Combined Heat and Power (CHP) for Hospitals

An Energy Efficiency Education and Implementation Program

Module #2

CHP: The Business Case

Why Hospitals?

March 18, 2003

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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

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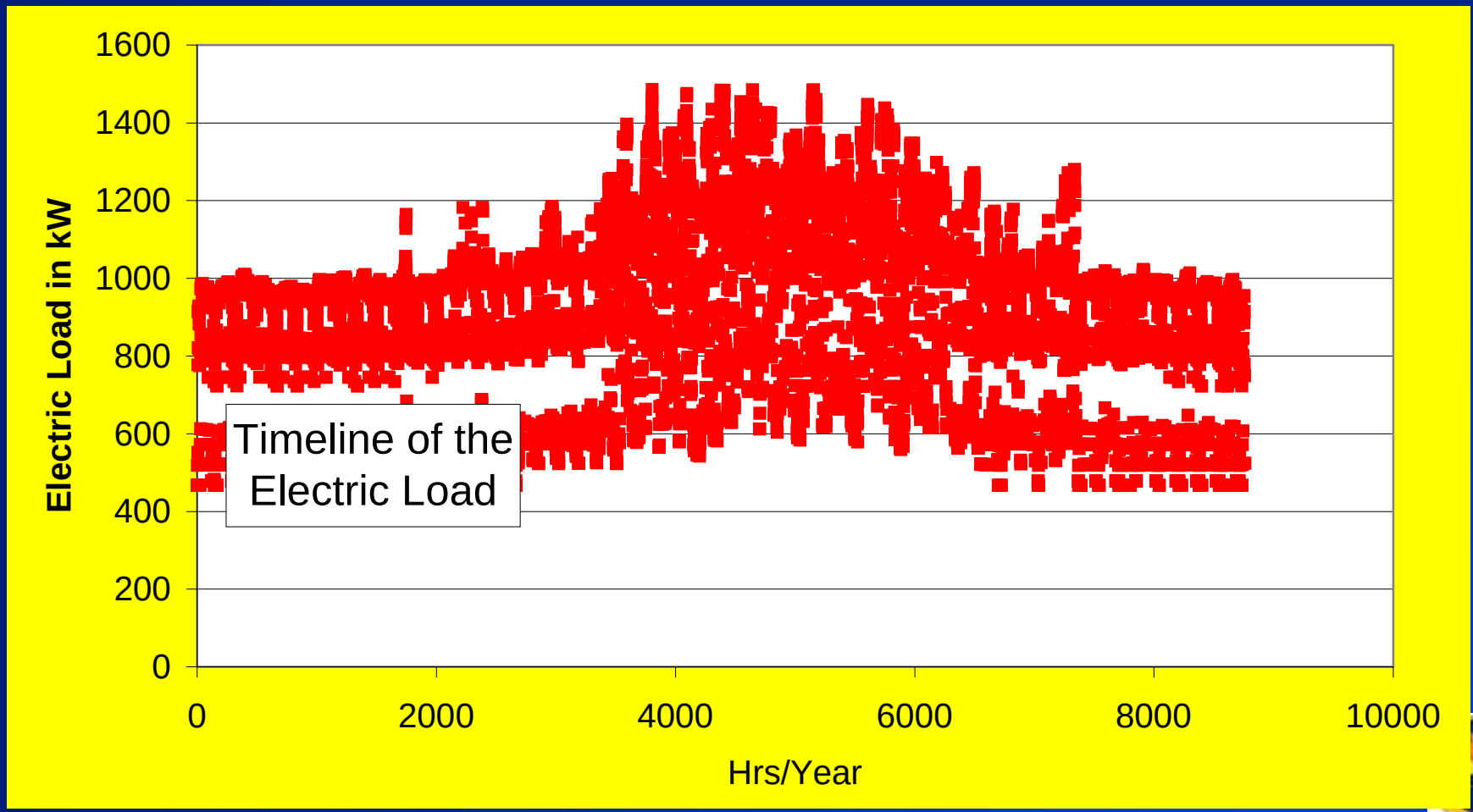
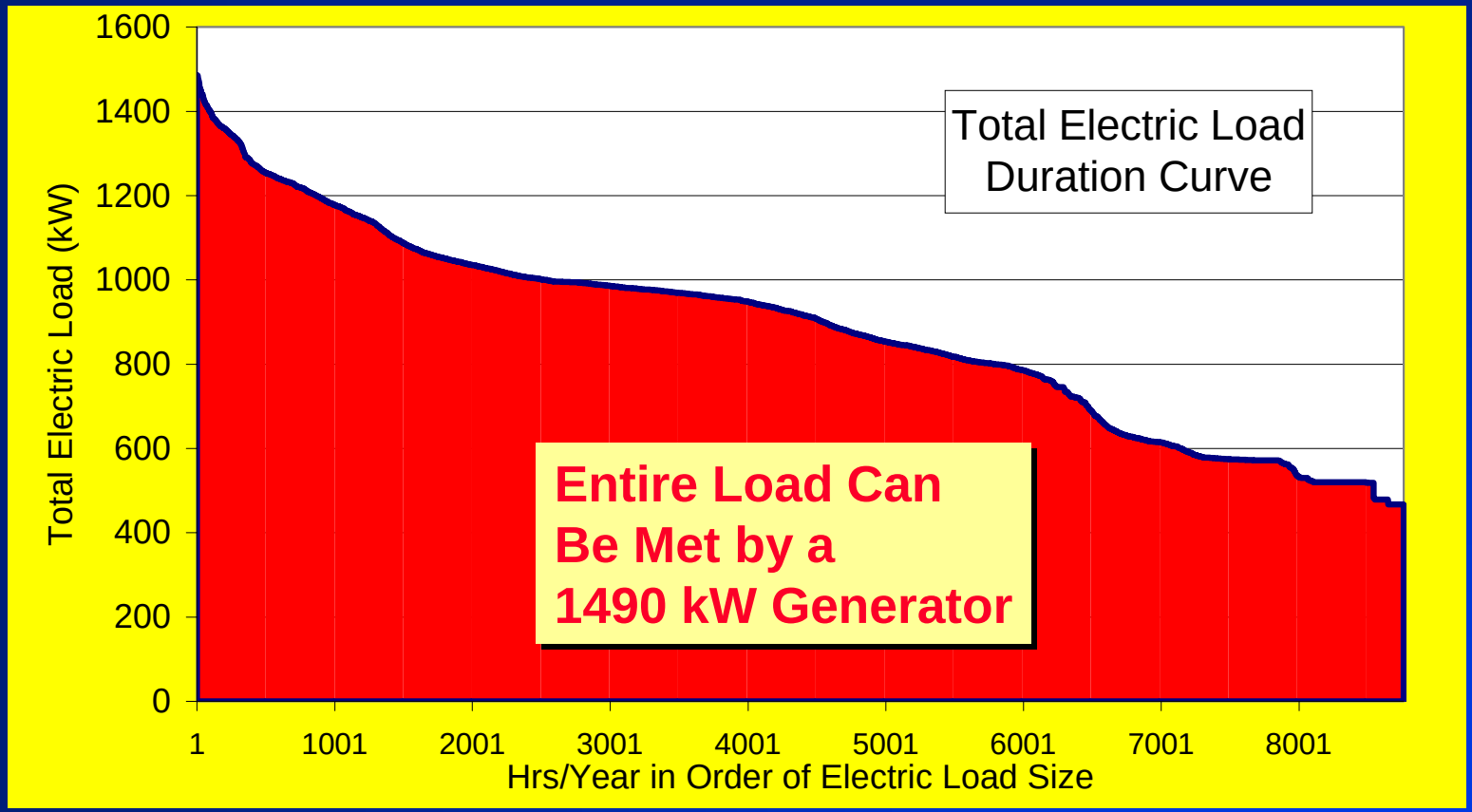
Quick Background on CHP System Operation - Hospital Example

