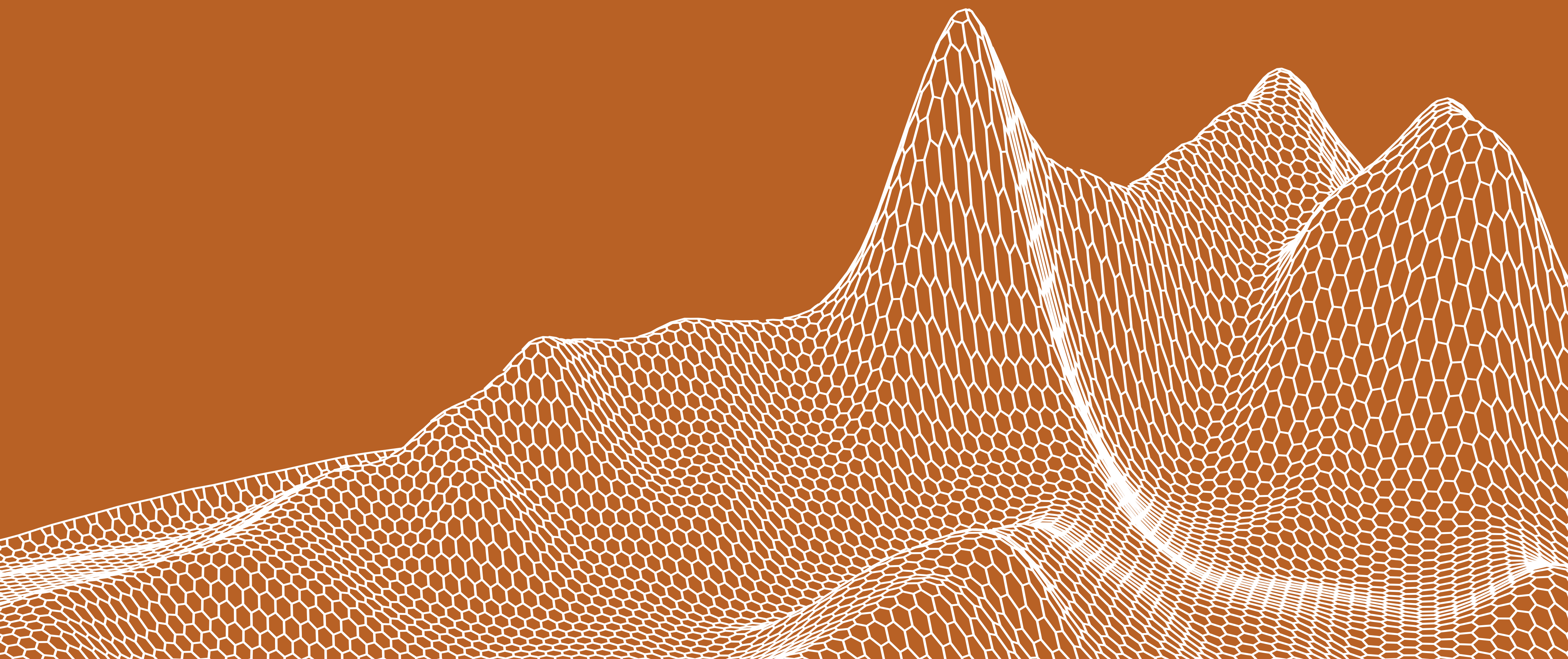
REACH PROJECT

# Mongolia's Renewable Energy for Rural Access Project: Providing Electricity to Nomadic Herders



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# CONTENTS

Background: Electricity for Mongolia's Hardest-to-Reach Population 4

The REAP Structure 8

Local Administrative Networks 13

Quality and Standards 17

Private Sector Participation 20

Cost and Financing 23

Checks and Balances 26

Lessons Learned 29

# Background: Electricity for Mongolia's Hardest-to-Reach Population

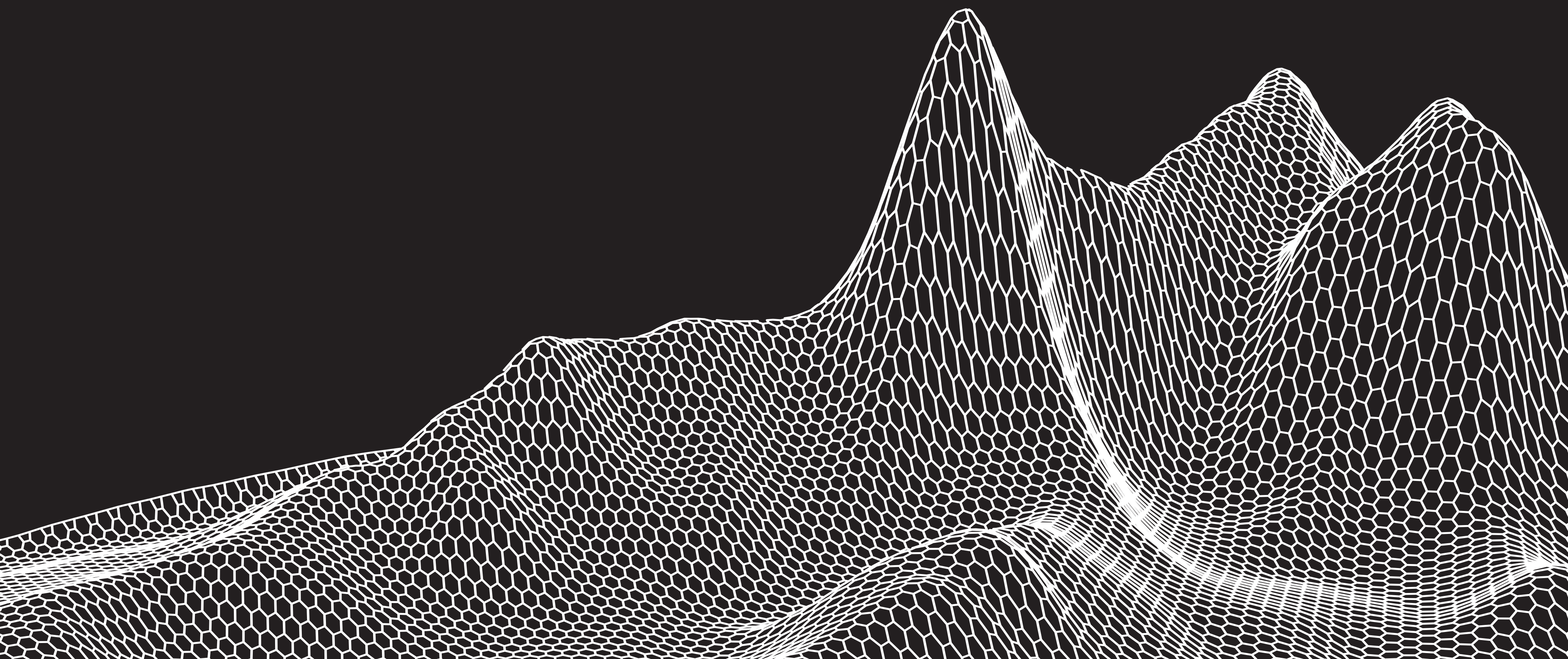


FIGURE 1. Solar panels have to reach the outskirts of rural Mongolia

For nomadic families practicing traditional herding in rural Mongolia, accessing essential services remains a difficult endeavor. The nomadic form of settlement across the country's austere terrain in the context of its challenging climate has typically rendered conventional fixed-line services—including electricity and telecommunications—impossible to deliver. Until recently, most Mongolian herders relied on candles for lighting in their *gers* (yurts), and information traveled at the speed of the fastest horse or vehicle. However, the development of off-grid delivery mechanisms, including solar home systems (SHSs), has spurred global initiatives to bring electricity to remote populations at substantially lower costs. The Renewable Energy for Rural Access Project (REAP) aimed to do just this by delivering 100,000 SHS units to nomadic families from the government of Mongolia and the World Bank. Beginning in 2000, the government's national 100,000 Solar Ger Program, using a combination of self-procured and donated SHS units, delivered approximately 33,000 units to herders by leveraging local financing, existing knowledge networks, and government distribution channels. After the project stagnated in 2006, the World Bank restructured the project under REAP to include cost-recovery mechanisms, quality standards, and private-sector participation in retail channels to support the effective governance of REAP's implementation. At the project's close, just over a decade after the first units were delivered, REAP surpassed the 100,000 delivery target, providing electricity to over 70 percent of nomadic herders across the country. In that time frame, the landscape of nomadic life has been completely transformed. The growth of private SHS manufacturing and accessory dealers made possible by widespread adoption has made appliances from LED lighting and satellite TV to refrigerators and mobile phones indelible fixtures of nomadic life. Today, the ubiquity of SHS units ensures Mongolia's nomadic herders have reliable access to electricity, thanks to the power of the sun.

