

# Ethereum Upgrades

The Ethereum network has undergone a series of significant upgrades since its launch, which can be broadly categorized as different stages in its development roadmap. The purpose of these upgrades is generally to improve **security, scalability, efficiency, and sustainability**.

## Past Upgrades

- **Frontier (2015):**
  - **Original Launch:** The initial, barebones launch of the Ethereum blockchain, allowing for the mining of Ether (ETH) and the deployment of a prototype decentralized application (Baldauf et al., 2023; Ahn et al., 2024).
- **Homestead (2016):**
  - **Core Functionality:** Enabled ETH transactions and the deployment of **smart contracts** (Ahn et al., 2024). It marked a stabilization phase for the network.
- **Metropolis (Byzantium & Constantinople):**
  - **Improvements:** Focused on improving **security, privacy, and efficiency**. Byzantium, in particular, introduced privacy-preserving technology like zk-SNARKS and delayed the "difficulty bomb," a mechanism designed to encourage the transition to Proof-of-Stake (PoS) (Informatica Unicam, n.d.).
- **London (EIP-1559, 2021):**
  - **Fee Mechanism:** Changed the transaction fee model from a user-bid auction to one with an **algorithmically determined base fee** that gets **burned** (destroyed), plus an optional priority fee (tip) for validators. This was intended to make fees more predictable and manage network congestion (Karaivanov & Zarifian, 2024).
- **The Merge (2022):**
  - **Consensus Shift:** This was the most profound change, where the network transitioned from the energy-intensive **Proof-of-Work (PoW)** consensus mechanism to the more energy-efficient **Proof-of-Stake (PoS)** (Kapengut & Mizrach, 2022).
  - **Impact:** This transition drastically reduced the network's energy consumption (by an estimated 99.98%) and established a consistent block time of 12 seconds, increasing the gas supply (Kapengut & Mizrach, 2022; Karaivanov & Zarifian, 2024).

## **Future Upgrades (in the current roadmap)**

Ethereum's development is often described by the stages: The Merge, The Surge, The Scourge, The Verge, The Purge, and The Splurge.

- **The Surge (Dencun/Cancun-Deneb)(Ongoing – 2023–2025):**
  - **Goal:** Scaling through **sharding** and **Layer 2 (L2) solutions**.
  - introduces “**proto-danksharding**” (EIP-4844) – improves Layer-2 (L2) transaction capacity.
  - Makes **rollups (Optimism, Arbitrum, etc.) cheaper and faster**.
  - Target: handle **100,000+ transactions per second**.
  - Focuses on **data availability and throughput**.
- **The Scourge (Upcoming):**
  - **Goal:** **Fairness and decentralization** in block production.
  - Addresses **MEV (Maximal Extractable Value)** issues – where validators reorder transactions for profit.
  - Aims to ensure **neutral, credible, and transparent block building**.
  - Introduces **PBS (Proposer-Builder Separation)** to reduce centralization.
  - Strengthens **economic fairness** and network integrity.
- **The Verge (Upcoming):**
  - **Goal:** **Efficiency and decentralization of validation**.
  - Introduces **Verkle Trees** (an upgrade from Merkle Trees).
  - Makes nodes **lighter and faster** to verify Ethereum's state.
  - Users can become **validators with minimal storage**, boosting decentralization.
  - Enhances **data verification efficiency**.
- **The Purge (Future):**
  - **Goal:** **Simplify Ethereum and reduce technical debt**.
  - Removes **old history and redundant data** from the blockchain.
  - Reduces **node storage requirements** → easier to run full nodes.
  - Streamlines the **protocol codebase**, improving long-term maintainability.
  - Makes Ethereum **leaner and more efficient**.
- **The Splurge (Pectra) (Ongoing/Final):**
  - **Goal:** **Miscellaneous improvements and fine-tuning**.
  - Includes **smaller upgrades and optimizations** not covered in other stages.

- Focuses on **user experience, performance, and minor feature enhancements.**
- Ensures **smooth operation** after the major transformations.