Modelling residential energy savings due to Ireland's National Retrofit Programme using DEAP and LEAP

2011 International Energy Workshop

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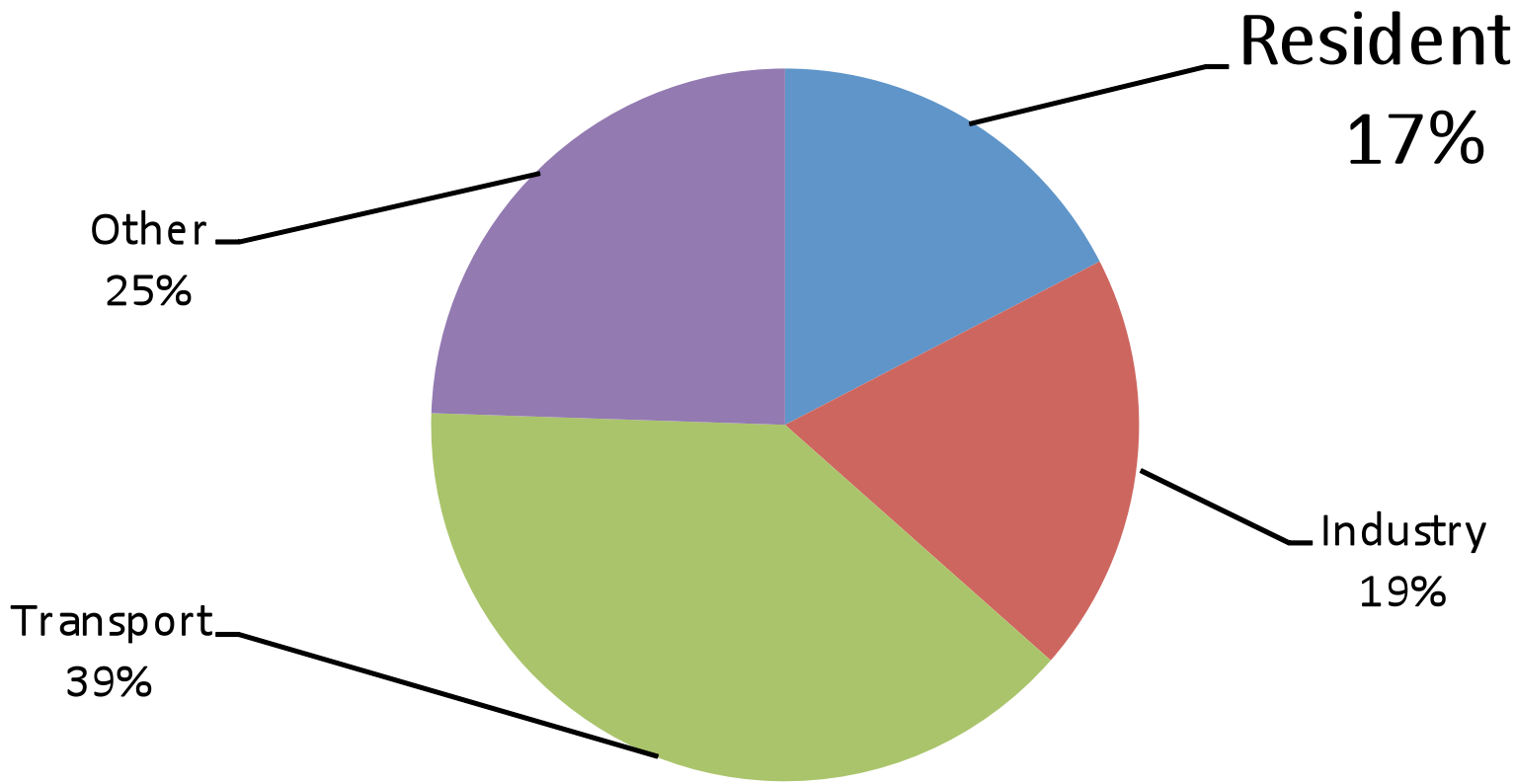
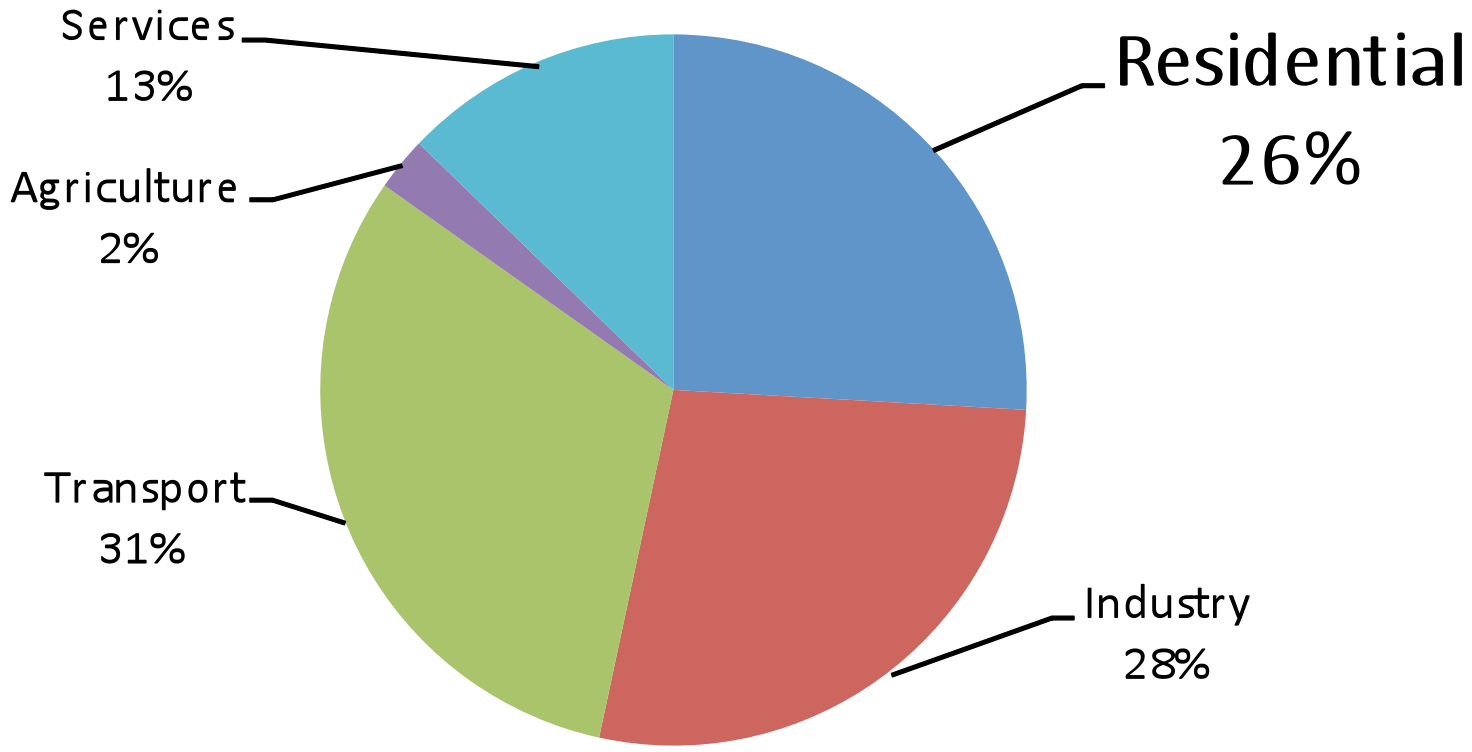
Overview

- Context to Irelands National Retrofit Programme
- Methodology
- Scenarios
- Results
- Next Steps