## THE LAND OF THE BLUE SKY

Mongolia—the Land of the Blue Sky, as it is traditionally referred to—is a nation with a unique terrain. Bordered by Russia to the north and China to its south, Mongolia is the world's least densely populated country, with roughly two people per square kilometer occupying the steppe, mountains, and desert regions that make up its territory. In these conditions, approximately 30 percent of its population of 3 million actively practice the nomadic ways of traditional herding life across the country, in the *gers* or yurts that have featured in Mongolian life for centuries. From the time of Genghis Khan and the Mongol Empire, herding has been firmly embedded in Mongolian cultural consciousness. However, the rise in Soviet control over Mongolian political affairs forced the growth of urban administrative centers and centralized economic power there.

With the advent of market-based democracy after its peaceful revolution in 1990, Mongolia's capital, Ulaanbaatar, became a thriving metropolis as the country's primary connection to global markets. With growth in the country's mining sector, migration from rural regions has increased significantly to Ulaanbaatar, where over 600,000 herders have moved over the past three decades.[1]

## INSTITUTIONAL CONTEXT

Mongolia's institutions have been essential in managing this transition. The vestiges of Soviet bureaucratic administration and governance systems in Mongolia are both hierarchical and accessible through the territorial division of the unitary state into twenty-one *aimags*, or provinces, 331 *soums*, or districts, and 1,568 *baghs*, or rural subdistricts. Each *aimag* has a capital where an elected governor implements and oversees national policy through the bureaucracy. Every *soum* also contains a *soum* center that serves as an outpost of *aimag* service delivery. This method of governance is uniquely suited to the Mongolian nomadic tradition in which local representation is paramount.

Mongolian herder families travel to their local *soum* center at least once per year in the winter to retain access to services, and thus regularly receive information on social programs and new technologies. In most *soum* centers, a local administrative office, a post office, a primary school, and a branch of the largest national bank, Khan Bank, provide necessary services to herders across the *soum*. Traveling by horse, motorbike, or car, herders conduct financial transactions and access government services at the local Khan Bank. For larger purchases of goods and materials, herder families travel either to the *aimag* center closest to their *soum*, or to Ulaanbaatar for more specific global imports. At each of these governance touchpoints, the national government communicates with herder families.

In Mongolia, over 140,000 households are nomadic, meaning they consistently follow their cattle herds as they feed from lowlands to highlands through summers and winters. With herding as the main industry in rural parts of the country, herder families are located in every *aimag* and have unique compositions of livestock. This practice has its origins in the nomadic tribes that once dotted the Mongolian landscape centuries ago. Although tribal identity has given way to family units, nomadic herding persists as rural families attempt to follow their ancestors' way of life. Herding is thus firmly institutionalized in the country's bureaucratic system.

Since Mongolian independence as a Soviet satellite republic in 1918, the nation has conducted an annual livestock animal census, tracking counts and distributions of herds. According to the latest census data, Mongolia's livestock population numbers over 66 million, composed mostly of inexpensive sheep and goats, with smaller numbers of more valuable cattle, horses, and camels.

While an extensive governance system promotes herders' access to personal and livestock services, Mongolia's geography remains the greatest barrier to effective service delivery. Fixed terrestrial services for electrical power and utilities are not feasible for nomadic families who resettle regularly. Instead, where possible, regional grid networks power Ulaanbaatar and other large *aimag* centers. However, for rural *soum* outposts, large distances between settlements mean the cost of reliably delivering these services to the so-called last mile is typically prohibitive. Without access to the most basic of services, herder families without electricity live traditional lifestyles, with no telecommunications, refrigeration, or even indoor lighting. Without innovative solutions to extend these services, many herding families have had no choice but to migrate to an already-overcrowded Ulaanbaatar, where similar service-delivery challenges persist at its urban periphery.

The city's air pollution is a prime example of the challenges to service delivery in the urban periphery: as herders on the city's mountainous periphery burn raw coal to heat their *gers* in the

[1] Patrick Kingsley, "Nomads No More: Why Mongolian Herders Are Moving to the City," *The Guardian*, 5 January 2017.

winter, toxic particulate matter precipitates into the city, causing smog levels so dangerous that some peripheral ger districts exceed air pollution limits by a factor of 100. As the threat of climate change accelerates declines in herd health, added urban migration pressures will only exacerbate the economic and health inequities that nomadic families face. Delivering these essential services to herders in both urban and rural contexts will remain Mongolia's key challenge in the near future.

