

**Long Run Energy Use  
and Prices in the UK**

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# Introduction

- While each country's energy experience is unique
- Example of UK's long energy & environmental histories
- Helps understand
  - Scale & limits of energy's contributions to socio-economic development
  - Path dependency & 'lock-in' of fuels, technologies & institutions
  - Impacts on resource depletion & environmental quality
  - Need for policies for 'sustainable innovation' and better mixes of policy instruments
- "A lantern on the stern can help with navigation ahead."

## UK Experiences and Challenges

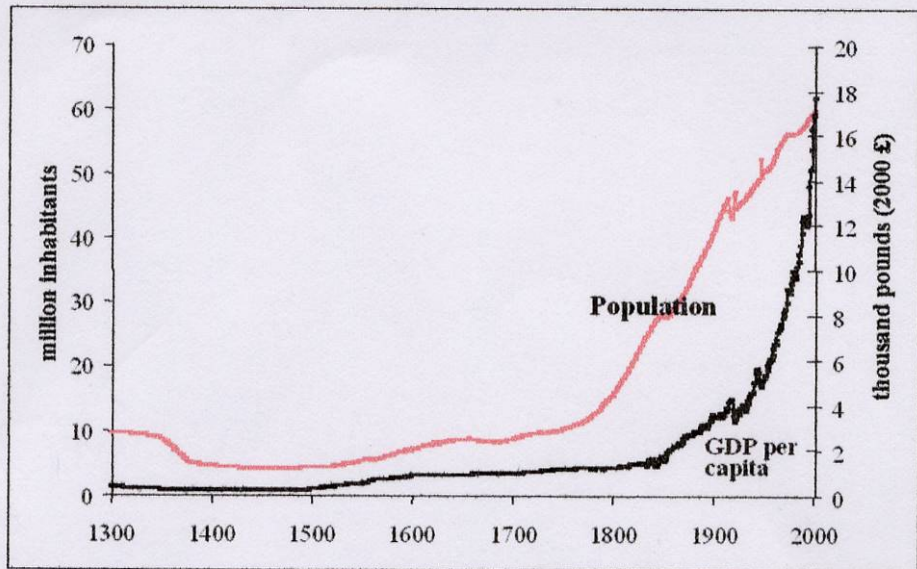
- UK's fossil energy resources freed it from limits of an agricultural economy
- Affordability/quality of energy *services* enhanced by modern fuels & technologies (light example)
- But environmental issues not seriously addressed until C20
- Today's challenges for the UK
  - Continuing access to affordable, secure, diverse energy services
  - And limiting damage to local, regional & global environments
- Policies & instruments for sustainable innovation?

## Energy and the UK's 'Industrial Revolution'

- 16<sup>th</sup>-19 century
  - UK moved from traditional agricultural economy
  - Bounded by productivity of scarce land resource, and
  - Limited **flows** of energy for food, clothing, housing & **fuel**
  - To a new regime
- Where growth and living standards transformed:
  - By exploiting **stock** of mineral (coal)
  - And **innovation**, steam engine, converting heat to mechanical energy
- With other innovations, drove mechanisation & urbanisation that led to the 'industrial revolution'

**Figure 1. Population and real Gross Domestic Product per capita  
United Kingdom (at year 2000 prices), 1300 -2000**

**in the**



Source: Snooks (1994) and others; see Fouquet and Pearson (1998) for details



Fig. 2: UK final energy consumption 1500-1800 (TWh)

