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# Don't Sleep on MEV

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## PM NOTES:

If you still own ETH, then you need to think about MEV and more specifically Flashbots. MEV is Maximal Extractable Value (formerly known as Miner Extractable Value), and while validator yield is important, it's MEV that quietly drives the world of ETH. To explain: Ethereum searchers, miners, and soon-to-be validators compete on millisecond timeframes, similar to high-frequency trading firms, utilizing arbitrage, frontrunning, and other methods to access latent on-chain alpha that comes from having a seat in front of Ethereum transaction flow. MEV measures the total amount of ETH obtained by optimally reordering, including, or excluding transactions to maximize profit. Right now, searchers and miners run the MEV game. After Ethereum transitions to Proof of Stake, the game changes. Here are the implications and what you need to know if you are invested in ETH:

- Scenario 1: Bull Case of ~\$8,400 in three years if MEV remains freely accessible to all block builders and validators post Proof of Stake go-live. Our bullish thesis on Ethereum assumes that MEV democratizes. In an increasingly likely scenario, a third-party solution developed by Flashbots, MEV-Boost, is activated on the network and adopted by most participants after the Merge to resist centralizing forces in the ecosystem. ETH holders will directly benefit in the long term from an economically sustainable and more valuable network as a result. We see an 85% probability of Scenario 1.
- Scenario 2: Bear Case of \$3,900 in three years if there is a structural shift toward highly centralized, vertically integrated actors who outcompete all others for MEV. In this scenario, there is downside potential for the ecosystem and ETH token value over prolonged periods induced by governance, pooled reward risk, and censorship involving a few or one highly sophisticated, primary entity. We see a 15% probability of Scenario 2.

## A Summer Refresher on Ethereum Block Building

Proof of Work: Pour yourself an Arnold Palmer, and let's get back up to speed. Currently, in Proof of Work, when an Ethereum user submits a transaction:

1. Their wallet sends it to the protocol where it propagates across the network. The transaction appears in a temporary holding queue known as a mempool. Miners select the transactions they want to include in their block. During congestion, miners prioritize processing transactions that pay the highest gas fees to fill a block to earn more. However, when congestion is low, they'll include all transactions, regardless of gas price. Once filled, these blocks are considered candidates yet to be selected by the network.
2. Miners then individually perform a mathematical calculation to find the correct hash value for a block. When a miner solves the hash, they publish it to the network so other nodes can validate and finalize it. Blocks contain hundreds or thousands of transactions. Block spacing gives the miners time to reach consensus on the contents of each block and decide the order.

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The nodes form consensus around the longest chain, which then becomes the official Ethereum blockchain.

Mining pools have long played the role of block builders for many years. Mining pool operators usually decide block contents with the help of advanced market participants called searchers. Searchers use strategies that optimally order transactions into bundles. The mining pool selects the most profitable bundles from searchers to add to a block and sends them to other miners for verification. Flashbot's MEV-GETH, third-party software and block space market developed for Ethereum Proof of Work, incentivizes searchers to send bundles to miners by ensuring their contents remain private to prevent frontrunning by miners. Searchers are willing to pay 90 to 95% of their MEV strategy profit to miners to stay competitive and have their bundles selected. Most MEV currently accrues to miners as a result and has become a significant portion of miners' income.

Before Flashbots, vertical integration started to occur. There were incentives for miners to behave like traders and lenders, identify and execute transactions, manage risk, and maintain an inventory of tokens. Mining pools began to strike exclusive deals with trading and financial firms, representing a step toward a network controlled by a few dominant parties in the mining space.

In June 2020, one of the largest mining pools, Poolin, stated, "[a] mining pool is a traffic business, and it is getting more and more competitive...Poolin has its unique advantage, but we also want multiple business lines – not just lending but also financial services – parallel to our pool business." It became a race as to who could make blocks more efficiently and who may not have been willing to let searchers join in the process. The dominant miners started to take on attributes of miners, lenders, and traders/searchers all in one to gain a competitive advantage.

Proof of Stake: After the Merge to Proof of Stake, which could happen as early as mid-August, blocks will be built and published differently than in Proof of Work. Miners will cease to exist, and validators will take their place. Validators must stake at least 32 ETH to serve as a solo validator. If they cannot meet this threshold, individuals can join staking pools to earn a portion of validating rewards.

The network selects validating nodes to publish blocks to the network based on the amount of staked ETH. The more staked ETH a node has, the higher probability they have of being chosen as the validator for a block. When a node is selected to propose a block to the network, all other nodes attest to the block. If the other nodes agree with the contents, a reward is given to the validating node based on network transaction fees. The block subsidy of ~2 ETH for Proof of Work disappears in Proof of Stake, and validator rewards are only distributed mostly through network inflation and transaction fees (tips). There are no additional subsidies. If nodes propose fraudulent blocks or statistics such as their uptime percentages suffer, they are also subject to slashing or forfeiture of their 32+ ETH staked on the network. Consequently, MEV becomes an even more critical revenue component for network participants.

