Appendix 5

Resource/Cost Estimates

For

Solar Thermal Space/Water Heating

2010 and 2020

Contents

1. Active Solar Thermal Energy Systems for Space and Water Heating

1.1 Introduction

The Solar heat resource is dependent in the first instance on the insolation falling on the surface of Ireland. The usable power generated by solar panels will vary depending on latitude, time of year and weather conditions. According to the European Solar Thermal Industry Federation, current technology produces per square metre of solar panel between 300 and 450 thermal kWh/year.

1.2 Resource Estimation

1.2.1 Basic Considerations

The resource base in Ireland for Solar Heating for hot water and space heating is summarised in Table A5.1 below from the theoretical resource through to the accessible resource for the year 2000. The resource area is based on the roof area of existing and future dwellings. The resource is measured in terms of metres squared which is the standard size of solar panels supplied into the Irish Market.

The starting point for determining the theoretical resource is the total surface area of the country, which if covered by solar panels is taken to yield a mean annual output of 350kWh (thermal)/sq. m based on averaged figures quoted by panel suppliers.

Table A5.1

National Resource Base for

Solar Thermal Power Ireland 2000 (000 sq. m)

Summary	Theoretical Resource km^2	Total Floor Area $000m^2$	Technical Resource $000m^2$	Practical Resource $000m^2$	Accessible Resource $000m^2$	
Commercial		13,988	6,304	3,152	2,364	5%
Public Sector		9,889	5,196	2,598	1,949	4%
Industrial		4,200	2,100	1,050	788	2%
Housing		204,360	102,180	51,090	38,318	87%
Agriculture		1,080	1,080	540	405	1%
Total	69,550	233,517	116,861	58,430	43,823	100%

(All above figures x 350kWh (thermal)/sq. m/yr)

1.2.2 Technical Resource

The technical resource is based on the assumption that roof area is a fraction of the total floor area of the five categories of existing buildings throughout the country. It is assumed that each square metre of area generates a specific kWh per year and does not incur efficiency deductions that would apply to other generation technologies.

1.2.3 Practicable Resource

The practical resource is defined as 50% of the technical resource. The technical resource has been further reduced to arrive at the estimate for the accessible resource to take account of planning and environmental constraints. Planning and environmental constraints are estimated at 25% of the practicable resource base.

1.2.4 Accessible Resource

The accessible resource base in Ireland for 2000 is estimated at 44 Million sq. m and 87% of this area is accounted for by the housing stock (1.4 million units) and is estimated to grow at 4% per annum or 55,000 units per year on average.

Assuming this overall growth rate for the total accessible area, the total resource area will increase to 59 and 70 Million square metres by the years 2010 and 2020 respectively.

The estimated resource base for solar power is shown in Table A5.2, 5.3 for 2010 and 2020 respectively.

In forecasting the resource area for 2010 it is assumed that

- New housing construction will continue until 2010 at a rate of 3.8% on 2000 levels of 50,000 units per annum.
- New housing construction will continue at a rate of 3% on 2000 levels between 2010 and 2020.
- All other dwellings will increase at a rate of 2% on 2000 levels per year from 2004 to 2020.

Table A5.2

National Resource Base for

Solar Thermal Power Ireland 2010 (000 sq. m)

Summary	Theoretical Resource km^2	Total Floor Area $000m^2$	Technical Resource $000m^2$	Practical Resource $000m^2$	Accessible Resource $000m^2$	
Commercial		16,786	7,565	3,783	2,837	5%
Public Sector		11,867	6,236	3,118	2,338	4%
Industrial		5,040	2,520	1,260	945	2%
Housing		280,017	141,008	70,504	52,878	89%
Agriculture		1,296	1,296	648	496	1%
Total	69,550	317,005	158,625	79,313	59,484	100%

(All above figures x 394kWh (thermal)/sq. m/yr)

Table A5.3

National Resource Base for

Solar Thermal Power Ireland 2020 (000 sq. m)

