Supplying Future Energy Needs: With and Without Fossil Fuels

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Partly based on a paper with David Ward

to be published by the World Economic Forum

Assuming billions of emerge from poverty

How much more Energy will be needed

to support them with food, water and other crucial services?

The global need will depend on

- future lifestyles
- how much demand for services that use energy can be moderated
- how much increased efficiency can reduce energy use

Whether the need can be met will depend on

- the future cost and availability of fossil fuels
- and of the alternatives

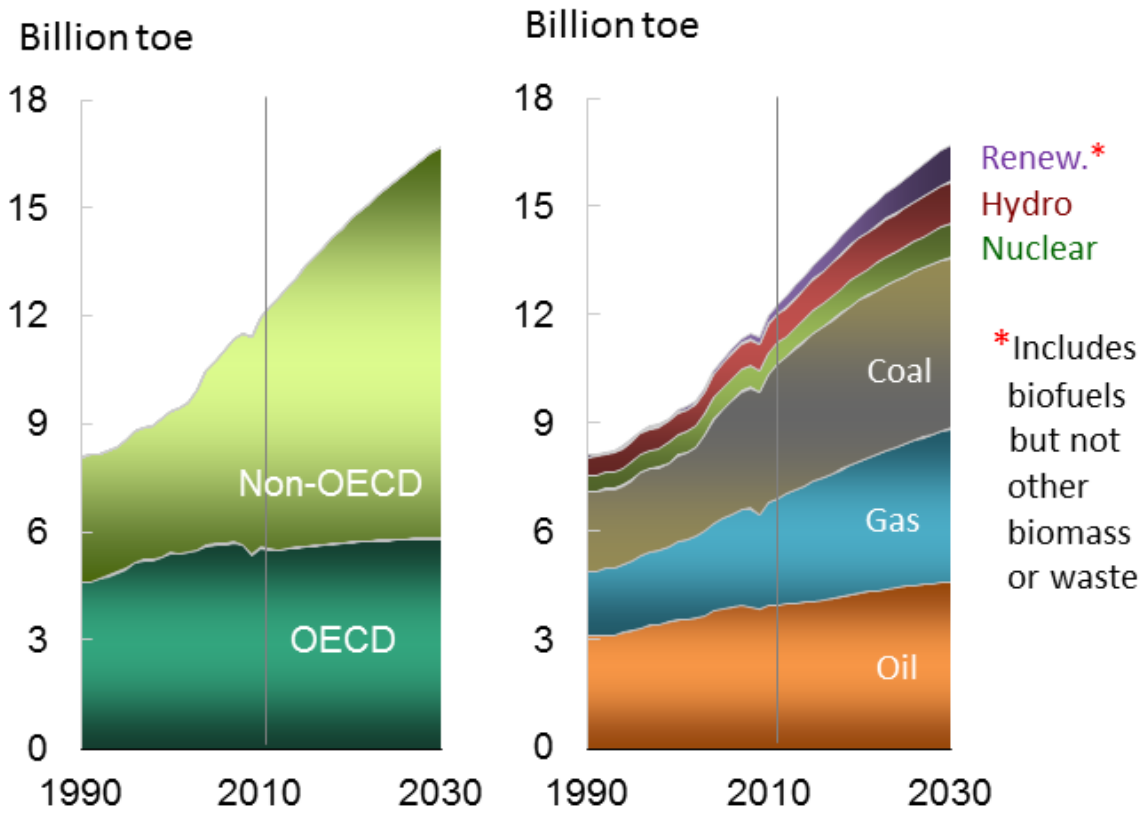
Crucial fact 1

The world is using a lot of energy at an average rate equivalent to that provided by burning 1.9 tonnes of oil (toe) a year for every man, woman and child on the planet, in a very uneven manner, e.g. per person

USA 7.0 toe, UK 3.0 toe, China 2.0 toe, Bangladesh 0.21 toe

Estimates of the differences of the energy embodied in manufactured imports and exports suggest that the annual per capita energy needed to support current lifestyles is around

