Tungsten Whitepaper

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Abstract

More than 700 million people today do not have access to electricity [1]. This is a very low estimate, as the definition used in international statistics adopts a very low cutoff for what it means to 'have access to electricity' (defined as having an electricity source that can provide very basic lighting, and charge a phone or power a radio for 4 hours per day). Setting up infrastructure to connect houses previously unconnected is expensive, energy consuming, and usually limited in range. The Tungsten network is a decentralized network that can facilitate peer-to-peer wireless electricity transfer at a fraction of the cost. As wireless electricity advances technologically, the Tungsten Network could enable people everywhere to have electricity access without needing to set up expensive infrastructure and get houses on the grid. The Tungsten network enables electricity pylons to send and receive infrastructure over long distances. Currently, people look to renewable energy farms as good investments but getting the electricity to places that need it becomes a challenge. The Tungsten network will be powered by a native token incentivizing the creation of a marketplace between small scale energy providers and consumers. With the power of the network, we bring decentralization into an industry that is currently run by monopolies. The vision for Tungsten is electricity that is available everywhere, fueled by competition, and provided to consumers at lower costs.

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1 Introduction

The Tungsten Wireless network provides unidirectional transfer of radio waves between two different wireless devices through a network of independent providers that does not rely on a single coordinator. In this network:

1. Devices pay to send and receive electricity
2. Miners (both the ones who send electricity and those who act as a go between for facilitating electricity transfer) earn fees from transactions.
3. Miners earn tokens for the number of Tungsten devices near them to incentivize the growth of the network.

Tungsten gives a way for producers to create energy where it is most efficient instead of having to think about building expensive infrastructure to get the energy to the people who need it. Tungsten provides the initial steps to get to a future where everyone can get electricity, affordably regardless of where they are in the world. Peer-to-peer systems will, in the future, enable this.

Decentralization is starting to become less of a feature and more of a necessity in many industries in the world today. Many companies and industries are making the shift from centralized systems to decentralized ones. Peer-to-peer networks that incentivized competition keep prices lower and more competitive so the users benefit the most at the end of the day. Networks like Ethereum show the value of decentralized transactions. Many existing services are being replaced with their blockchain versions (ie. Helium for Internet, IPFS for File Storage, ENS domains for DNS domains, etc). Networks in the real world are harder to decentralize because they need entire systems and hardware coordinated in a way that makes them incentivized in the short term and sustainable in the long term. Tungsten proposes a phased plan for wireless, peer-to-peer electricity access.

1.1 Key Components

The Tungsten Network consists of various hardware to facilitate the wireless transmission of electricity, outlined here.

1.1.1 Sending Pylons

Tall structures similar to those used for wired transmission will serve as sending pylons. Connected to a power source and an adjustable rotating top, they can send electricity up to 30km to the nearest relay with minimal loss to give electricity access over long distances.

1.1.2 Receiving Pylons

To receive waves to convert into electricity, one receiving pylon may be set up to serve a larger community. With a rotating top, they can catch radio waves from different directions to provide access to electricity in remote areas.

1.1.3 Antennas

Antennas will be used to get electricity from the receiving pylons to individual houses. With lower energy capacities and adjustable heights, they can be smaller devices planted on top of individual homes to enable users to send electricity to within the network and receive electricity from the main receiving pylons.

1.1.4 Relays

Relays between sending and receiving pylons will be used to redirect electricity to different pylons and antennas. With relatively lower costs than pylons, setting up more relays can help more homes get access to electricity at the fraction of the cost that was previously possible.

1.1.5 Tungsten Network and Fee Structure

The Tungsten network will connect devices on a network allowing them to communicate and effectively route electricity from point A to point B. The network is designed to reward early adopters of the technology by rewarding users with antennas for growing the network and contributing to electricity access for all. The inherent nature of the network allows power suppliers to be paid easily, users to become suppliers, and people to receive and pay for their electricity in a trustless and reliable manner.

1.2 System Overview

An overview of the system, highlighting function and benefits of the Tungsten Network.