Flashbots is also developing a Proof of Stake predecessor to MEV-GETH, called MEV-Boost, to create a Proof of Stake market for block space and MEV extraction. The software aims to democratize MEV, ensure that anyone can participate in building and proposing blocks, and resist centralizing forces on the network. It will provide fair access to the protocol's block space market, specifically by implementing a block proposer/builder separation (PBS) and will bridge the gap until a similar concept can be implemented on Ethereum's Proof of Stake chain. MEV-Boost will be critical to the early formation of a fair block space market after the Ethereum Merge.

The inner workings can be simplified down to the following: based on a set of transactions, searchers specialize in finding the optimal way to combine the transactions that maximize economic value. They create bundles that they can then send to builders. Everyday users also send transactions to builders but aren't specialized like searchers are to arrange transactions optimally. Builders construct payloads using the bundles and user transactions they receive. Relayers coordinate routing the payload to the validator, who then signs and submits the block to the network. Escrows are introduced to the flow to improve data availability and duplicate transaction content across providers. The separation of duties and low barrier to entry creates a fairer landscape for all network participants to extract MEV and prevent control from pooling to one or a few centralized entities.



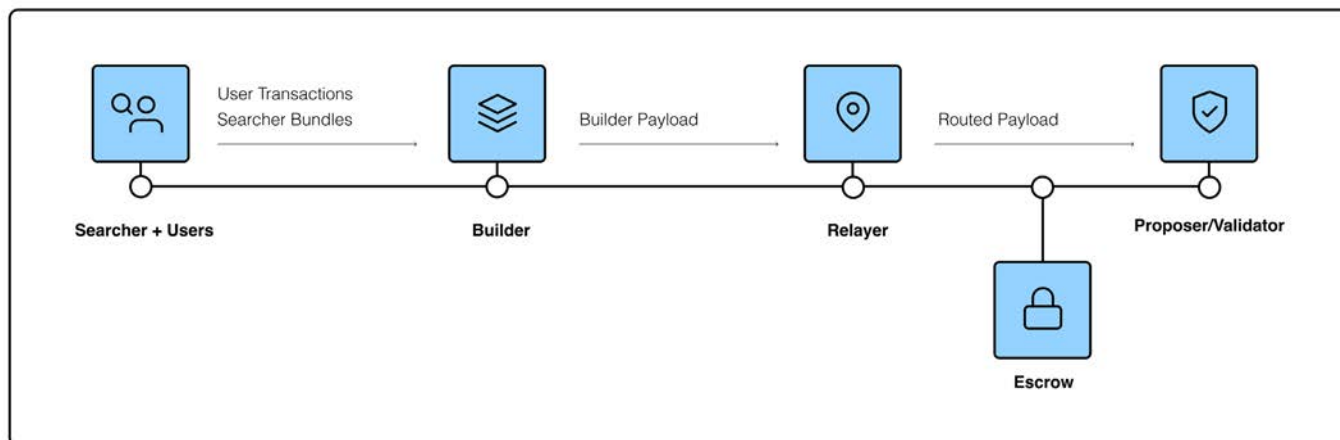


Figure 1: MEV-Boost Design

Source: Osprey Funds

### Why does this matter? MEV is THE incentive structure for consensus. Watch it closely.

After the Merge, Ethereum will convert to Proof of Stake. This changes incentives and how actors in the ecosystem create blocks compared to a Proof of Work environment. We believe MEV will still play a crucial role in supplementing fees as Proof of Work block subsidies disappear and limit revenue for block builders; the question is who now captures it. MEV will be relied on to replace waning subsidies. We see two main scenarios that can develop around the block space market based on varying levels of centralization.

**Scenario 1:** A less centralized, fairer, and accessible block space market: Notwithstanding this market downturn, we reiterate our Bull Case target of ~\$8,400 ETH in three years if the block space market develops into a freely accessible, inclusive ecosystem where various individuals and entities can participate. Accessibility and transaction value growth are different sides of the same coin as a free and decentralized Ethereum attracts value, given its ability to facilitate true decentralization.

We see an 85% probability of the MEV market developing democratically, especially with the introduction of MEV-Boost, the third-party software designed to facilitate an open and transparent market for block space. While it is not a perfect solution, we think it is enough to make a democratized difference and influence the development of the block space market to prevent our more bearish Scenario 2. For clues, one can look to the quick uptake and fast adoption of MEV-GETH, its Proof of Work predecessor. Validators will need additional revenue in Proof of Stake and participating in the MEV-Boost block space market is their best chance at subsidizing their income more efficiently and regularly. We say validators should join the collective – a better market structure for all – especially for the smaller, solo contributors.

Suppose MEV is accessible amongst all parties of block builders and proposers.