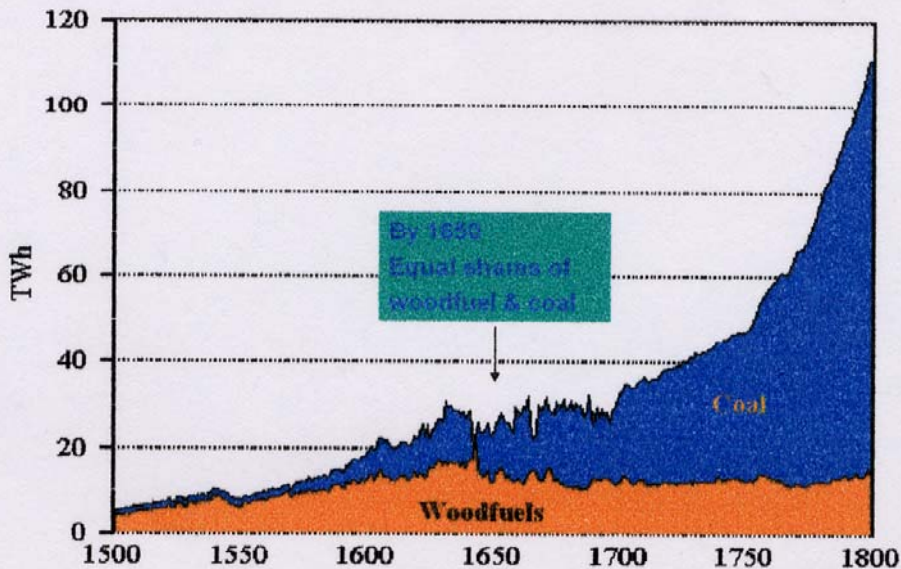


Fig. 3: UK final energy consumption, 1800-2000 (TWh)

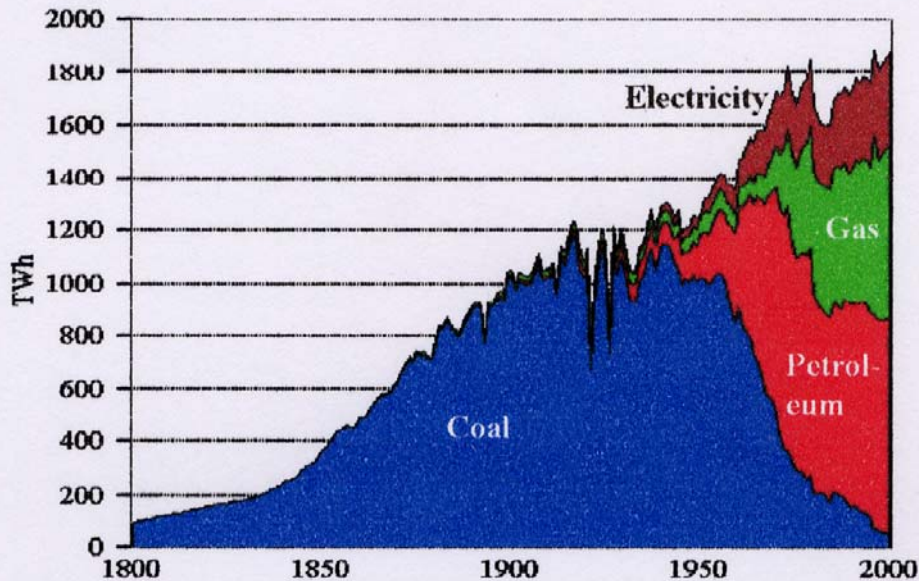
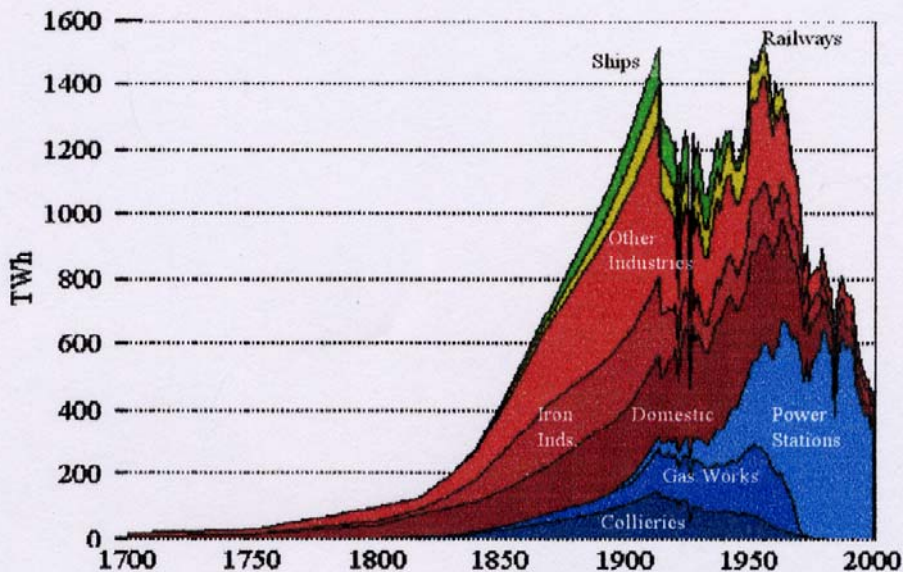


Fig. 4: Coal consumption by economic sectors, 1800-2000 (TWh)





