THE ImpEE PROJECT

IMPROVING ENGINEERING EDUCATION

Domestic Energy Use and Sustainability

The Cambridge-MIT Institute

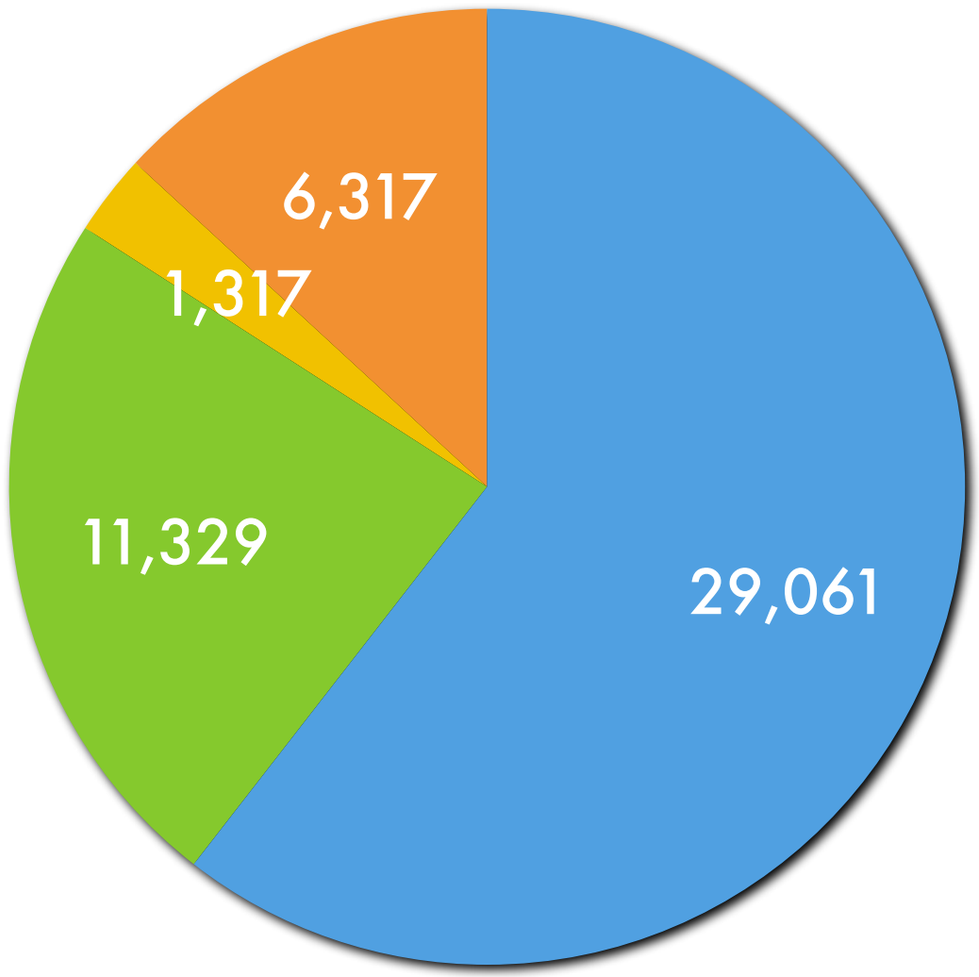
UNIVERSITY OF CAMBRIDGE

Energy Consumption Units

ToE = Ton of oil equivalent

- 1 ToE = 42 GJ = 11 630 kWhr
- 1 ToE = 32 full (4.5l) car petrol tanks
- 43 kToE = annual production of a medium (60MW) gas plant
- 3 mToE = annual consumption of a fluorescent light bulb