- In this case, the network is more efficient, less centralized, and accessible, unable to be controlled by privileged actors and ultimately accretive to long-term token holders.
  - Governance issues, pooled reward risk, censorship and whitelisting problems are mitigated and, as a result, reduce the risk of control by vertically integrated actors.
1. The act of building is more suited for capitalized entities. Separating the builder and proposer roles creates a fairer market for proposers since it does not require as many resources. It also allows solo stakers to participate and receive optimal MEV blocks, just like large pools, to create an open and permissionless marketplace for blocks.



2. Relayers, a new role in the Proof of Stake MEV-Boost model, sit between builders and validators. The coordination role inherits the task of proper routing from builders and confirms block validity and accuracy for the validator. Separation of roles adds objectivity, better aligns incentives and is another attempt to prevent the buildup of control by any one entity. The important point is that anyone can choose to be a relayer, receive a bundle from a builder and route it to the validator.
3. There are downsides to this model, however. For instance, MEV-Boost is an independently maintained piece of software. Suppose there is a software bug, but everyone considers blocks produced by MEV-Boost valid. In that case, a situation materializes where a third-party piece of software, external to the main codebase, could cause consensus on the wrong chain. Still, the pros of MEV-Boost's open and transparent market for block space outweigh the cons.

There is also always a risk that most Proof of Stake actors do not adopt MEV-Boost as the de facto standard for the MEV market and thus rely on the native functionality of Ethereum. If the ecosystem develops in such a way without a mitigating centralization factor, it may lead to the Bear Case scenario we describe in Scenario 2.

Scenario 2: Centralized, oligopolistic, or monopolistic block space market, vertically integrated actor(s): We revert to our Bear Case of \$3,900 ETH in three years if a structural shift toward highly centralized, vertically integrated actors occurs who outcompete all others for MEV. While we see a 15% probability of the MEV market developing into a highly consolidated structure, the ecosystem has downside potential over prolonged periods. A few, or even one, highly sophisticated entity could induce governance and pooled reward risk.

1. With overriding network control over a large pool of validators, one entity could control attestations from validators ahead of other validators. As a result, liquidity could be bifurcated and provide significant validators with an outsized advantage to optimize their MEV profit. The scenario would leave all other validators with a lesser share of MEV and rewards.
2. In a similar vein, control over most of the transaction flow allows an entity to censor transactions that are not as economically beneficial to them. This can lead to a network where certain transactions are given preference or not processed and included in the chain.
3. Centralized validators with significant stake may not extend the longest chain but instead back competing versions and capture MEV across multiple blocks. Doing so could turn into a routine activity if not curtailed. MEV-Boost prevents this type of MEV extraction and does not consider multi-block MEV a valid strategy.
4. LIDO, a liquid staking protocol for Proof of Stake ETH, is one entity that may fit a future profile of an overly centralized entity endemic to the network. LIDO distributes ETH to stake to different node operators and currently controls about 32% of staked ETH on the protocol. This number will continue to grow. Although LIDO distributes ETH to many entities for staking, they still centrally engage in selecting healthy validators, adding to objectivity concerns.
5. Risks of LIDO staking dominance include future situations where they collude with other staking operators to act solely in their interests, execute chain reorganizations or censor transactions to their benefit. Currently, the top 100 wallets control 95% of LDO governance tokens. The LDO token governs all LIDO DAO governance and network decisions.



## Find and Replace

Before EIP-1559, only flash bots (searchers), not miners, focused on MEV and arbitrated the mempool to frontrun existing transactions and identify profit opportunities. Miners did not seek MEV before Ethereum's burn mechanism implementation, as there was enough revenue from fees and block subsidies alone.

In the lead-up to EIP-1559, miners anticipated a future where approximately:

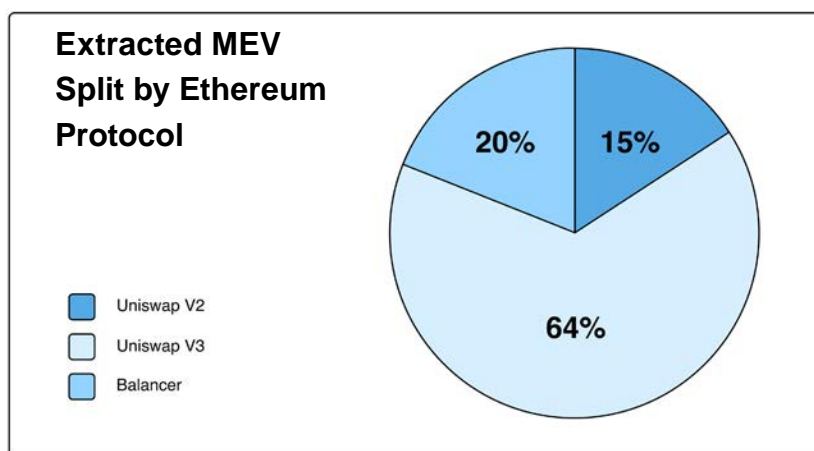
- 80% of network fees per transaction were on track to be burned, leaving them to search for other ways to juice or maintain their revenues.
- Priority fees (miner "tips") to push transactions to the head of the queue were deemed optional after EIP-1559 and up to the individual initiating a transaction on the network, which compounded the miner revenue dilemma.
- As the implementation of EIP-1559 approached, miners started to focus on transaction ordering, inclusion, and exclusion, using priority fees as a determining factor to maximize the value they squeezed from processing each block.