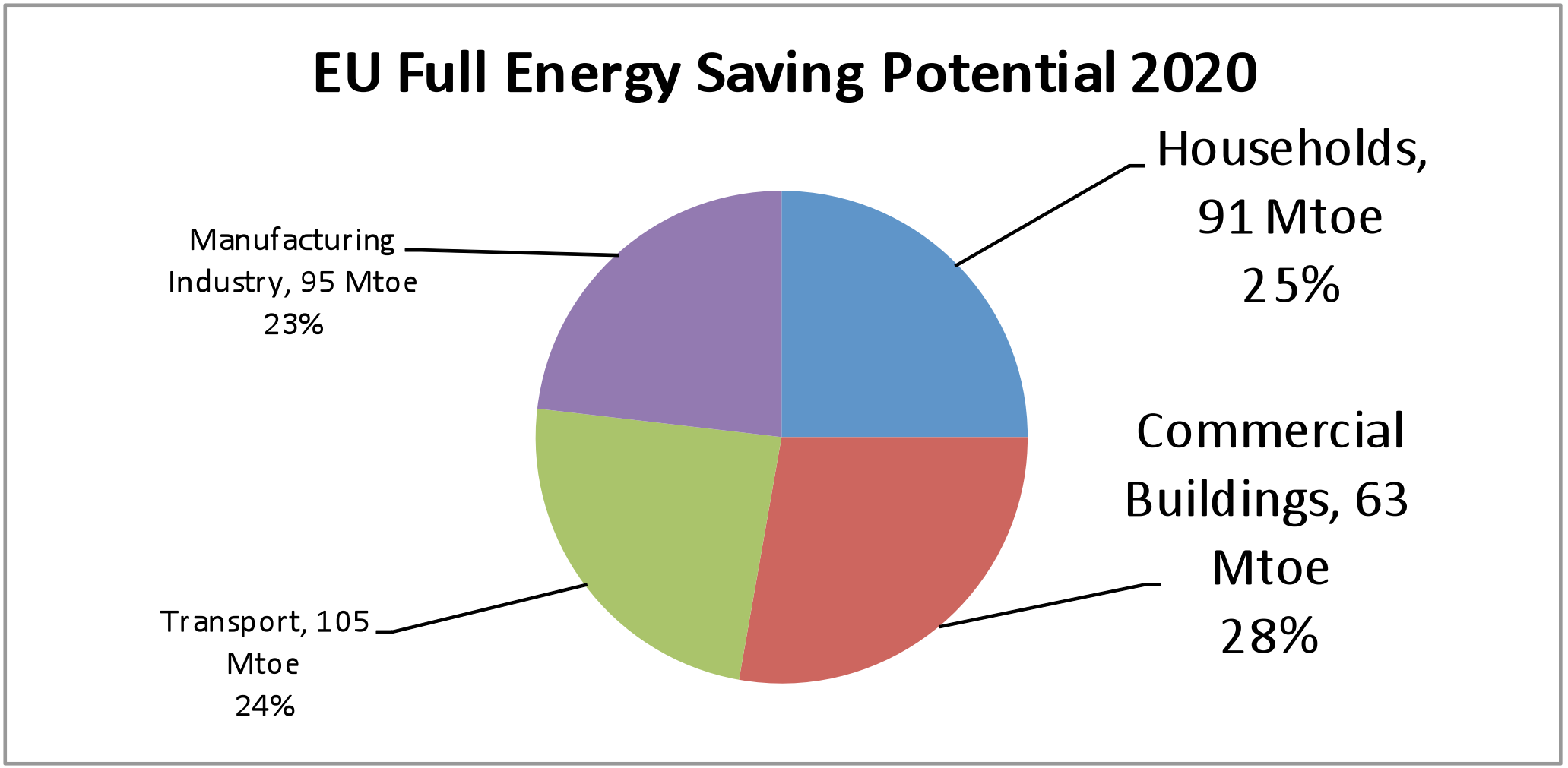
Context – US


Share of TFC for USA 2008
Residential
17%
Industry
19%
Transport
39%
Other
25%

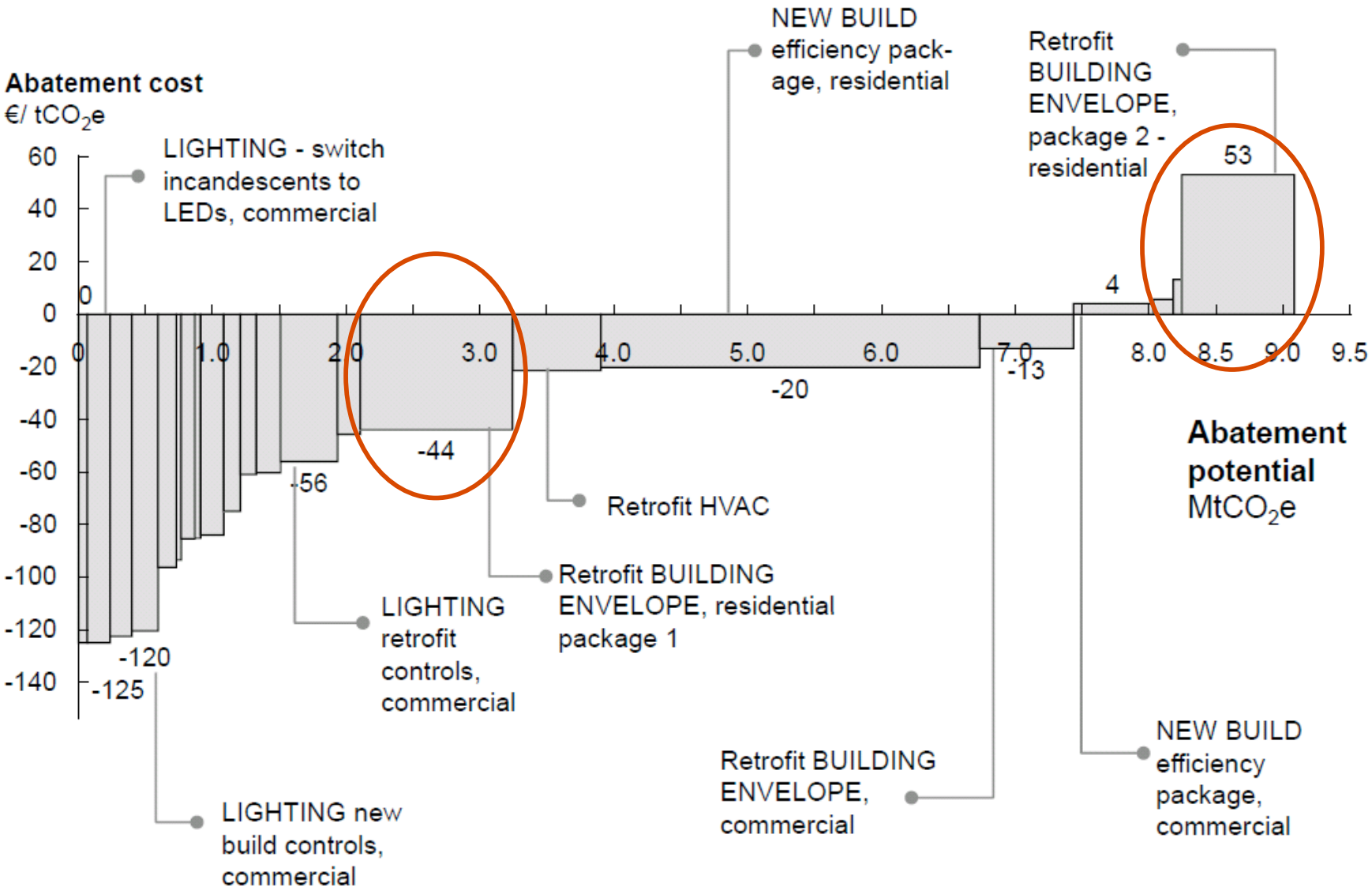
Context – EU


Share of TFC for EU 25 2009
Services
13%
Residential
26%
Agriculture
2%
Transport
31%
Industry
28%

Context – Savings



Context – Ireland MACC Curve



Context – previous programmes

- Retrofitting Schemes Recently Operated by the Sustainable Energy Authority of Ireland (SEAI):
  - Warmer Homes Scheme (addressing fuel poverty)
  - Home Energy Saving Scheme (retrofitting grant support)

	% of total	
	Applied for measure	Completed measure
External Wall Insulation	4	2
Internal Wall Insulation	8	4
Oil & Boiler Controls	17	10
Gas & Boiler Controls	19	15
Heating Controls	7	4
Cavity Wall	61	53
Roof Insulation	84	70

