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**SAFE Fission Consult™**

# Technical Memorandum

## TTN-TM-031

### Economic Comparison Report: Xlinks Morocco-UK Renewable Project vs. Nuclear Power (CAP1000 & VVER-1200)

A report by SAFE Fission Consult™, a division of The Thorium  
Network

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# 1.0 Introduction

This review provides a **high level economic comparison** between the **Xlinks Morocco-UK** renewable energy project and nuclear power plants based on **CAP1000** and **VVER-1200** technologies. The objective is to evaluate the financial viability and lifecycle costs of delivering **3.6 GW of firm power capacity** to the UK over a **100-year project lifetime**. The analysis incorporates **realistic equipment replacement cycles**, especially for renewable and battery components located in the harsh sea side environment of Tan-Tan, and accounts for nuclear plant maintenance, life extension and decommissioning costs. This comparison aims to guide stakeholders and decision-makers on the most cost-effective and sustainable option for long-term energy supply.

## 2.0 Executive Summary

The Xlinks Morocco-UK Power Project proposes to deliver 3.6 GW of firm renewable power to the UK via 11.5 GW of solar and wind generation combined with 5 GW battery storage and two 4,000 km HVDC subsea interconnectors. While offering a zero-carbon energy source, over a 100 year horizon the project faces significant lifecycle costs due to necessary multiple replacements of solar panels, wind turbines, batteries, and the subsea cables themselves.

In contrast, nuclear power plants using CAP1000 or VVER-1200 technology provide stable, high-capacity-factor (~90%) power with far fewer major replacements and lower operating costs over the same period. Nuclear plants' longer equipment lifespan and proven operational reliability result in significantly lower total lifetime costs and levelized cost of electricity (LCOE).

Note that the figures have not been adjusted for inflation.

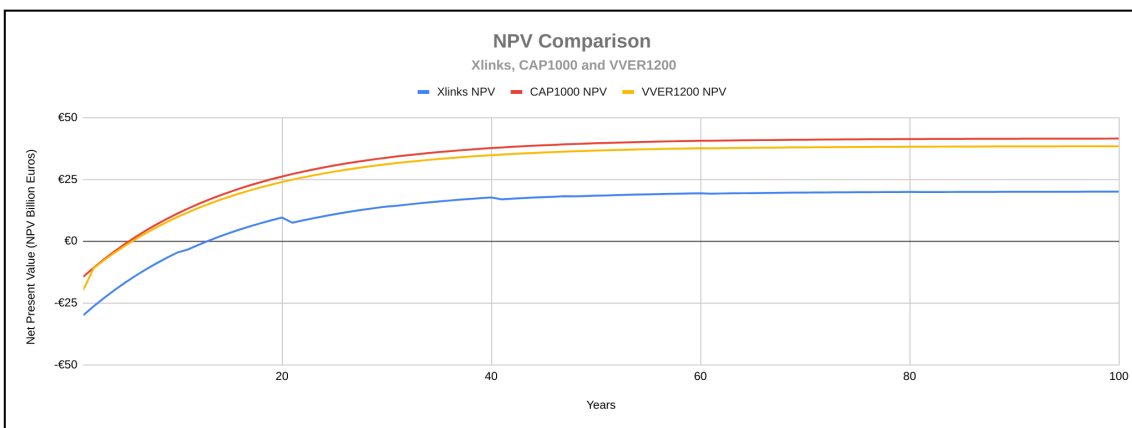
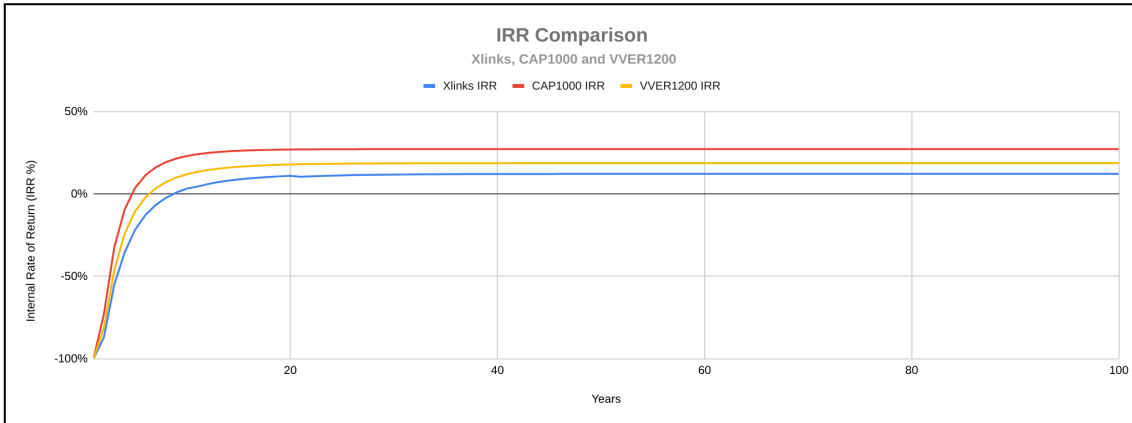
## 3.0 Key Findings