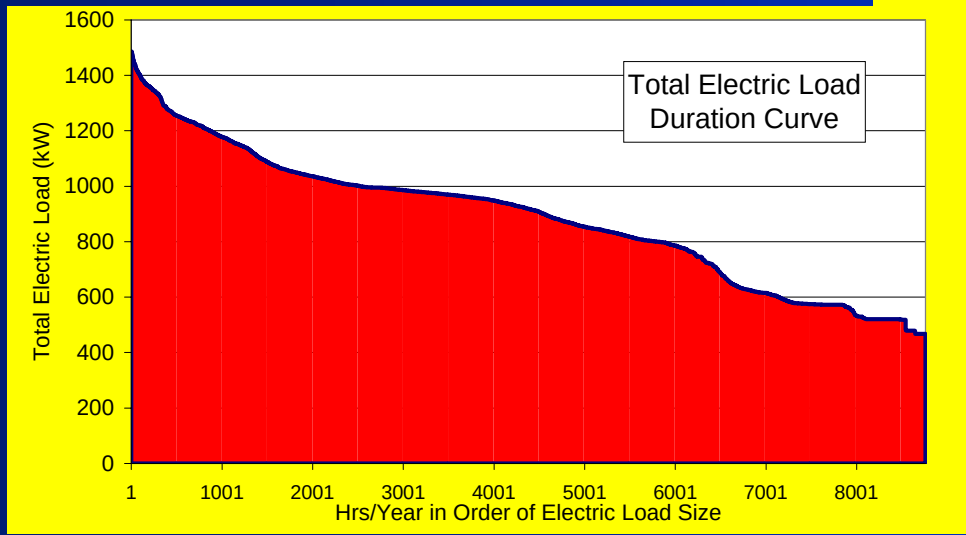


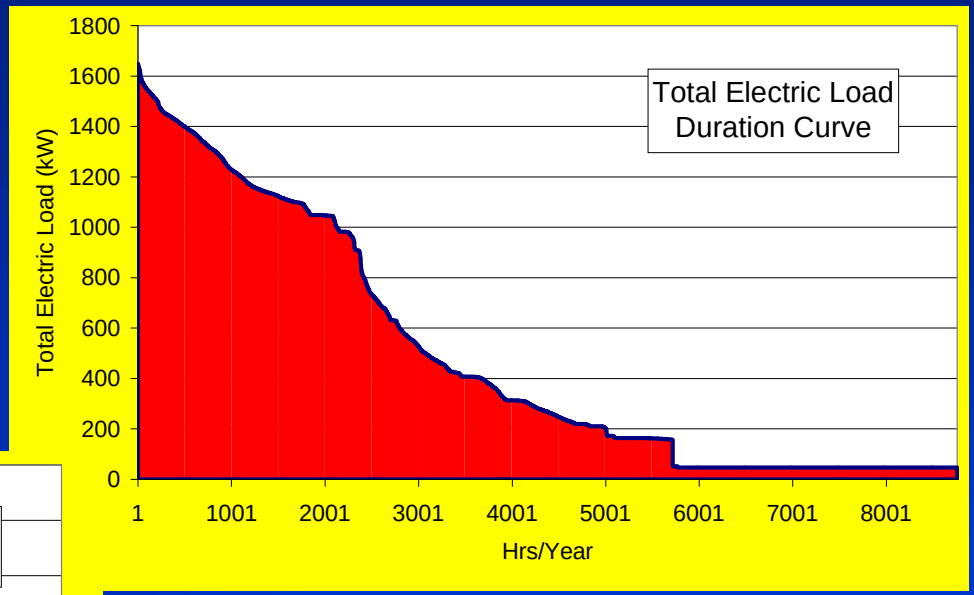
Power Needs are More Easily Viewed by Ordering into a Duration Curve