Context – new

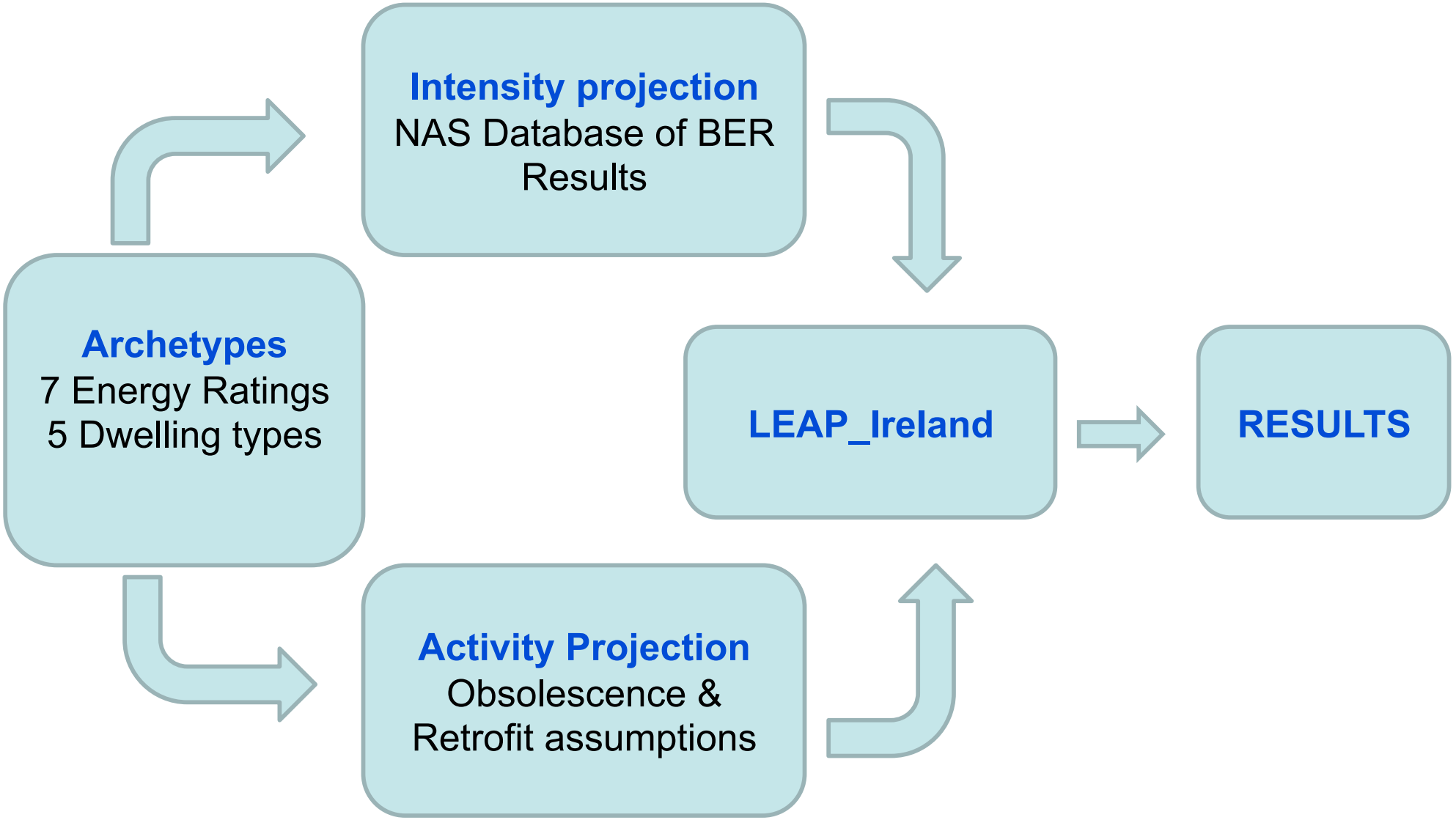
Plans for National Retrofit Scheme

- 1 million residential, public and commercial buildings to be retrofitted by 2020
- 75% of the available funding is to go to the residential sector, of which 40% will go to addressing energy poverty
- Aim to achieve total savings of 8,000 GWh by 2020,
  - **5,200 GWh in the residential sector.**
  - 2,800 GWh in the servies sector

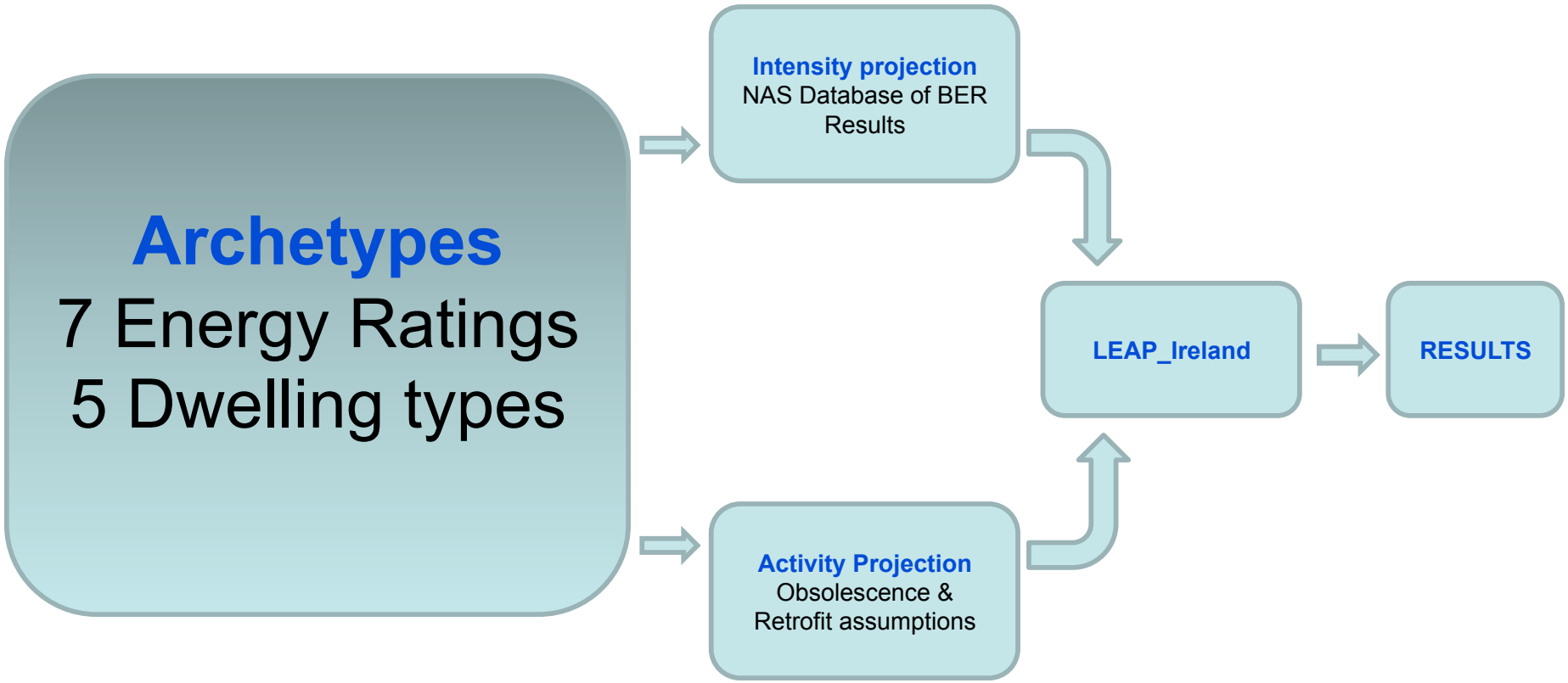
Context - Building Energy Rating

- Dwellings assigned an asset rating from A-G based on energy/floor area (kWh/m^2)
- Required at point of sale or rent for all dwellings under the Energy Performance in Buildings Directive (EPBD)
- Calculated using standardised procedure; Dwelling Energy Assessment Procedure (DEAP)
- Data gathered for and results of every BER survey carried out in Ireland stored by SEAI in the “NAS” Database (>100,000 surveys)

Methodology



Methodology



Methodology

- DEAP (Dwelling Energy Assessment Procedure)
  - Gives asset rating of the energy efficiency of dwellings
  - Based on a detailed survey of:
    - U Values of building elements
    - Ventilation and air tightness
    - Efficiency of heating systems
    - Heat system controls
    - Presence of on site renewable energy technologies

Methodology

Dwelling Archetypes

Label	kWh/m^2/yr
A1	<25
A2	>25
A3	>50
B1	>75
B2	>100
B3	>125
C1	>150
C2	>175
C3	>200
D1	>225
D2	>260
E1	>300
E2	>340
F	>380
G	>450

Methodology

Dwelling Archetypes

- Under BER Scheme, Dwellings assigned a grade from A-G based on energy/m^2 as calculated using DEAP
- The 2008 dwelling stock is first split by BER category, A to G
- Under the NRP it is proposed that grants be allocated based on a before and after Building Energy Rating (BER) of the dwelling
- NRP Model will focus on the aggregate effect of moving dwellings from one BER band to another

Methodology

Dwellings also split by dwelling type.