Summary	Theoretical Resource km^2	Total Floor Area $000m^2$	Technical Resource $000m^2$	Practical Resource $000m^2$	Accessible Resource $000m^2$	
Commercial		19,583	8,826	4,413	3,310	5%
Public Sector		13,845	7,275	3,638	2,728	4%
Industrial		5,880	2,940	1,470	1,103	2%
Housing		333,107	166,563	83,277	62,458	89%
Agriculture		1,512	1,512	756	567	1%
Total	69,550	373,927	187,106	93,563	70,156	100%

(All above figures x 480kWh (thermal)/sq. m/yr)

The accessible resource is used for estimating the resource cost curves in Appendix 5 is shown below. The largest resource area is for housing of which 10% is estimated as apartments in 2004 rising to 14% in 2010 and 20% in 2020.

Table A5.4

Breakdown of Accessible Area (000 Sq M)

for Solar Thermal Panels

Resource Area (000 M2)	**2000**	**2010**	**2020**
Commercial	2,364	2,837	3,310
Public Sector	1,949	2,338	2,728
Industrial	788	945	1,103
Housing		-	0
Total Houses	34,486	45,475	49,966
Total Apartments	3,832	7,403	12,942
Inc. New Houses		10,989	15,480
Inc. New Apartments		3,571	8,660
Total Housing	38,318	52,878	62,458
Agriculture	405	405	567
Total	43,823	59,403	70,165

To develop the resource area above for both space and water heating the solar combi system can be applied to all sectors including the retrofit of old buildings. The costed energy outputs of the resource are detailed in Section 2.

2. Active Solar Thermal Power Resource Cost Curves

2.1 Resource Assumptions

The accessible resource (identified in Section 1) is used for estimating the resource cost curves for 2010 and 2020. The largest resource area is for housing of which 10% is estimated as apartments in 2000 and 20% in 2020 as shown in Table A5.4 above.

2.2 Active Solar Thermal Power Technology

The technology evaluated is the Solar Thermal Combi Power Systems which can be used for space and water heating in conjunction with conventional heating systems.

2.3 Output and Cost Assumptions

The resource costs curves developed below are based upon the accessible resource in terms of the levelised cost of generation of thermal electricity in cents/kWh.

2.4 Outputs

It is assumed in the analysis that in the absence of a new technology there will be no large stepwise increase in the efficiency of the solar panels. Rather there will be an annual increase in the efficiency of the solar panels of 2% (compounded) per year of manufacture resulting in a 37% efficiency increase by 2020 over 2004 levels.

Table A5.5

Productivity Increase in Active Solar Thermal Panels 2004 – 2020

	2004	2010	2020
Annual Output kWh	350	394	480
% Change in 2004		13%	37%

It is assumed that the life of the panels is 20 years and the outputs of the panels are those identified in 2010 and 2020 above.

2.4.1 Cost Assumptions

The cost of the Solar Thermal Power Combi systems is shown in Table A5.6 below.

Table A5.6

Active Solar Thermal Combi System (2004)

	Units	
Existing House (Euro per House)	Euro	8,000
New House (Euro Per House)	Euro	9,500
Area Heating (sq. metre)	Sq. Metres	100
Roof Area	Sq. Metres	50
Number of Solar panels	Sq. Metres	20
Average Cost Square Metre	Euro	438
Output square metre	kWh per year	350

- The development of the total accessible area for solar thermal power in Ireland (70 million sq. metres in 2020) would require mass production of the solar panels on an unprecedented scale which would result in significant economies of scale in the cost of manufacture.
- It is assumed in the analysis that between 2004 and 2020 the capital and maintenance costs of the solar panels would reduce by 2% per year. This would result in a cost reduction of 39% by 2020 as shown below.
- A further reduction of 20% in capital and maintenance costs have been applied to large scale installations of solar panels. These costs apply to all sectors with the exception of retrofitting existing houses.
- Retrofitting of existing houses (2004 levels) is assumed to be undertaken on an individual basis and therefore would result in a higher unit capital, maintenance and installation cost than for large installations. Therefore the small scale costs detailed below have been used for retrofitting existing houses. This excludes apartment blocks where the large scale cost structure has been applied.