- **Total Lifetime Cost (CAPEX + OPEX):**
  - Xlinks: €160 billion
  - CAP1000: €78 billion
  - VVER-1200: €105 billion
  
- **Levelized Cost of Electricity (LCOE):**
  - Xlinks: €50 per MWh
  - CAP1000: €25 per MWh
  - VVER-1200: €33 per MWh

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- **Financial Returns (IRR, NPV, ROI):**

- Nuclear options show higher IRR (19–27%) and high positive NPV, reflecting better investment efficiency.  
Xlinks project IRR estimated at 12%, impacted by high replacement and maintenance costs.



Calculations are here:

<https://docs.google.com/spreadsheets/d/1xrqAjenjKIKuogGFuBLHmvoVUNjf6FzQWI7ZGfj29Jc/>

- **Capacity Factor and Energy Output:**

- Xlinks firm capacity factor ~30% (battery-backed)
- Nuclear plants ~90% capacity factor, producing more energy per installed MW.

## 4.0 Conclusion

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While Xlinks offers a renewable, zero-direct-emission solution with grid flexibility, its high lifecycle costs and replacement demands reduce its financial attractiveness compared to nuclear power. CAP1000 and VVER-1200 nuclear plants provide a more cost-effective, durable, and reliable source of firm power over a century. The choice between these technologies should consider energy policy goals, carbon targets, risk tolerance, and infrastructure capabilities.

## 5.0 Detailed Analysis

### 5.1 Project Scope and Technology

- **Xlinks:** 11.5 GW solar + wind (50/50), 5 GW battery, 3.6 GW subsea cable
- **CAP1000:** 3 units × ~1.2 GW each, advanced Chinese PWR design
- **VVER-1200:** 3 units × 1.2 GW each, Russian PWR design

### 5.2 Equipment Replacement Cycles (100 Years)

- **Xlinks:**
  - Solar panels: 5 replacements
  - Wind turbines: 5 replacements
  - Batteries: 10 replacements
  - HVDC cable: 2 replacements
- **Nuclear:**
  - 1 major refurbishment and life extension to reach 100 years

### 5.3 Capital and Operating Costs

- Xlinks' frequent equipment replacements and complex transmission infrastructure drive CAPEX to ~€180–200 billion over 100 years.
- Nuclear plants' longer equipment life and fewer replacements keep CAPEX around €52–74 billion.
- OPEX for Xlinks (~2% CAPEX annually) totals ~€60 billion.
- Opex for nuclear (~3-4%) totals €30–45 billion.

### 5.4 Energy Output and Cost Efficiency

- Nuclear's high capacity factor (~90%) yields greater total energy output, lowering LCOE to €25–33 per MWh.
- Xlinks' battery-backed renewables deliver firm power at a higher LCOE of ~€50 per MWh due to intermittency and storage costs.

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## 6.0 Recommendations

- For long-term, cost-effective, and reliable firm power supply, nuclear technologies (CAP1000 or VVER-1200) are economically superior.
- Xlinks provides a valuable renewable option but requires significant capital and operational investment to manage equipment lifecycle and transmission complexity.
- Policymakers should weigh carbon reduction targets, energy security, and financial feasibility when selecting the optimal energy mix.

This report aims to provide a clear, data-driven foundation that can be used for strategic energy planning and investment decisions regarding large-scale power generation options for the UK market.

## 7.0 Project Scope and Technologies

Project	Firm Power Capacity	Technology	Notes
Xlinks Morocco-UK	3.6 GW	11.5 GW Solar + Wind + 5 GW Battery Storage + 3.6 GW HVDC cable	Multiple replacements over 100 years required
CAP1000 Nuclear Plant	3.6 GW	CAP1000 (Chinese AP1000 variant)	3 units, 100-year lifetime with maintenance
VVER-1200 Nuclear Plant	3.6 GW	VVER-1200 (Russian PWR)	3 units, 100-year lifetime with maintenance

## 8.0 Equipment Lifespan and Replacement Cycles over 100 Years

Equipment Type	Typical Lifespan	Adjusted Lifespan (Tan-Tan)	Replacement Cycles in 100 years	Notes
Solar PV Panels	25-30 years	20 years	5 replacements	Accelerated degradation due to desert conditions

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Wind Turbines	20-25 years	20 years	5 replacements	Corrosion and abrasion in coastal desert
Battery Storage	10-15 years	10 years	10 replacements	High temperatures accelerate degradation
HVDC Subsea Cable	40+ years	40 years	2 replacements	Long-lasting but periodic replacement needed
Nuclear Plant (CAP1000/VVER-1200)	60 years	60 years	1 major refurbishment	Life extension with moderate capital expenditure