## Long-run perspectives (1)

- But diffusion of new technologies took time in UK
  - E.g. major economic growth effects of stationary steam engines & then steam locomotives only after 1850
  - Although steam pumps in coal mines from 1720s
  - And electric light also slow to dominate
- And complex interactions of fuels, technologies, infrastructures, institutions & financing mechanisms underlie long-run energy transitions
- So we are dealing with *evolving* complex systems
- And it is not wise to limit our focus only to fuels & technologies

Fig. 5: UK energy intensity - final use energy consumption per unit real GDP, 1500-2000



Fig. 6: UK average real 'energy' price series, 1500-2000

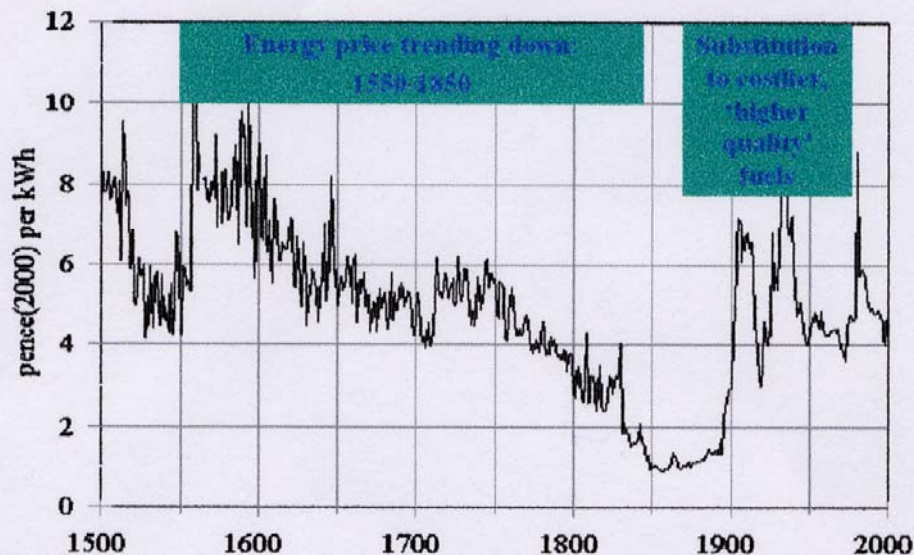
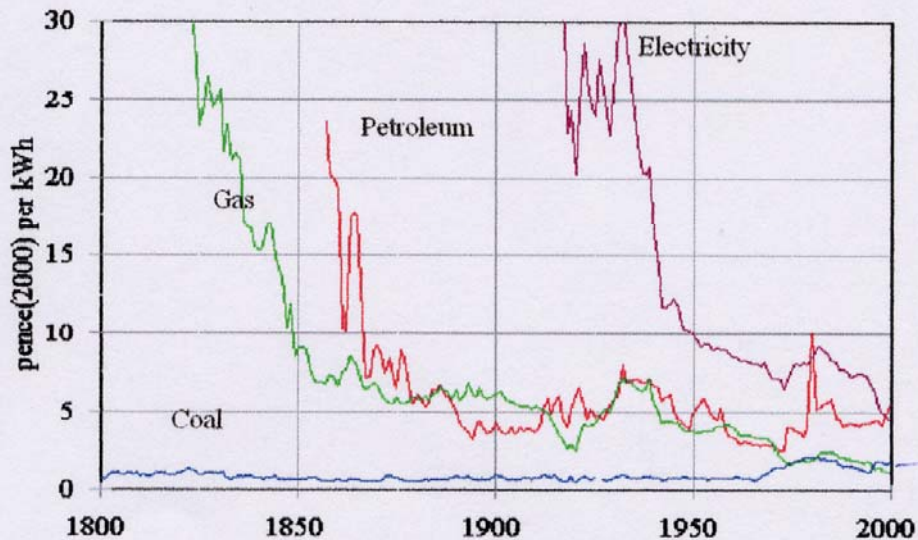


Fig. 7: Real consumer fuel prices, 1800-2000 (p/kWh)