Total UK Domestic Energy Consumption

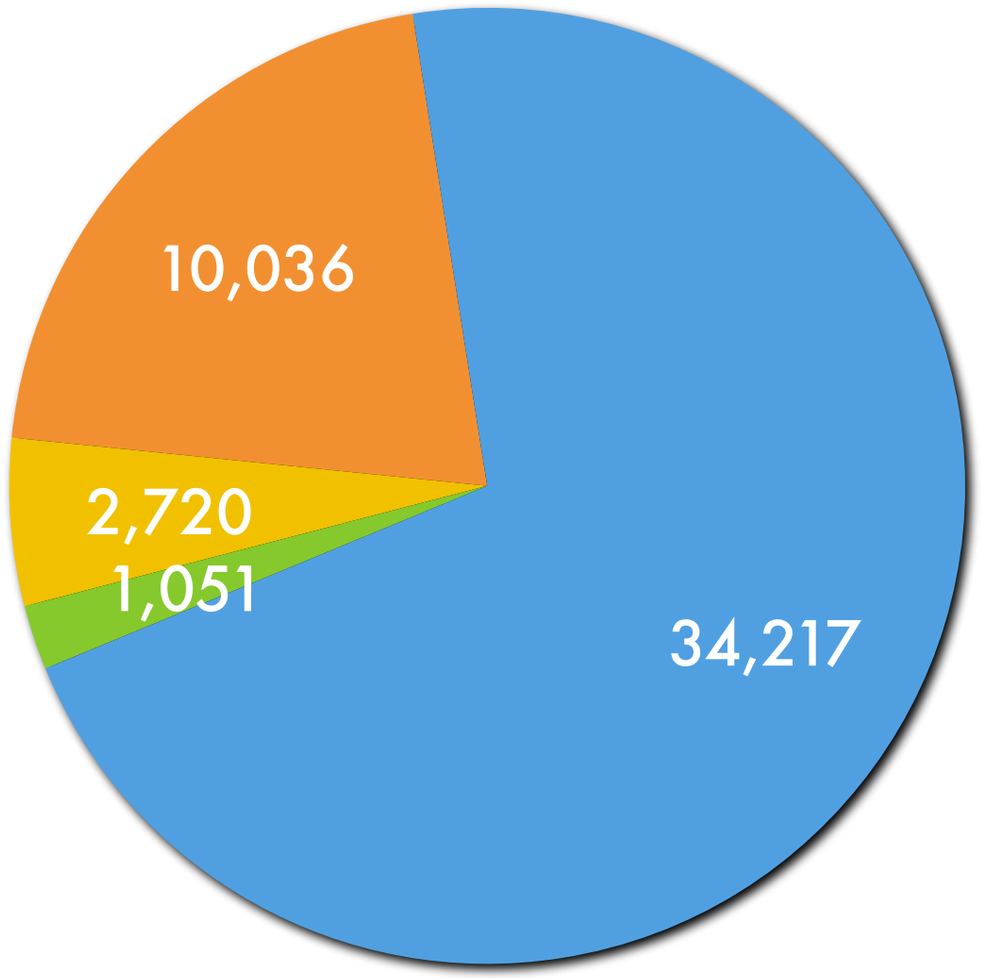


Total Energy Consumption by End Use (2003), in kToE

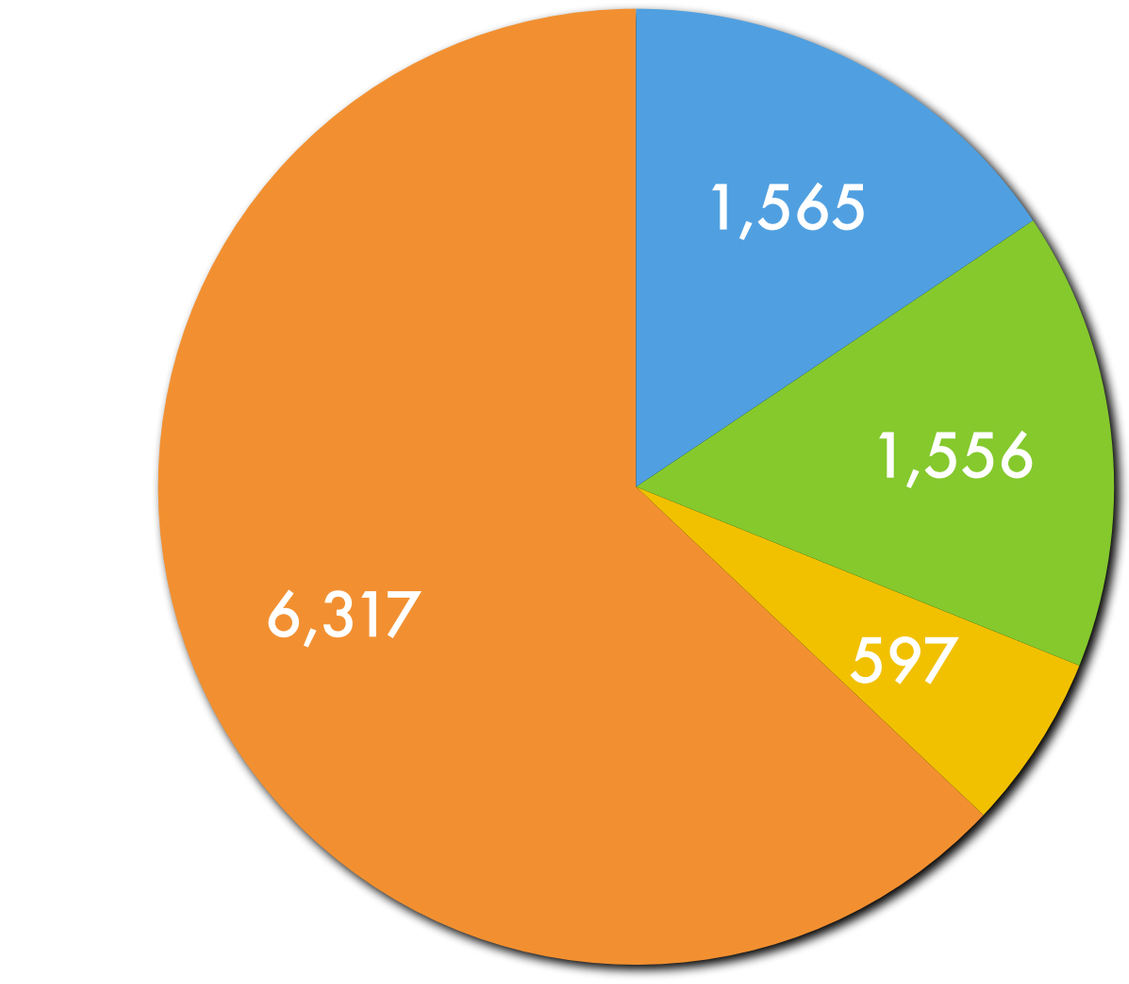
Space Heating
Water
Cooking
Lighting & Appliances