Once Flashbots released MEV-GETH, it quickly gained traction with almost 100% adoption. It solved the issue of miners stealing a searcher's bundle by only allowing trustworthy entities to use the marketplace with a clear history of not taking advantage of the bundles proposed by searchers. There was also social pressure for mining pools to redistribute bundle payouts to their constituents. Payout distribution mitigated economic centralization and dispersed rewards more equitably to other participants in the system.

## Searchers with a Side of Arb: Block Space Bazaar

We dive deeper into MEV-GETH, MEV-Boost's predecessor, to look for hints as to how a future Proof of Stake market for block space could develop.

MEV-GETH is a market for block space developed by Flashbots, and a fork of the Geth client used to run an Ethereum node. It allows miners to delegate finding the most profitable ordering of transactions to a cohort of searchers who compete to win a sealed-bid Priority Gas Auction (PGA). Searchers open private communication channels with miners and, as a result, decrease network load and volatility in gas prices due to bidding wars. There is a symbiotic relationship between searchers and miners. Searchers directly profit if their submission transaction bundle is selected. At the same time, miners benefit from a bid system made possible by MEV-GETH and bring forward the best transaction ordering most beneficial to their operation.



Most realized MEV through means of arbitrage happens in Uniswap's protocol (v2, v3) or Balancer on Ethereum.

Figure 2: MEV by Ethereum Protocol

Source: Etherscan, Osprey Funds; ~1% extracted MEV from other protocols



Since January 2020, \$663M in total extracted MEV has been realized by miners. Over 30 days between April and May of 2021, Ethereum miners made \$140 million from MEV income. The last 30 days of extracted MEV are multiples lower at around \$29M. However, these numbers ebb and flow with market activity and should be considered lower bounds. The true extent of MEV is hard to quantify. Of known activity, during the week of June 6 to 12, there were over ~85K bundles sent to miners by 9,300 searchers. In the last 30 days, miner revenue was improved by 3.7% from Flashbots. The boost is significant and welcomed by miners, as it will become even more important after the Merge for validators.

<b>\$662,898,385</b>	<b>\$29,083,861</b>	<b>\$94,000</b>
Total Extracted MEV	Last 30 days Extracted MEV	Last 24h Extracted MEV