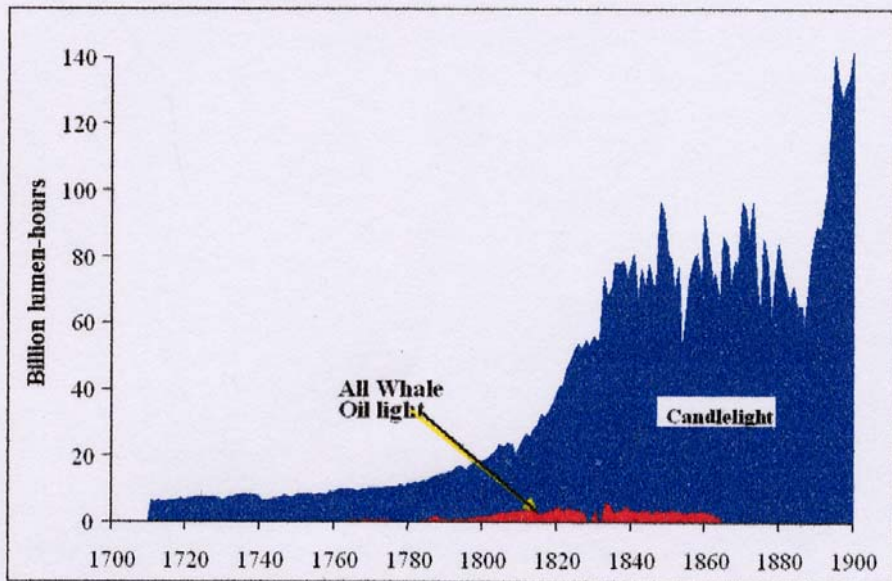


## Energy services: UK lighting experience

- Energy access gives benefits through *energy services*
  - E.g. *illumination*, transportation, cooked meals, refrigeration, comfortable temperatures
- Evidence of extraordinary potential of technological & institutional change
  - to reduce costs & enhance quality of energy services
  - and raise economic welfare
- Example of UK lighting services(1800-2000)
  - Innovation in fuels & technologies, improved infrastructures, mass production & rising incomes
  - Led to lower cost of illumination & revolutions in light use



**Figure 8. Consumption of Lighting from Tallow Candles and Whale Oil in the United Kingdom (in billion lumen -hours), 1711 -1900**

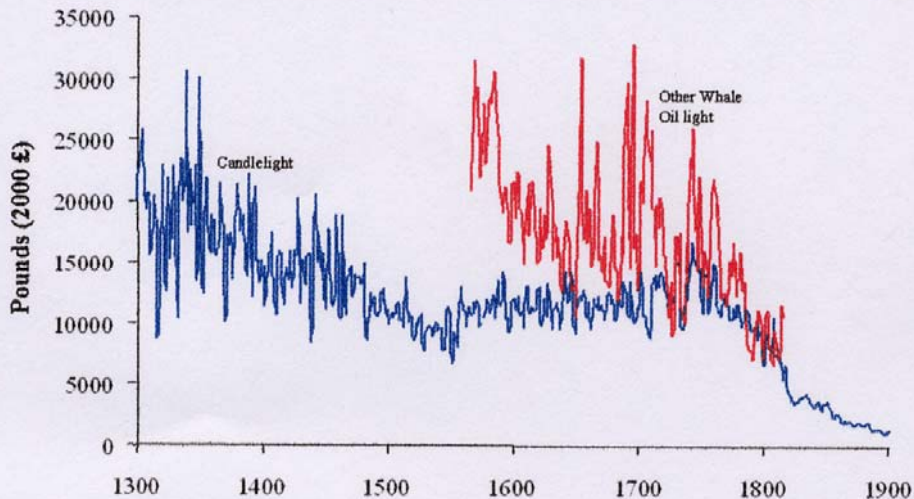


Source: authors' own estimates – see Sections II.2.1 -2 and II.3

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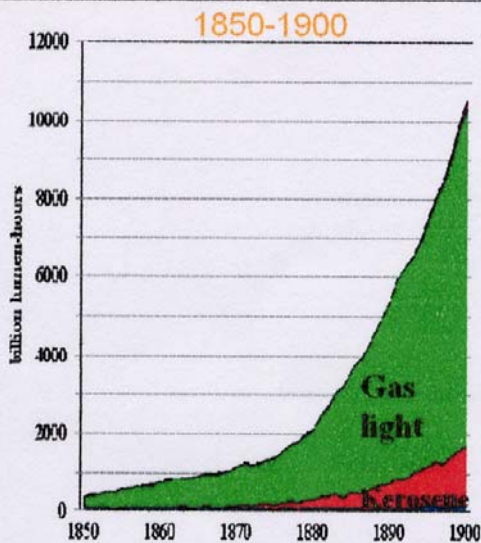
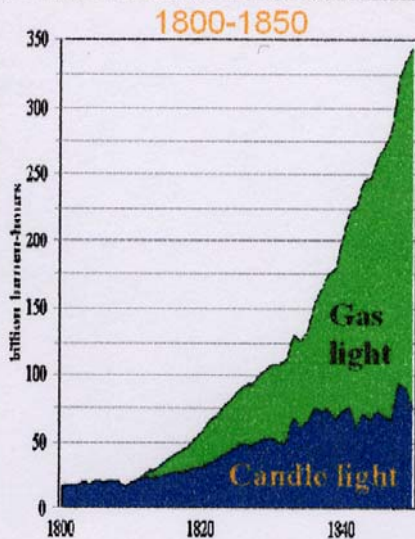
Billion:  $10^9$  (i.e. one thousand million)

