

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

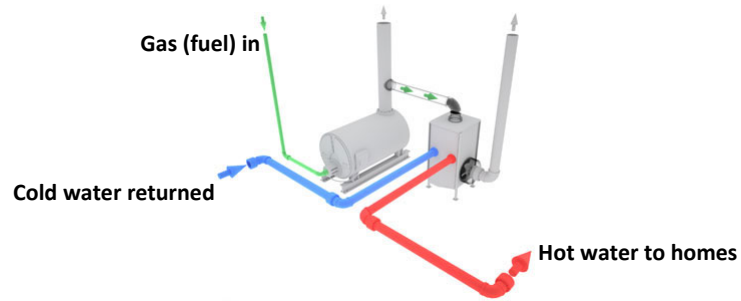
6. Conclusion

1. Introduction



-What is the system?

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

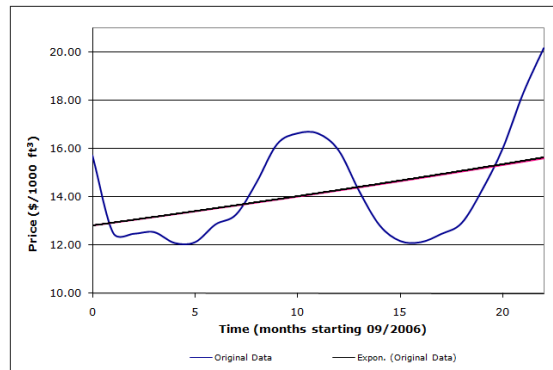


2. Uncertainties

-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

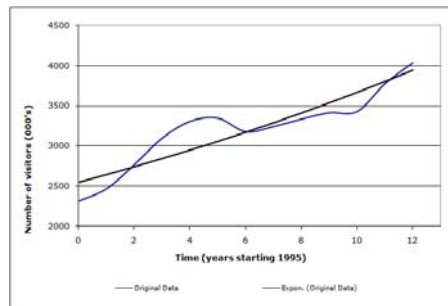
(b) Demand for heat

Assumption:

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

$\nu = 3.63\%$

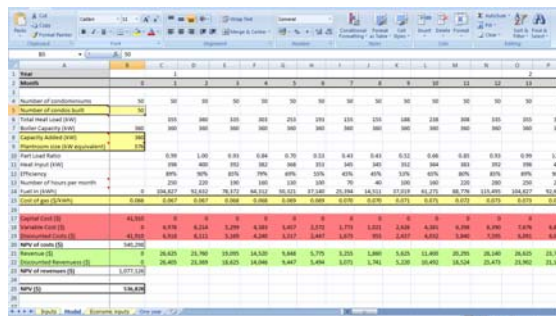
$\sigma = 6.74\%$



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

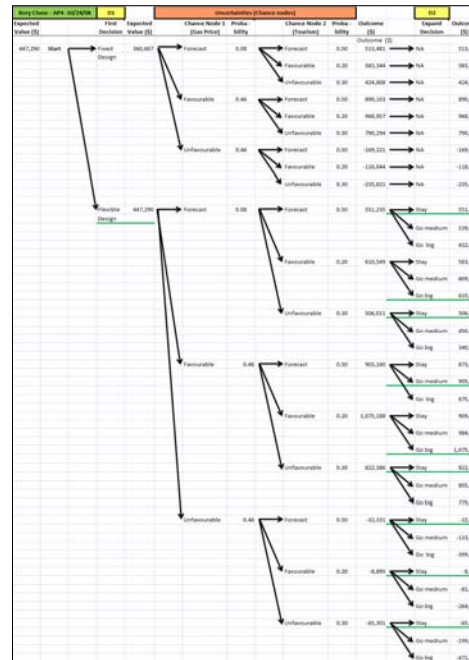
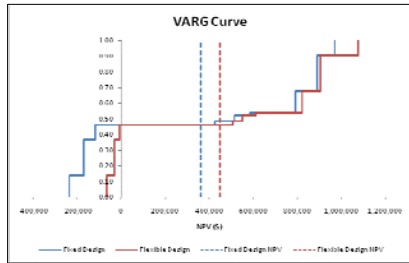
Two uncertainties (gas price & demand level)

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

| | Lattice of Cashflows | | | | | |
|--------------------------------|----------------------|---------|---------|---------|---------|---------|
| Annual undiscounted cash flows | 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 |
| (Year 0 includes Capex) | | | | | 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

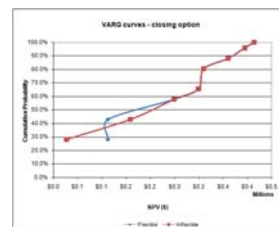
-Binomial Lattice:

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