Table A5.7

Forecast Real Price Decrease in Capital and Maintenance costs of Active Solar Thermal Panels

	2004	2010	2020
Small Scale Installations			
Unit Capital Cost Euro	438	388	317
Unit Maintenance Cost Euro p.a.	10	9	7
% reduction on 2004		11%	28%
Large Scale Installations			
Unit Capital Cost Euro	350	310	253
Unit Maintenance Cost Euro p.a.	10	9	7
% reduction on 2004		11%	28%

Table A5.8

Computation for Solar Thermal Resource Cost Curve 2010

		Units	2010	2020	
1	Total housing	Sq Metres	59,403	70,165	
2	Existing houses (Small scale)	Sq Metres	34,486	34,486	
3	Difference (Large Scale)	Sq Metres	24,918	35,679	(1- 2)
4	Unit outputs	kWh/Sq Metre/pa	394	480	
5	Large scale outputs	MWh	9,821	17,143	(3 X 4)
6	Small scale outputs	MWh	13,593	16,570	(2 X 4)
7	Total Annual Outputs	MWh	23,414	33,712	(5 + 6)
8	Panel Life	Years	20	20	
9	Total Large scale outpurs	MWh	271,856	331,391	(5 X 8)
10	Total Small scale outpurs	MWh	196,430	342,859	(6 X 8)
11	Discout Rate	%	6.88%	6.88%	
12	NPV Large scale outputs	MWh	105,054	183,367	NPV of 9
13	NPV Small scale outputs	MWh	145,394	177,234	NPV of 10
14	Unit Capital Costs (Large Scale)	Euro	310	253	
15	Average Unit Maintenance Costs (Large Sca	Euro/ pa	147	179	
16	Unit Capital Costs (Small Scale)	Euro	388	317	
17	Average Unit Maintenance Costs (Small Sca	Euro/ pa	249	214	
18	No of Units (Large Scale)	No of Panels	24,918	35,679	(=3)
19	No of Units (Small Scale)	No of Panels	34,486	34,486	(=2)
20	Total Capital Costs (Large Scale)	M Euro	7,726	9,039	(14X18)
21	Total Capital Costs (Small Scale)	M Euro	13,365	10,920	(16 X19)
22	Total Maintenance Costs (Large Scale)	M Euro	2,935	3,578	(8X15)
23	Total Maintenance Costs (Small Scale)	M Euro	4,982	4,282	(8X17)
24	NPV of Capital and Maintenance Costs LScale	M Euro	8,867	10,420	NPV of 20 + 22
25	NPV of Capital and Maintenance Costs SScal	M Euro	15,288	12,561	NPV of 21+ 23
26	Levelised Costs Large Scale	Cents/KWh	8.44	5.68	(24 / 12)
27	Levelised Costs Small Scale	Cents/KWh	10.52	7.09	(25 / 13)

2.5 Accessible Resource Cost Curves

2.5.1 Basis of Curves

The accessible resource cost curves shown below demonstrate the potential effect of economies of scale in the production and installation of solar panels and efficiency increases.

The cost curves below show the cost of developing the total accessible resource area in 2010 or 2020 assuming there is no development of the resource in previous years. The methodology for identifying the unit costs (Cents/kWh) is based upon the levelised cost analysis and is compared with the levelised cost of Natural Gas. The forecast capital and operating costs have been discounted at the Weighted Average cost of Capital (WACC) 6.88 % as used by the CER and divided by the Present Value of the annual output of the panels over an estimated life of 20 years.