**Figure 9. The Price of Lighting from Tallow Candles and Whale Oil in the United Kingdom (per million lumen -hours), 1300 -1900**



Source: authors' own estimates -- see Sections II.1.1 -2 and II.3

Fig. 10. UK Consumption of Gas, Kerosene & Candle Light, 1800-1900 (billion lumen-hours)

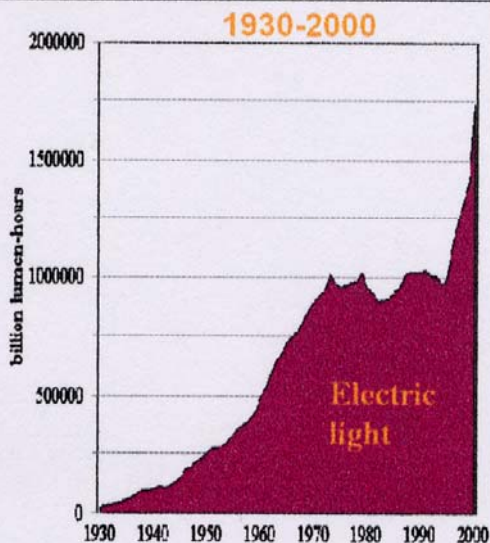
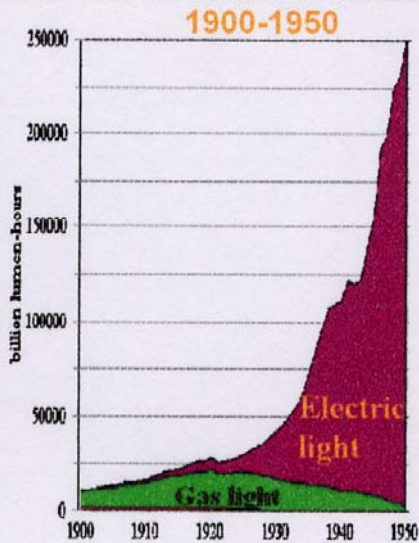


**Table 1. Street Lighting in London (1599-1809)**

|                                | <i><b>Pre-<br/>1599</b></i> | <i><b>1599-<br/>1662</b></i> | <i><b>1662-<br/>1694</b></i> | <i><b>1694-<br/>1736</b></i> | <i><b>By<br/>1736</b></i> | <i><b>By<br/>1750</b></i> | <i><b>By<br/>1809</b></i> |
|--------------------------------|-----------------------------|------------------------------|------------------------------|------------------------------|---------------------------|---------------------------|---------------------------|
| <i><b>Hours/<br/>year</b></i>  | <b>189</b>                  | <b>303</b>                   | <b>351</b>                   | <b>750</b>                   | <b>4,000</b>              | <b>4,000</b>              | <b>4,000</b>              |
| <i><b>No. of<br/>lamps</b></i> |                             |                              |                              | <b>1,000</b>                 | <b>4,800</b>              | <b>15,000</b>             | <b>35,000</b>             |