- The Tungsten network is a decentralized wireless network that, in the future, can facilitate transactions and fees between long distances.
- Devices take the form of antennas containing a radio chip which tracks electricity sending and receiving activity. The hardware allows the spending of tokens by small scale electricity generators to send electricity to within the network.
- Pylons, relays, and antennas are connected on the Tungsten network to coordinate the degree of transmission to effectively maximize the use of the infrastructure - getting electricity to as many receiving antennas as possible.
- In order to facilitate wireless transmission, a line of sight must be maintained between the sending device and the receiving device. The devices on the network come at an adjustable height that gets coordinated and programmed on the network so that electricity can be transmitted at reasonable efficiency.
- Miners earn tokens by providing wireless electricity. When electricity flows through an antenna to get to a final destination, the individual with the antenna earns tokens for helping facilitate electricity transfer. Generators and renewable farm owners earn tokens based on the amount of electricity they supply the network.
- The receivers of electricity pay fees depending on the amount of electricity and distance travelled which covers costs paid to electricity generators and individual antennas. This cost is estimated to be 60-70% lower than buying form the grid (in most cases involving developing countries and remote areas, connecting to the grid is not possible).

2 Use Cases

2.1 Renewable Energy Projects

As the race for sustainable electrification ramps up across developing nations and continents, new wind, solar, and hydroelectricity plants are constructed every year. In South Africa, more than 95 sustainable energy projects have been established to date since the commencement of a nationwide initiative to encourage independent power producers. While the program is certainly a step in the right direction to meet Africa's energy needs sustainably, 49% of projects get cancelled due to complications with energy transmission [4]. The United States, with a population of rough 350 million, would require $4.5 trillion USD in additional wired transmission infrastructure to accommodate an entirely renewable future[2]. With Africa's population at a staggering 1.3 trillion and rapidly growing, it's clear that wired electricity simply won't be an option for an electrified African future.

With Tungsten, we're drastically decreasing electricity transmission costs, allowing more people to have access to sustainable, affordable and abundant electricity. One recent project, the Batoka Gorge Hydroelectric Power Plant along the Zambezi River, has drawn Tungsten's attention. The dam is located on the border between Zambia and Zimbabwe, but due to its remote location, it has required the construction of hundreds of kilometers of transmission lines to various substations across the two nations. Zimbabwe's cost of transmission line construction is estimated to be at minimum $213,000,000. With Tungsten's technology, we can bring this cost down to just $20,000,000, an over 90% reduction in price.

2.2 Remote Communities

In many cases, the costs associated with connecting a few rural villages hundreds of kilometers away from the nearest grid are too large to ever justify providing them with power. The result is millions of people living in small communities condemned to a life of electricity poverty. Even when provided with placeholder solutions like home solar panels and microgrids, the amount of electricity produced is relatively little, and production times are strictly limited to the day. People may be able to power a few lightbulbs, but 12W solar systems won't be enough to power refrigerators or electric tools.

With Tungsten, we envision a future where the cost of wireless electricity transfer will be low enough to enable individual communities to set up antennas and receive energy wirelessly from dozens of kilometers away. The antenna will provide them with sufficient electricity to power the entire communities' needs, enabling them to purchase tools without having to worry about availability or affordability of electricity.

2.3 Remote Power Generation

One of the main concerns among engineers and governments is the location of renewable energy sources. Projects need to be where the wind, sun, and water are. This remoteness is often a deterring factor when considering investing in a project, as transmission costs lead to a heightened payback period. On a smaller scale, individual entrepreneurs seeking to develop small scale solar farms face challenges in connecting to the grid from remote locations.

Tungsten alleviates these concerns by providing an energy transfer solution that requires comparatively little investment and minimal maintenance concerns. By transmitting wirelessly, we cut out the cost of wired pylons set up in intervals, wires and substations. Maintenance cost are significantly lower as individual pylons do not need to be inspected and breaking points for large-scale outages are almost entirely eliminated. Tungsten's network is also minimally impacted by weather events, meaning that power can be relied on rain or shine. In the case of wired transmission over deserts, for example, sandstorms often interfere with wires and cause inefficiencies that have significant impact on power output over time. With Tungsten, such environmental concerns are no longer an issue.

3 The Tungsten DWN

The core components of the Tungsten Decentralized Wireless are outlined below.

