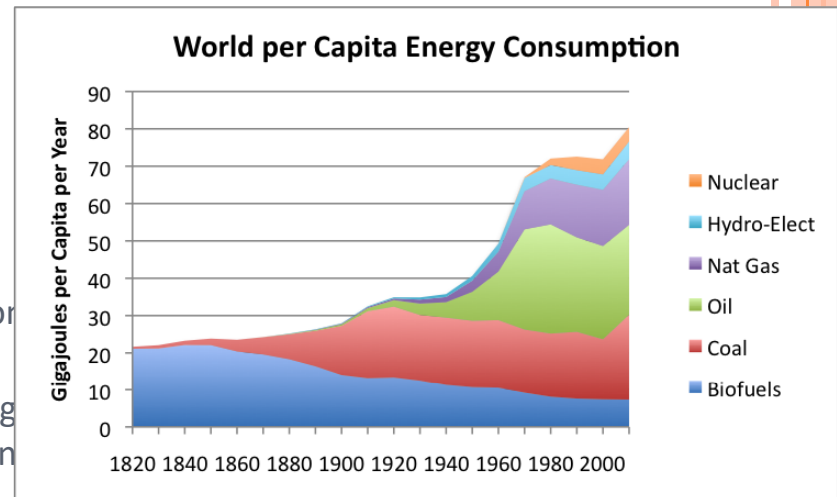


STAR TRAVEL WITHOUT NEGATIVE ENERGY

- If you have negative energy, no problem
 - Negative inertia or wormholes will be possible
- If you don't, conditions of plausibility:
 - Robots which are oblivious to time factors
 - Information traveling by light signals
 - Upload is usable travel for robots
 - Measurement reference for Quantum Teleportation
 - Near speed of light for organic life
 - Requires several "tons" of mass converted to energy
 - Requires solution to biological cross-contamination
- Getting a feel for the energy required
 - Acceleration of 1g for 8000 hours (approx. 1 year)
 - 30 doublings from per capita annual energy use today
 - 2000 years at 20th century growth rates (which are not continuing)
 - Compare to other 2000 year events:
 - Horsepower ~ 4000 BCE
 - Wheel ~ 2000 BCE
 - Paved roads ~ 0 BCE
 - Natural resource power (age of sail 1500 AD, steam 1800, nuclear 1955)
 - Expected interstellar age ~ 3000 to 4000 AD (sail + 1500 to nuclear + 2000)



EVALUATION OF ALTERNATIVES

- Carry fuel and energy
 - Fusion is about .4% efficient
 - Each stage cannot add more than about .4% C
 - Hard to imagine anti-matter more than a few % of total mass
 - Fuel for stopping and return journey
- Re-fuel along the way
 - Fuel supplies at various positions and velocities
 - Essentially a very large infrastructure problem
- Externally supplied energy
 - Mass driver
 - In principle would work like a star gate or wormhole (interstellar subway)
 - @ 1g would need to extend half a light year, with another for slowdown
 - Circular mass driver impractical (10%C needs 600g's at 1AU)
 - Concentrated solar beam might be usable (sun converts 10^6 kg/sec to energy)
 - Use neutron stars as switching hubs
- Ideally, find & connect with a pre-existing transportation infrastructure
 - Proposed by Carl Sagan, though in fiction