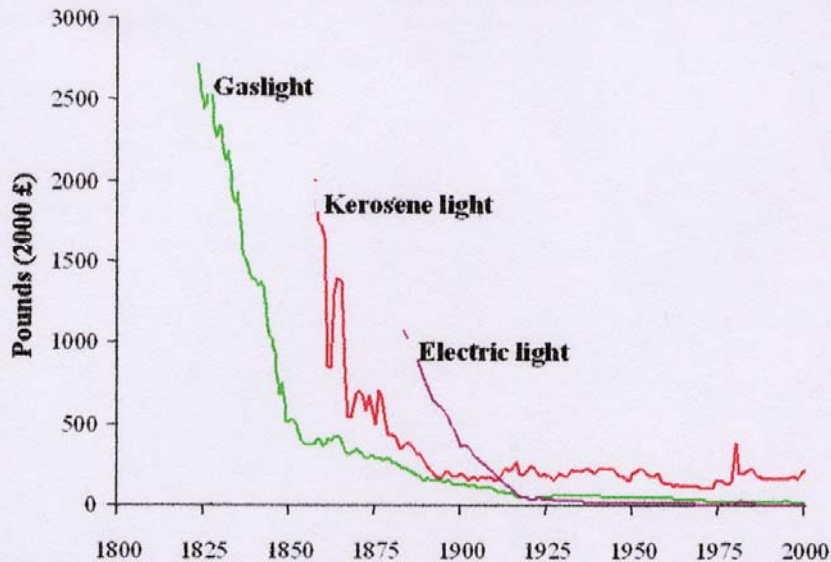
**Source:** Falkus (1976 p.261)

Fig. 11. UK Consumption of Kerosene, Gas and Electric Light 1900-2000 (billion lumen-hours)

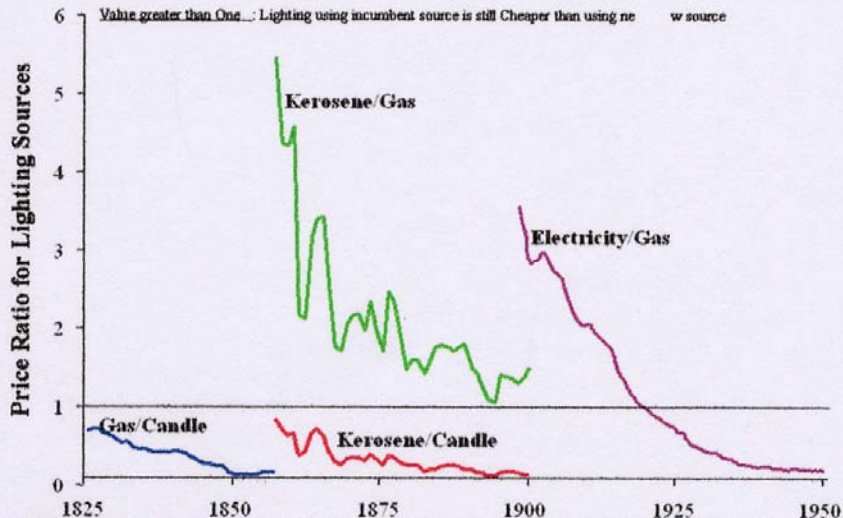




**Figure 12. Price of Lighting from Gas, Kerosene and Electricity in the United Kingdom (per million lumen -hours), 1800-2000 [In UK Pounds (year 2000 £)]**