Proportions of UK Domestic Fuels

Proportions of Fuel Use (2003), in kToE

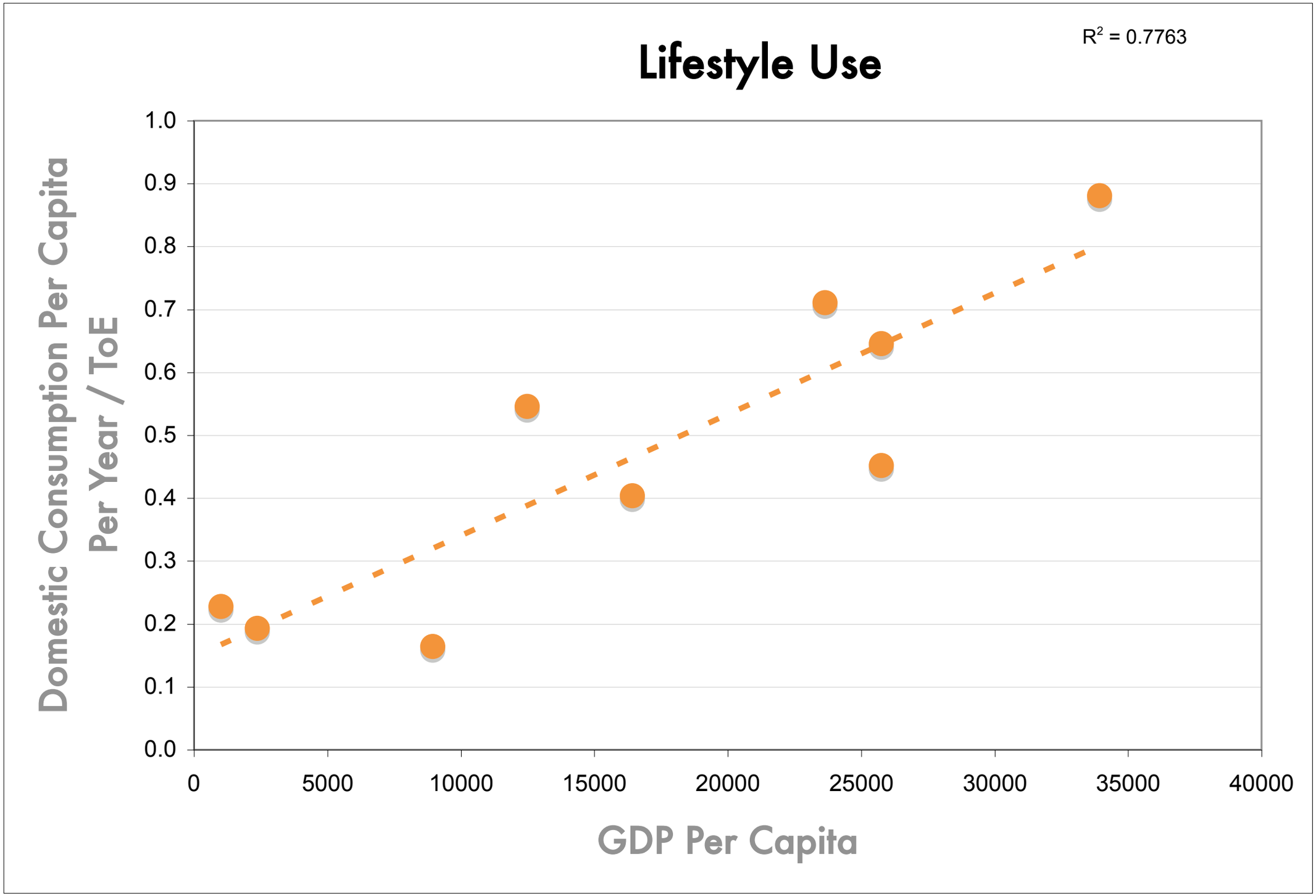


Total UK Domestic Electricity Consumption



Electricity Consumption by End Use (2003), in kToE

Lifestyle Use



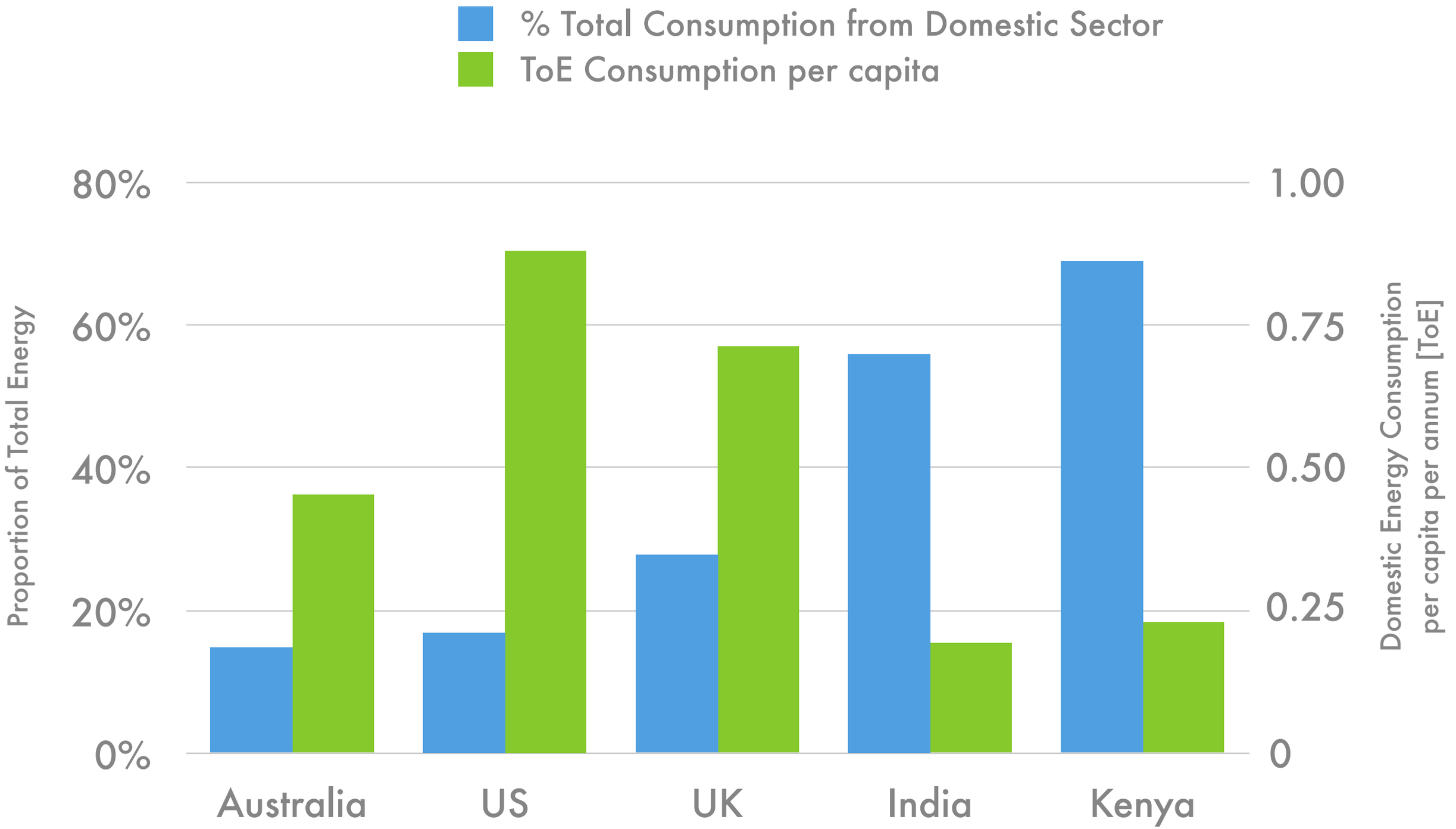
Domestic Sustainability

	Total Energy Consumption / kToE	Domestic Energy Consumption / kToE	Population	Domestic Energy Consumption per capita / ToE
World	7 585 443	2 085 997	5 992 485 000	0.348
Australia	107 930	8 828	18 948 000	0.466
China	1 088 349	289 489	1 264 764 000	0.229
India	480 418	200 781	1 000 161 000	0.201
Kenya	14 690	7 283	29 991 000	0.243
UK	230 324	42 424	58 494 000	0.725
USA	2 269 985	254 209	281 975 000	0.902