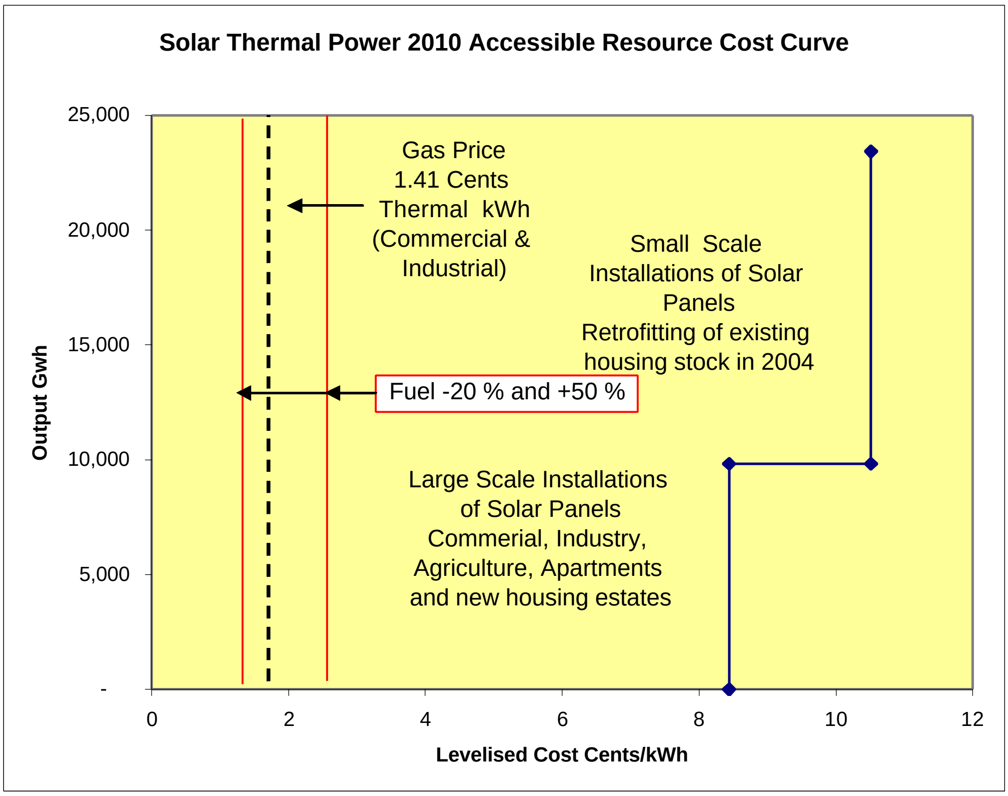
Table A5.9

Summarised Basis of Solar Thermal Resource Cost Curves

Resource Curve 2010	Quantity GWh	Cost Cents/kWh
Large Scale Installations	-	8.44
Large Scale Installations	9,821	8.44
Small Installations	9,821	10.52
Small Installations	23,414	10.52

Resource Curve 2020	Quantity GWh	Cost Cents/kWh
Large Scale Installations	-	5.68
Large Scale Installations	17,143	5.68
Small Installations	17,143	7.09
Small Installations	33,712	7.09