USA 7.6 toe, UK 3.5 toe, China 1.6 toe



BP Past data + Projections

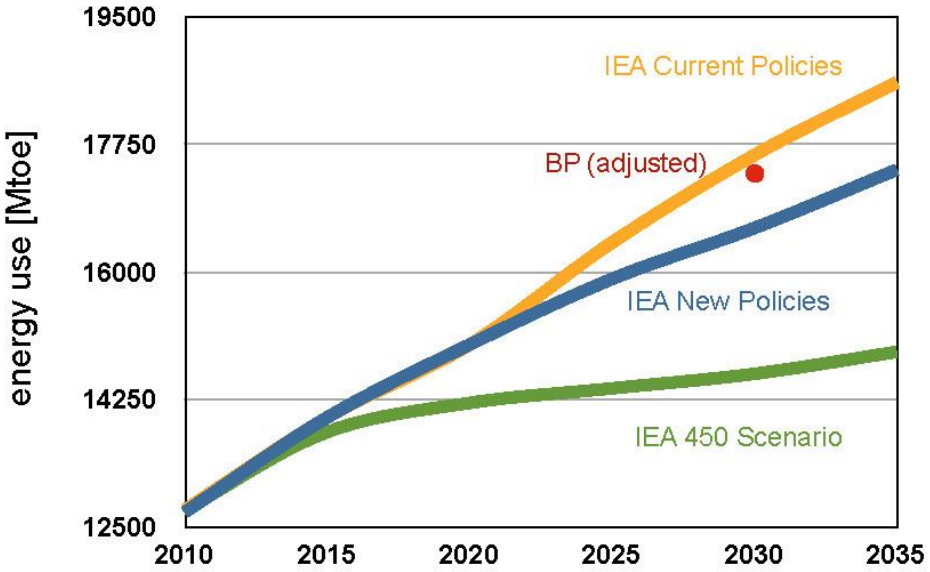
Based on "most likely" assessment of future policy trends. Not included: 10% from biomass *(apart from biofuels which contribute ~ 0.5%)* and waste

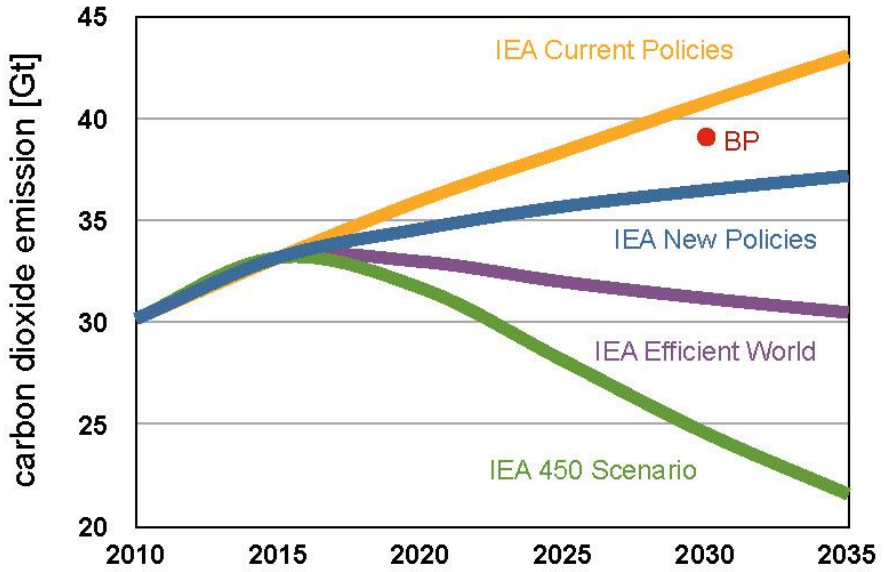
Crucial Fact 2 Energy use is growing rapidly: the growth is from Non-OECD countries and is expected to continue

Crucial Fact 3 Fossil fuels are set to continue to dominate

Crucial Fact 4 The contribution of renewables is expected to remain relatively small, despite rapid growth in percentage terms