## DISTRIBUTING PORTABLE ENERGY

Traditionally, as a result of their nomadic lifestyle, Mongolian herders cannot be connected to an electricity grid. In 2000, only 25 percent of Mongolian herders had access to electricity compared to 80 percent in the *soum* centers and over 90 percent in urban areas. Without electricity, herder populations remained isolated in an increasingly connected world.

In 2000, the government committed to expanding electricity access for nomadic populations in rural areas by launching the 100,000 Solar Ger Program which sought to provide 100,000 herder households (approximately 500,000 people) with clean, reliable electricity. The program aimed to harness one of the country's most abundant resources, the sun, by providing solar home systems (SHS). In the Land of the Blue Sky, the average number of sunny days exceeds 250 days each year. With high levels of incoming solar radiation, in the range of 3.4 to 5.4 kilowatt hours (kWh)/per square meter each day, Mongolia can produce 4,774 TerraWatt Hours (TWh) of solar electricity each year. The SHS distributed by the program included a fifty-watt panel, a battery, a charge controller, and plugs that can support basic DC appliances. With the SHS units, herders could power a satellite radio, charge their mobile phones, and light their *ger* in the evening using clean, renewable electricity. The small, portable SHS units could be carried with herders as they moved with their livestock.

While initially successful, the 100,000 Solar Ger Program faced a number of implementation challenges that stagnated progress and threatened the program's long-term viability. In 2006, the World Bank stepped in to support the program by developing the Renewable Energy for Rural Access Project (REAP), which incorporated the 100,000 Solar Ger Program. The World Bank helped to address some of the challenges the program faced and sought to increase the private sector's role to support the long-term adoption of solar technology among herder populations. By the project's close in 2012, REAP had exceeded its target, delivering over 100,146 SHS units to herder families, providing an estimated 70 percent of herders (500,000 people) with access to clean, reliable electricity. Since the project closed, SHS units have grown in popularity with expanded demand for higher-capacity solar home systems and appliances. According to a professor of engineering and applied sciences at the National University of Mongolia, the program has been so successful that the use of SHS units among herder families is now nearly ubiquitous.