### Cumulative Extracted MEV - Gross Profit

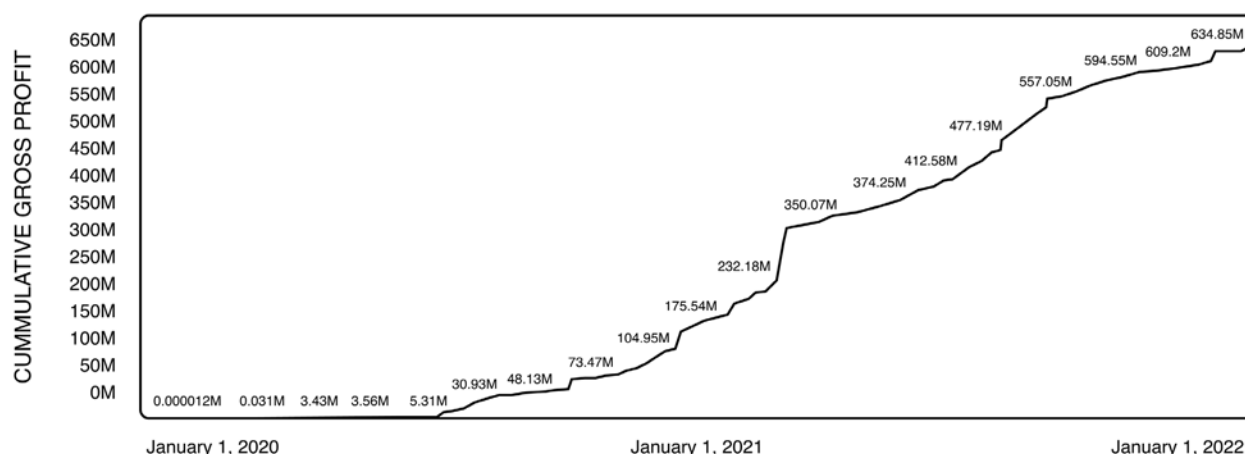


Figure 3: Cumulative Extracted MEV

Source: Flashbots

### Percent of Total Block Gas Used by MEV Transactions

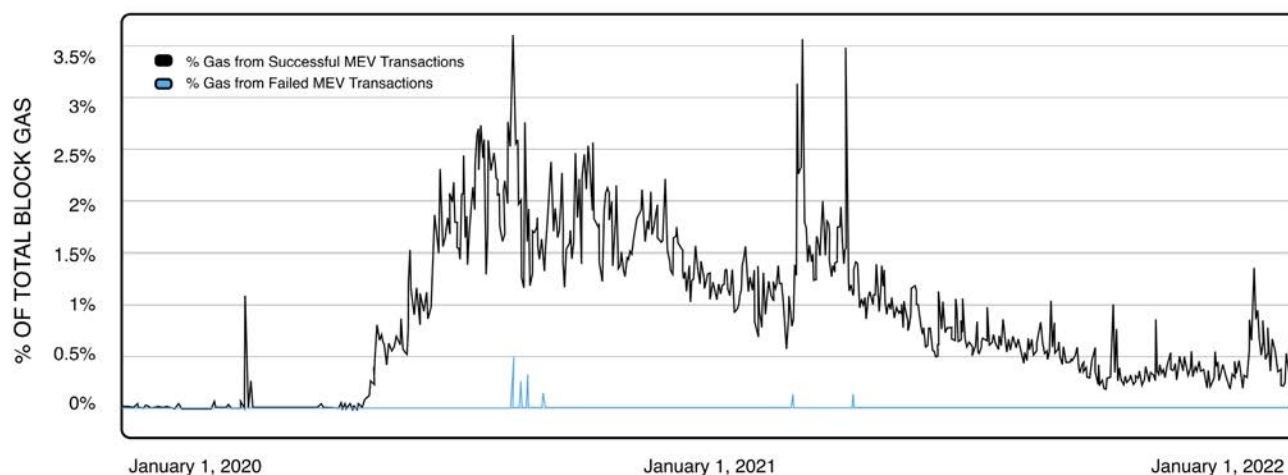


Figure 4: Percent of Total Block Gas Used by MEV Transactions

Source: Flashbots



MEV-GETH also allows searchers to submit transactions without publicly revealing them in the mempool to prevent their transactions from being frontrun by other market entities. While generalized MEV strategies were initially executed by bots opportunistically lurking in the temporary transaction queue, most activity now takes place using the MEV-GETH marketplace. Flashbots developed the transaction bundle marketplace to democratize MEV, decrease censorship of transactions, lessen unnecessary on-chain congestion through efficiency, and ultimately level the playing field and create a system with no privileged actors (information access for all).

## Market of Hidden Bots

Searchers detect profitable opportunities across a multitude of different strategies. Some do this by monitoring the mempool where transactions lay publicly visible for a short period. MEV strategies range from frontrunning by copying transaction details and including a higher gas payment to execute first, otherwise known as a sandwich attack, decentralized exchange (DEX) arbitrage, liquidation opportunities, or even just-in-time liquidity strategies. Searchers look for pending swaps, provide liquidity to the pool, get a cut of the trading fee and pull liquidity out in the same block. Other long-tail strategies aren't as popular but are still used by searchers and may be kept secret due to their success.

The average profit for searchers per MEV opportunity will vary widely due to different market conditions, scales with transaction volume and a searcher's ability to find opportunities. Currently, we estimate that it hangs around .013 ETH on average since the average miner profit was around \$200 per Flashbots block during the week of June 6 to 12. We assume \$1,500 ETH over the week. Searchers will give 90 to 95% of their revenue to miners to have miners select their transaction bundle, as mentioned previously. While miners receive the largest share of MEV revenue, there is enough to support a healthy market for searchers and builders.

There was a recent example of a searcher (bot) obtaining MEV in March 2022. The bot focused on a \$24 million stablecoin swap of USDC to USDT and received 147 ETH (\$446K at the time) from the arbitrage opportunity. Another notable win for a searcher in October 2021 where a bot took home 30 ETH from a \$2M arbitrage opportunity. Some of the known, all-time most profitable MEV transactions by gross profit were from liquidations on Compound executed by searchers when collateralization ratios fell below set thresholds. Searchers are paid a fee to find and execute liquidation opportunities to keep DeFi lending protocols functioning. For example, a transaction occurred in February of 2021 where the searcher earned a gross profit of \$3.26M.

There is a lower bound of \$650M+ profit from easy-to-spot, known MEV strategies recorded by Flashbots to date. However, this number is likely much higher since all MEV strategies cannot be known and are usually held secret by those executing them, as noted earlier.

While the MEV market in Proof of Work remains lucrative for those playing the game well, the market structure for MEV may even become more competitive after the Proof of Stake transition, especially for validators. Variability of rewards and the lack of block subsidies will cause many more validators to look for additional rewards. While searchers will continue competing for profitable strategies, MEV will be diluted among a wider distribution of validators compared to the number of miners in the system. We'll dive into reward variance in a bit.

## Back to its Roots, Decentralized for All

While MEV-GETH unleashed a fairer way to access dormant alpha in the context of Proof of Work access for all market participants, there will be intensified MEV risks associated with the upcoming Ethereum merge in Q3 and transition to Proof of Stake. The most significant MEV issue is our proposed Scenario 2 – the potential drift toward vertical integration of the transaction supply chain – mainly driven by the number of validators in a Proof of Stake regime compared to mining entities in Proof of Work.