Projections and Scenarios 1





BP projection based on "most likely" assessment of future policy trends

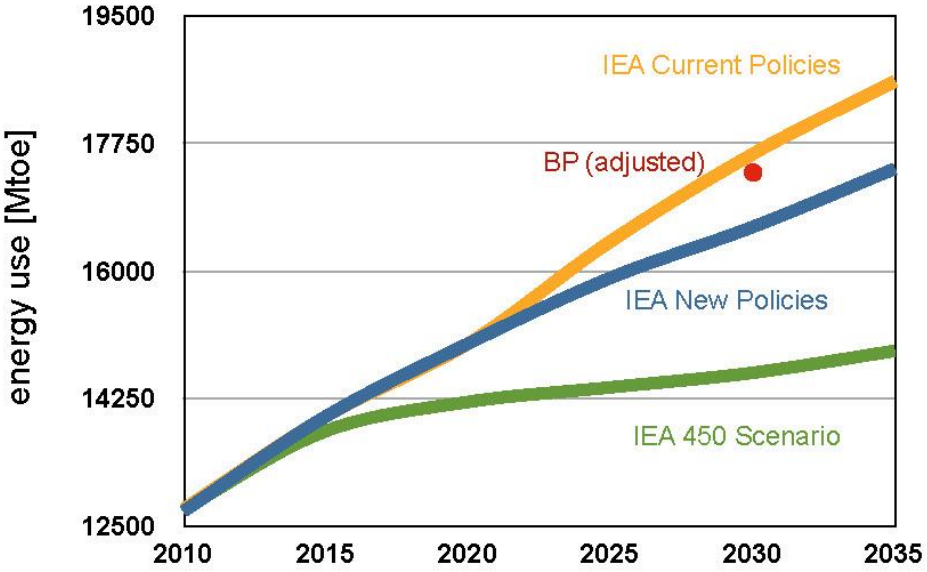
IEA Current Policies Scenario (CPS) - policies already enacted

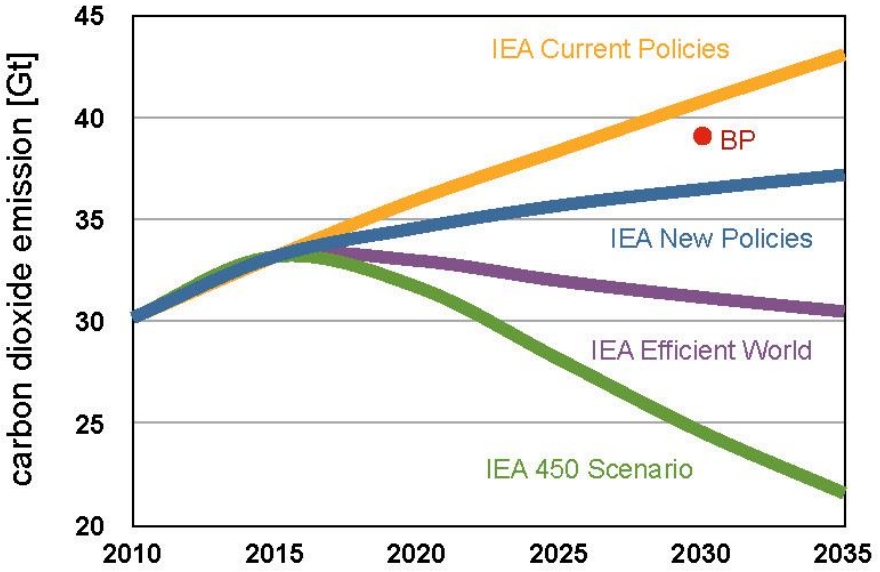
IEA New Polices Scenario (NPS) - assumes implementation of all agreed national policies and commitments designed to save energy and reduce use of fossil fuels

IEA 450 Scenario - keeps CO2 in the atmosphere below 450 ppm

IEA Efficient World Scenario (EWS) - NPS + all actions that would both reduce energy use and save money

Projections and Scenarios 2





- Consumption and emissions set to grow substantially in the NPS, despite assumptions
- Hard to imagine that BP's Outlook 2030 could be badly wrong (much of 2030 infrastructure in place or planned) - so energy consumption and carbon emissions set to grow much more than in NPS
- NPS and EWS very different → is it really possible to simultaneously save so much energy and money? If so why's it not happening?
- Looking in more detail, the differences in CO2 in different scenarios are largely determined by the different amounts of coal. Reducing use of coal (and emissions through CCS, if affordable) should be a priority – to mitigate climate change **and** reduce pollution