## FACTORS FOR SUCCESS

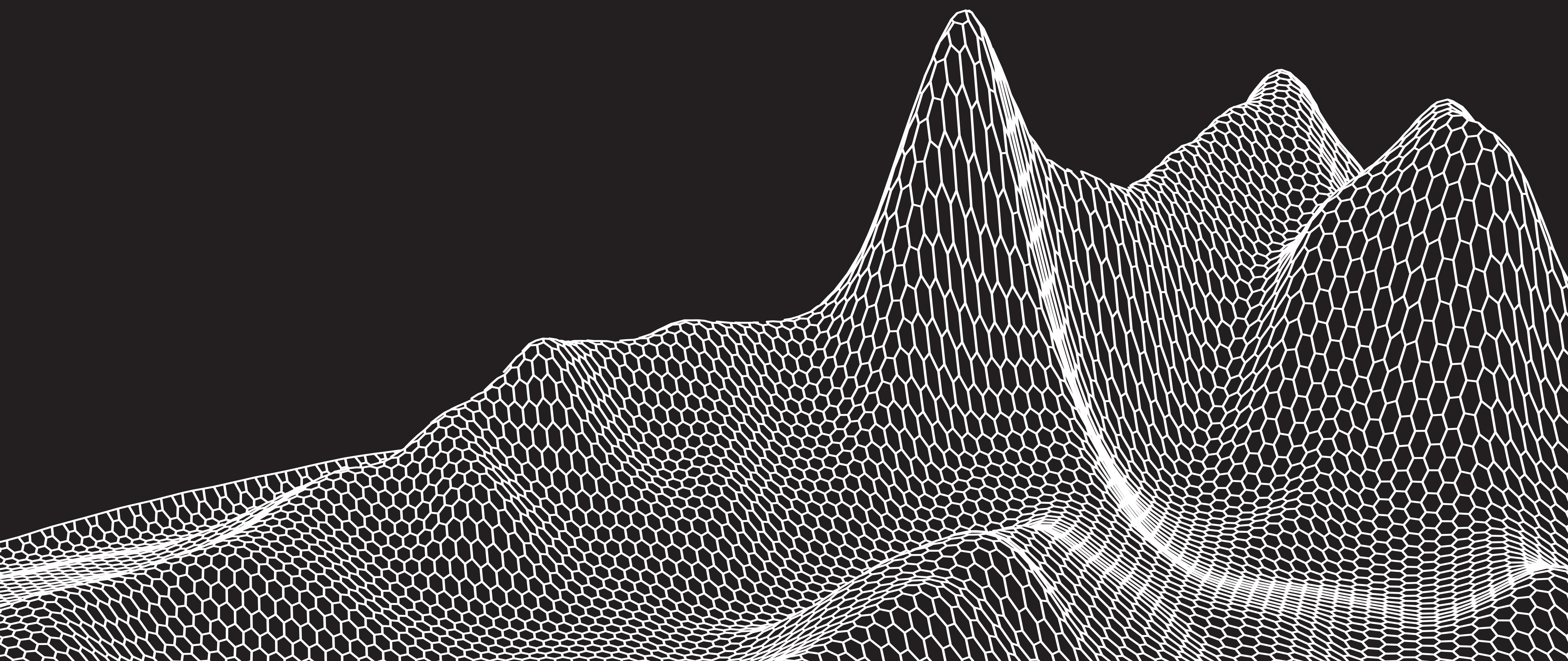
The SHS units that REAP distributed deployed a new technology to complement a traditional lifestyle to improve quality of life. With access to technical support and a guarantee of longevity, the majority of herder families have embraced the technology offered under the project. Today, herders enjoy enhanced connectivity because they have electricity required to communicate using mobile phones and can access media from around the globe using satellite televisions. With improved connectivity, herders have access to market prices and weather forecasts, allowing them to manage their livestock more efficiently. The SHS units provided under the REAP project greatly improved the quality of life for approximately half a million herders. For the first time, herders are guaranteed low-cost electricity to their mobile *gers*. As herders move throughout the countryside, they can be assured that their access to electricity, a basic human right, will be fulfilled.

Through our research, we sought to better understand the success of REAP in providing electricity access to remote, nomadic populations. We uncovered five pillars that were essential to REAP's reach. Notably, the program:

1. harnessed the power of local networks to develop a program tailored to Mongolia's unique societal structure;
2. balanced affordability and cost recovery through bulk procurement and a partial subsidy;
3. established quality standards to ensure reliability and longevity while building trust in new technology;
4. encouraged private-sector participation by establishing localized sales and service centers and by supporting private dealers; and
5. implemented a variety of checks and balances to keep the system accountable and transparent.

Without every single one of these pillars, the project's reach would likely have been significantly diminished.

# The REAP Structure



The disparity in access to reliable sources of electricity between herders and those in urban centers was a major marker of herders' lower quality of life and served as an impetus for growing migration to cities. In a country of long traveling distances and a harsh climate, access to electricity provides unprecedented connectivity, including access to mobile phones, television and digital media, and online government resources. However, the nomadic movement of rural herding families in Mongolia made conventional electrical grid expansion untenable—mobile populations without fixed housing are incompatible with traditional electrical distribution systems. With growing efficiencies in solar technology arriving at decreasing costs, solar home systems (SHSs) became a viable off-grid alternative to serve this unique mobile group of users. The impact on herders' quality of life, envisioned at the outset of the government's 100,000 Solar Ger Program, would be transformative across the country's diverse landscapes.

Prior to the Renewable Energy for Rural Access Project (REAP) and the involvement of the World Bank, the 100,000 Solar Ger program followed a different operating model (Figure 2). The distribution of SHS units was directly handled by the responsible *aimag* government and the program did little to support market development or involve the private sector. In the program's early stages, panels were procured from a variety of sources and sold to herders at a subsidized price. Although the government purchased some of the panels, many were donated by the Japanese and Chinese governments. When systemic inefficiencies and cost overruns challenged the program's cost recovery, it became clear that the goal of reaching 100,000 herder families was not on track. Because the program was unable to