Domestic Sustainability

- 750 billion tonnes carbon dioxide in the atmosphere
- If a billion people – e.g. in developing China and India – adopt Western lifestyles, an extra 500 MToE/yr will be consumed.
- Using existing coal, oil, electricity and gas sources, this corresponds to 1.43 billion extra tonnes carbon dioxide released – just from the domestic sector!
- MUST tackle domestic energy issues before power-hungry technology and inefficient building and heating become available and are implemented worldwide

Domestic Sectors Worldwide



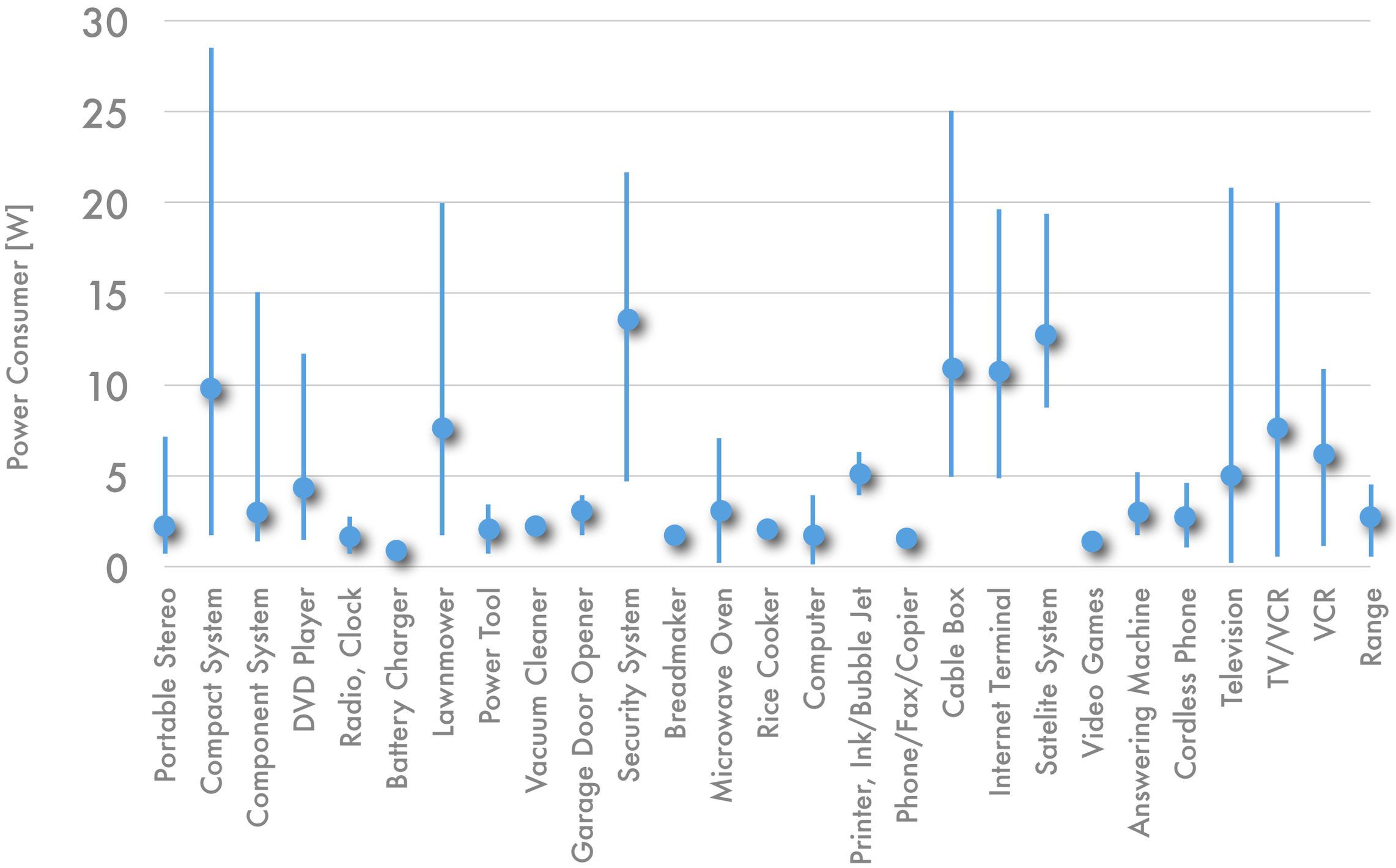
Example 1: ZED Housing

- BedZED, a development of around 100 apartments in south London which emits no net carbon.
- A bottom-up approach to the problem of domestic energy consumption
- Design which maximises solar gain - the urban block is shaped to allow direct solar radiation in any season
- Thermal mass for internal heat retention in winter and external heat exclusion in summer.
- Passive ventilation with outgoing heat capture.
- Use of photovoltaic cells to generate zero emission power.
- A distributed heating system fired by carbon-neutral biomass (landscaping waste).
- Designed as a complete system, so all elements contributed to the zero emission performance.

Standby Power Wastage

- Also known as “vampire power”… arises from “always-on” components like clock displays, memory, remote sensing etc.
- Power converters, e.g. phone chargers, employ transformers that consume energy even when not charging.
- Inefficient technology like linear converters often couple with e.g. remote control sensing to increase impact.
- Entertainment and security appliances are particularly strong vampires.