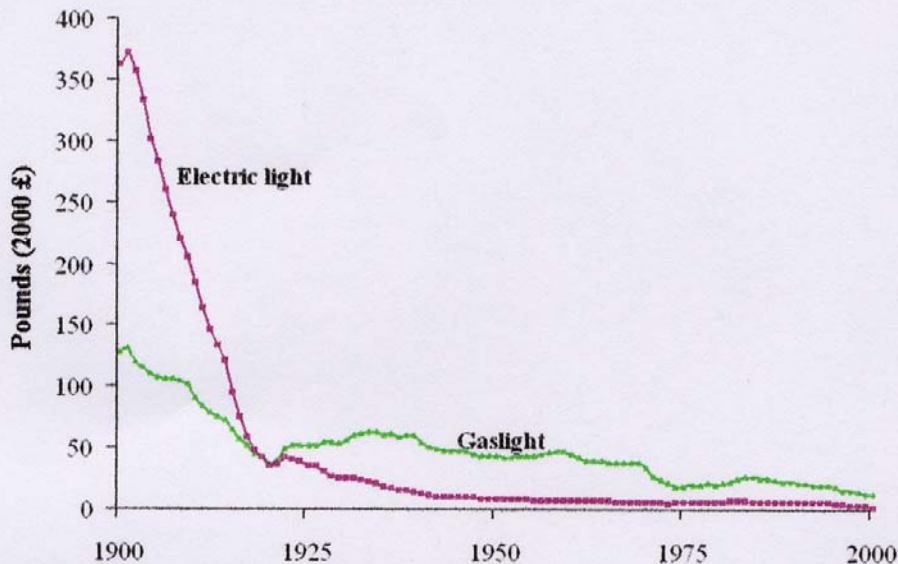


**Figure 13. Price Ratio of Lighting from Competing Energy Sources in the United Kingdom, 1820 -1950**



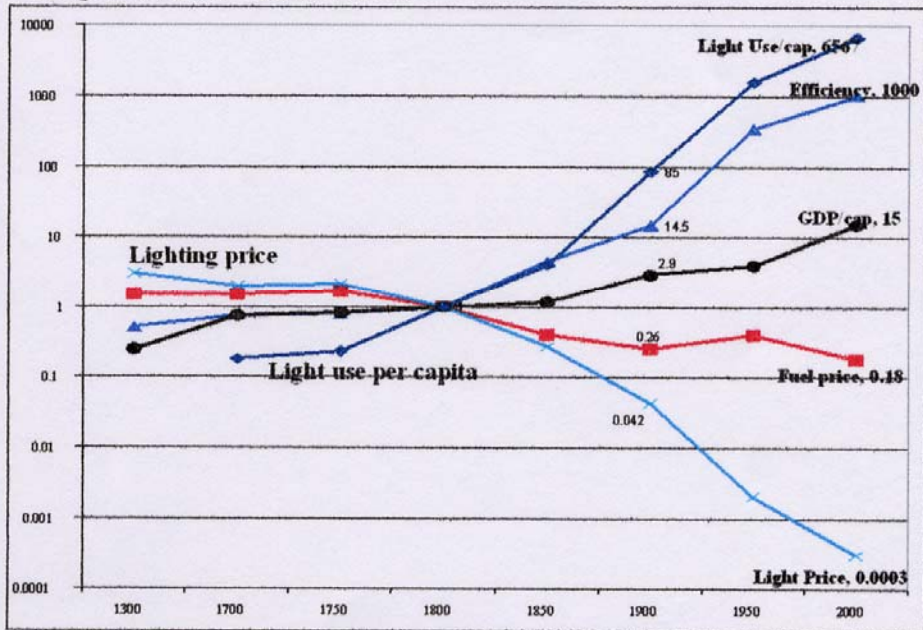
Source: authors' own estimates - see Sections II.1.1 -5 and II.3

**Figure 14. Price of Lighting from Gas and Electricity in the United Kingdom (per million lumen -hours), 1900 -2000**



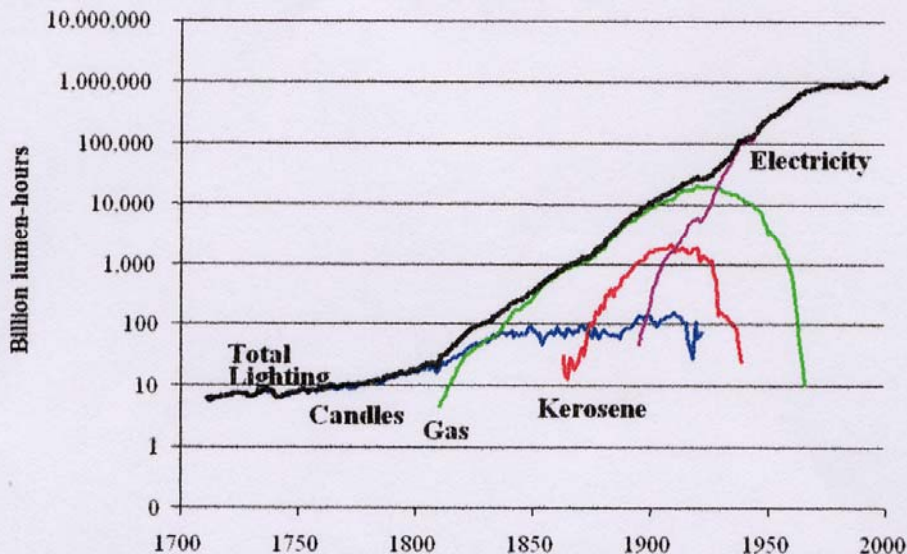
Source: authors' own estimates - see Sections II.1.4 -5 and II.3

**Figure 15. Indices of Key Lighting Variables in the United Kingdom  
(Log Scale, 1800 = 1), 1300-2000**



Source: authors' own estimates – see Section II

**Figure 16. Consumption of Lighting from Candles, Gas, Kerosene and Electricity in the United Kingdom (in billion lumen-hours – 1700-2000)**



Source: authors' own estimates – see Sections II.2 and II.3

Billion:  $10^9$  (i.e. one thousand million)