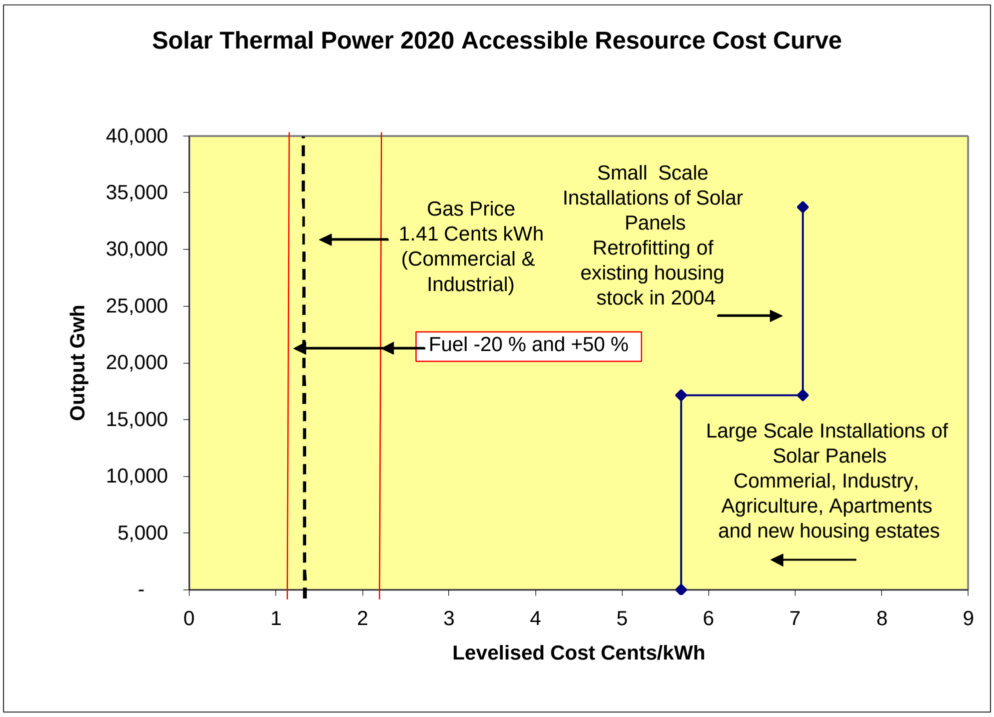
Figure A5.1



2.5.2 Solar Thermal Resource/Cost Curve (2010)

Figure A5.1 shows that large scale new installations with an annual aggregate thermal yield level of up to 10TWh have a levelised cost of 6.05c/kWh(t) but that levelised cost of small scale and retrofit installations amounts to 8.24c/kWh(t) for an equal sized aggregate installation. The levelised natural gas price is only 1.41c/kWh(t) and it is clear that this is so far below the solar cost that there is no viable open market. To create a viable managed market levelised injections of at least 6.05c/kWh(t) and 8.24c/kWh(t) for large and small installations respectively would be required. Even gas price increases of +50% would still leave gaps of 4c/kWh(t) and 6.1c/kWh(t) to be bridged. Thus the solar thermal/water heating technology does not appear to be attractive on the basis considered for 2010.

Figure A5.2



2.5.3 Solar Thermal Resource/Cost Curve (2020)

Figure A5.2 shows that due to improved performance and increased output unit levelised costs are projected to reduce somewhat by 2020, but the gap between the levelised costs at 5.68c/kWh(t) (large installations) and 7.09c/kWh(t) (small installations) each with aggregate outputs of 17.143TWh are too large to allow of a viable open market. A viable managed market would require levelised injections of 4.27c/kWh(t) (large) and 5.68c/kWh(t) (small installations). Although the unit performance is improving it has not yet the level where it would be competitive with natural gas.