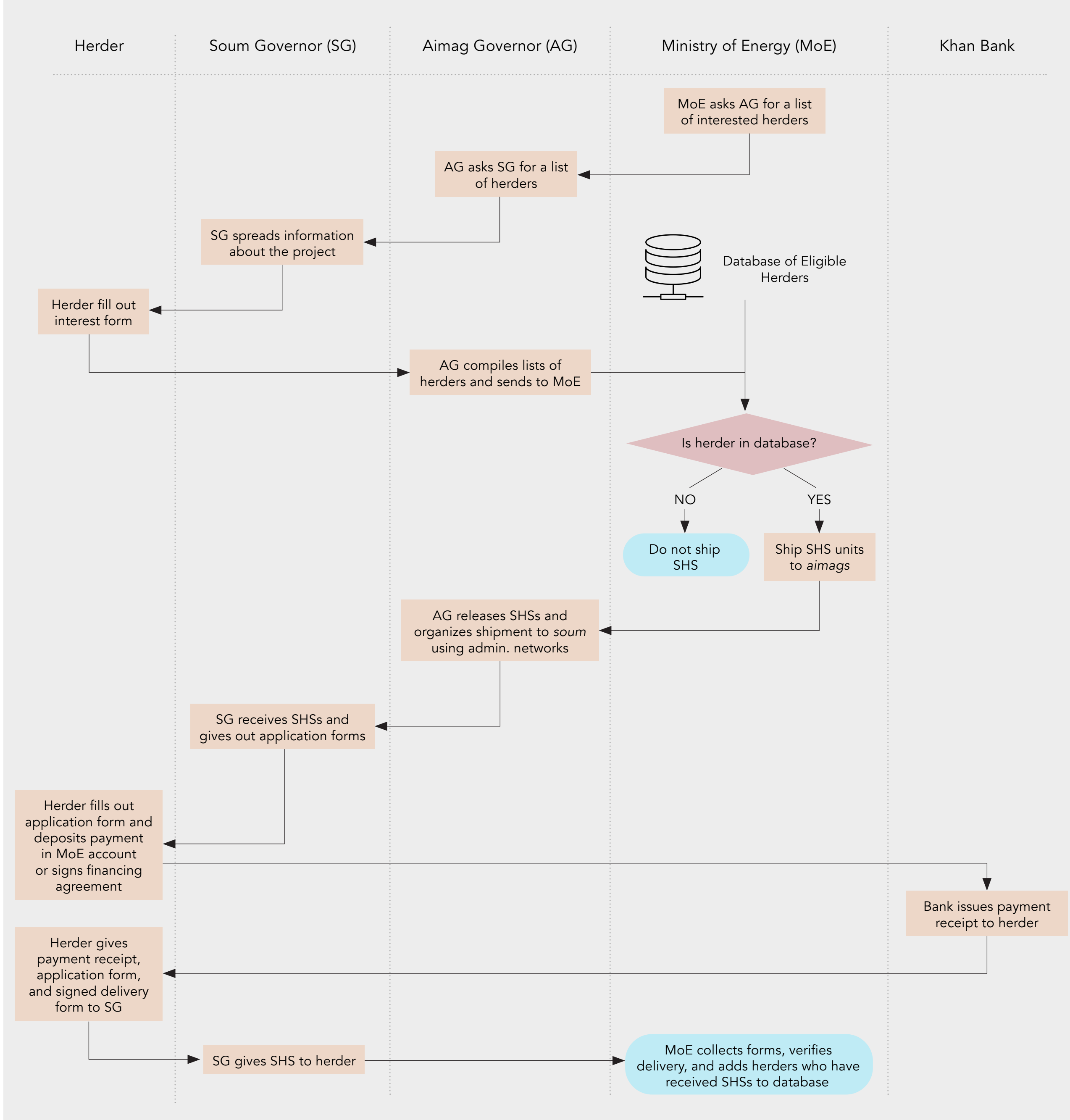



FIGURE 2. Delivery process under 100,000 Solar Ger project

recover the funds necessary to purchase additional SHSs, the program stalled after it had distributed approximately 33,000 units.

## AFFORDABILITY AND REACH

In 2006, the government of Mongolia enlisted the World Bank's help to strengthen and improve the program. At this time, the World Bank built the 100,000 Solar Ger Program into REAP, the bank's wider Mongolian rural electrification strategy. The government of the Netherlands also became involved by providing financial support to the program. REAP successfully improved program efficiency and addressed the challenges that the 100,000 Solar Ger Program faced. Notably, REAP established an independent project implementation unit (PIU) that oversaw the program's operations and allowed it to function independently of the Ministry of Energy.

