Executive summary

Scope: concise, evidence-backed synthesis of your conversation and calculations about using nuclear-generated steam (U-235) to extract/upgrade global oil-sands/shale oil, the reactor build rate required, and uranium/thorium resource lifetimes under different fuel cycles.

Bottom line: supplying steam to match current global oil production requires ~1,000 GW(th) of continuous thermal power (~300-1,000 "1-GW class" nuclear plants depending on rating). At today's build rate (~10 1-GW reactors per year) that scale would take 3-10 decades. A fleet of 3,000 x 1 GWe once-through LWRs would exhaust conventional terrestrial uranium in ~15-40 years; with full breeder/thorium cycles that same fleet could run for centuries to millennia.

Key findings

- Steam demand to replace current oil extraction:

Product energy ~ 210 EJ/yr; process energy assumed 15% -> 31.5 EJ/yr ~ 1,000 GW(th) continuous.

- Number of 1-GW plants required:
- If counting 1 GW(th) units: ~1,000 plants.
- If counting 1 GWe LWRs (~3 GW(th) each): ~330 reactors.

- Current global build rate: ~10 one-gigawatt reactors per year (~70 under construction; average build time ~7 years). At that rate, building 300-1,000 reactors takes 30-100 years.

- Fuel-supply lifetimes (3,000 x 1 GWe fleet):
- Once-through LWRs, conventional identified resources (~6-8 MtU): ~12-16 years.
- All identified + undiscovered terrestrial uranium (~19-20 MtU): ~39 years.
- Breeder reactors using U-238 and/or Th-232: ~750-1,500 years (rule-of-thumb 50-100x extension); theoretical multi-millennial supply if seawater uranium and breeders are used.

Assumptions and methodology

Primary assumptions used in calculations

- Global oil consumption: ~100 million barrels/day -> ~210 EJ/yr product energy.
- Process energy fraction for oil sands extraction/upgrading: 15% (mid-range of 10-20%).
- Conversion: (1 EJ/yr ~ 31.7 GW continuous).
- 1 GWe LWR thermal rating: ~3 GW(th).
- Per-reactor uranium use (once-through LWR): ~170 tU/yr per 1 GWe.
- Identified recoverable uranium: ~5.9-6.0 MtU at <$130/kgU; ~8.0-8.2 MtU at <$260/kgU; identified + undiscovered terrestrial ~ 19-20 MtU.

Methodology summary

- Converted oil energy to required process heat using a percentage multiplier.
- Converted EJ/yr to continuous GW to get thermal power requirement.
- Divided thermal requirement by per-plant thermal or reactor thermal rating to get plant counts.
- Scaled per-reactor uranium consumption to fleet size and compared to resource categories to estimate lifetimes.
- Considered breeder multipliers (50-100x) and seawater uranium to illustrate theoretical extensions.

Detailed calculations (concise)

- Process energy: 210 EJ/yr x 0.15 = 31.5 EJ/yr.
- Thermal power: 31.5 EJ/yr x 31.7 GW per EJ/yr ~ 1,000 GW(th).
- Plants required:
- 1,000 GW(th) / 1 GW(th) ~ 1,000 units.
- 1,000 GW(th) / 3 GW(th per 1 GWe) ~ 330 reactors.

- Uranium demand for 3,000 reactors: 3,000 x 170 tU/yr ~ 510,000 tU/yr.
- With 8 MtU resource: 8,000,000 / 510,000 ~ 15.7 years.
- With 20 MtU resource: 20,000,000 / 510,000 ~ 39 years.

Policy, technical, and deployment implications

- Scale and time: meeting oil-extraction steam demand with nuclear requires a multi-decadal, highly concentrated build program or major shifts to faster modular deployment (SMRs) and supply-chain scaling.

- Fuel strategy matters at design stage: once-through deployment at scale locks in short resource lifetimes and makes later transition to breeders harder and more expensive. A "design for breeding from day one" approach preserves U-238/Th-232 leverage but raises cost, complexity, and political hurdles.
- Uranium sourcing options: relying on conventional identified ore yields decades only; including undiscovered terrestrial ore extends that to decades; seawater extraction plus breeders effectively removes resource scarcity on civilizational timescales but requires technological and economic maturation.

Recommendations and next steps

1. Decide the fuel-cycle policy early. If longevity of parent material matters, commit to breeder/recycling infrastructure and fuel-fabrication pathways at the outset.
2. Run sensitivity cases: vary process-energy fraction (10-20%), per-reactor fuel use (150-200 tU/yr), and reactor thermal/electrical ratings to bound plant counts and resource lifetimes.
3. Compare deployment pathways: model centralized 1-GWe LWR expansion vs accelerated SMR rollouts vs a breeder-first program (cost, timeline, supply chain, non-proliferation risk).
4. Estimate supporting requirements: uranium mining scale-up, enrichment capacity, spent-fuel handling, and workforce/training needs for a 300-3,000 reactor program.
5. Assess alternatives: electrification, efficiency, and non-thermal extraction methods for oil sands to reduce steam demand before committing to massive nuclear builds.

Two representative sentences from the attached analysis:
"So you're looking at roughly 1 terawatt of thermal power just to run the extraction/upgrading at today's global oil burn rate."
"With 3,000 once-through LWRs, running flat-out, conventional uranium resources last on the order of 15 years once that fleet is fully deployed."