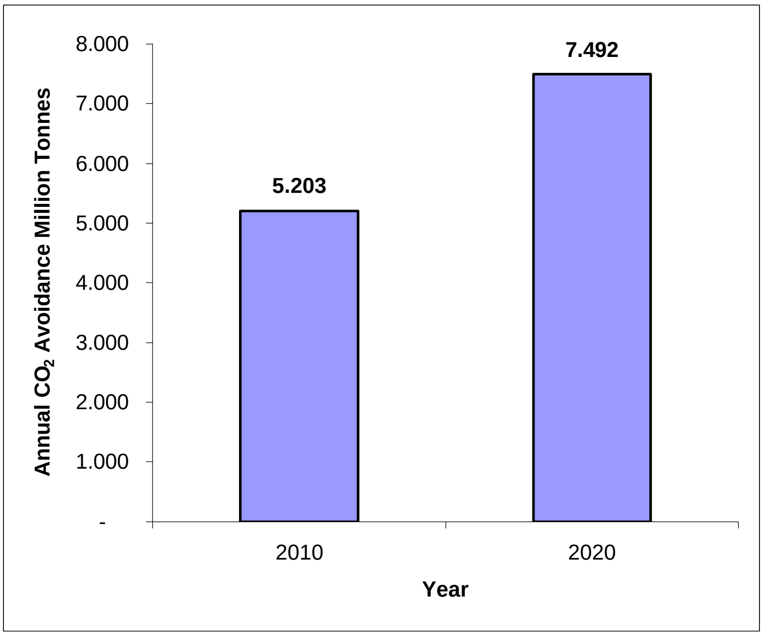
2.5.4 Comparison with Previous Work

In the 1997 study (Ref. 6) doubts were expressed as to the appropriateness of using levelised costs at particular discount rates for areas other than swimming pools and commercial buildings as the decision to utilise solar heating was seen as a discretionary ‘quality of life’ issue rather than a commercial matter. The estimated accessible resources to be taken up for 2020 were 40.25GWh(t)/yr and 33,679GWh(t)/(yr) in this study (both housing dominated). Given that the 1997 study was projecting a resource of 582GWh(t)/yr for 2000 and the present study took 870GWh(t)/yr as a base for the same year, which figures are of the same order of magnitude, the real deviation occurs after this where the projected rates of increase differ significantly (see Table A5.10). This indicates the importance of monitoring the actual rate of solar thermal system take up on housing stock where the projected figures may be seen as being vulnerable to a downturn in the new housing market and a slower than expected rate of retrofit on existing buildings.

2.6 Accessible Area Potential Annual CO_2 Avoidance

The potential annual CO_2 avoidance using the solar combi system if all of the accessible resource is exploited in 2010 and 2020 is shown in Figure A5.3: below. For each MWh of solar thermal energy displacing thermal energy provided by gas fired heating 0.22 Tons of CO_2 is avoided assuming 90% efficiency of gas boilers.

Figure A5.3



2.7 Potential Impact of Active Solar Thermal Power on the Irish Market

2.7.1 Market Penetration Scenarios

In 2000 a total of only 2,485 sq.m of solar panels for water heating were installed in Ireland. Three penetration scenarios have been developed for Active Solar Thermal power (Ref. 13) and are quantified as shown in Table A5.10 below.

Low Growth Scenario

The low scenario assumes very little or no public support, the development of the industry being left more or less to its own devices and the present relatively marginal growth rate.

Medium Growth Scenario

The medium scenario assumes moderate public support, quality assurance schemes, regional campaigns and some additional initiatives. The cost of the Govenment support is estimated in the analysis below at 2% of market turnover.

High Growth Scenario

A high or accelerated scenario as achieved in several European countries, containing public support for small and large scale systems, quality assurance schemes for products and installations, education of solar engineers and architects and regional and national campaigns. The cost of the Government support is estimated in the analysis below at 5% of market turnover in the accelerated scenario.

Table A5.10

Projected Penetration Scenarios for Solar Water Heating

Scenario	2000 m^2/yr.	2010 m^2/yr.	Rate of Increase	2020 m^2/yr.	Rate of Increase
Low	2,485	10,000	402%	40,000	1610%
Medium	2,485	27,000	1087%	90,000	3622%
High	2,485	55,300	2225%	180,000	7243%
Output kWh(t)/m^2/yr.		394		480	

Figures A5.4 to A5.6 below show the associated Outputs (MWh/year), CO_2 avoidance (tons/year) and cumulative capital costs (€M Euro) for the three market penetration scenarios.