Hospital Power Consumption is More Constant than Other Commercial Loads

Hospital 300,000 SF





Office Bldg 300,000 SF

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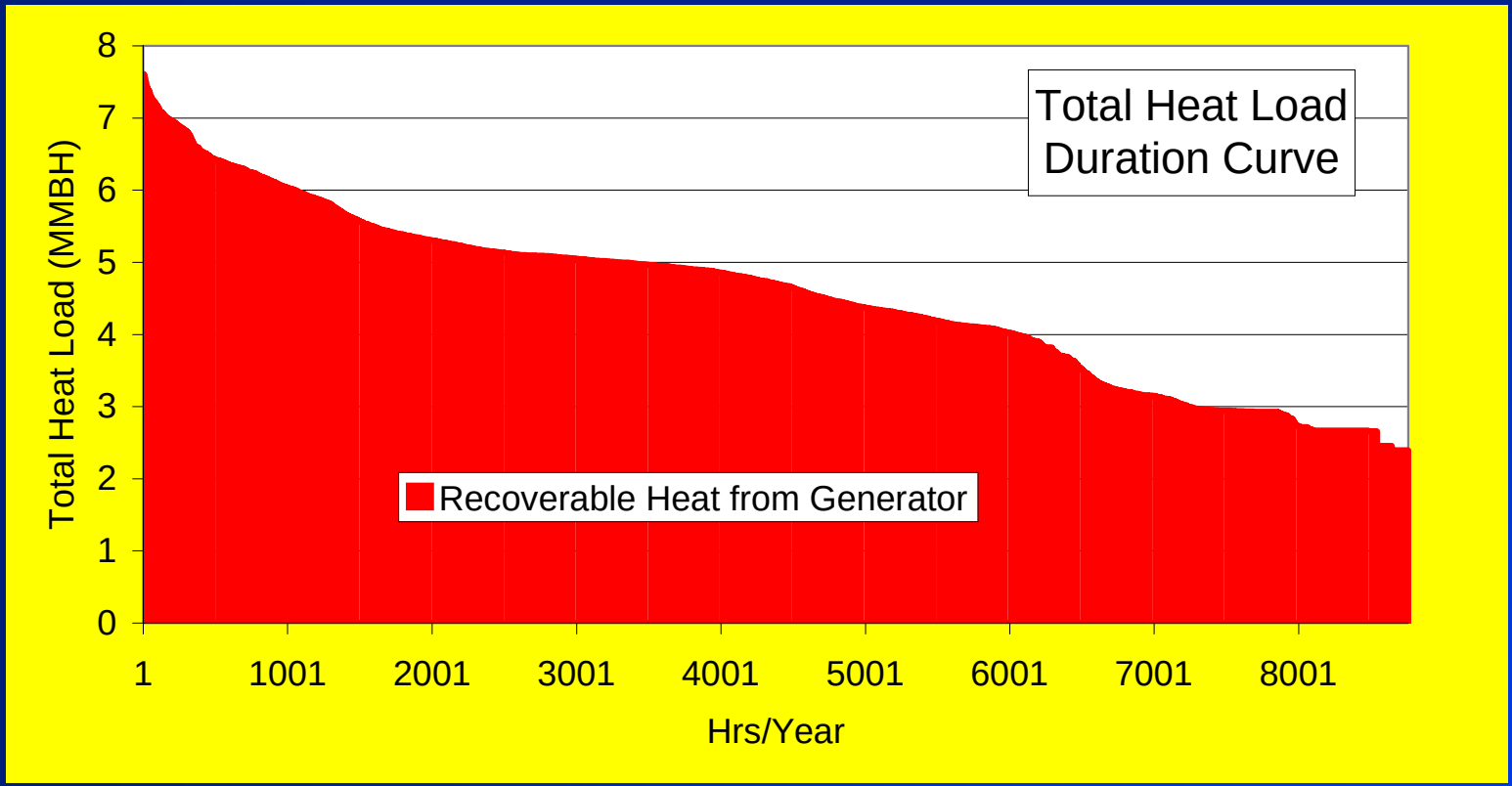
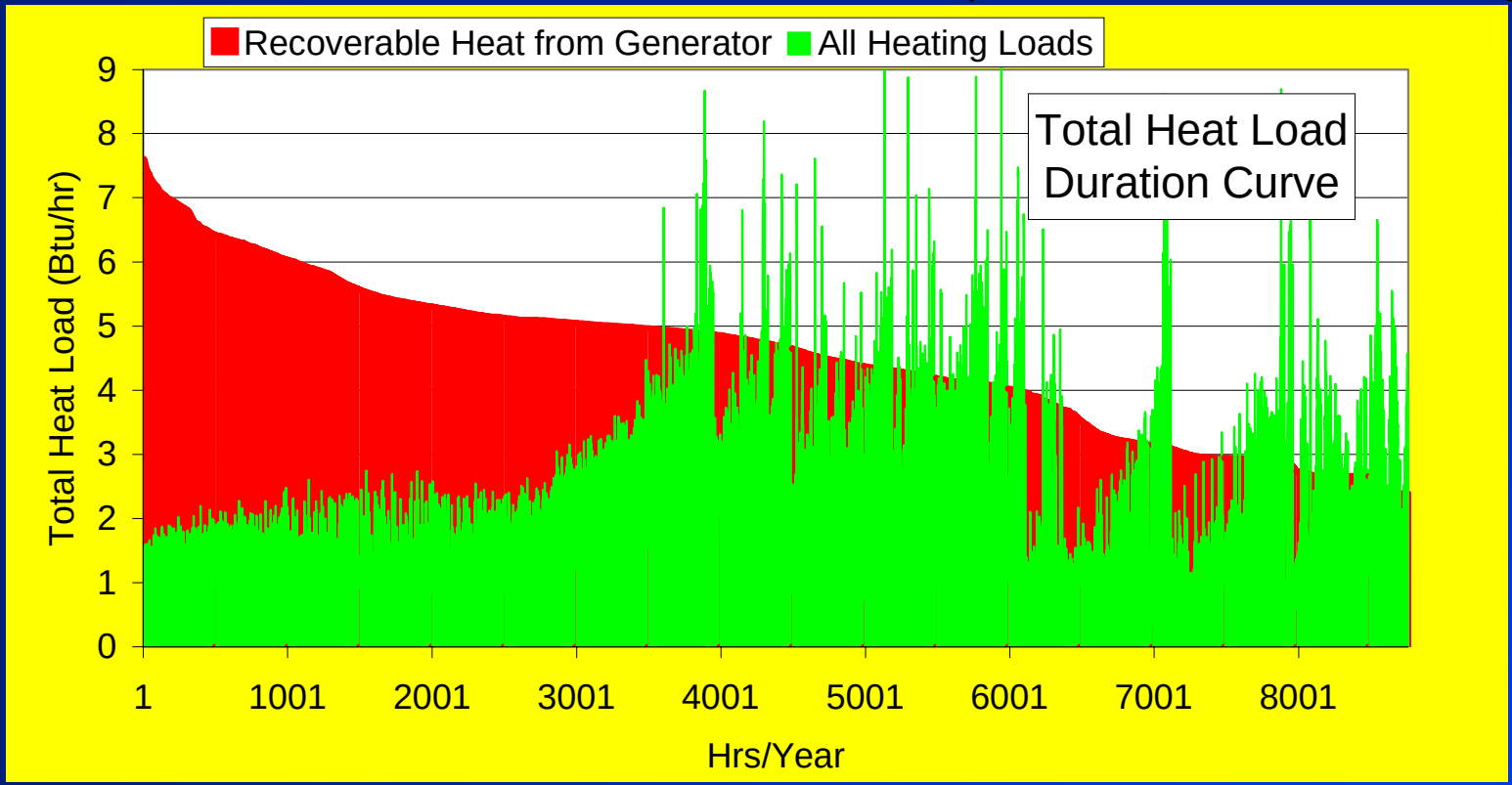
If the Facility has a Generator that Supplies ALL Power Needs, How Much Waste Heat is Available ?



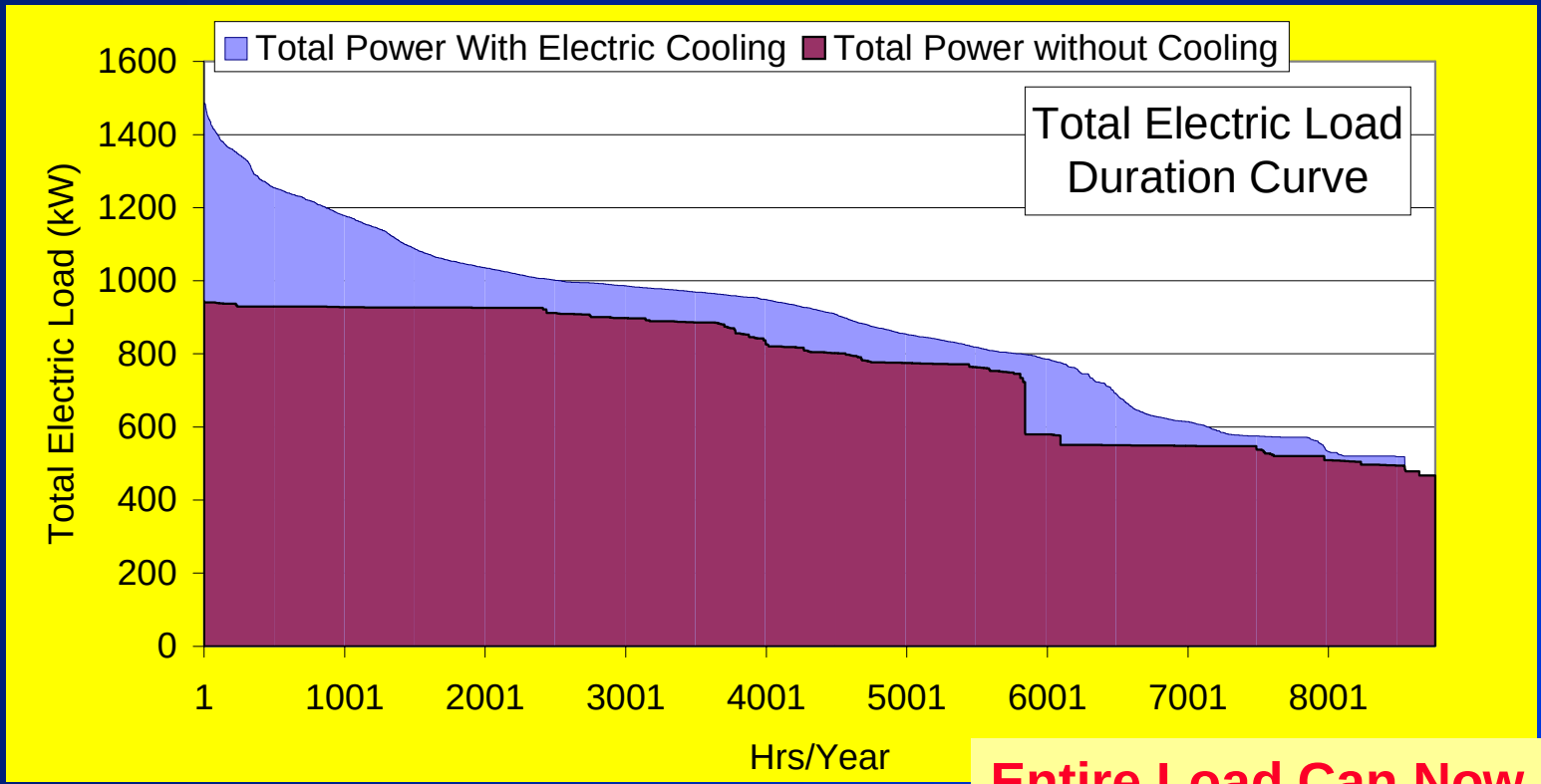
Note: For Simplicity, the Engine is Assumed to Be Capable of Running Down to Zero Load at a Constant Efficiency and Heat Rejection Rate. This is Not True of Actual Engines