Standby Power Usage



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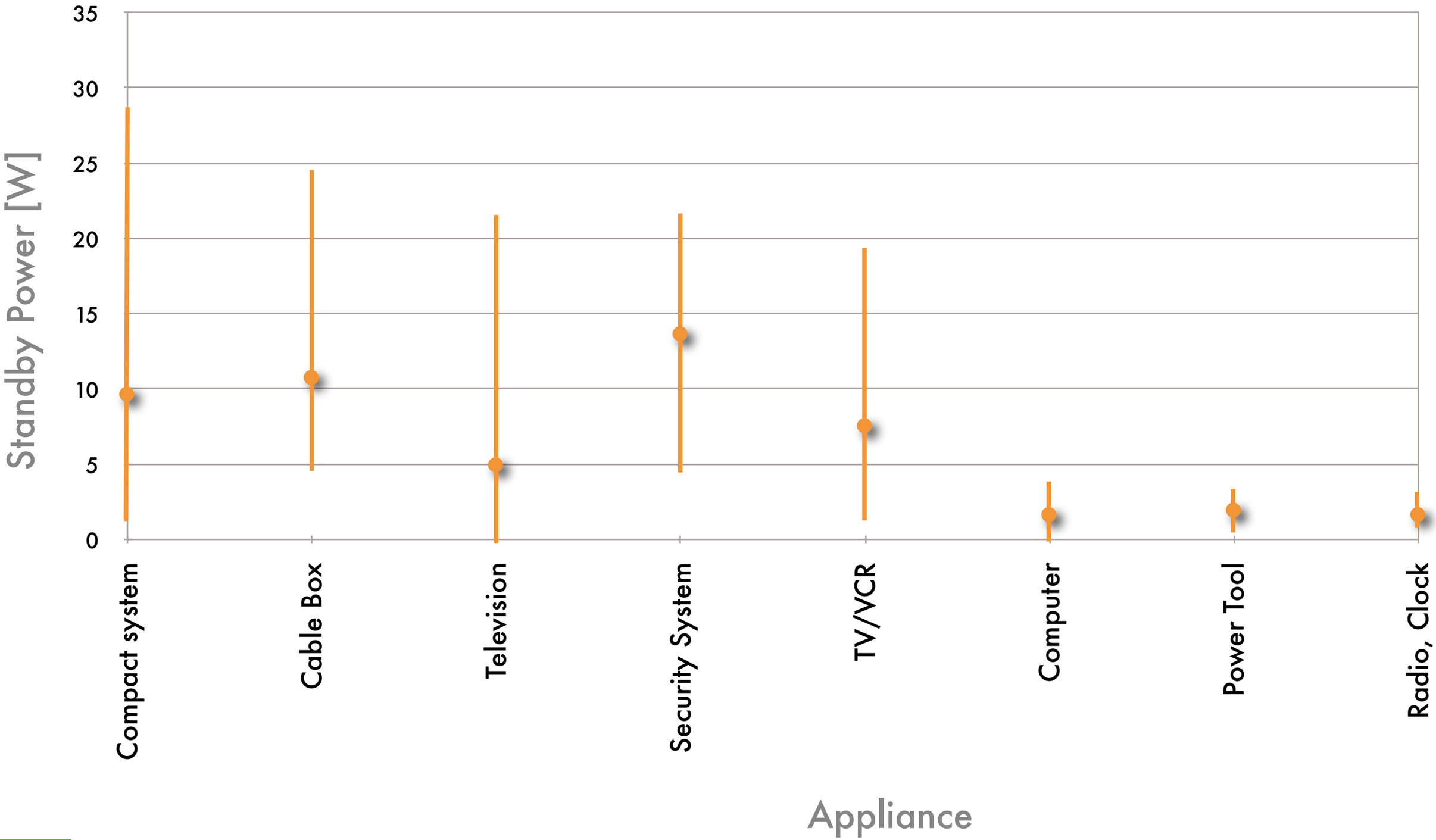
Selected Standby Power Data



Case Study: Set-Top Vampire

- Standby power wastage or "vampire power" causes a significant impact on the environment from the domestic sector

- Average passive standby consumption of a digital set-top box is 7.5W, with highs of over 20W – active standby even higher.
- If this mode is used 70% of the time… 5000 hrs/yr…38 kWh are used annually.
- Corresponds to 25kg CO_2… just to avoid flicking the switch.
- …enough to fill the living room with the GHG.

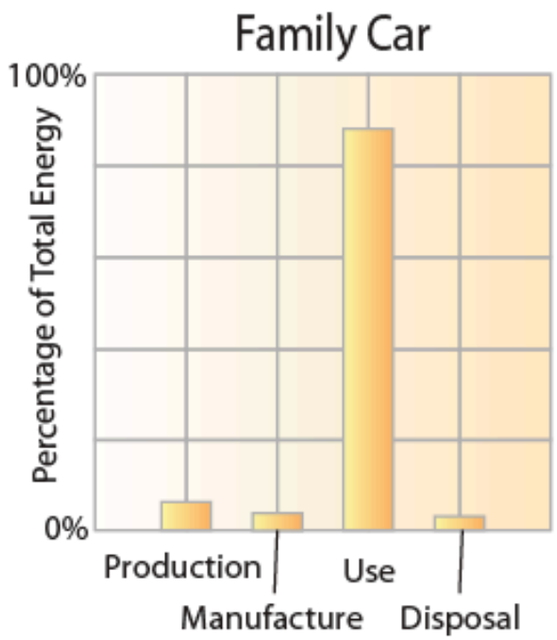
Appliance Efficiency

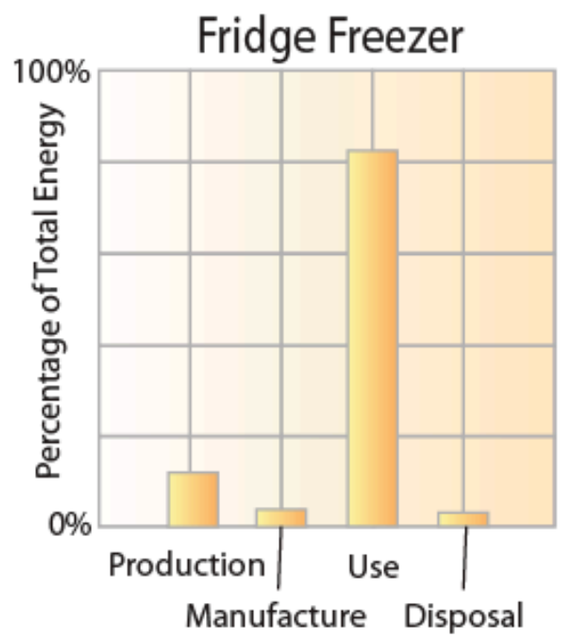
- Legislation and rating systems have made appliances like refrigerators much greener in the last decade
- BUT the lifetime of an appliance is > 10 years: inefficient appliances are still abundant
- And CHEAPER to buy second-hand

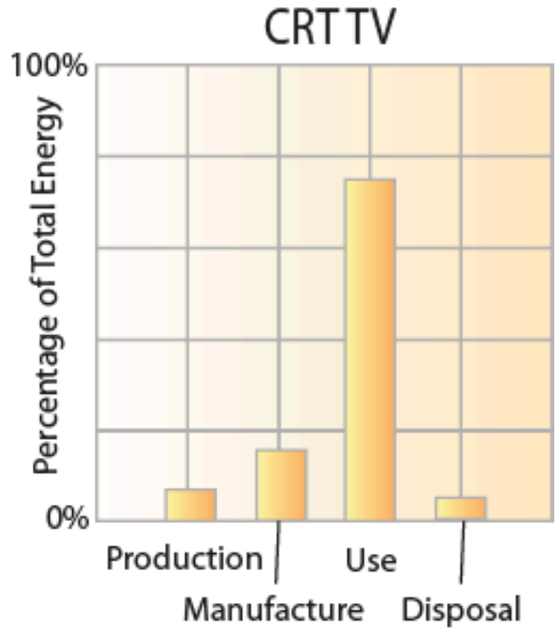
Case Study: Lighting The Domestic Sector