Figure A5.4

Annual Outputs Market Penetration Scenarios MWh (t)

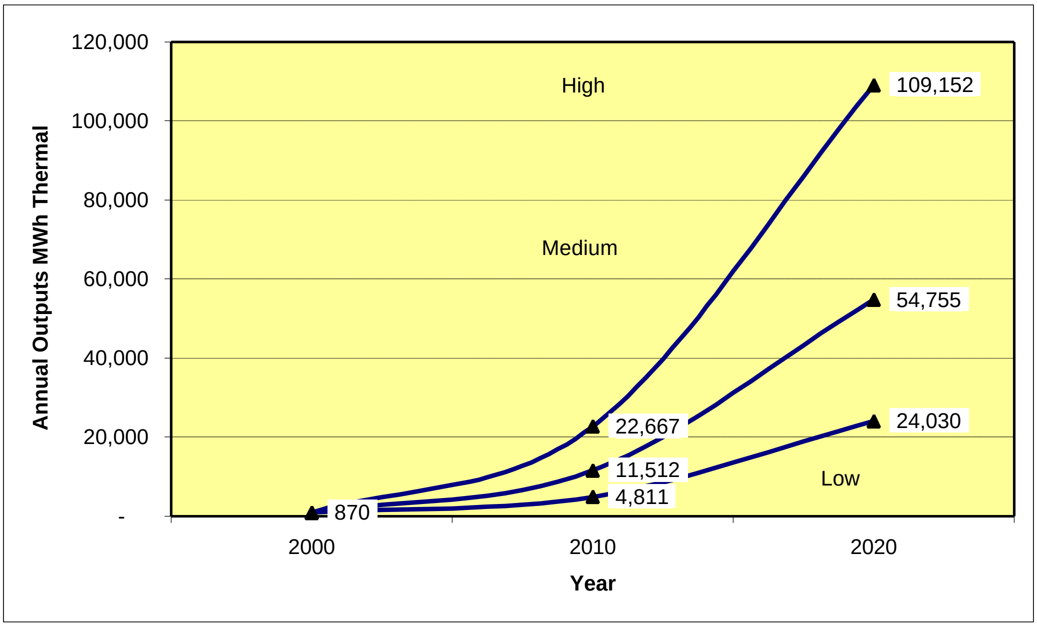


Figure A5.5

Annual CO_2 Avoidance Market Penetration Scenarios

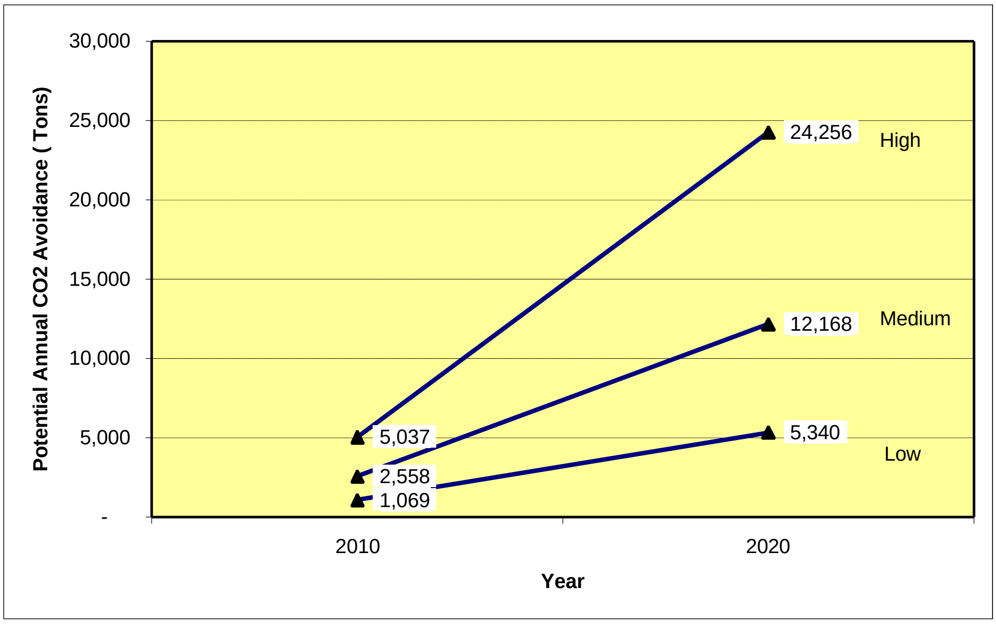
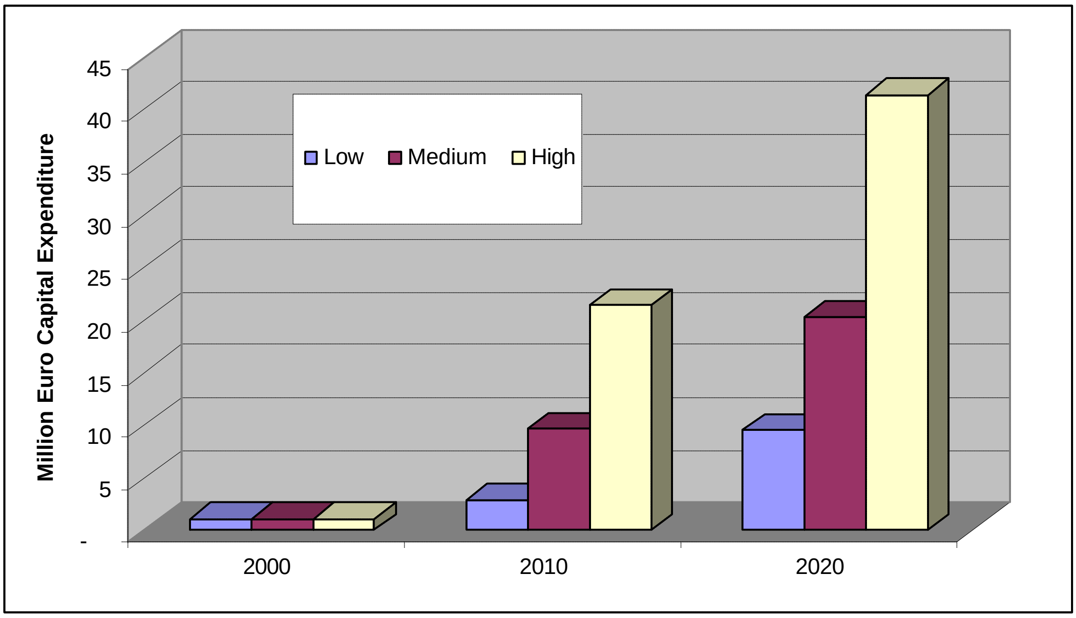


Figure A5.6

Cumulative Capital Expenditure Market Penetration Scenarios

Active Solar Thermal Power



2.8 Conclusions

(1) The solar thermal heat resource can be derived by allowing a mean annual solar panel rating of 350kWh (thermal)/sq. m/yr. multiplied by an accessible building roof area of 59.484 x 10^6 sq. m (2010) and 70.165 x 10^6 sq. m (2020). This is dominated by the housing area.

(2) Levelised cost analysis shows that Active Solar Thermal combi systems produce thermal energy at a cost of 14 Cents/kWh in 2004.

(3) The proportion of thermal energy that could be supplied by Active Solar Thermal power may have the potential to compete with electricity assuming there is no real price reduction in electricity over the period of analysis and there are significant real price decreases in Active Solar Thermal Technology and significant productivity increases.

(4) The potential impact of Active Solar thermal Power on the Irish Market is limited however as

- An analysis of the levelised unit costs of Active Solar Thermal technology shows that it cannot compete with natural gas or CHP in the absence of a significant technology innovation or subsidisation.
- Active Solar Thermal Applications must be used in conjunction with auxiliary heating systems as the technology cannot fully replace conventional space heating systems.
- The potential for Active Solar thermal power systems to be competitive may be further eroded with technical innovations in competing technologies such a micro CHP.
- The highest market penetration scenario considered credible is less than 1% of total Thermal Demand by 2020 and thus the potential for CO_2 avoidance is small.