## Long Run Trends in UK Lighting Services (1300-2000)

- By 1800 lighting services cost 1/3rd of their 1300 value.
- By 1900 lighting services cost 1/25th of their 1800 value.
- By 2000 lighting services cost 1/33000<sup>th</sup> of their 1800 value
  
- GDP per capita has grown 15 times since 1800, i.e.
  - Three times (1800-1900), and
  - Five times (1900-2000)
  
- *Total* UK lighting use has risen 25,000 times since 1800
- *Per capita* lighting use has risen 6,600 times since 1800

## Welfare Gains & Gaps between Rich & Poor

- Falling costs, rising quality & higher consumption implies big long run welfare gains in the UK.
- Also means possible growing gaps between rich & poor people because of differential access to & ability to pay for modern fuels & end-use technologies.
- The poor pay more per unit of energy service because they can't afford the first costs of the efficient technologies.
- Writing about light in Africa, van der Plas (1994) observed: "The level of services many rural households 'enjoy' now is only barely distinguishable from that of medieval Europe."

## Environmental Issues: Air Pollution

- Growing 19th UK concerns
- But no serious action until 20th century
- London's long history of air pollution
  - 1952 'Great London Smog'
  - Estimated 3500-4000 premature deaths
- 1956 Clean Air Act
  - 'smokeless zones'
  - Power stations relocated
  - Later substitution to natural gas
- Concern over small particles and acid deposition
- And now greenhouse gases, especially CO<sub>2</sub>

## Today's UK Energy/Environment Challenges

- Maintain access to affordable, secure, diverse energy services, *and*
- Limit damage to local, regional & global environments
  - New challenge of greenhouse gases
    - transitions to lower carbon energy economy?
  - UK has set some difficult long-term CO<sub>2</sub> targets
    - UK & EU emissions trading schemes, Renewables Obligation, etc.
    - But crowded 'policy space'- need better 'mix' of instruments
  - Policies & instruments for 'Sustainable Innovation'?

## UK Energy/Environment Challenges (2)

- UK aspires to follow path to cut CO<sub>2</sub> emissions by 60% by 2050
  - A low carbon economy
  - While also achieving economic and social goals
- Requires radical transitions and systems level innovation
  - To meet end-user demands and energy and transportation services
- But we have had separate policy regimes for energy, innovation and sustainability issues



## Recommendations for sustainable innovation (SI) policy processes

- (1) Develop a Sustainable Innovation policy regime
  - *With clear, long-term sustainability goals*
  - *That brings together innovation, energy and environmental policy regimes*
- (2) Apply *systems thinking*
- (3) Advance *procedural and institutional* basis for policy delivery
- (4) Develop a more *coherent and integrated* mix of policy instruments to promote SI
- (5) Incorporate *policy learning and review*

## UK Experiences and Challenges: Summary

- UK's fossil energy resources freed it from limits of an agricultural economy
- Affordability/quality of energy *services* enhanced by modern fuels & technologies (light example)
- But environmental issues not seriously addressed until C20
- Today's challenges for the UK
- A Sustainable Innovation policy regime?

## Sources

- Fouquet, R and Pearson, PJG (1998). 'A Thousand Years of Energy Use in the United Kingdom', *The Energy Journal*, 19(4).
- Fouquet, R and Pearson, P.J.G. (2003). 'Long Run Trends in Energy Services: The Price and Use of Road and Rail Transport in the UK (1300-2000)', Proceedings of the BIEE Conference, St John's College Oxford, September (CD-ROM):  
<http://www.biee.org/downloads/conferences/HISLIG20.PDF>
- Fouquet, R and Pearson, P J G (2003). 'Five Centuries of Energy Prices', *World Economics*, 4(3): 93-119.
- Fouquet, R and Pearson, P J G (2006, forthcoming): 'Seven Centuries of Energy Services: The Price and Use of Light in the United Kingdom (1300-2000)', *The Energy Journal*, 27(2)
- Foxon, T.J., Pearson, P., Makuch, Z. and Mata, M. (2005), 'Transforming policy processes to promote sustainable innovation: some guiding principles', Report for policy-makers, March 2005, ISBN 1 903144 02 7, Imperial College London.  
[www.sustainabletechnologies.ac.uk/PDF/project%20reports/SI\\_policy\\_guidance\\_final\\_version.pdf](http://www.sustainabletechnologies.ac.uk/PDF/project%20reports/SI_policy_guidance_final_version.pdf)