How Much Can be Used for All Heating?

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

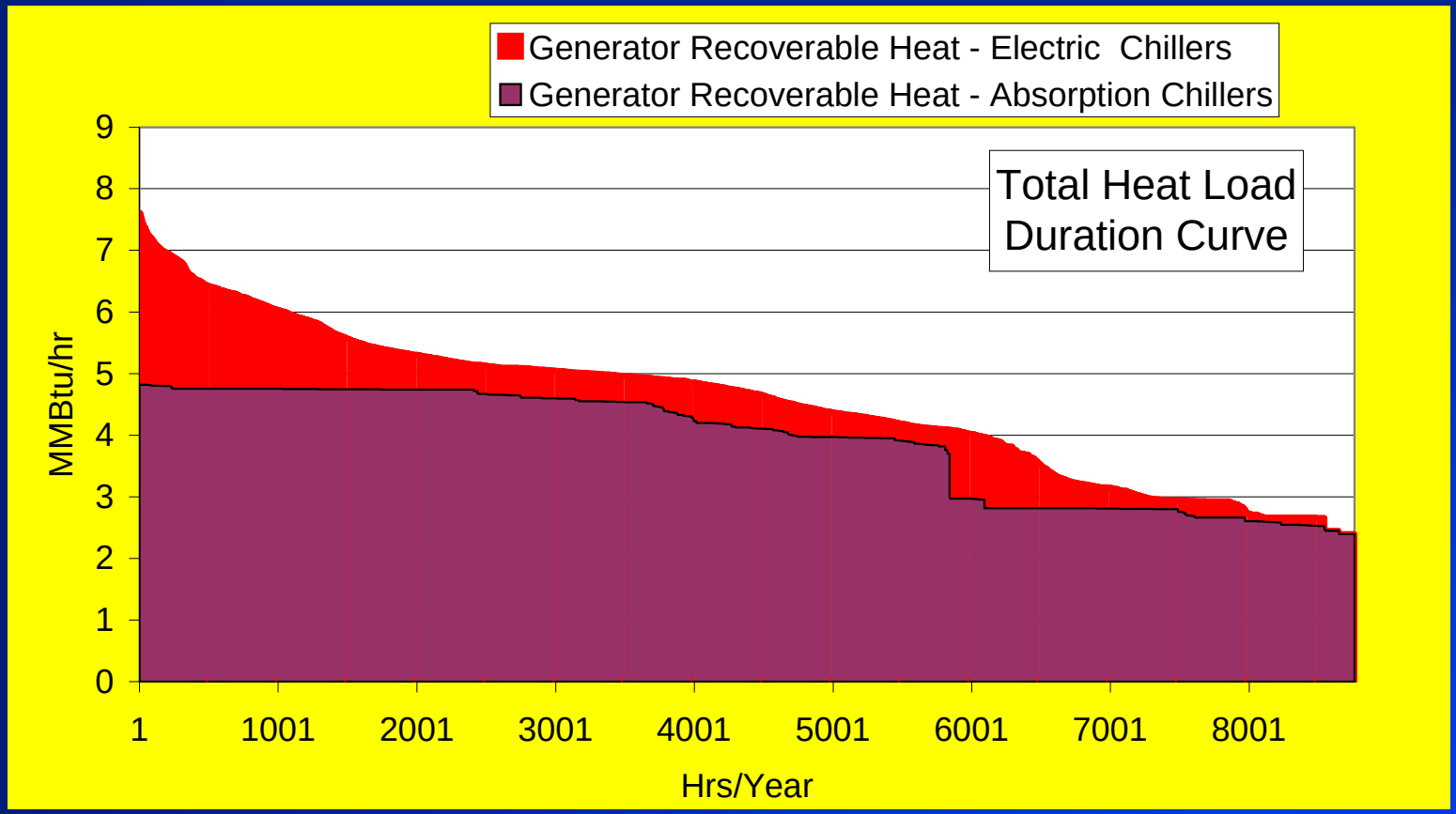


If the Cooling Load is Now Also Operated by Waste Heat – The Electric Load is Changed

