

Why Each American Lives Like a 40-Ton Whale: Power, Overshoot, and Climate with Tad Patzek | Episode 219

Show Notes and Links to Learn More

The TGS team puts together these brief references and show notes for the learning and convenience of our listeners. However, most of the points made in episodes hold more nuance than one link can address, and we encourage you to dig deeper into any of these topics and come to your own informed conclusions.

00:00 – [Tad Patzek, Works](#), Blog: [Life Itself](#), Books:

- Tad’s recent book referenced in the episode: [Thermal Power and Climate Change: A Data-Driven Analysis of Cause and Effect](#)
- [Drilling Down: The Gulf Oil Debacle and Our Energy Dilemma](#) (with Joseph Tainter)

Insert in video interview: [Energy and Material Flows](#)

03:15 – [Pimentel and Patzek ethanol production paper](#)

03:45 – [Thermal Power and Climate Change: A Data-Driven Analysis of Cause and Effect](#)

04:37 – [Energy vs. Power](#)

04:50 – [Climate change](#), [Overpopulation](#), etc. comes from [surplus energy available to humanity](#)

05:01 – [Human energy output is ~100 watts and the brain consumes ~20 of those watts](#)

05:19 – [Average American ~10,000 watts of continuous power \(More info on pg 6\)](#)

05:55 – [40-ton sperm whale metabolic equivalent \(More info on Tad’s blog\)](#)

08:20 – [Advanced societies are those with surplus power](#)

08:54 – [Collapse of Complex Societies](#)

09:07 – [Joseph Tainter \(TGS Episode\)](#), [Drilling Down \(Patzek and Tainter\)](#)

10:00 – [Roman Empire geographical area](#)

10:25 – [English Industrial Revolution and coal](#)

11:15 – [England as dependent on coal in 1800s as the U.S. was dependent of fossil fuels in 2010](#)

11:37 – [Exosomatic energy \(More info\)](#)

11:50 – [Power output difference between fossil fuels and renewables \(see pg 4\)](#)

12:03 – [Renewables better termed “Rebuildables”](#)

12:30 – [Dispatchable vs. non-dispatchable power](#)

13:15 – [Fossil amoeba / Economics for the Future: Beyond the Superorganism](#)

13:23 – Insert in video interview: [Energy and Material Flows](#)

13:50 – [Coal, oil, and natural gas \(80–85% of global primary power\)](#)

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- 14:26 – [Global primary power \(~15–18 terawatts\)](#)
- 15:11 – [19 Terawatt economy, Energy consumption by source](#)
- 15:21 – [Photosynthesis as a planetary power flow](#)
- 16:07 – [Human appropriation of net primary production \(HANPP\)](#)
- 16:30 – [Agriculture efficiency in sequestering solar light](#)
- 16:59 – [Solar photovoltaic efficiency](#)
- 17:10 – The [cost](#) and [lifespan](#) of renewable energy components
- 17:34 – [Electricity as the purest form of energy](#)
- 17:54 – [Global electricity generation \(~3.4 terawatts\), By source](#)
- 18:25 – [Thermal power sources \(coal, natural gas, nuclear\)](#)
- 18:40 – [Hydropower](#)
- 20:37 – [Energy blindness](#)
- 21:55 – Number 1 material flux in human economy: [Global freshwater withdrawals \(~4,000 km³/yr\)](#)
- 23:00 – [Irrigation uses 70–75% of total freshwater usage](#)
- 23:17 – [Conflict in the Middle East – Iran War 2026](#)
- 23:26 – [Gulf Cooperation Council \(GCC\)](#)
- 23:41 – [Seawater desalination in the Middle East, Amount of desalinated in Middle East per year](#)
- 24:32 – [Escalation in the Middle East since recording date: March 12, 2026](#)
- 24:52 – [Global food biomass \(~10–12 Gt/yr\)](#)
- 25:17 – [Sand, gravel, cement, and steel \(~50 Gt/yr\)](#)
- 25:47 – [Concrete and global infrastructure](#)
- 26:44 – [Chinese policymakers are majority engineers/scientists, while the U.S. politicians are majority lawyers](#)
- 27:59 – [Every energy transition has been additive, not subtractive](#)
- 28:39 – [Renewable energy infrastructure built on fossil fuels](#)
- 29:35 – [Mining infrastructure behind renewables](#)
- 29:44 – [Fragile food supply chains](#)
- 30:14 – [Energy inputs to food you eat before it arrives at the grocery \(pg 11\)](#)
- 30:34 – [Aquifer depletion, Other factors that can limit water supply](#)
- 31:25 – [Economics as a claim on future physical production, We think finance systems substitute physical reality](#)
- 33:15 – [Technology increases efficiency, but increases throughput even more \(Jevons paradox\)](#)
- 33:36 – [Human economic superorganism paper \(Hagens\)](#)
- 34:03 – [Ecological overshoot](#)
- 34:22 – [Carrying capacity](#)
- 35:10 – [Human overpopulation, TGS Episodes on such: #136, #9](#)
- 35:25 – [Current climate breakdown is a direct consequence of human overshoot](#)
- 35:47 – [Ecological overshoot scaling with the cube of primary power](#)
- 35:55 – [I=PAT equation \(Ehrlich and Holdren\)](#)
- 37:03 – [William E. Rees \(TGS Episode\), Our Ecological Footprint](#)