REAP featured three key components to facilitate new technology adoption by herder families. At its core, REAP sought to maximize the SHS units' affordability for herders. Using an international competitive bidding (ICB) process and a bulk procurement strategy, the program could obtain the units at the lowest possible price while ensuring quality standards. Although the program initially relied on both government and private-sector procurement, the government's bulk procurement process was so cost effective that, in the latter half of the project, the SHSs were purchased almost entirely through the ICB process.

To avoid the up-front costs and logistical challenges of buying in bulk, the bulk order payment and delivery was scheduled incrementally. With staggered payment and delivery, REAP benefited from the lowest bulk prices but was not required to pay and store the large order up front. This both limited the amount of storage space that the National Renewable Energy Center (NREC) needed and allowed funds recovered from the program to be used to pay for the units purchased in the bulk procurement.

On top of the lower cost as a result of ICB, REAP offered a 50 percent subsidy on the units, making them more affordable for herders while balancing cost recovery. Even with the 50 percent subsidy, the purchase of an SHS constituted a significant investment for herders—nearly 40 percent of herders have an income of less than USD 450 per year. A limit of one subsidized unit per household was set to maximize the program's reach. The program maintained a database of eligible herders, checked and verified by the PIU to enforce this limit. The bank required the PIU to check its database to confirm that the family had not yet received a subsidized SHS unit prior to processing each herder's payment.

In addition to offering subsidized SHS units, the program also oversaw the distribution of the panels to the country's remote regions. Given the isolated nature of the herder way of life, herders often have to travel great distances to obtain goods and services. REAP sought to alleviate this challenge by ensuring that SHS units were available at the *soum* level. The REAP team coordinated and oversaw the delivery of the SHS units to the *aimag* level. From the *aimag*, REAP engaged local businesses to facilitate distribution to the *soums*. Deliveries were scheduled with efficiency in mind: REAP required a minimum of ten orders from a *soum* prior to shipping SHS units from the NREC warehouse in Ulaanbaatar. In instances where fewer than ten orders were received, the SHS units were instead shipped to the *aimag* level. Because the cost of delivery was factored into the subsidized price, delivery and distribution costs were uniform for all beneficiaries of REAP, regardless of their distance from the capital.

Finally, REAP sought to engage members of the private sector in the sale and distribution of SHS units and their accessories. Businesses operating at the *aimag* level had an opportunity to receive technical training and certification under the REAP program. The training allowed them to operate sales and service centers (SSCs) which oversaw the distribution of the SHS units from the *aimag* to the *soums*, offered panel-maintenance services, and sold products complementary to the SHS units (light bulbs, replacement batteries, television sets, etc.). Private-sector engagement was targeted across the country—a minimum of two SSCs were opened in each *aimag* during REAP. By providing training and business opportunities, REAP supported rural businesses and facilitated the transfer of technical knowledge at the local level. Involving the private sector in the program established localized technical support for the SHS units to ensure continual sales and servicing that extended beyond the program's close.

## PROCUREMENT

REAP featured two purchasing channels through which panels were procured and distributed by both private dealers (Figure 3) and the NREC (Figure 4). To promote long-term sustainability and economic opportunity, REAP supported private-sector dealers by providing training and support to enable the growth required to cover the post-REAP market. The PIU helped develop connections between certified Chinese suppliers and private dealers by facilitating networking trips to China. The dealers would independently source SHS units from these suppliers. Under REAP, private dealers could procure and distribute their