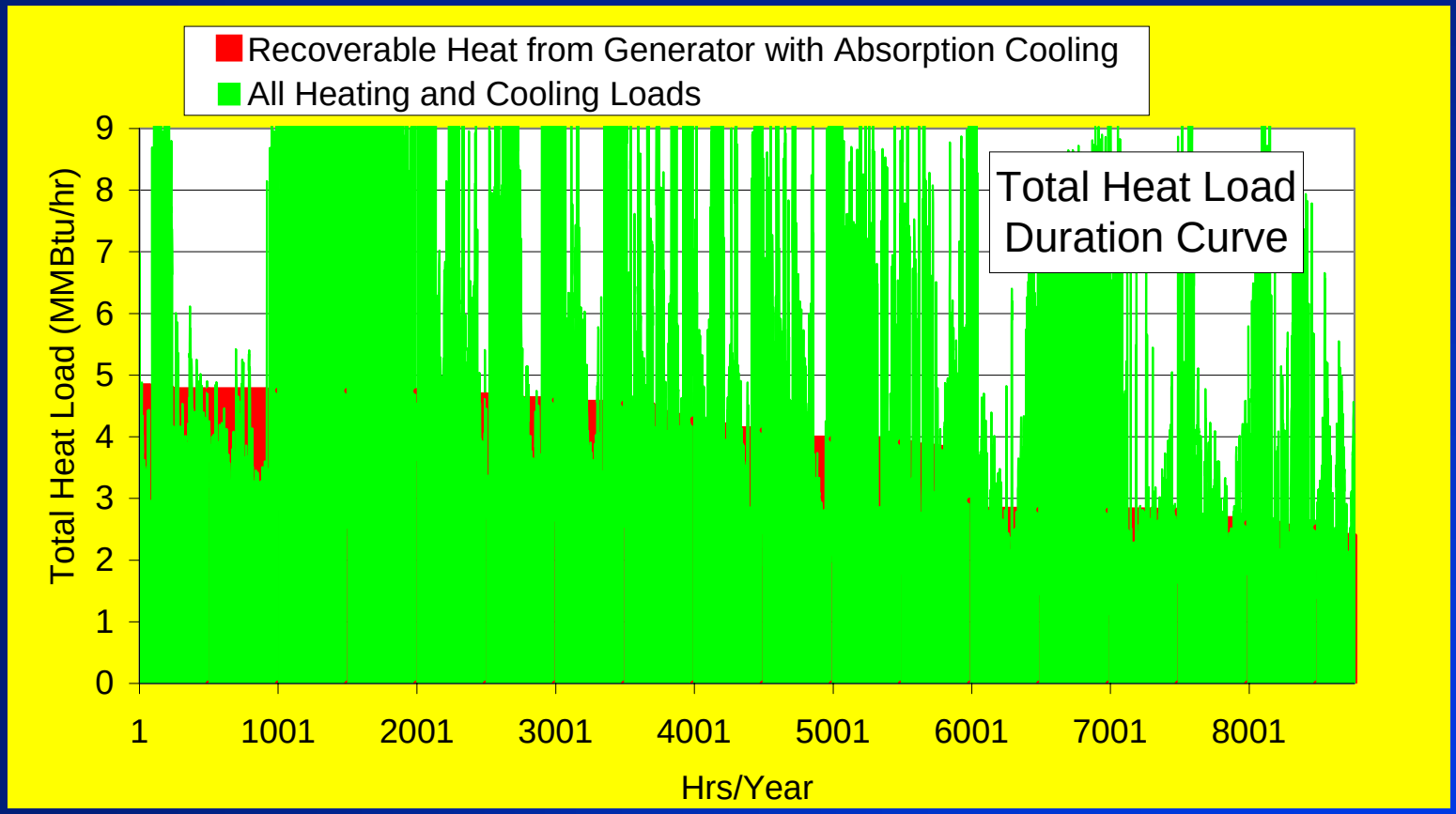


Entire Load Can Now Be Met by a 940 kW Generator

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

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

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

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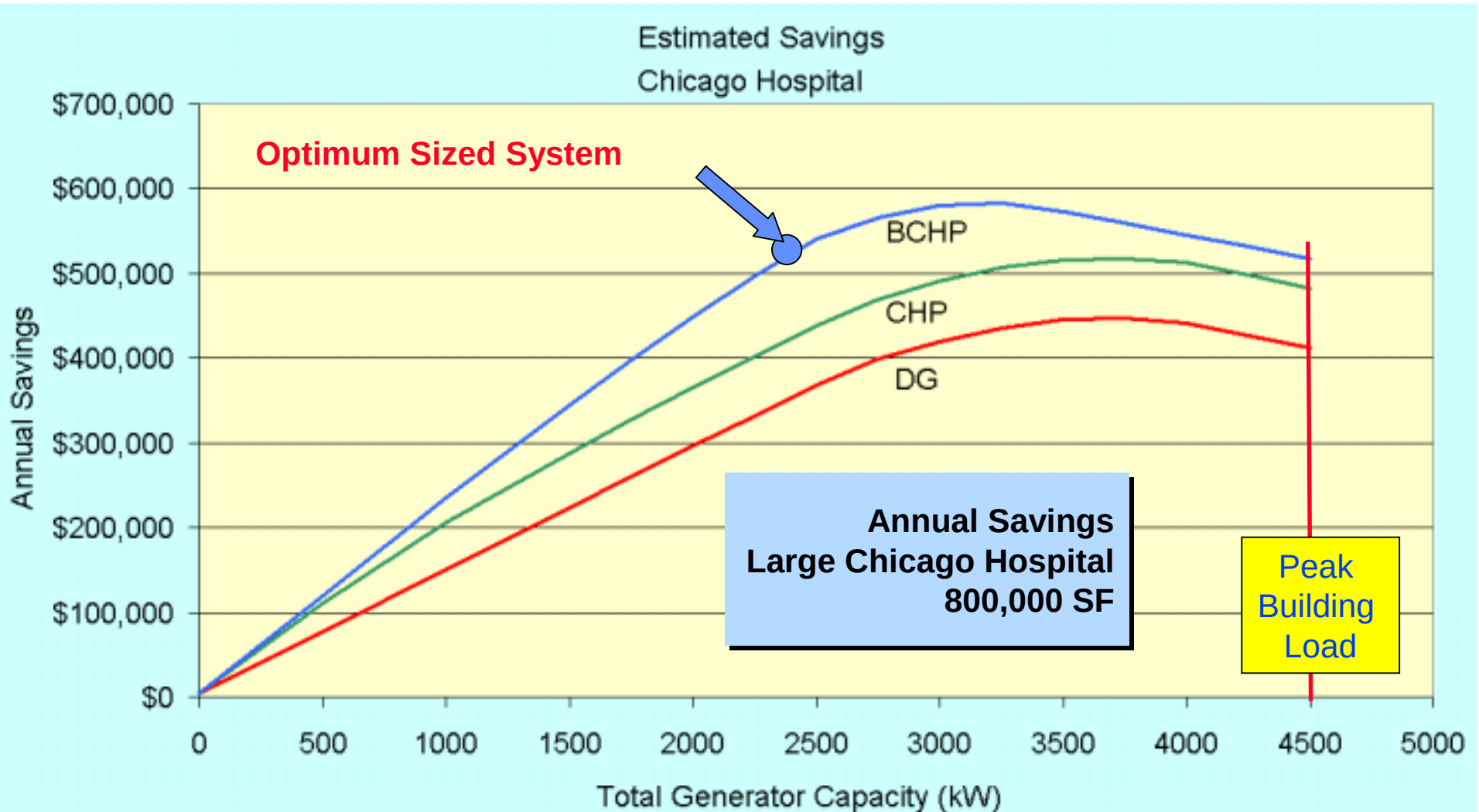
Load Size Dictates the Best Cogeneration Size