Three main issues arise as a result:

1. Governance issues / pooled rewards;
2. Censorship; and
3. Whitelisting + widening of validator reward variance.

## Governance Issues / Pooled Rewards and Censorship – The Staking Pie is Growing

The leading liquid staking solution on Ethereum, LIDO, has already achieved a 32% share of staking on the network with 4.1M ETH and a 90% share of liquid staking overall. The cost of incorrectly setting up an individual validating node can lead to penalties, slashing and loss of ETH. Illiquidity is another risk factor for entities or individuals deciding whether to stake their Ethereum without a liquid staking option.

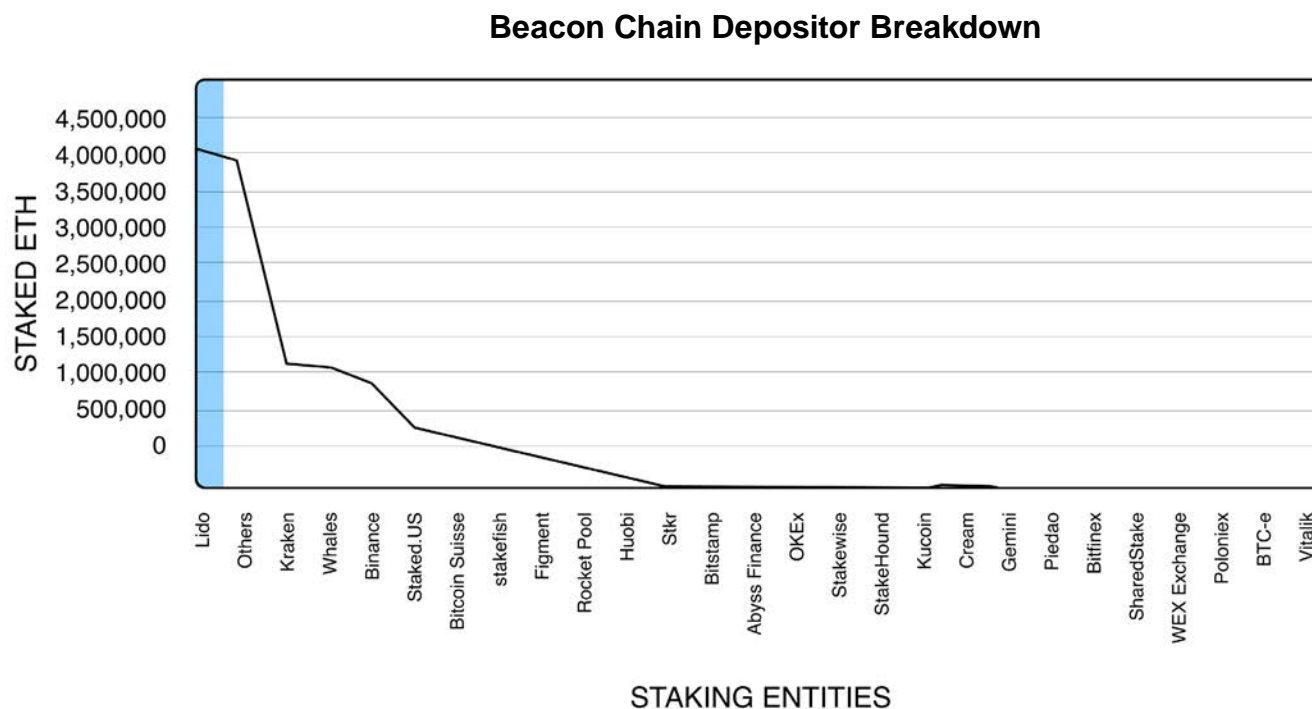


Figure 5: Staking Entities on the Beacon Chain

Source Data: Etherscan

Use of stETH from LIDO, the 1:1 token for staked ETH, is widespread on DeFi platforms and unlocks user liquidity compared to staking directly on-chain. It is easy to acquire and use as a point of leverage for other positions. 50%+ control of the staked Ethereum supply isn't far off. Yes, the protocol is considering ways to mitigate its control over the network via protocol governance solutions. Some arguments make the case that "at least it's not Coinbase" (a large organization with centralized control), but that doesn't change the issue – a growing, increasingly centralized staking entity critical to Ethereum itself.

Censorship could also become an issue as more of the transaction supply chain is vertically integrated. If the landscape shifts toward an oligopolistic model with only a few main validators, those that build blocks could be more apt to censor and omit transactions that are not economically favorable/optimal.