Whether future needs can be met depends on five factors:

1) The energy needed to support the lifestyles to which development will lead

- cannot be at the US level for all, which would require a four [five] fold increase in global energy use now [in 2050]

Need less energy intensive life styles, and/or demand must be lowered by means that do not compromise life styles, and energy used very much more efficiently

2) How much the demand for energy services can be reduced

e.g. by designing buildings to make good use of natural light, planning cities to encourage walking, bicycling or use of public transport: major opportunities in rapidly developing countries

Demand management is vital but is unlikely to mitigate rising demand very significantly

3) How much energy efficiency can be improved

Technically, large reductions (40% or more) look possible, but they are not happening

- Appraisal optimism and neglect of transaction costs
- Direct and (more importantly) indirect rebound effect
- No incentives for the affluent to make small savings, which collectively can be large, e.g. electric lighting – uses 20% of electricity
- Poor lack capital

Need regulation, cars, buildings, light-bulbs

Guess efficiency could save around 10%, beyond 1% p.a. drop in energy/gdp which is happening 'automatically'

4) Whether/how much the cost of fossil fuels will increase as demand rises and reserves are consumed

Saudi saying: "My father rode a camel. I drive a car. My son flies a plane. His son will ride a camel"

True? I think not

The sun may be setting on production of conventional oil in conventional places, **but**

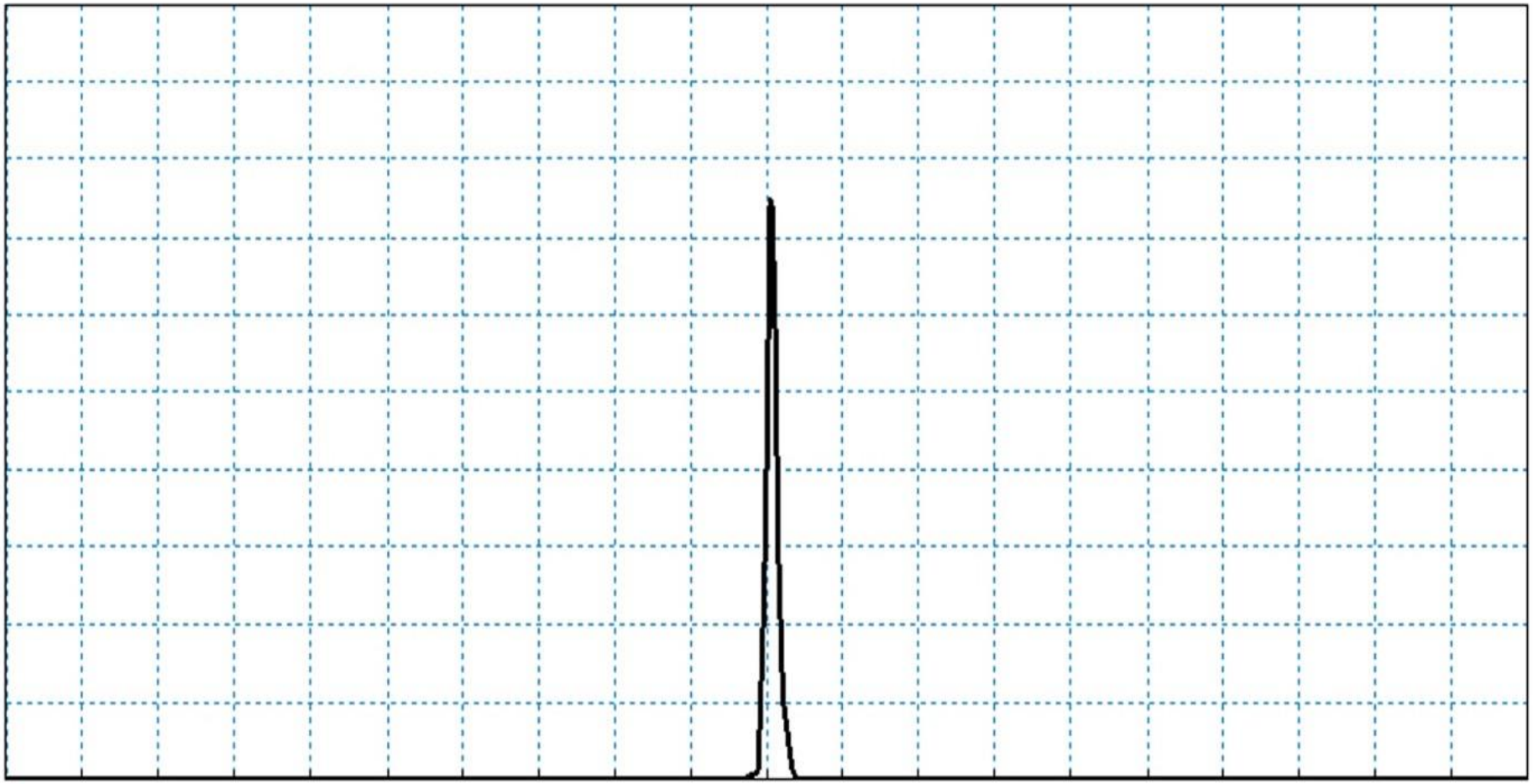
world awash with fossil fuels, much in forms (shale gas, tar sands,…) or places (under 2 km of water and 5 km of rock and sand off Brazil, the arctic,..) thought economically or technically out of reach until recently

