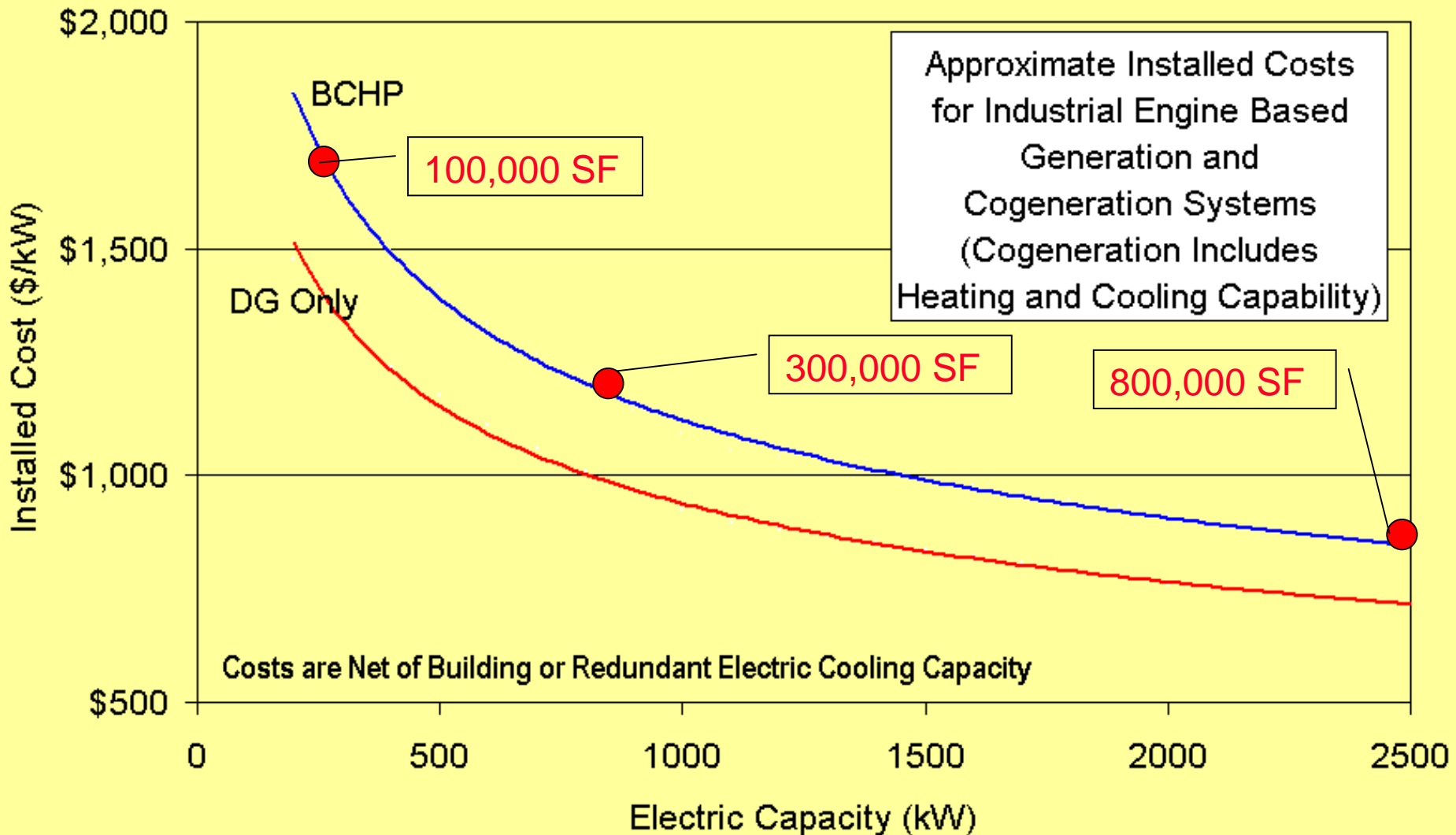


# How Important is Proper Sizing? – VERY

Oversizing Equipment Can Significantly Reduce Economic Performance



# Cost per kW for Cogeneration Drops Significantly with Increasing