LIDO governance proposals are in the works to limit its own ETH-staked dominance. The protocol understands that doing so is positive for the network, such as limiting their percentage of total staked ETH, delegating governance votes, allowing operators to permissionlessly join its validator set, and providing a mechanism to penalize malicious validators. They are also working on a timelock between governance voting and execution as a safeguard to avoid automatically implementing poor governance ideas. Currently, execution happens immediately after a governance vote. While these actions are noble and promising potential mitigants, it is still unclear how these will ultimately affect staking dominance.

## Whitelisting and Reward Variance – Unlucky Few

There is no perfect solution, and while Proof of Stake can resist MEV centralizing forces, validator rewards will vary more in a Proof of Stake than in a Proof of Work regime since there are many more validators (many hundreds of thousands). Not every validator can continuously validate blocks for payment but instead will spend time attesting to blocks validated by others. Rewards will be variable based on factors like the amount of staked ETH. Solo validators will rely on statistical luck to validate in hopes of receiving the most rewards; however, they may be unlucky and receive fewer rewards out of the complete set of validators over a year.

In the Proof of Stake world, 400K entities are currently validating on the Beacon Chain. We assume this number will increase, but:

- There are still too many validators to identify those who remain trustworthy and will not steal searchers' bundles.
- It is impossible to create an allow-list for the honest, validating entities like how current miners are tagged for inclusion.

Not correctly identifying truthful validators creates issues since too many individual validators will validate independently separate from staking pools (hundreds of thousands compared to 10s of mining pools). Reward variance will widen as a result.

- Those in staking pools or with large stakes will receive an outsized portion of payouts, while those who validate solo will not have a chance to propose blocks as often.
- These solo validators may not care to follow the precedent of not stealing the searchers' bundles and jump at the opportunity for additional MEV given fewer chances to propose blocks.
- Oligopolistic network control, and ultimately, one primary vertically integrated entity with a 50%+ stake may form.

@Pintail\_xyz studiously reviews an ideal validator reward scenario and assumes 200k validators.

- The luckiest 1% of validators receive a 2.1% greater reward than average; and
- The unluckiest 1% of validators receive a 1.7% smaller reward than average.



## Ideal Annual Validator Reward

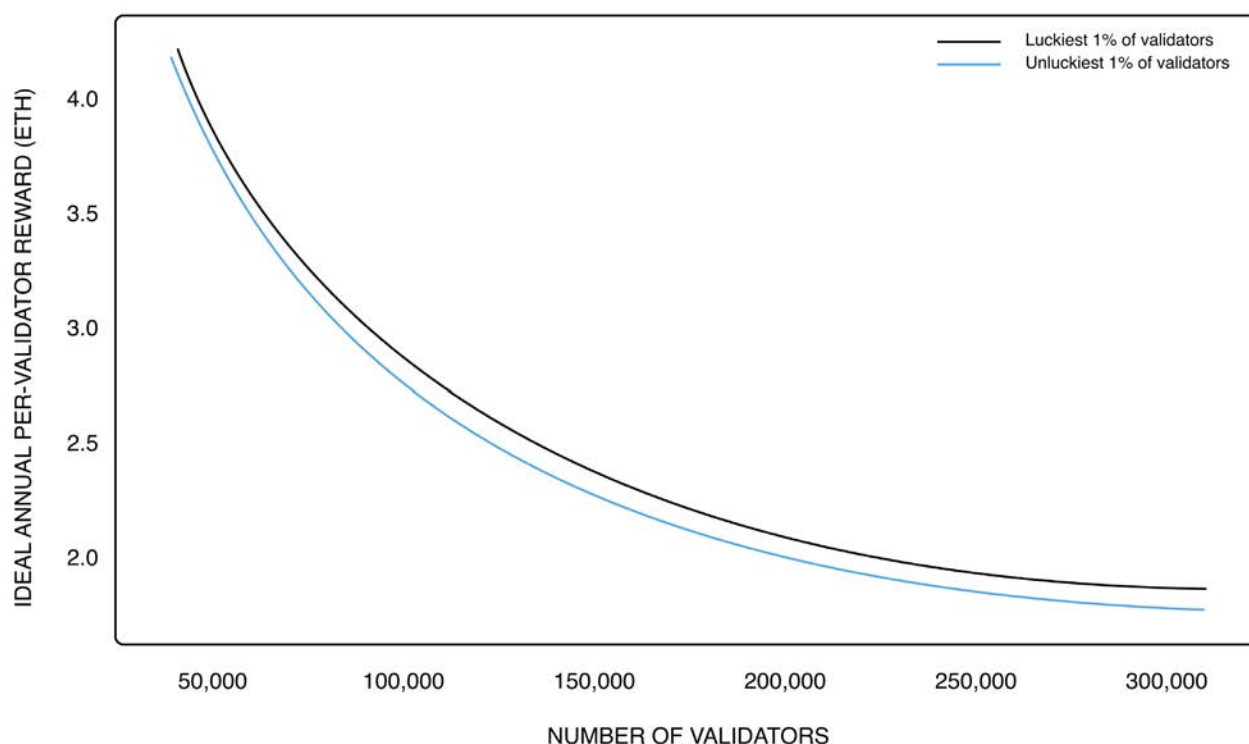


Figure 6: Ideal Validator Reward Variance

Source: @Pintail\_xyz

However, since the Beacon Chain penalizes negative network behavior, in a more realistic world where validator uptime is not 100%, Pintail calculated those validators with 99% uptime can see their rewards drop by .9%, and those with a slightly lower 96% uptime could see rewards drop up to 3.6%.