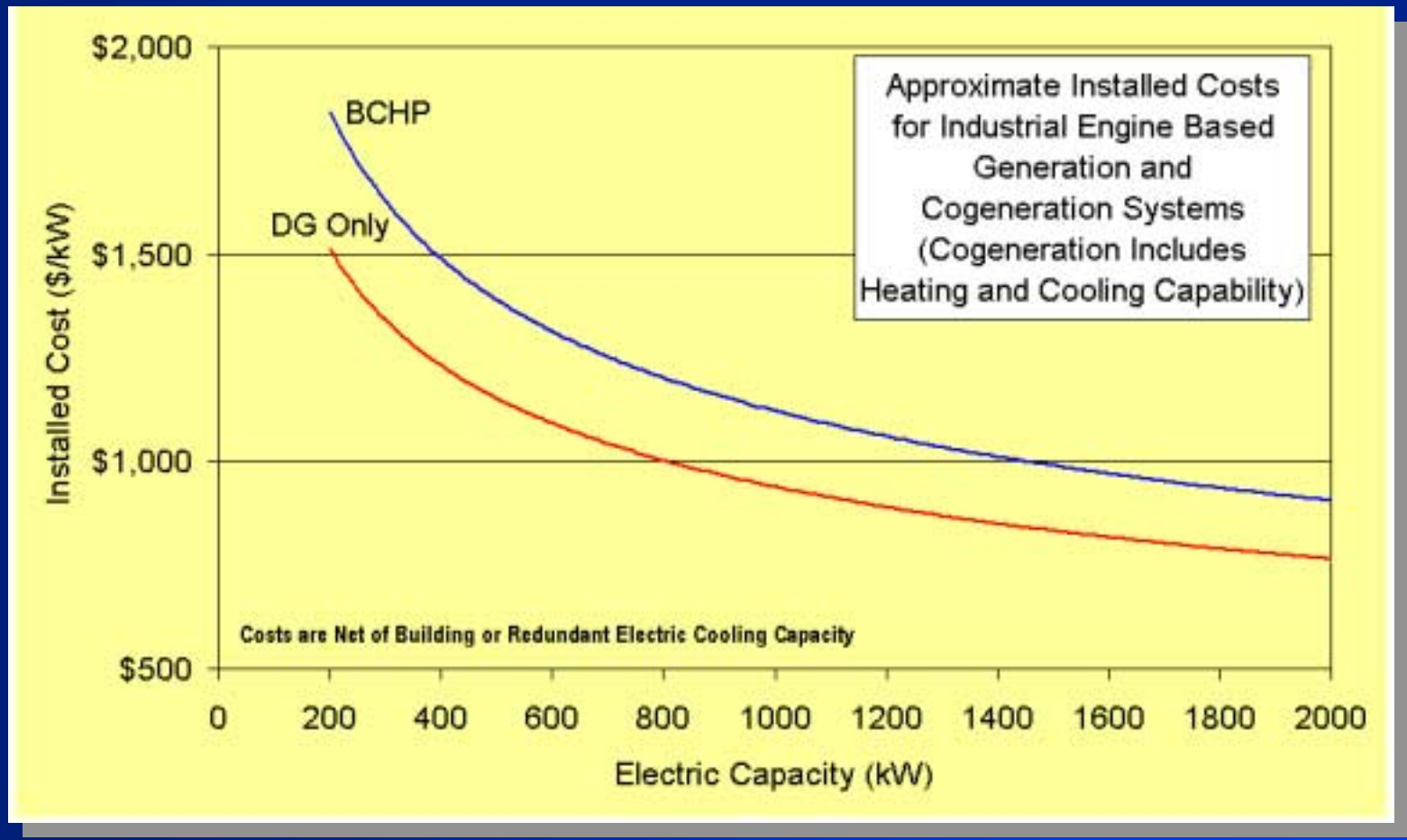
Too Large and the Savings/Unit Size Fall

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



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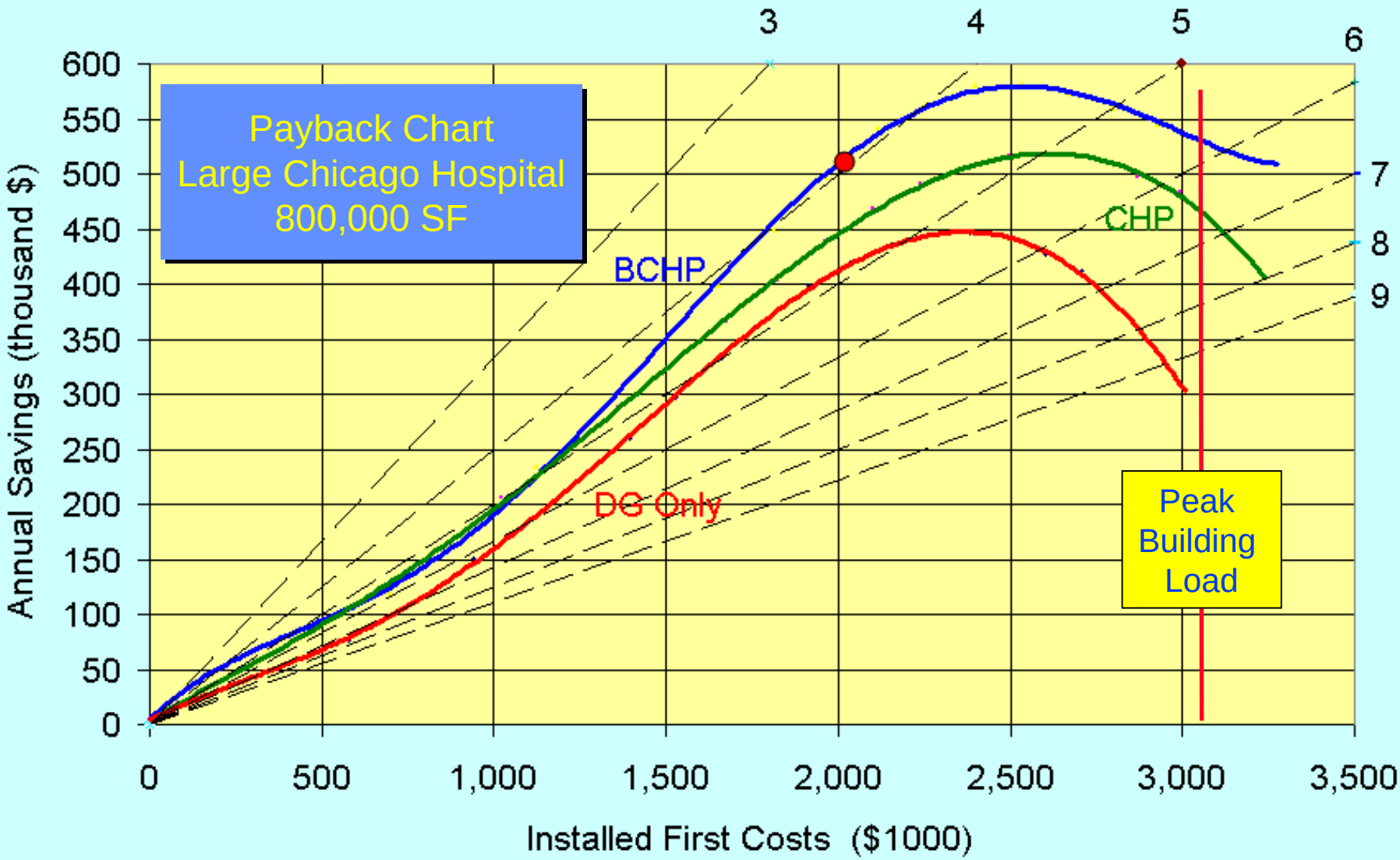
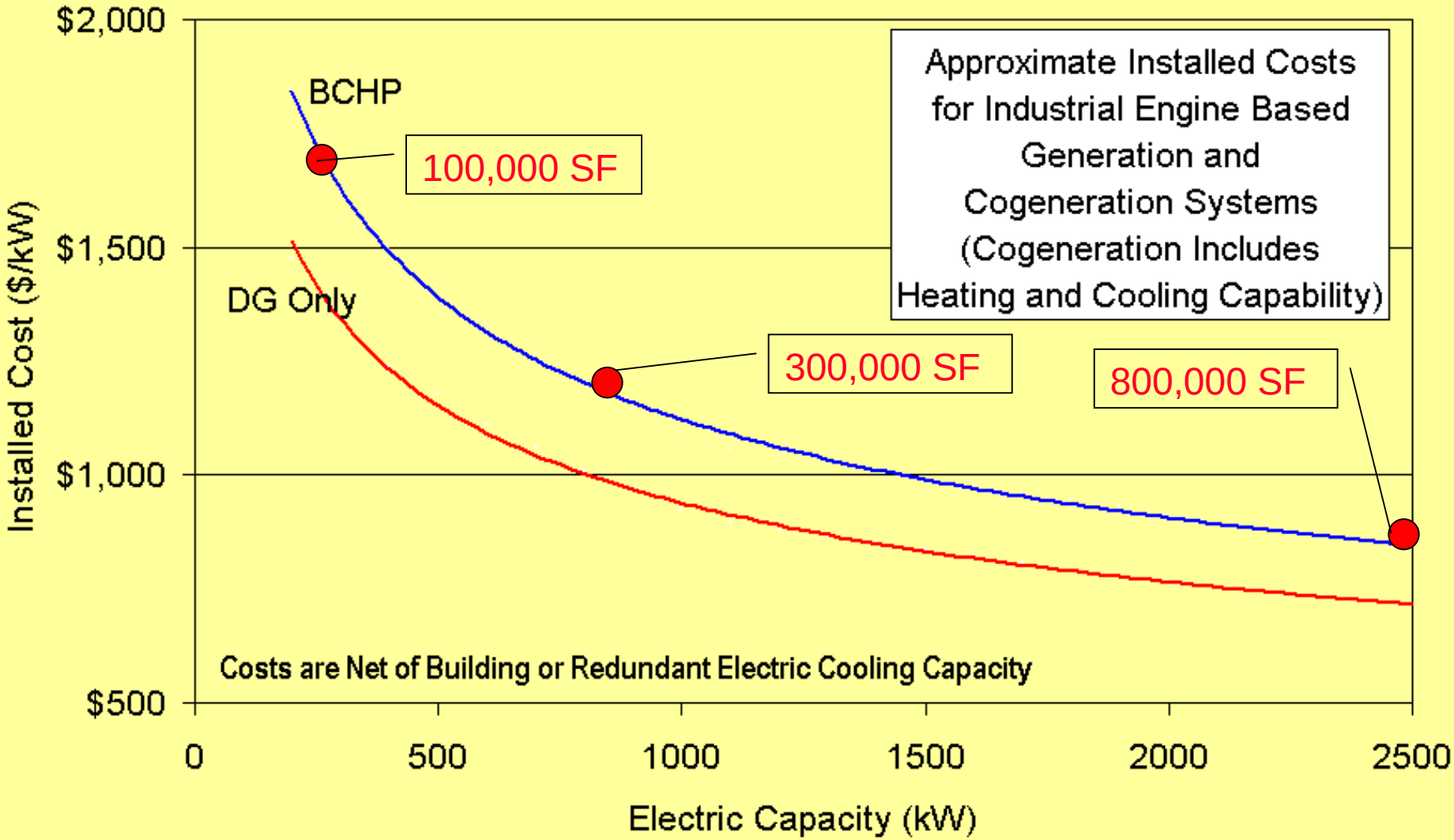
How Important is Proper Sizing? – VERY