System Size

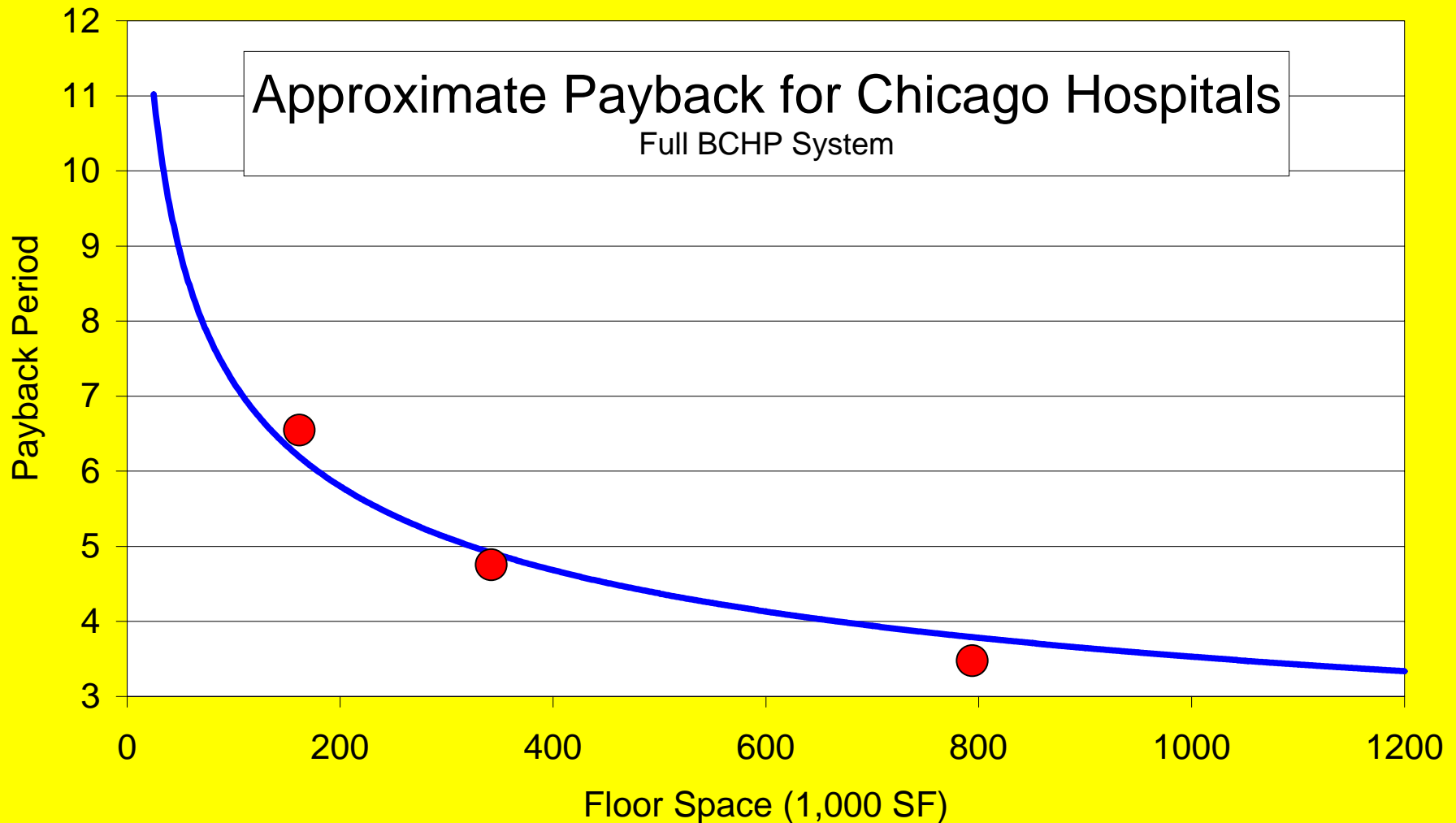


# Is There a Pattern Here?

- Load Profile Used was Scaled Between Buildings
- Savings are Roughly Linear with Square Footage
- But this is NOT True of the First Cost