## Predicting Future Flows

Users and wallets will always follow short-term network incentives. As a new Proof of Stake era is entered, builders may compete to pay for order flow to process more transactions on the network – essentially an arms race to pay users and gain a competitive advantage. Doing so can eventually create dark liquidity pools that bifurcate global liquidity and price. One entity can control network activity and centralize control over the supply chain. Developers recognize payment for order flow could be the model of the future and believe:

- A centralized system that includes not just searchers and validators, but users/wallets, must also be considered.
- Flashbots, while working on MEV-Boost, is also working on a system that includes user payment for order flow in the equation, as they realize they may have to embrace the reality that the block space market may naturally develop this way.



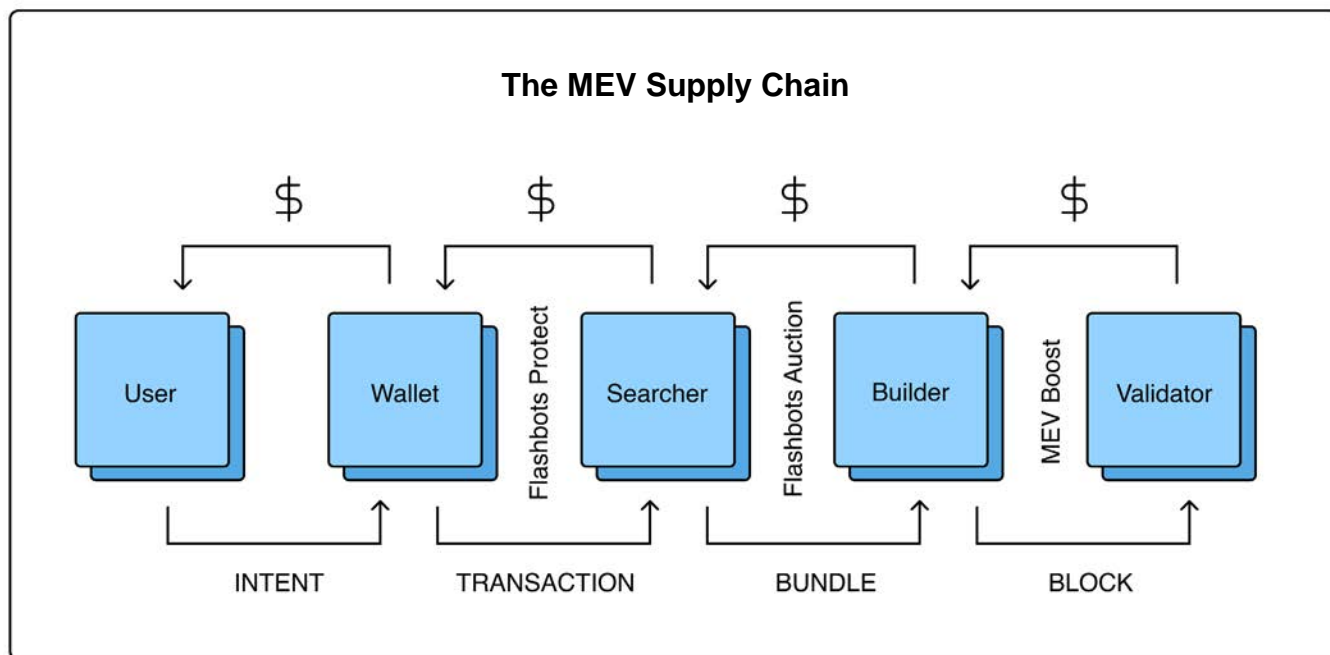


Figure 7: MEV Supply Chain (" \$" = Payment for Order Flow)

Source: Flashbots

## Solutions for the Next Level

Finally, Layer 2s will also be an Integral Part of Ethereum Proof of Stake. Two leading solutions that currently exist and for Arbitrum and Optimism. MEV on L2 chains will become critical as searchers compete to refine their strategies for cross-chain or L2-specific MEV. Both solutions take a different approach to the MEV issue.

- Optimism Rollup - FSS (Fair Sequencing Service) is a solution created to thwart MEV. Transactions are initially sent to a smart contract, in which they're then sorted by arrival time in the mempool. If most nodes receive one transaction first, they will be processed in the order received, which overrides the current method of ordering transactions for MEV.
- Arbitrum Rollup – MEV Auction Program bifurcates the roles between validators and sequencers. Once transactions are confirmed, they cannot be ordered. The sequencer role instead addresses ordering.

Don't sleep on MEV... you'll need it.

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