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- 37:24 – [Free energy \(Gibbs\) vs. Non-free energy aka heat](#)
- 37:45 – [Laws of thermodynamics](#)
- 38:10 – [Ore grade and concentration of free energy](#)
- 38:35 – [We use the best resources first and only once](#)
- 38:45 – [70% of primary power rejected as waste heat when using fossil fuels to generate electricity](#)
- 39:29 – [Climate change / Global heating](#)
- 39:59 – [Climate change intensifies extremes, Climate change and the water cycle, Climate extremes: intensification of frequency and magnitude](#)
- 41:10 – [Statistics of extremes \(Appendix D in Tad's book on pg 325\)](#)
- 41:38 – [Gaussian / bell curve, Fat-tailed distributions](#)
- 42:25 – [Climate impacts on global agriculture](#)
- 42:44 – [Ocean warming](#) and [Overfishing](#) disrupt fisheries, [Coral reef die-off](#), TGS Episodes on such: [#197](#), [#179](#)
- 42:57 – [Fish is a primary protein source for hundreds of millions of people](#)
- 43:10 – Freshwater storage in [snowpacks](#) and [glaciers](#), [Rapid melting in spring causes water shortages in summer and fall](#)
- 43:45 – [Himalayan glacial melt lakes and rivers drying up](#)
- 45:00 – [Solar insolation ~240 W/m², Balanced by outgoing infrared radiation](#)
- 45:45 – [Earth's energy imbalance \(~1 W/m²\)](#)
- 46:55 – [Energy imbalance totals ~300–500 terawatts \(20x human economy\)](#)
- 47:40 – [Nine planetary boundaries, Johan Rockström \(TGS Episode\)](#)
- 48:32 – [Paul and Anne Ehrlich role in planetary boundaries framework development \(Paul Ehrlich TGS Episode\)](#)
- 49:10 – [Habitat degradation globally](#)
- 49:30 – [Aquifer depletion](#)
- 49:48 – [Nitrogen and phosphorus cycles overwhelmed because of fertilizers](#)
- 50:08 – [Gulf of Mexico dead zone](#)
- 50:23 – [Ocean acidification](#)
- 50:38 – [Atmospheric aerosol loading](#)
- 50:53 – [Stratospheric ozone depletion, Why we need the ozone layer](#)
- 51:40 – [Climate breakdown and cumulative CO₂ emissions](#)
- 52:10 – [Atmospheric CO₂ at ~430 ppm and projections](#)
- 53:19 – [Tad's scenarios vs. IPCC RCP scenarios \(pg 145\)](#)
- 53:40 – [Economic collapse is a matter of time](#)
- 54:18 – Climate change and [monsoon patterns](#), [El niños](#), and [AMOC](#)
- 55:20 – [Land warms ~2x faster than ocean](#)
- 55:49 – Current [Gulf of Mexico temperature anomaly](#)
- 56:04 – Recent [Los Angeles heat wave](#)
- 56:19 – [Oceans absorb ~90% of excess planetary heat](#)
- 57:04 – [Earth's albedo declining, Albedo definition](#)
- 57:45 – [Green house gases \(GHGs\)](#)

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- 58:04 – [IMO 2020 low-sulfur fuel regulations for ships](#) and [cloud loss](#) (therefore albedo loss)
- 58:29 – [Dimethyl sulfide \(DMS\) and cloud condensation nuclei](#)
- 58:30 – [Small ocean life is producing less DMS, therefore cloud loss \(CLAW hypothesis\)](#)
- 59:09 – [Global heating](#) and [Arctic and Antarctic sea ice loss and reflectivity](#)
- 1:00:35 – [Home insurance withdrawing from climate-exposed markets](#)
- 1:01:00 – [Rising food prices from climate-disrupted agriculture](#)
- 1:01:55 – Grid failure under [heat load](#) / [EV charging](#)
- 1:02:00 – [Climate change and infrastructure damage](#)
- 1:02:20 – [Germany's infrastructure ranking decline](#)
- 1:03:56 – [Rebuilding transportation around public transit](#)
- 1:04:26 – [Reducing beef and other meat consumption](#)
- 1:05:41 – [Logistic growth curve thought experiment](#) (Tad's book example in chapter 6, pg 114)
- 1:05:50 – [Humans are not rational beings, Cognitive biases](#) (More info)
- 1:06:00 – [1650-1920 population growth, Baby boom](#)
- 1:06:51 – [Life expectancy: 32 years \(1900\) vs. 72 years \(2022\)](#)
- 1:07:38 – [World GDP per capita, 1820 to 2022](#)
- 1:08:50 – [Energy slaves / fossil fuel labor equivalents](#)
- 1:10:23 – [Techno-optimism](#)
- 1:12:05 – [AI and energy demand, AI and efficiency, Tad's book chapter on AI \(pg 13\)](#)
- 1:13:11 – [AI used by elites to obtain political power](#)
- 1:14:10 – [Just-in-time supply chains as single points of failure](#)
- 1:15:46 – Embodied [energy](#) and [materials](#) going into AI-systems
- 1:16:00 – [AI data centers consume 100-300 MW of electricity each and are affecting electricity utilities/grids](#)
- 1:16:37 – [Centralization of decision-making by AI](#)
- 1:19:04 – [Managed decarbonization transition](#)
- 1:19:39 – [Degrowth / absolute economic output decline](#)
- 1:20:34 – Turbulent transition: [resource competition](#) and [climate migration](#)
- 1:21:30 – [Fragmentation: geopolitical tensions and wars](#)
- 1:22:37 – [Nuclear fusion as a cornucopian promise](#)
- 1:24:04 – [Napa County agricultural and water reform](#)
- 1:28:31 – [Learn science for free online](#)
- 1:29:05 – [Human ability for abstract/fanciful thinking, False dichotomy](#)
- 1:29:31 – [Practical manual skills and making things](#)
- 1:32:12 – [Human inability to plan far in the future & Time blindness](#) (More info), [Deep time](#)
- 1:33:07 – [Free hyperlinked PDF of Tad's the book](#)