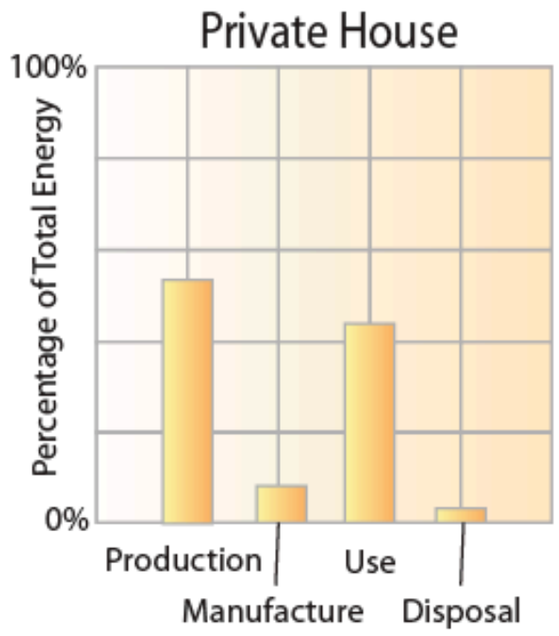
Bulb Type	100W Incandescent	23W Fluorescent	8W LED
Purchase Price	£0.45	£3.99	£5.95
Bulb Lifetime	750 hours	10 000 hours	50 000 hours
Hours on per day	4	4	4
Number of bulbs	~ 6 over 3 years	1 over ~ 7 years	1 over ~ 34 years
Total cost of bulbs	£2.70	£3.99	£5.95
Lumens Produced	1 690	1 500	120
Cost of Electricity	£13.14	£3.02	£1.05
Total cost over 3 yrs	£15.84	£7.01	£7.00