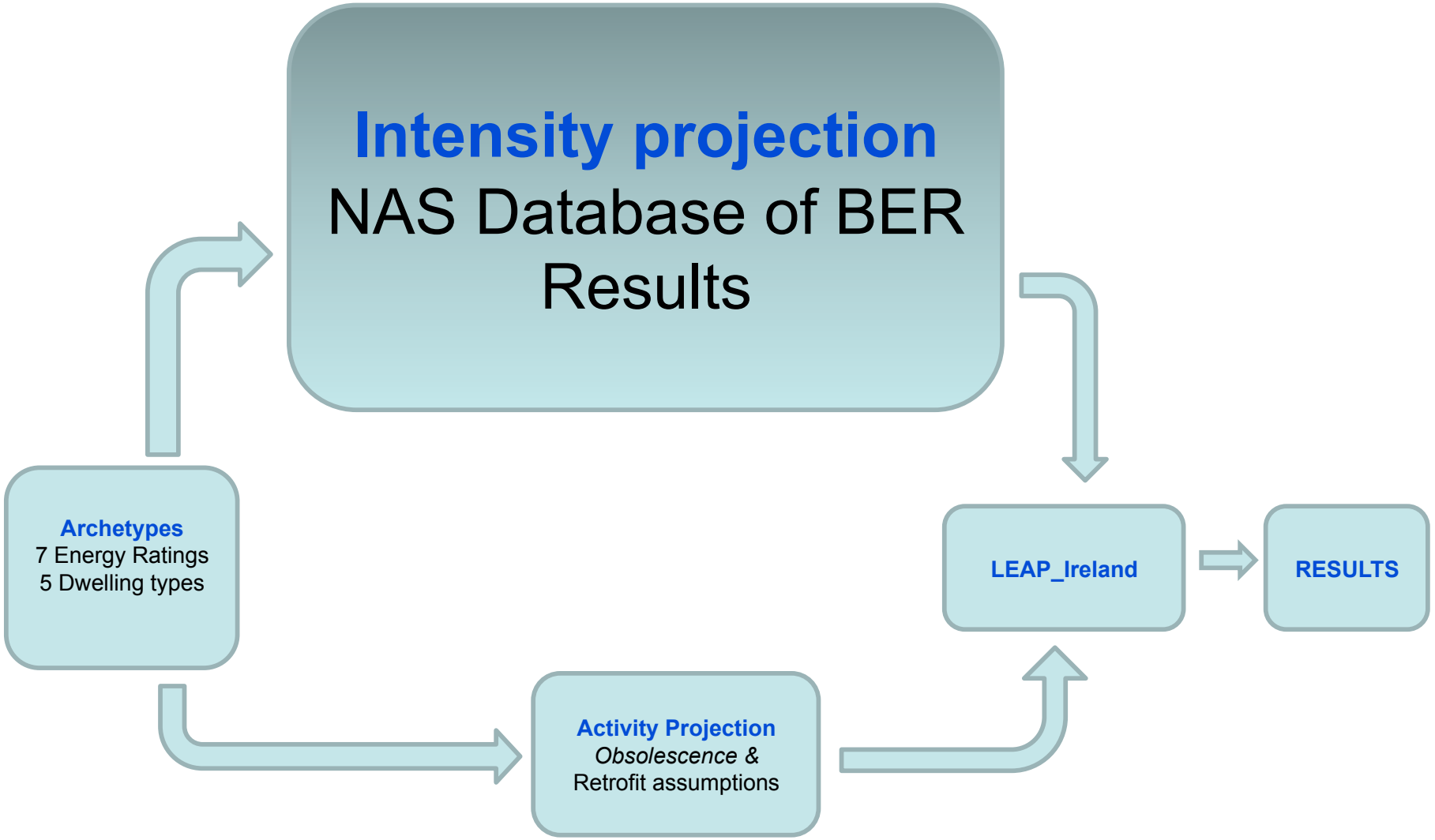
- One storey detached,
- Two storey detached
- Two storey semi-detached
- Terraced
- Apartment

Methodology

Dwelling Archetypes

- 7 energy ratings by 5 dwelling types gives 35 Dwelling archetypes to represent the housing stock

Methodology



Methodology

Energy Intensity

- NAS Database
- Average kWh/m^2 values for all 35 archetype dwellings for:
  - Main space heating
  - Secondary space heating
  - Main water heating
  - Secondary water heating

Methodology

Energy Intensity

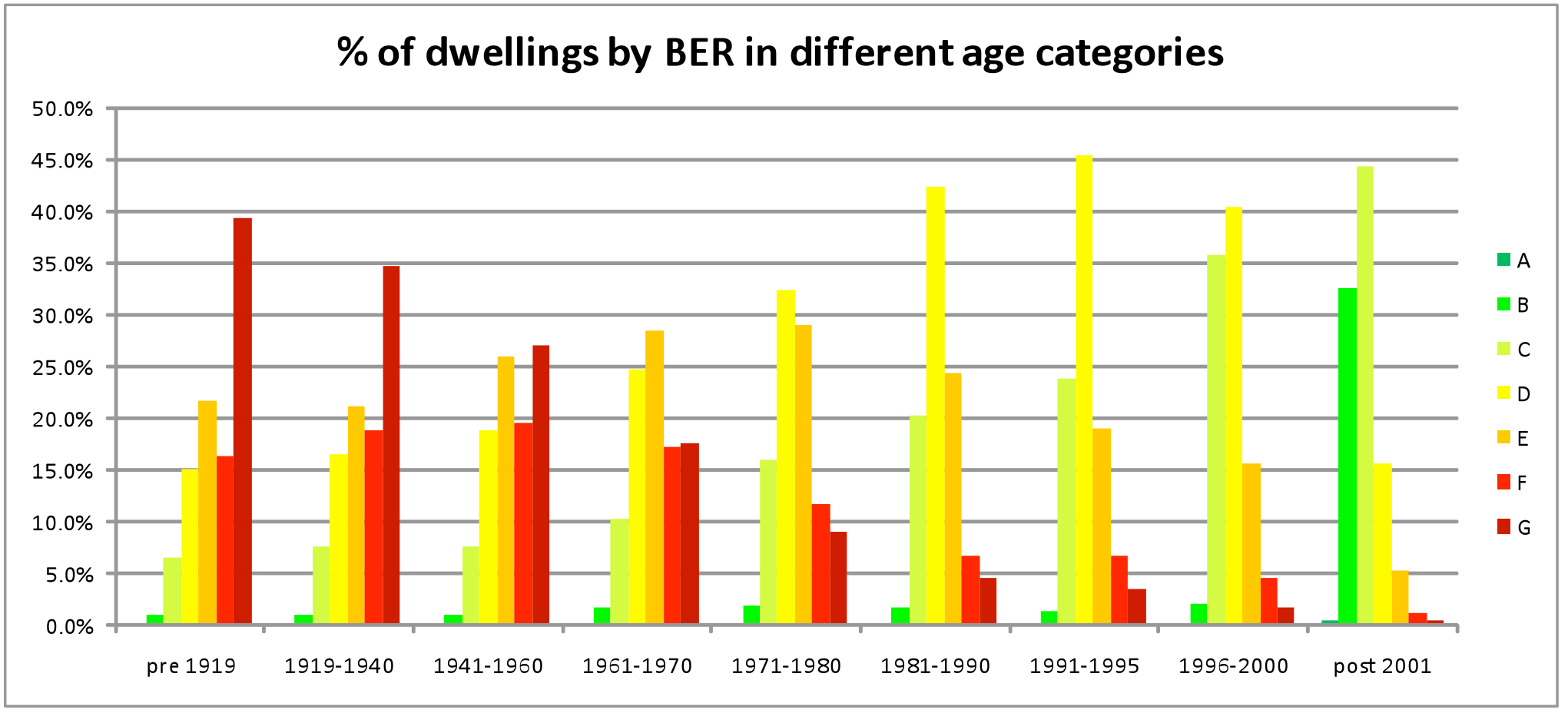
- Caveats!
- DEAP gives asset rating
  - Assume that for large numbers of dwellings this figure will be representative of the average energy consumption

  ...but...

  - Likely to over-estimate consumption of poorer performing dwellings due to assumptions on internal temperature.
  - No real world data on Irish dwellings available to calibrate against
- Rebound/behavioural effects