## 9.0 Capital Expenditure (CAPEX) over 100 Years (Including Replacements and Decommissioning)

Project	Equipment	Cost Estimate (Euros)
Xlinks Morocco-UK	Subsea HVDC Cables	€13.5 billion
	Power Conversion & Management Systems (Converter Stations, HVDC Converters)	€3 billion
	5.5 GW Solar Panels & Infrastructure	€5 billion
	6 GW Wind Turbines & Infrastructure	€5.5 billion
	5GW / 22 GWh Battery Energy Storage Systems (BESS)	€3 billion
CAP1000 Nuclear Plant	Chinese adaptation of the Westinghouse AP1000 1250 MWe capacity	€4 million per MWe
VVER-1200	Russian Generation III+ pressurized water reactor 1,200 MWe capacity.	€5.5 million per MWe

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Project	Initial CAPEX (EURO)	Replacement and Decom CAPEX (EURO)	Total CAPEX over 100 years (EURO)	Notes
Xlinks Morocco-UK	€30 billion	5× solar + 5× wind + 10× battery + 2× cable replacements + decommissioning €1 billion	~€100 billion	Battery replacements significant
CAP1000 Nuclear Plant	€14.4 billion	At 60 years 1 major refurbishment (30% initial CAPEX) + EoL decommissioning €1 billion	~€18 billion	Life extension costs moderate compared to replacements
VVER-1200 Nuclear Plant	€19.8 billion	Same as CAP1000	~€25 billion	Slightly higher initial CAPEX and refurbishment costs

## 10.0 Operating Expenditure (OPEX) over 100 Years

Project	Annual OPEX (% of CAPEX)	Total OPEX over 100 years (EURO)	Notes
Xlinks Morocco-UK	2%	€60 billion	Includes maintenance and cable upkeep.
CAP1000 Nuclear Plant	4%	€60 billion	Includes fuel, operations, maintenance, life extension
VVER-1200 Nuclear Plant	4%	€80 billion	Similar to CAP1000

## 11.0 Total Lifetime Cost (CAPEX + OPEX) over 100 Years (no discount)

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Project	Total Cost (EURO)	Notes
Xlinks Morocco-UK	€160 billion	High replacement frequency drives costs
CAP1000 Nuclear Plant	€78 billion	Lower replacement and OPEX costs
VVER-1200 Nuclear Plant	€105 billion	Slightly higher initial and OPEX costs

## 12.0 Energy Output and Capacity Factors over 100 Years

Project	Annual Energy Output (GWh)	Total 100-year Output (TWh)	Notes
Xlinks Morocco-UK	~31,500 GWh	~3,150 TWh	Battery storage enables firm delivery
CAP1000 Nuclear Plant	~31,500 GWh	~3,150 TWh	High availability
VVER-1200 Nuclear Plant	~31,500 GWh	~3,150 TWh	Similar to CAP1000

## 13.0 Levelized Cost of Electricity (LCOE) over 100 Years (Indicative)

Assuming 3.6 GW provided with allowances for plant utilisation already considered

Project	LCOE (EURO/MWh)	Notes
Xlinks Morocco-UK	~€50	Higher due to frequent replacements and battery costs

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CAP1000 Nuclear Plant	~€25	Lower due to long life, high capacity factor, and stable OPEX
VVER-1200 Nuclear Plant	~€33	Similar to CAP1000 nuclear

## 12.0 Financial Metrics (NPV, IRR, ROI) over 100 Years (Indicative)

Metric	Xlinks Morocco-UK	CAP1000 Nuclear Plant	VVER-1200 Nuclear Plant
IRR	12%	27%	19%
NPV (7% discount rate)	€20 billion	€41 billion	€38 billion
ROI (annual average)	67%	285%	190%

## 13.0 Key Insights and Conclusions

- Xlinks project's high upfront cost is compounded by frequent replacements of solar panels, wind turbines, batteries (up to 10 times), and subsea cables (twice) over 100 years, driving total lifecycle costs to €160 billion.
- Nuclear plants (CAP1000 and VVER-1200) benefit from longer equipment lifespans, fewer major replacements, and stable OPEX, resulting in significantly lower total lifetime costs (~€78 to 105 billion).
- Nuclear's higher capacity factor (~90%) translates to more energy output per installed MW, lowering LCOE to around €25 to 33 per MWh, compared to €50 per MWh for Xlinks.
- Financial returns (IRR, NPV, ROI) favor nuclear options substantially over a 100-year horizon, reflecting better cost efficiency and asset longevity.
- Xlinks offers renewable energy with zero carbon emissions and grid flexibility but at a much higher lifecycle cost and lower financial returns due to equipment replacement demands and transmission complexity.
- Nuclear power remains the more economically efficient and financially attractive option for long-term, firm power supply at this scale.

## 14.0 References

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