As the world becomes increasingly reliant on these sources, will costs inevitably rise steeply?

Maybe, but don't bet on it. Technology will advance and other sources (methane hydrates, oil shale..) may become economically accessible

But in the (very) long run fossil fuels will become increasingly scare and expensive

From a longer perspective



Fossil Fuel Use

- a brief episode in the world's history

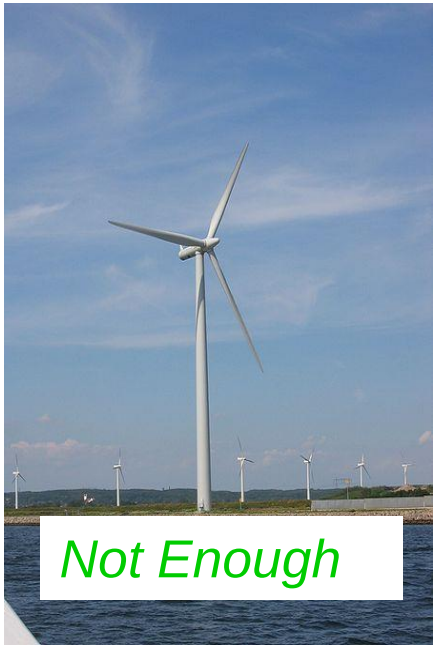
5) The extent to which non-fossil fuels can replace fossil fuels?

Extreme form of question: could we replace the 10.9 Btoe p.a. (rising) we get from fossil fuels with low carbon power?

Wind + Hydro + Bio + Enhanced Geothermal + Marine could at best replace half

Should expand these sources as much as reasonably possible – but hard as many are more expensive than fossil fuels, and wind & marine *(and solar)* need back-up and/or support of large scale storage and/or large scale grid

Will also need a lot of solar and/or nuclear



US EIA (2013) projected range of levelized generation costs per kW-hr for plants entering service in US in 2018 (depending on technology and location):

Gas - $(6*-15)c, Coal without CCS $(9-14)c, Advanced Coal with CCS $(12-15)c, On-shore wind $(7-$10)c, Off-shore wind $(18-29), Solar PV $(11-22)c, Concentred Solar Power $(19-42)c, Nuclear $(10-12)c