Methodology

Analysis of data in NAS database



Methodology

Analysis of data in NAS database

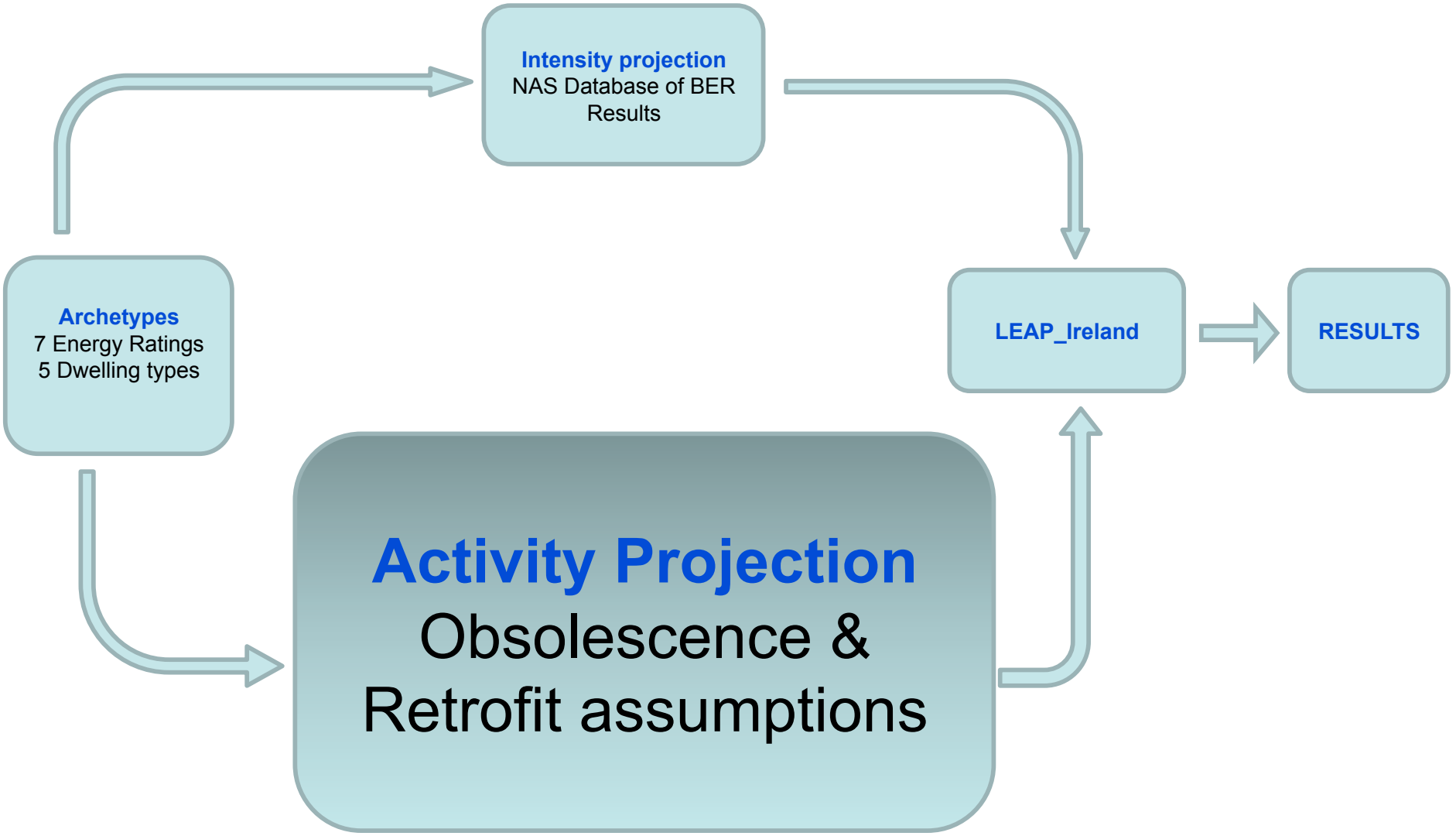
Period in which Built	CSO	%	BER d/b	%
1919 (pre)	155,752	10%	4,837	5%
1919-1940	108,622	7%	3,958	4%
1941-1960	143,706	9%	5,171	5%
1961-1970	113,994	7%	3,548	4%
1971-1980	214,309	14%	6,467	7%
1981-1990	167,527	11%	7,389	8%
1991-1995	93,930	6%	5,679	6%
1996-2000	156,178	10%	12,101	12%
2001-2008	395,982	26%	48,415	50%

Methodology

Analysis of data in NAS database

- NAS database biased towards newer dwellings
- Bias corrected to match age split observed in whole stock by giving each age category the correct weighting as per data from the Central Statistics Office (CSO)
- This modified data set is used to characterise the stock of dwellings existing in 2008

Methodology



Methodology

Retrofitted Dwellings

- National Retrofit Programme (NRP) aim of retrofitting 1 million domestic, public and commercial buildings between 2011 and 2020
- 75% of funding to go to residential sector
- 65% of target savings to come from residential sector
- Assume 800,000 residential dwellings to be retrofitted.

Year	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
1000 Annual Retrofits	-	-	50	70	100	100	100	100	100	100	50	30
1000 Cumulative Retrofits	-	-	50	120	220	320	420	520	620	720	770	800

Methodology

Activity Analysis - Scenarios

- Two issues to consider:
  - Which houses? differing initial BER profiles of dwellings being retrofitted
  - How deep a retrofit? differing depth of retrofit work carried out

Methodology

Differing initial BER profiles of dwellings being retrofitted

- Dwellings with poorer initial BER ratings have potential for greater savings than dwellings with higher initial BER ratings
- Assume no BER grade A or B dwellings will be retrofitted
- Assume initially that the numbers of dwellings being retrofitted will be weighted towards poorer BER grades
- Adjust weighting in further scenarios to investigate sensitivity

Methodology

Activity Analysis

- Differing initial BER profiles of dwellings being retrofitted

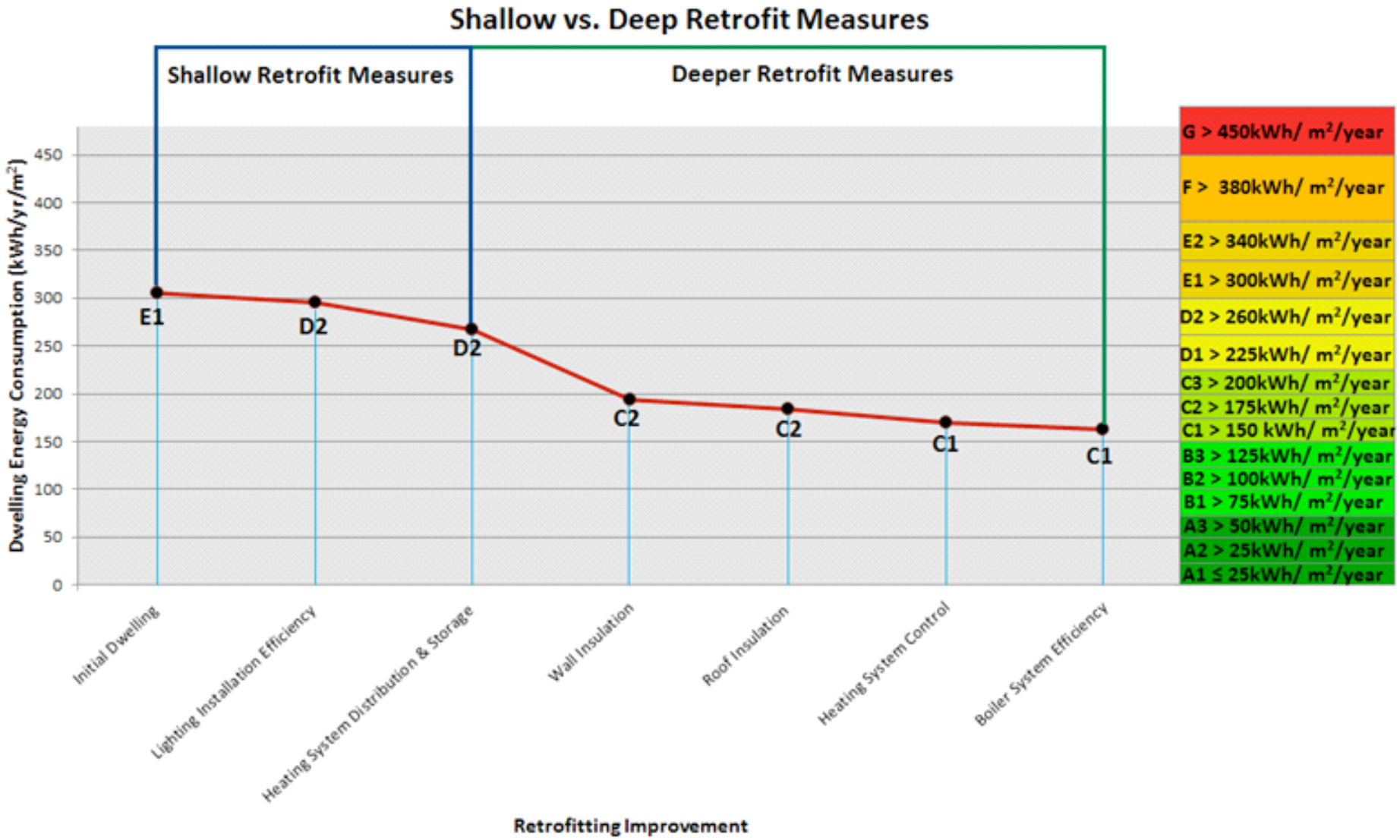
Uptake of Retrofit Works							
	Unweighted	Standard		Low Initial BER		High Initial BER	
BER	%	Weighting	%	Weighting	%	Weighting	%
A	0.0%		0.0%		0.0%	0.0%	0.0%
B	0.0%		0.0%		0.0%	0.0%	0.0%
C	25.3%	-12.5%	12.8%	-25.0%	0.3%	0.0%	25.3%
D	28.4%	-10.0%	18.4%	-20.0%	8.4%	0.0%	28.4%
E	20.9%	0.0%	20.9%	0.0%	20.9%	0.0%	20.9%
F	10.8%	10.0%	20.8%	20.0%	30.8%	0.0%	10.8%
G	14.6%	12.5%	27.1%	25.0%	39.6%	0.0%	14.6%

Methodology

Activity Analysis

- Differing depth of retrofit work carried out
  - Depth is a loose term that refers to the scale of cost and/or effectiveness of retrofit measures carried out
  - A “Deeper” retrofit would typically involve greater cost and achieve greater energy savings than a “Shallow” retrofit
  - Assume an initial improvement profile and adjust depth in further scenarios to investigate sensitivity