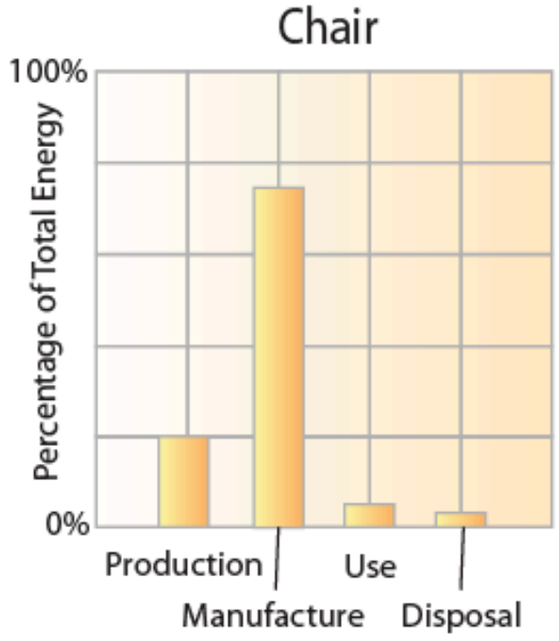
Energy Consumption of Products









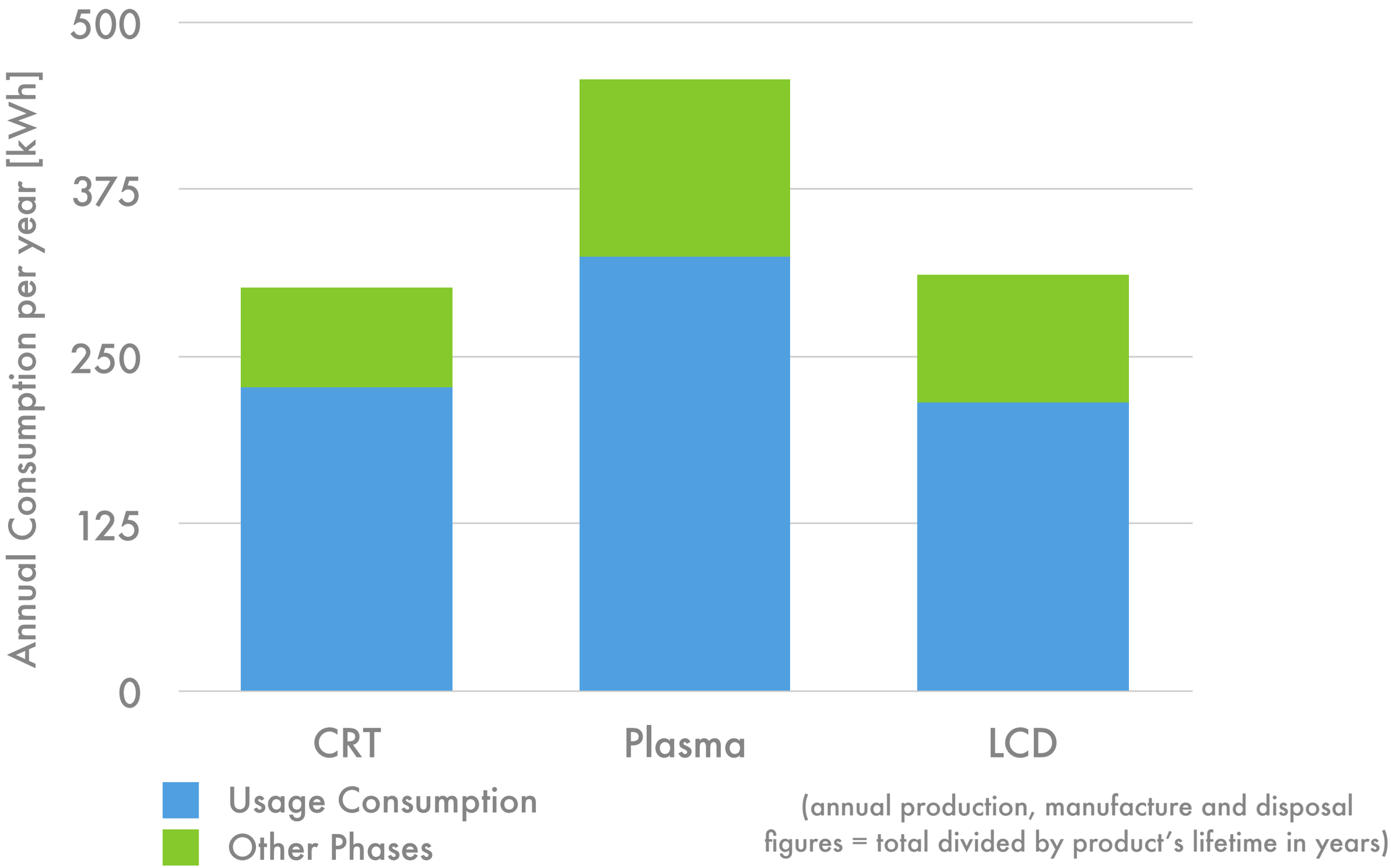


Case Study: Televisions

- LCD displays consume less power than CRTs and are generally regarded as the "greener" option.
- BUT construction of an LCD screen and set require a significant release of greenhouse gases…320 kg compared to 220 kg for a CRT…which forms a significant proportion of the overall appliance lifespan emission (~30%).
- Plasma screens are even worse: 430kg, and less efficient in the Use life phase than a CRT
- Also, although LCD screens are more efficient in the Use phase, they are considerably larger… very similar power consumption figures.

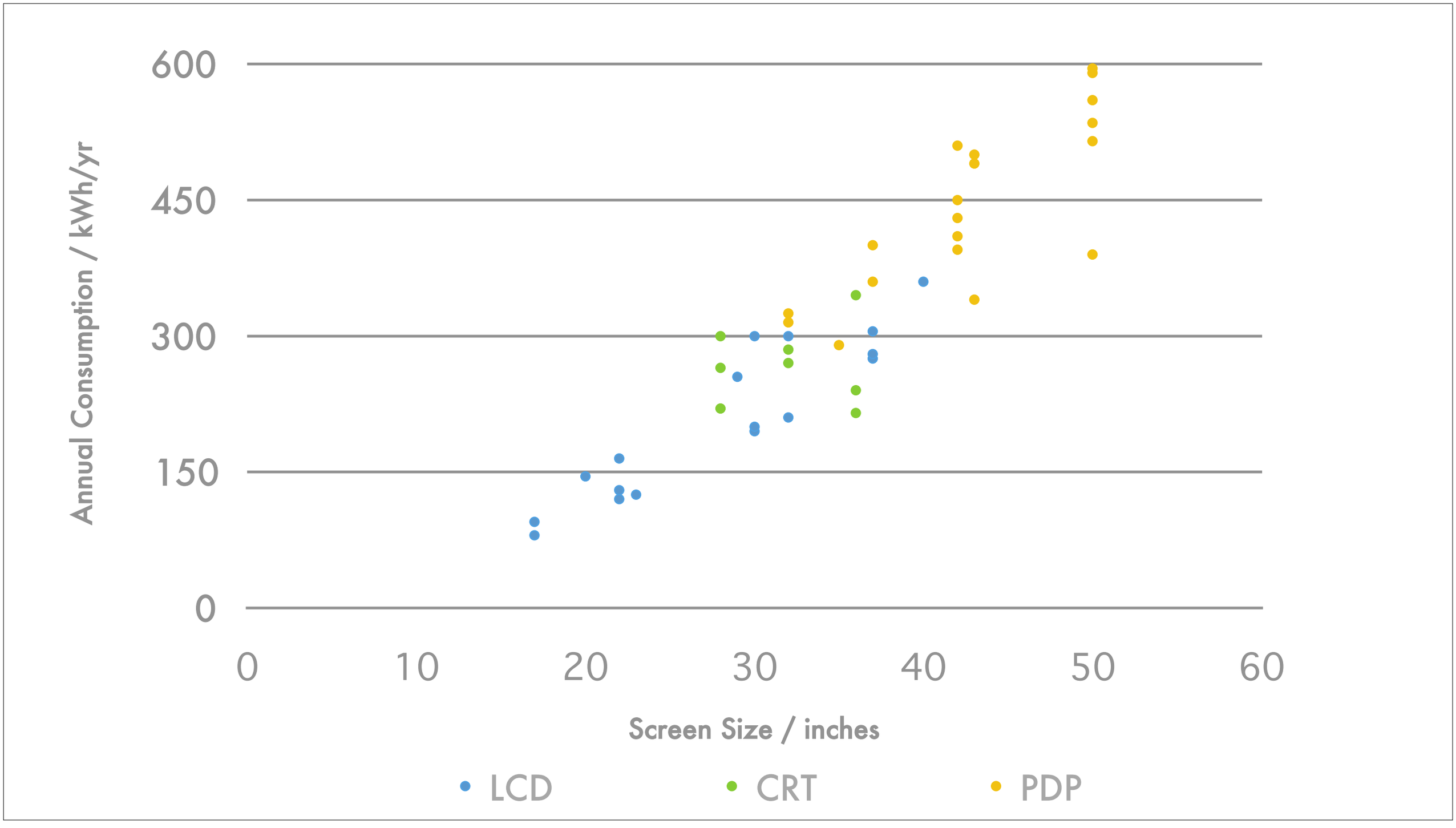
Television Consumption

All TVs 32-inch screen size.



(annual production, manufacture and disposal figures = total divided by product's lifetime in years)