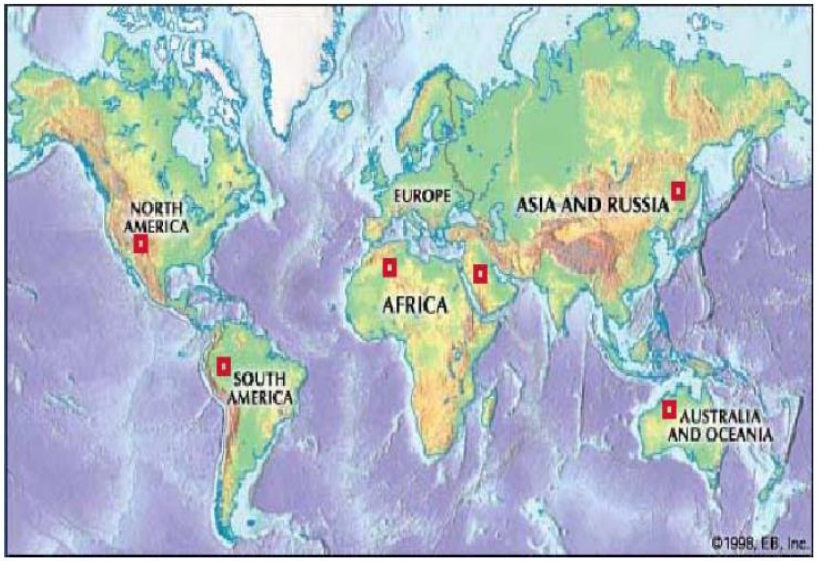
*Over $10c with European gas price

Solar

Enormous potential: in principle could power the world - must push hard, but

- in 2012 provided only 0.4% of electricity
- not yet competitive with gas or coal, even without cost of back-up, or storage and better transmission

Photovoltaics – cost falling and promise of further reductions (perovskites?) but cost of solar cells in now only half the total



6 boxes sized to produce 3.3TW of power each (20TW total – 630EJ)

Source: Lewis et al 2003c

Nuclear

Big potential – **but** (misplaced) perception of risks, proliferation worry (largely political issue)

Big question is cost – new generation running late/over budget. EIA numbers low?

Must drive done cost (SMRs?) + **develop:**
alternative fuel cycles, fast breeders and thorium reactors – to reduce the amount of waste needing long-term storage + prolong the nuclear age
and fusion (return later)

Can we meet need (assuming continued development)?

- **With fossil fuels**

  Certainly for 25 years, probably for 50 years – then too many uncertainties to be sure

- **Without fossil fuels**

  With existing technology – incredibly difficult: impossible at a price society would be prepared to pay

Must drive down cost of low carbon energy sources and try to moderate demand and improve efficiency

Need to decarbonise:

- **Pollution** – outdoor [indoor] air pollution causes 1.3 m [1.5 m] premature deaths very year (big numbers in China, India.. but 41 k in USA, 11 k in UK,…)
- **Climate change**
- **Security of supply**, but currently many sources and willing sellers
- **Prepare** for when fossil fuels finally become increasingly scarce and expensive

Necessary actions

- carbon (or pollution?) price
- face the fact that for foreseeable future the world will be heavily depended on fossil fuels, **and:**

  - Replace coal with gas as far as possible (pollution, CO2)
  - Develop CCS – and roll out on large scale if competitive with low carbon sources
  - Drive up efficiency of use of fossil fuels: anticipated (NPS) 2011-35 increases in efficacy of Chinese coal power plants (which today consume 26% of the world's coal production) → 47% more power in 2035 from only 26% more coal
  - Abandon sterile/counter productive fossil fuels *or* renewables *or* nuclear debate

Final Question: will fusion be too late?

Not sure if/when reliable fusion power on the scale of a power station will be available at a competitive (with what?) cost

But I am 100% sure that we must develop fusion as vigorously as we can

In reply to the question **“When will fusion be ready?”**

Lev Artsimovitch famously replied **"Термоядерная энергия будет получена тогда, когда она станет необходима человечеству"**

“Fusion will be ready when society needs it”

Lev Andreevich Artsimovitch (1909-1973) **Father of fusion research**

Hope this is still true: fusion is not yet necessary (although desirable as large-scale low-carbon energy sources would be helpful now). In any case

When/if fusion becomes available it won’t be too late

The potential and advantages are enormous

Concluding Remarks

- To allow everyone on the planet to lead decent lives, much more energy will be needed
- We can probably meet the need with fossil fuels for (at least) 50 years - but we should be decarbonising
- No real progress with decarbonisation – need to drive down cost of low carbon technologies, manage demand, improve efficiency (regulation)
- Need to put a price on carbon (or pollution?), more R&D
- Fusion (if it can be made competitive and reliable) will not be too late

Without secure fossil fuel supply the world's poor will remain poor for the foreseeable future

Without vigorous development of non-fossil sources, serious decarbonisation will not be possible