Methodology



Methodology

Activity Analysis

- Differing depth of retrofit work carried out

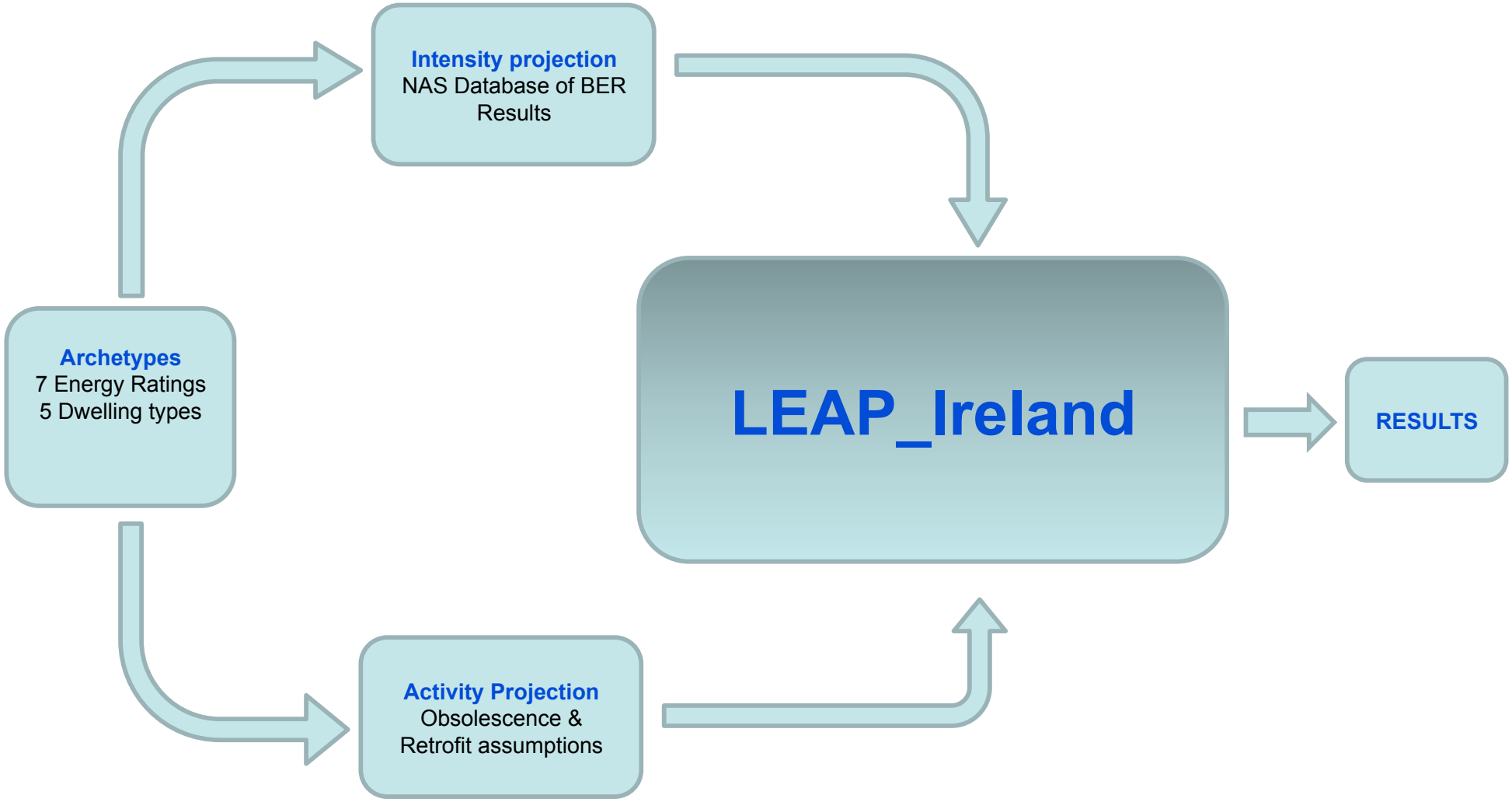
Retrofit Depth								
Standard			Shallow			Deep		
Initial	Post Retrofit	Increase in bands	Initial	Post Retrofit	Increase in bands	Initial	Post Retrofit	Increase in bands
B	A	+1	B	A	+1	B	A	+1
C	B	+1	C	B	+1	C	A	+2
D	B	+2	D	C	+1	D	B	+2
E	C	+2	E	D	+1	E	B	+3
F	C	+3	F	D	+2	F	B	+4
G	D	+3	G	E	+2	G	C	+4
		Total: +12			Total: +8			Total: +16

Methodology

Activity Analysis

- Combine different assumptions of uptake profiles and depth of retrofit in scenario analysis
- Carried out in LEAP

Methodology



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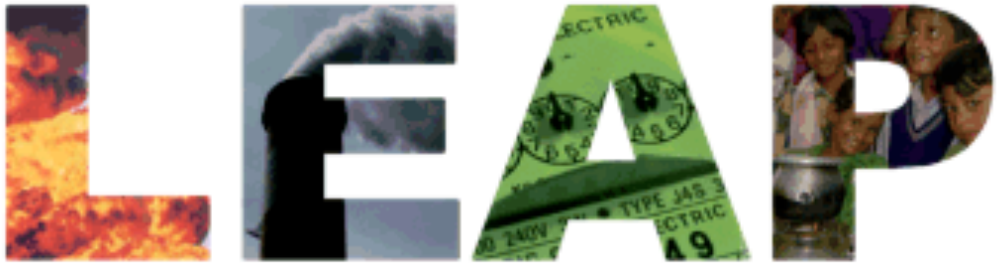


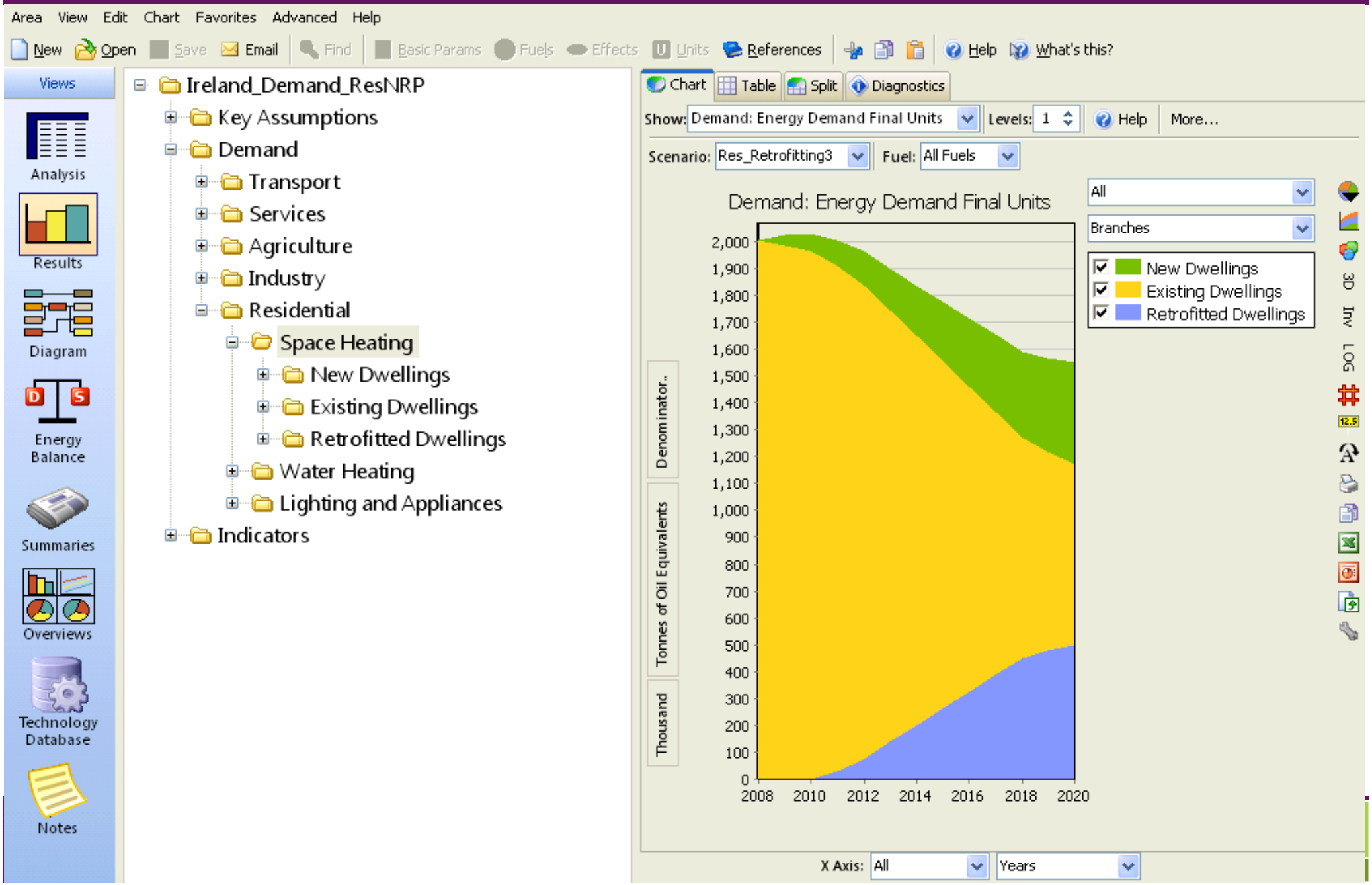
Tools for Sustainable Energy Analysis

- LEAP: Long-range Energy Alternatives Planning system
- Can be used at many different scales (city, national, regional)
- Does not have a rigidly defined model structure
- Each model requires its own internal tree structures and its own approach to energy demand calculations
- Supports a wide range of different modelling methodologies

Methodology

- Retrofitted dwellings model part of a residential sector model, including
  - space and
  - water heating
  - electricity demand of lighting and appliances.
- part of an LEAP Ireland from 2008-2025 model being developed at University College Cork.