3.1 Participants

3.1.1 Devices

A Pylon is a device that is able to communicate with both antennas and other pylons to provide wireless electricity. Set up by governments and energy providers as a cheap alternative to power lines, these pylons can get electricity from point A to point B at a fraction of the cost of setting up powerlines. Designed to convert electricity to radio waves, sending pylons can transmit large amounts of energy over long ranges to get electricity to remote areas.

3.1.2 Miners

People with independent renewable energy farms can set up a sending pylon or an antenna to circulate their energy through the network. The energy consumed by the network can then be paid for by consumers of the energy.

Both consumers and providers can provide wireless network coverage to the Tungsten network via purpose-built hardware, called Pylons which provide a long-range bridge between energy sources . Users join the Tungsten network by buying either an antenna that is supplemented by a larger pylon or by buying a pylon. People with antennas may act as go-betweens for relaying electricity to further locations.

3.1.3 Relays

Relays are rotatable devices connected on the Tungsten network designed to help direct electricity and accurately pay everyone involved on the network. In locations with a sufficient number of antennas, relays can pay several Miners to obtain enough copies of a packet to geolocate a Device without needing satellite location hardware. Relays are responsible for electricity transfer over the distances not covered by the sending and receiving Pylon. Meter functions on the relay confirm the distance electricity has travelled to reach the correct destination, helping to decide what miners should be paid for their services.

3.2 Sending Pylons

Tungsten uses much of the same technology that can be found in traditional antenna and radio wave technology. There are three key structures underpinning the Tungsten system: antennas, relays, and rectifying antennas (also referred to as rectennas). Tungsten antennas are installed on-site at remote renewable energy projects, whether that be solar farms in the desert or wind farms in the jungle. Depending on surrounding geography and the transmission needs of the project, antennas could be installed on tower to ensure line-of-sight capabilities[5].

Tungsten sending pylons work similarly to existing antenna technologies. Antennas receive DC electrical power, which is the fed into an electric dipole. The oscillating charges in the dipole produce electromagnetic radio waves that are sent to either a relay or directly to a rectifying antenna in the system. Radio waves are omnidirectional in nature, leading to a problem in electricity transmission accurately between two points. To ensure the efficiency and the unidirectional integrity of the system, a collimator is used. These devices function to concentrate the wave to ensure there is minimal energy loss from dispersal of the wave.

Tungsten has a variety of in-lab and on-site tests to carry out before determining an accurate cost for each antenna, taking into consideration cost of materials, efficiency metrics, and installation costs. However, from preliminary conversations with industry consultants, we estimate such an antenna would cost $7,000,000 to $9,000,000 USD.

Tungsten relays serve to redirect radio waves further along into their route without requiring more cost intensive antennas and rectifying antennas. Relays do not require any electrification and are generally easier to erect in remote locations due to their minimal technological requirements. They allow for the redirection of radio waves, meaning that there are no prohibitive geographical challenges for Tungsten - we can transmit through deserts, around mountains, and over oceans.

Current limitations around conversion from electricity to radio waves limit restrict conversion efficiency in sending pylons to approximately 70%. One of Tungsten's development goals is to increase this efficiency to a level comparable with traditional wired transmission lines, which means an improvement to 95+% efficiency[3].

3.3 Relays

Relays are the integral part of the Tungsten network. They facilitate the redirection of radio waves, whether that be in cases of natural obstacles or urban populations requiring maneuvering to reach. Tungsten relays are the optimal solution for the redirection of radio waves as they are cost-effective, hyper-efficient, and do not require any electrification to run. They can be installed in remote locations and require little maintenance, making them optimal for extreme geographic conditions.

The relays between sending and receiving pylons would be erected on a case to case basis, depending on the specific needs and geographical necessities of a project. In terms of construction, they are made up of a vertical tower holding up a sheet of dielectric material, which includes dielectric mirrors and a large variety of metals. Such a material would be finalized after field tests for metrics on efficiency, cost-effectiveness, and weight. The relay would simply be angled to reflect radio waves in a particular direction, and multiple relays could be chained together based on the needs of the project.

Due to the relative simplicity and non-electrification of Tungsten relays, a rough estimate price-projection is $500,000 USD. This pricing is subject to change based on the costs of raw materials, especially in cases of metal markets, and the particular material chosen for each relay.