Oversizing Equipment Can Significantly Reduce Economic Performance



Cost per kW for Cogeneration Drops Significantly with Increasing System Size

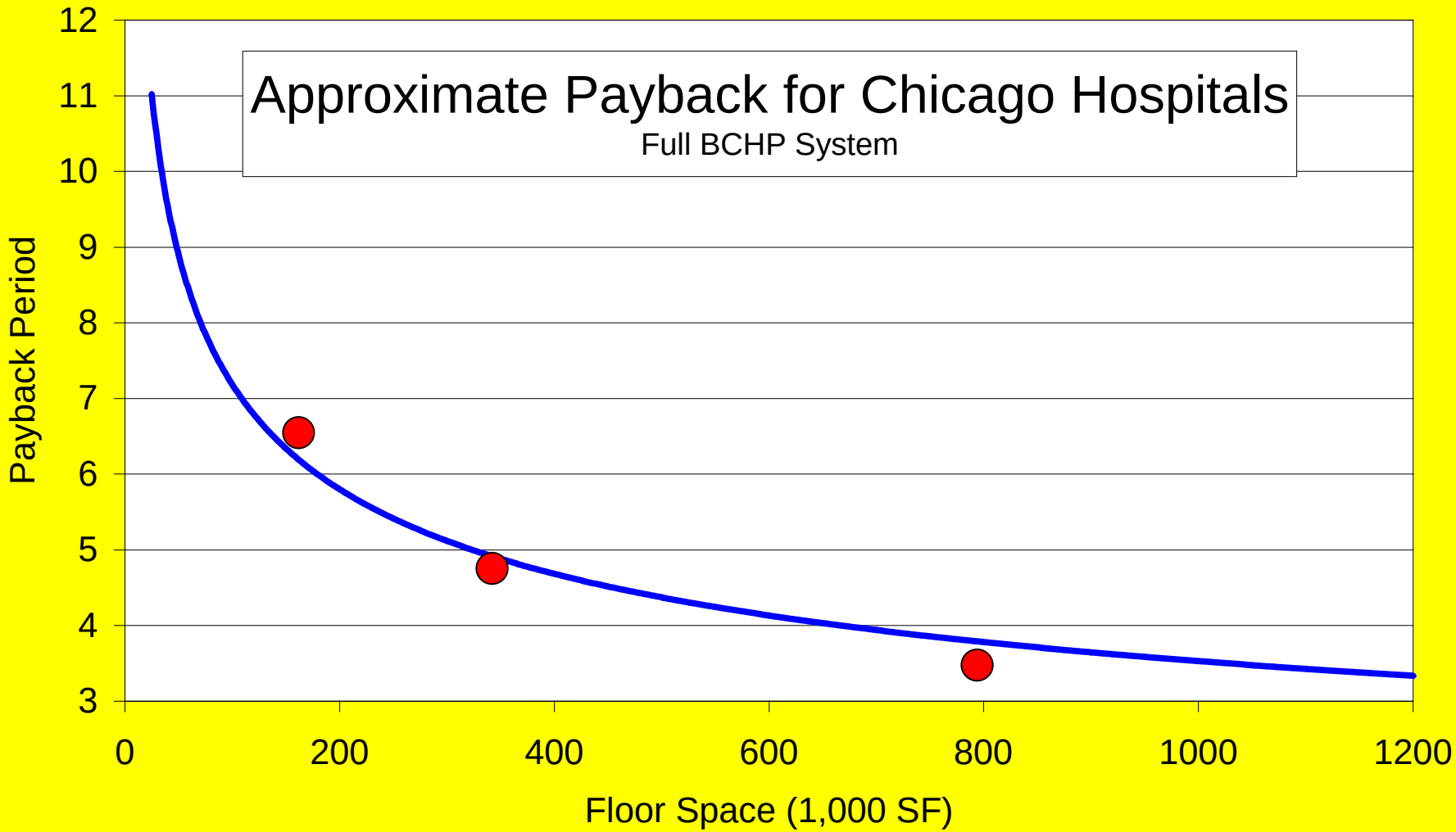


Is There a Pattern Here?