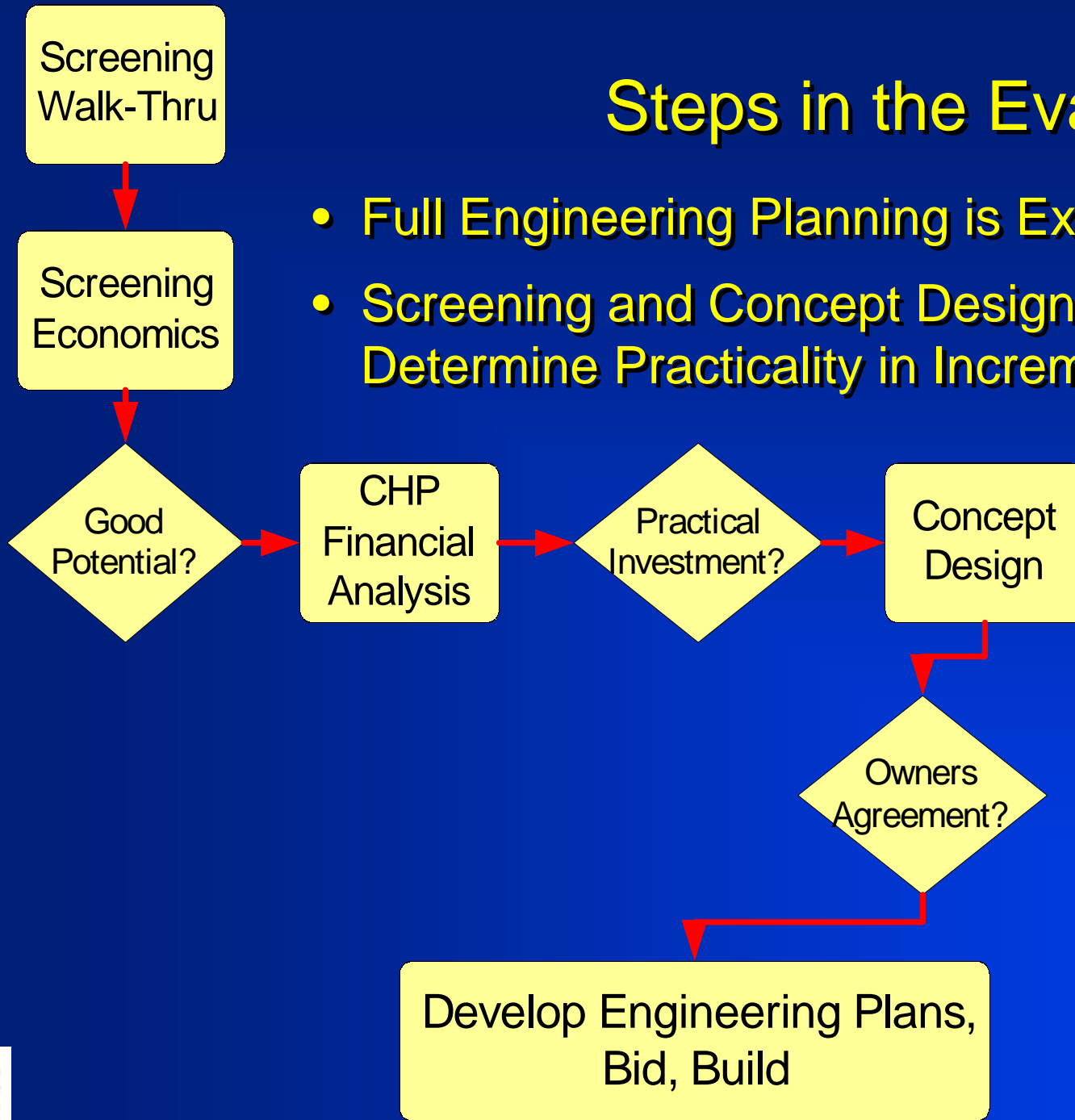
# Chicago Hospital Market Generalization

- Numbers are Best Case for a Straightforward Installation
- Site Specific Issues Can Have a Major Effect on Payback



# Steps in the Evaluation

- Full Engineering Planning is Expensive
- Screening and Concept Design Steps Determine Practicality in Incremental Stages



# Things to Watch for in the Energy Analysis

- Assuming 100% Utilization of Waste Heat - Unrealistic
- Rule of Thumbs
  - Can Not Recover More than 60-70% of the Engines NET Useful Output for Most Commercial Loads
  - Best Payback Is Achieved When Operating Generator Only During Peak Hours
- Reasonable Projections on Future Fuel Prices
  - No Hidden Fuel or Electric Price Escalators
- Are They Basing the Projection on a Fraction of the Facility's Electric Load
  - A Cogeneration System Capable of Powering Your Entire Facility is Not Usually Optimum Unless the Owner Needs Such a Capability



# Things to Watch for in the Financial Analysis

- Using Recent Year Utility Bills - Correcting Results Back to Average Weather Year Conditions is Best
- Comment on Heat Recovery “Usually Not Paying”
  - Generally Indicates a Designer More Comfortable with the Power Industry than HVAC
  - In Some Cases – Heat Recovery May be Too Difficult – BUT Then, Suspect the Project Overall - VERY Difficult to Compete with the Electric Utility if You Have No Practical Use for Waste Heat
- Avoid “Leveraged” Paybacks or IRR’s
- Use Gas Rates that Provide 3-5 Year Confidence Horizon
  - DON’T Necessarily Lock in Long Term Contract
- Must Include
  - Back-Up Charges
  - Maintenance Allocations
  - Should Include a Full Business Case Analysis as Well



# Items Needed from the Concept Design Level

In Concept Design, a Basic Layout of the Equipment is Done Including:

- Rough Floor Plans to Determine Equipment Fit
- Determining Interconnection Costs and Problems - Thermal and Electric ( Begin Interconnection Process with Electric Utility)

Output

- Is the System Still Practical After Site Specific Issues are Considered.
- Better First Cost Estimate or “Concept Level Budget” than in Initial Analysis
- Better Understanding of How the BCHP System Can be Integrated and Controlled (P&ID Diagrams)
- Original Energy Analysis Should Be Reviewed – Have Issues Arisen that Will Change the Saving Expectations





# Summary

- Good CHP Potential in Hospitals
  - Large Facilities
  - Relatively Level Electric Loads
- Taking Care Up-Front to Determine Application Issues Can Save Time and Money
- Analysis Based on Energy Savings
  - Other Benefits May be As or More Important
    - » Reducing/Eliminating Momentary Outages
    - » Energy Flexibility and Reduced Exposure to Energy Price Volatility
    - » Back-Up for Cooling and Non-Life Critical Loads
    - » Power Quality Improvements