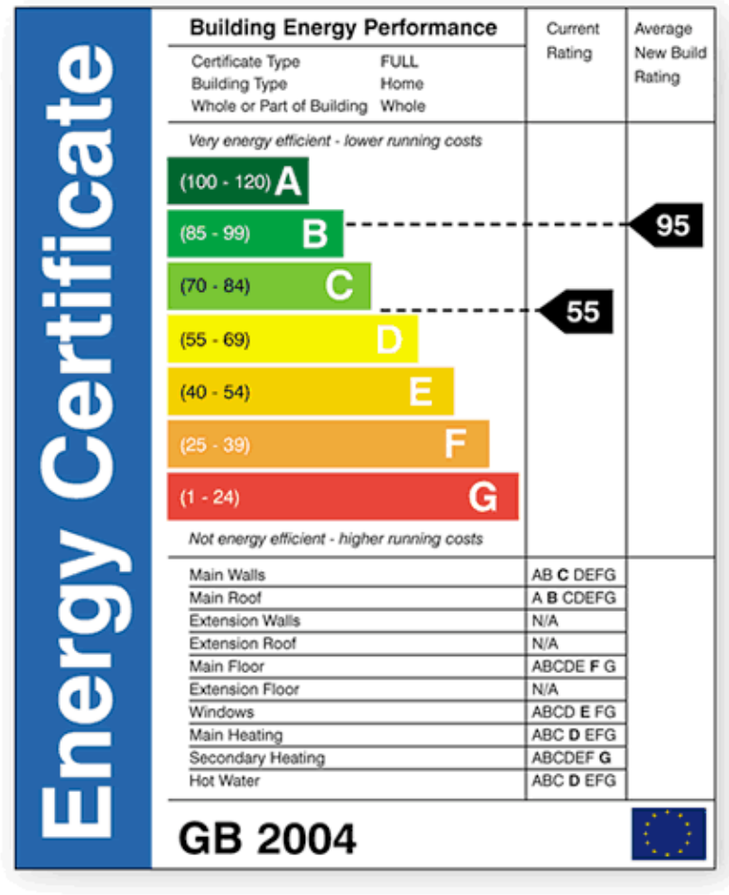
Television Consumption by Size



Legislation

Since 2000, all businesses pay Climate Change Levy.
Current rates (Spring 2004) are:

- 0.43p/kWh for electricity
- 0.15p/kWh for gas
- 1.17 p/kilogram for coal
- 0.96 p/kilogram for LPG
  similar arrangement for residential sector?
- Now environmentally sound solutions are economically encouraged…
- But legislation may not always work for the best…



Source - Energy Efficiency: The Government's Plan for Action 2004

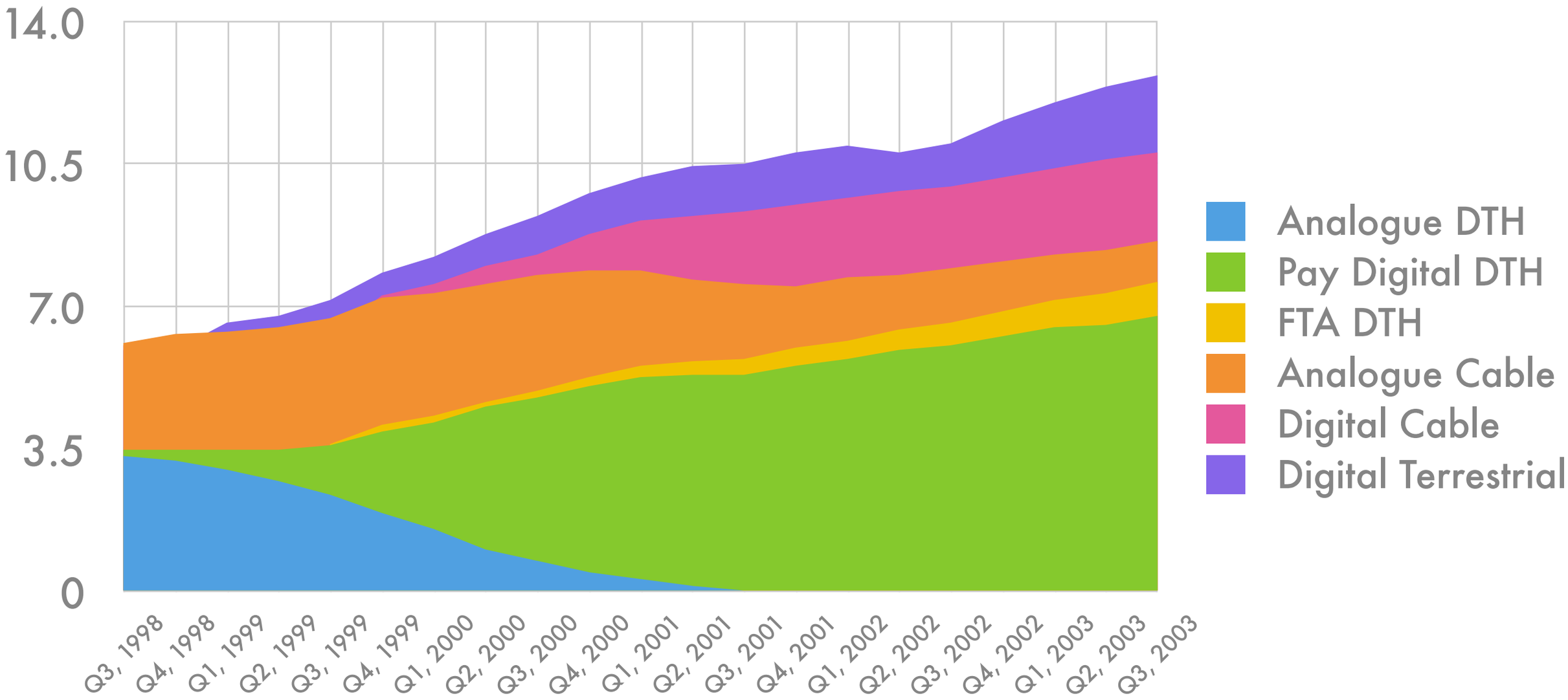
Example 2: Non-linear Switching

- Linear low-dropout regulators (LDOs) frequently used in electronics
- Efficiency > 85% for e.g. 3.3V audio power amp supply from 3.6V single cell Li battery
- Efficiency < 25% when generating a sub-1V processor core voltage: energy dissipated as heat
- Non-linear switching involves using switch-mode dc/dc converters that exhibit high conversion efficiency.
- Recent advances in IC process and packaging technology now allow integration of dc/dc controllers with FETs into small chip-sized packages.
- Increased switching frequencies drive down inductor size and cost, a key factor for small price-sensitive applications.

Digital Broadcasting

- Digital set-top boxes are large consumers of both standby and active power.
- Combined with larger, higher-tech TVs, digital penetration has large electricity consumption implications.
- The UK has a greater percentage of digital households than another country - 53% (more than 13 million) of UK households.

Digital Penetration



- Compare 5W Standby power for a non-multichannel TV to 15W for digital TV and set-top box
- 6 million more households is 60MW more standby power
- This is equivalent to a medium gas power plant

Perspective

- The USA uses standby power equivalent to 26 power plant's outputs.
- $1 million were spent in the US keeping "Exit" lights turned on last year.
- The UK uses enough standby power to power 400 000 homes.
- Tumble-dryers can use 38% of their power waiting at the end of a cycle.
- Turning lights off when not in use would save 375 000 tons CO_2 or £55m costs.

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