Methodology



Methodology

Scenarios

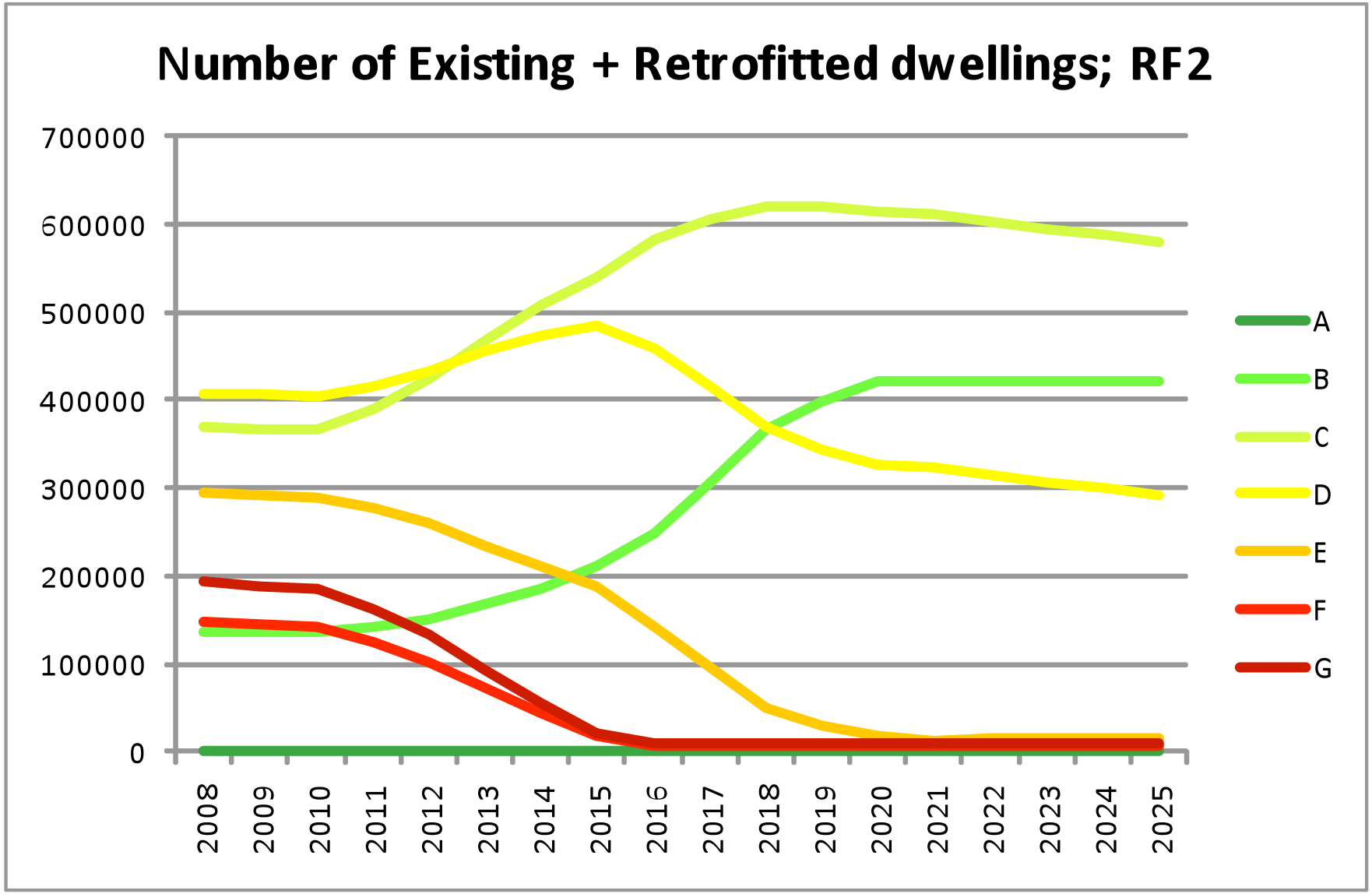
- 7 Scenarios developed in total
  - Reference scenario assuming no retrofit work (Ref)
  - Standard retrofit scenario (RF1)
  - 2 scenarios investigating the effect of differing initial BER profiles of dwellings being retrofitted. (RF2, RF3)
  - 2 scenarios investigating the effect of differing depth of retrofit work carried out (RF4, RF5)
  - Maximum potential for energy savings scenario (RF6)

Methodology

Scenarios

	Number Dwellings Retrofitted	Pre-Retrofit BER Profile	Depth of Retrofit works
Ref	0	-	-
RF1	800,000	Standard	Standard
RF2	800,000	Low	Standard
RF3	800,000	High	Standard
RF4	800,000	Standard	Shallow
RF5	800,000	Standard	Deep
RF6	800,000	Low	Deep

Methodology



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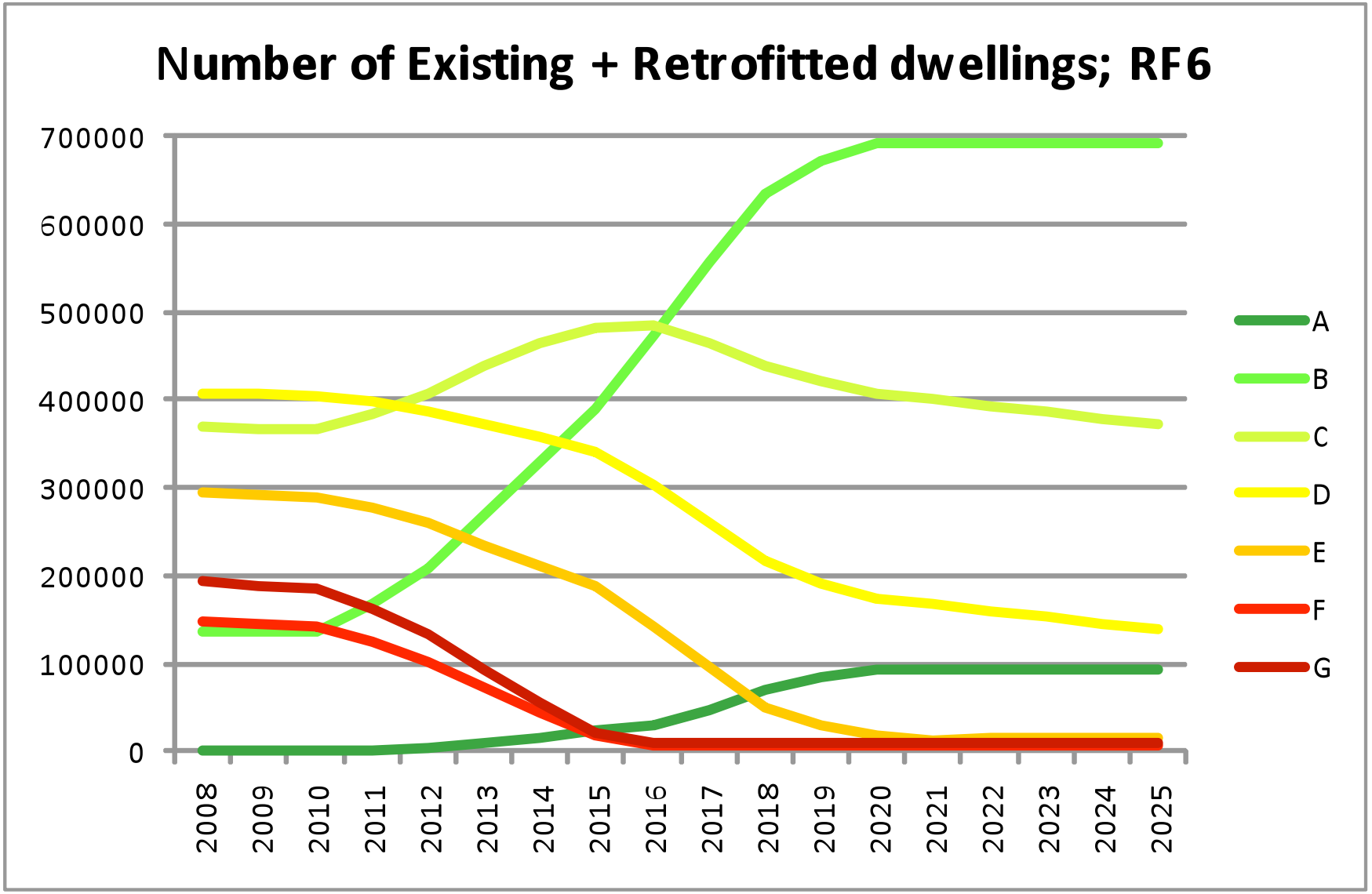

