

ESD.71 Application Portfolio

Heating System for a Group of Condominiums



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1. Introduction

2. Uncertainties

3. Modelling & Design Levers

4. Decision Tree

5. Binomial Lattice

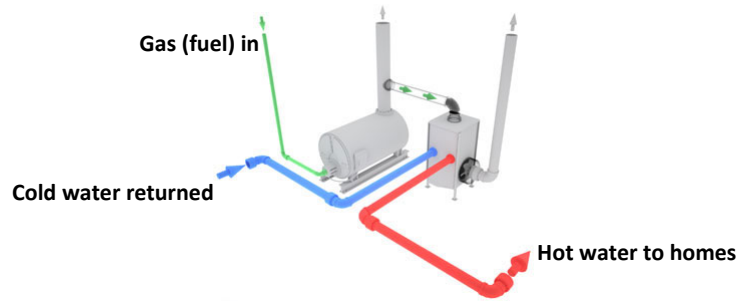
6. Conclusion

1. Introduction



-What is the system?

-Heating plant – natural gas boiler heats water & pipes it to holiday homes

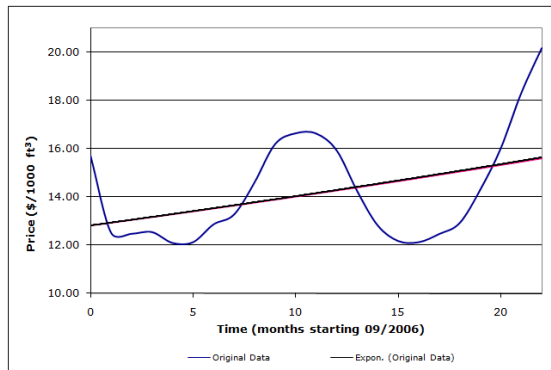


2. Uncertainties

-Two major uncertainties

(a) Price of natural gas – an input cost

$\nu = 0.90\%$
 $\sigma = 14.00\%$



Source: Energy Information Administration (<http://tonto.eia.doe.gov/dnav/ng/hist>)

2. Uncertainties

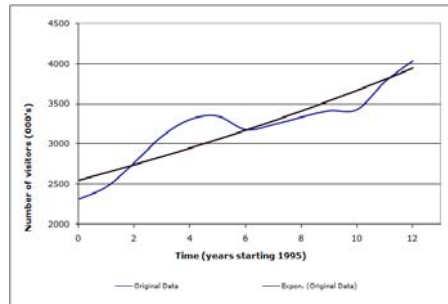
(b) Demand for heat

Assumption:

Demand for heat ~ number of tourists visiting condos
 ~ number of tourists visiting Ireland (for which data available)

$\nu = 3.63\%$

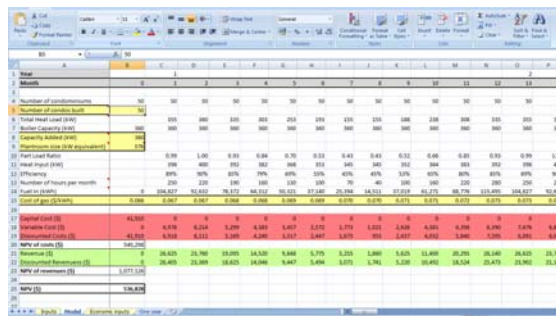
$\sigma = 6.74\%$



Source: Central Statistics Office of Ireland (<http://www.cso.ie>)

3. Modelling & Design Levers

-Excel – Based on thermodynamic/HVAC theory



-NPV over 10 years. Monthly resolution

-Option to 'expand medium', 'expand big' or do nothing at year 5

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4. Decision Tree

Fixed Design

Capacity to meet forecast demand level at year 5 (my decision point)

Bigger now means less efficient initially – boiler theory

Flexible Design

Capacity to meet today's demand only

Capability to expand to meet anything up to maximum possible demand

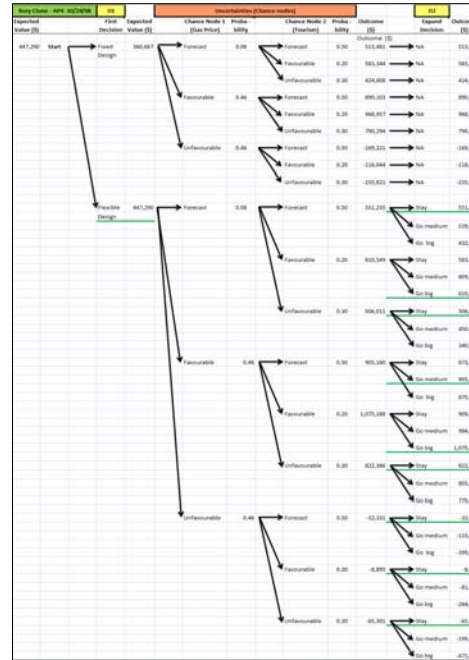
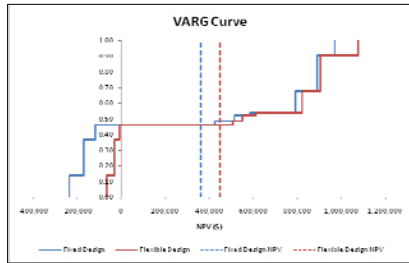
Two uncertainties (gas price & demand level)

3 levels over each period – favourable, forecast & unfavourable

4. Decision Tree

2 decision nodes (shown in yellow)

2 uncertainties, each with 3 possible outcomes



5. Binomial Lattice

-Analysis over 6 years

-Just one uncertainty – natural gas price

Monthly σ , ν parameters from regression converted to annual

Outcome Lattice					
20.19	32.63	52.74	85.25	137.78	222.70
	12.49	20.19	32.63	52.74	85.25
		7.73	12.49	20.19	32.63
			4.78	7.73	12.49
				2.96	4.78
					1.83

(\$ per kWh of gas)

5. Binomial Lattice

Annual undiscounted cash flows

(Year 0 includes Capex)

Lattice of Cashflows						
61,128	61,650	5,245	113,365	288,118	570,567	
	128,646	103,039	61,650	5,245	113,365	
		144,489	128,646	103,039	61,650	
			154,292	144,489	128,646	
				160,356	154,292	
					164,109	

-Option: close at any time, without penalty. Can be exercised only once

Lattice Analysis						Strategy - Exercise Option?					
282.95	143.48	5.24	113.37	288.12	570.57	NO	NO	YES	YES	YES	-
	435.68	271.68	114.83	5.24	113.37		NO	NO	NO	YES	-
		463.70	320.28	180.04	61.65			NO	NO	NO	-
			409.96	269.46	128.65				NO	NO	-
				303.69	154.29					NO	-
					164.11						-

Double-checked using standard NPV of annual cash flows method

5. Conclusion

-Decision Tree:

Flexibility increases E(NPV) & shifts most of VARG to the right

Noticeably reduced downside

Easy to adapt to situation, but laborious

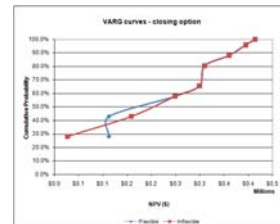
-Binomial Lattice:

Flexibility to expand increases E(NPV)

Effect on VARG curve not remarkable (short time period)

More awkward to apply – assumptions had to be made

- number of uncertainties = 1
- path independence



End