3.4 Receiving Pylons

Tungsten receiving pylons are again utilize pre-existing antenna technologies to harvest incoming radio waves into DC electricity. As a radio wave comes into contact with the electric dipole, opposite charges are produced at each end of the dipole. These oscillating charges are then converted into electricity which is fed on to the local municipal grid, ideally powering major urban centres.

Again, depending on local geographical constraints, receiving pylons may need to be installed on elevated platforms to ensure efficient transmission of radio waves. Due to the collimation of radio waves conducted in the sending phase of the Tungsten network, receiving pylons have a much higher efficiency rating, approximately 90%. Of course, there are still further technological breakthroughs to be made before reaching a 95+% conversion efficiency of radio waves to electricity.

Cost estimates are once again limited, but are estimated to be approximately the same as the sending pylons, $7,000,000 to $9,000,000 USD. Readers are reminded that as the principle of economies of scale begins to play a larger impact on Tungsten's infrastructure, costs will be driven down significantly.

4 Transactions

Transactions on the Tungsten network provide functionality that enables address-to-address transfers of protocol tokens, similar to many existing blockchain networks, but also provide a set of primitives that enable core functionality that is critical to the operation of a DWN.

4.1 Overview

On the Tungsten network, miners receive Tungsten native tokens for facilitating electricity access and contributing to the growth of the network. Electricity producers get fees from the electricity they send across the network. Consumers of electricity pay on the decentralized Tungsten network which allows transactions to be made restlessly even across borders.

4.2 Types of Fees

The types of fees on the Tungsten network and solutions to building in economic incentives for mass adoption of the solution.

4.2.1 Transport Fees

Fees for electricity will increase as the distance from the power source increases. With larger distances, electricity loss will increase and as a result, it will cost more to get the same amount of electricity to a home that requires more relays in between. The nature of removing the grid from the equation will reduce electricity costs for the end user by 60%. Furthermore, the peer to peer nature of the network allows neighbors to trade electricity within their communities, minimizing transportation distances.

4.3 Transaction Fees

Transaction fees are paid to electricity producers and anyone owning an antenna involved in the transportation process in getting electricity from point A to point B. The fees earned are directly proportional to the amount of power that is transmitted through the device. The network is designed to align consumers and producers to continue producing electricity to supply the network in a way that is financially advantageous to producers while providing significant cost reductions to the consumer.

5 Future Work

Beyond the pilot pursuits of Tungsten, we envision a future in which wireless electricity can be transferred efficiently and affordably to everyone in the world in a decentralized way to incentivize the creation of more renewable energy projects and effectively phases out the need for a centralized grid. Electricity companies are monopolies that often take advantage of the consumers' lack of options. With Tungsten, we're working towards a future where even something traditionally centralized like energy can be provided at competitive prices, bringing more producers into the sector and helping work towards a sustainable future.

In the future, we imagine all homes to be directly connected to the Tungsten network. Having an antenna will not just serve as a means of receiving energy - it's the way in which people can make money off of growing the network. and contributing to our vision of a fully powered world.

This paper presents a well thought-out design for building the Tungsten network. However, we consider this to be just the beginning of the engineering and mechanisms of the Tungsten network. The integration of real world hardware with a blockchain is a unique innovation originally mass adopted by Helium. When attempting to solve the issue of electricity access, we saw their model as one of the most efficient ways of aligning incentives to advance a global agenda.

There are several initiatives that we either have or intend to undertake, including:

- Explore the potential for the delivery of electricity through other methods including 5G to help more people get electricity access.
- Research and implement a consensus mechanism to keep the network secure as it grows.
- Analyze the incentives system to create more incentives for governments and power suppliers to undertake large financial costs to join the network.
- Create and release wireless specifications for sending and receiving pylons.
- Manufacture devices with modules for easy coordination with other devices to allow for easy communication.
- Provide devices at smaller costs to the consumer with a payback period to make it easier to finance the large investment
- Explore the interconnectivity of antennas that could significantly reduce costs of electricity transmission.
- Investigate the deployment of a smart contract environment beyond the basic DWN primitives.
- Continue work on minimizing errors and points of failures on the network given limited maintenance and large structures in unstable areas.

6 Acknowledgements

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