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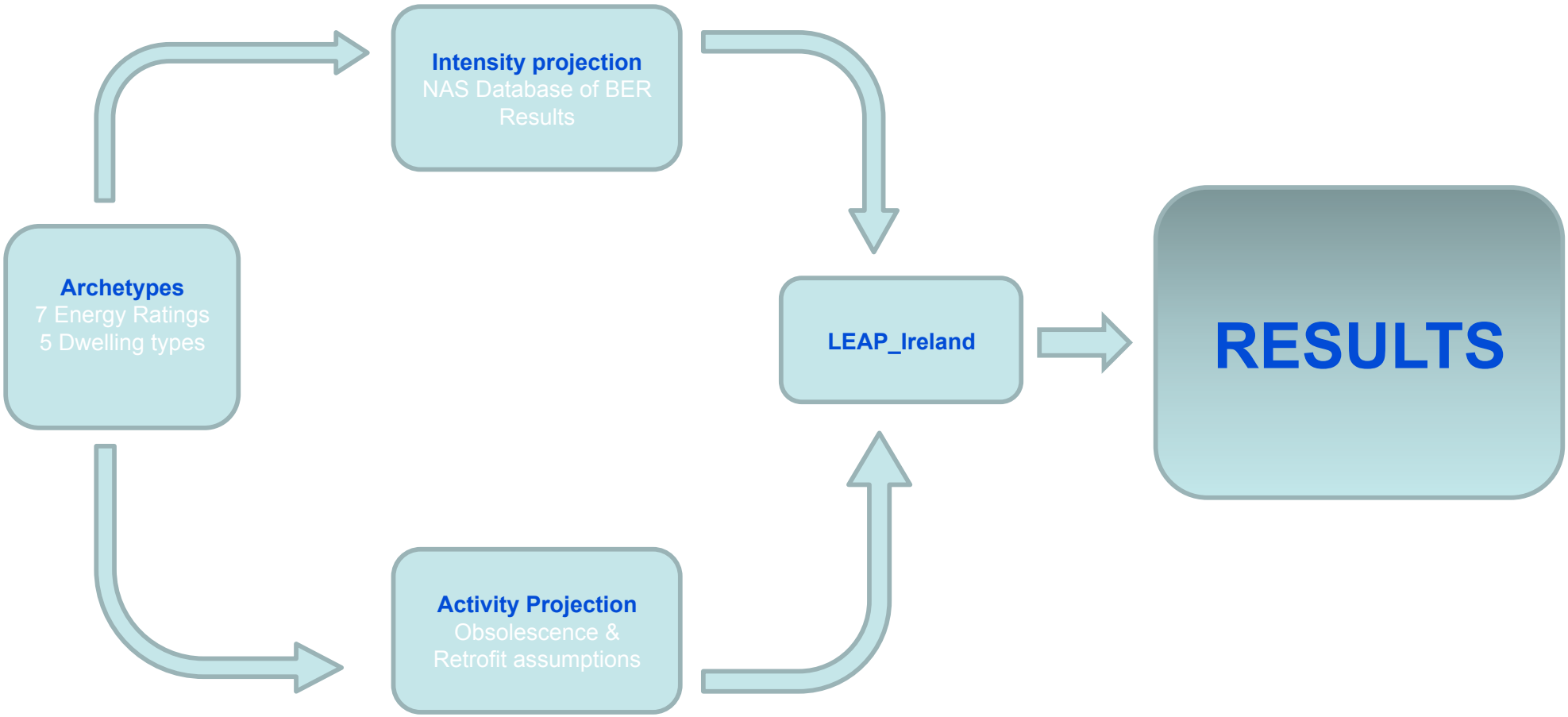
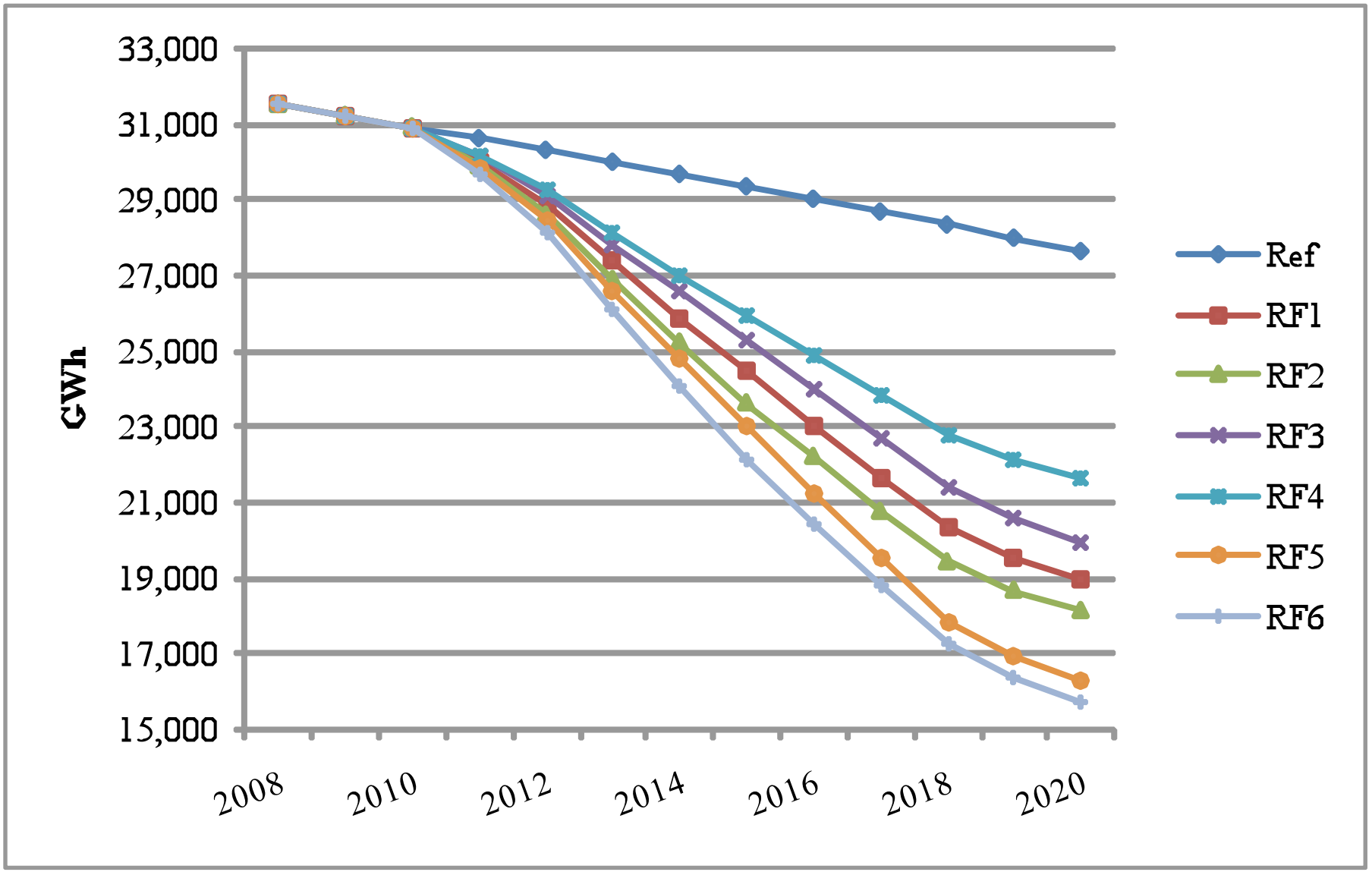


Results – space & water heating



Results

Energy demand for space and water heating in existing and retrofitted dwellings

Energy for Space and Water Heating in Existing and Retrofitted Dwellings					
	Energy Demand 2020	Savings WRT Ref		Savings WRT RF1	
	GWh	GWh	%	GWh	%
Ref	27,635				
RF1	18,945	8,690	31%		
RF2	18,136	9,499	34%	809	9%
RF3	19,962	7,673	28%	-1,016	-12%
RF4	21,631	6,003	22%	-2,686	-31%
RF5	16,283	11,352	41%	2,663	31%
RF6	15,751	11,884	43%	3,194	37%

Conclusions

- Model estimates savings potential of 6,000-11,900 GWh by 2020
- Conclude the scheme goal of 5,200 GWh savings is technically achievable
- Scheme should be targeted towards deeper retrofits and toward poorer dwellings to achieve maximum savings

Next Steps

- Calibrate model against empirical energy consumption values
- Rebound effects, behavioural shifts to be accounted for
- Who is retrofitting and what is prompting them (free riders)?
- Cost benefit analysis of retrofitting programme
- Incorporate within optimisation (least cost) scenarios - OSeMOSYS

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