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

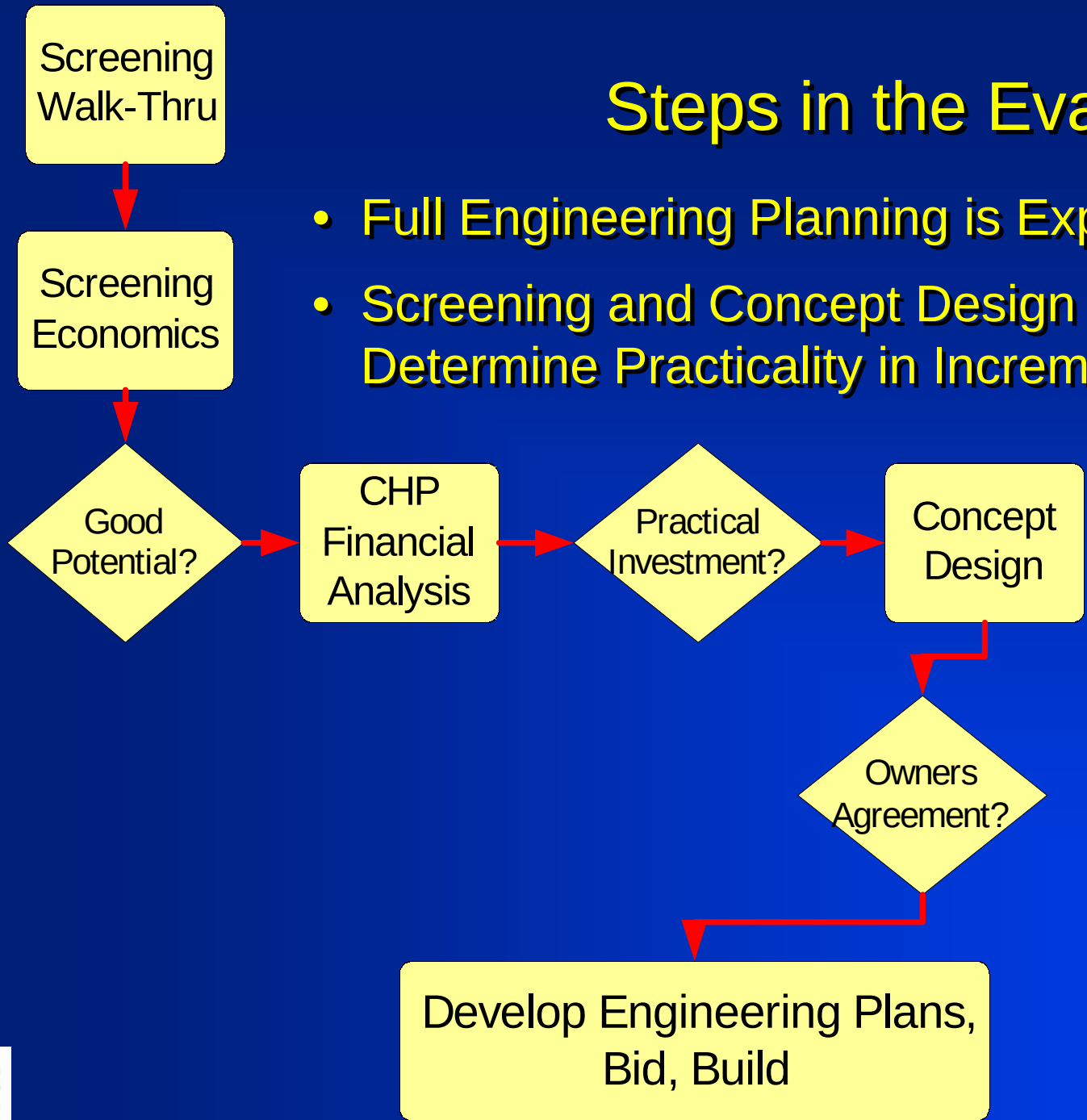
Chicago Hospital Market Generalization

- 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

Business Case Analysis

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Project: Hospital ABC

Scenario: Cogeneration with Heating and Cooling

CHP FOR BUILDINGS

Economic Analysis		
Interest or Bond Rate	6.0%	
Marginal Tax Rate	0%	
First Cost of Plant	$1,003,000	
Annual Power Generation	363	MWH
Projected Change in Electric Charges	$230,000	
Projected Change in Fuel Charges	$0	
Depreciation Period (Straight Line)	6	Years
Financing and Cash Flow Period	7	Years

IRR= 18.80%

7 YEAR CASH FLOW IS POSITIVE

Year	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Installed Cost of Plant ($1000)	$1,003																				
Gross Revenues																					
Change in Electric Cost (Red. is Positive)	1000$	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230
Change in Gas Cost		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Average Year Annual Savings		$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230	$230
Operating Costs																					
Maintenance Allocation (@ $11/MWH)	1000$	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40	$40
Maintenance Cost of Generator System	1000$	$20	$20	$20	$20	$100	$20	$20	$20	$20	$220	$20	$20	$20	$20	$140	$20	$20	$20	$20	$20
Cumul. Maint. Sinking Fund Balance	1000$	$20	$40	$60	$80	$20	$40	$60	$80	$100	-$80	-$60	-$41	-$21	-$1	-$101	-$81	-$61	-$41	-$21	-$1
EBIDA	**1000$**	**$210**	**$210**	**$210**	**$210**	**$130**	**$210**	**$210**	**$210**	**$210**	**$10**	**$210**	**$210**	**$210**	**$210**	**$90**	**$210**	**$210**	**$210**	**$210**	**$210**
Tax Implications																					
Interest Payments Financed Over (Years)	7	-$60	-$53	-$45	-$37	-$29	-$20	-$10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Depreciation (Straight Line)	5	-200.6	-200.6	-200.6	-200.6	-200.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total Deductions		-$261	-$254	-$246	-$238	-$229	-$20	-$10	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Tax Reduction		$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Income After Taxes		**$210**	**$210**	**$210**	**$210**	**$130**	**$210**	**$210**	**$210**	**$210**	**$10**	**$210**	**$210**	**$210**	**$210**	**$90**	**$210**	**$210**	**$210**	**$210**	**$210**
Internal Rate of Return Calculation		**IRR=**	**18.80%**																		
In/Outflows ($1,000)	-$1,003	$210	$210	$210	$210	$130	$210	$210	$210	$210	$10	$210	$210	$210	$210	$90	$210	$210	$210	$210	$210
Financing Cash Flow																					
Cost of Financing - Uniform Payments	1000$	-$180	-$180	-$180	-$180	-$180	-$180	-$180	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Net Income After All Loan Payments	1000$	$30	$30	$30	$30	-$49	$30	$30	$210	$210	$10	$210	$210	$210	$210	$90	$210	$210	$210	$210	$210
Cumul. Net Income After Loan Payments		$30	$61	$91	$121	$72	$102	$133	$343	$553	$563	$773	$983	$1,193	$1,403	$1,493	$1,703	$1,913	$2,123	$2,333	$2,543
Principle Repayment Component	$1,000	-$119	-$127	-$134	-$142	-$151	-$160	-$170	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0
Principal Balance	$1,000	$884	$757	$623	$480	$329	$170	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0	$0

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

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