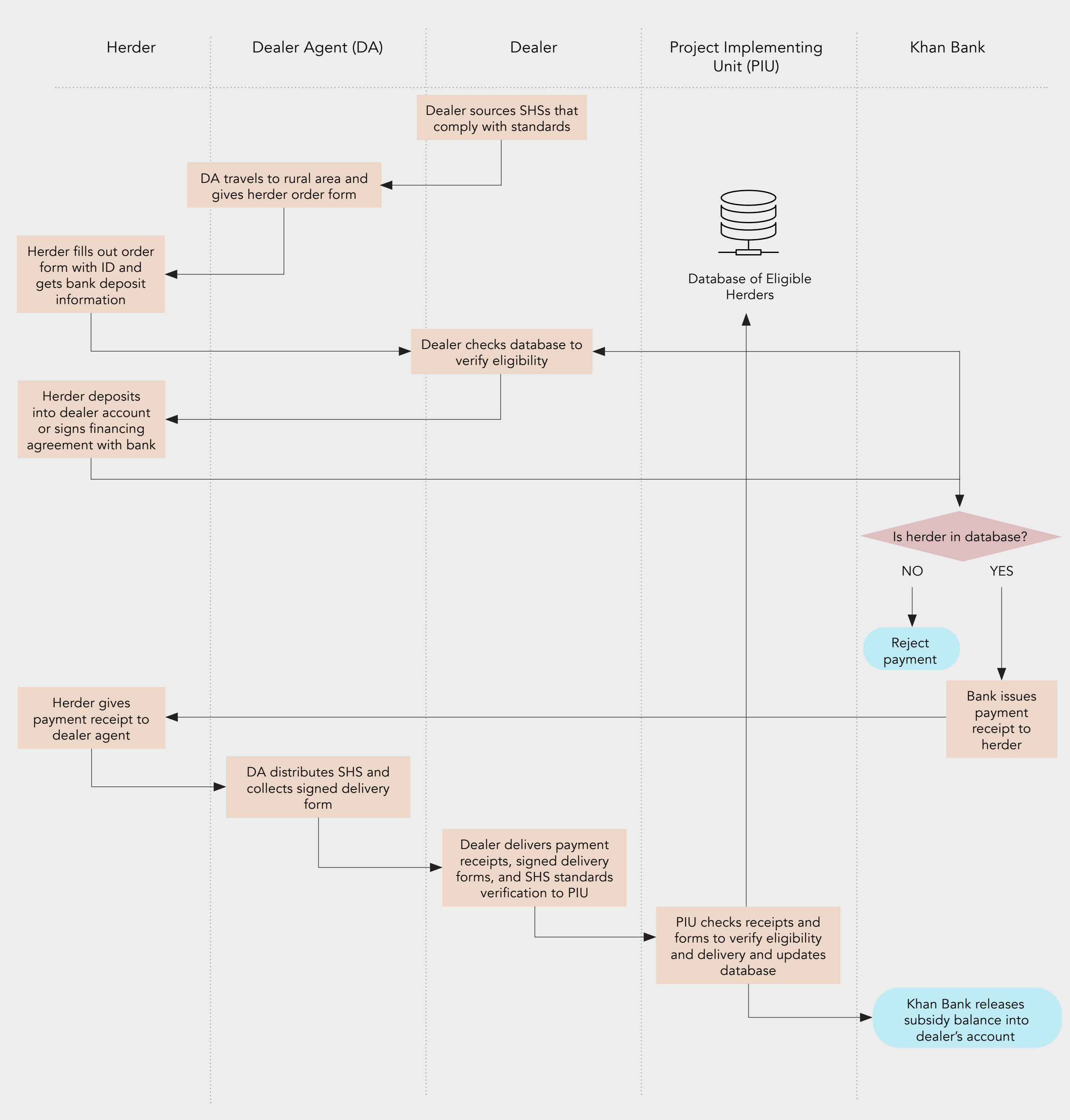


FIGURE 3. Delivery process of private channel under REAP

own SHS units with a 50 percent subsidy provided that the units met the program's quality standards (Figure 3).

Initially, REAP intended to transition away from government procurement and utilize private-sector dealers as part of their own distribution network following the phase-out of the 100,000 Solar Ger Project's operations. Although support for private dealers was effective to an extent, dealers were unable to procure panels in the necessary volume because of their small size and limited access to capital. It was difficult for these small dealers to compete with the government's bulk procurement process. Since it took several years for private dealers to grow to scale, dealers sold only a few hundred systems during the first few years of REAP.

As a result, the private dealer model in REAP was restructured. The budget that was initially allocated for subsidies under the private dealer channel was used instead for bulk procurement through government channels (bypassing the private dealers). Although private dealers still had the option to source and distribute their own panels with a 50 percent subsidy, many opted to distribute government-procured units given their comparatively low cost.

## SUMMARY

With growing efficiencies in solar technology arriving at a decreasing cost, the government of Mongolia launched the 100,000 Solar Ger Program as solar home systems became a viable off-grid alternative to provide electricity for nomadic herders living in the countryside. However, the program experienced systemic inefficiencies and cost overruns that threatened its ability to reach its goal of providing 100,000 herder families with access to clean, reliable

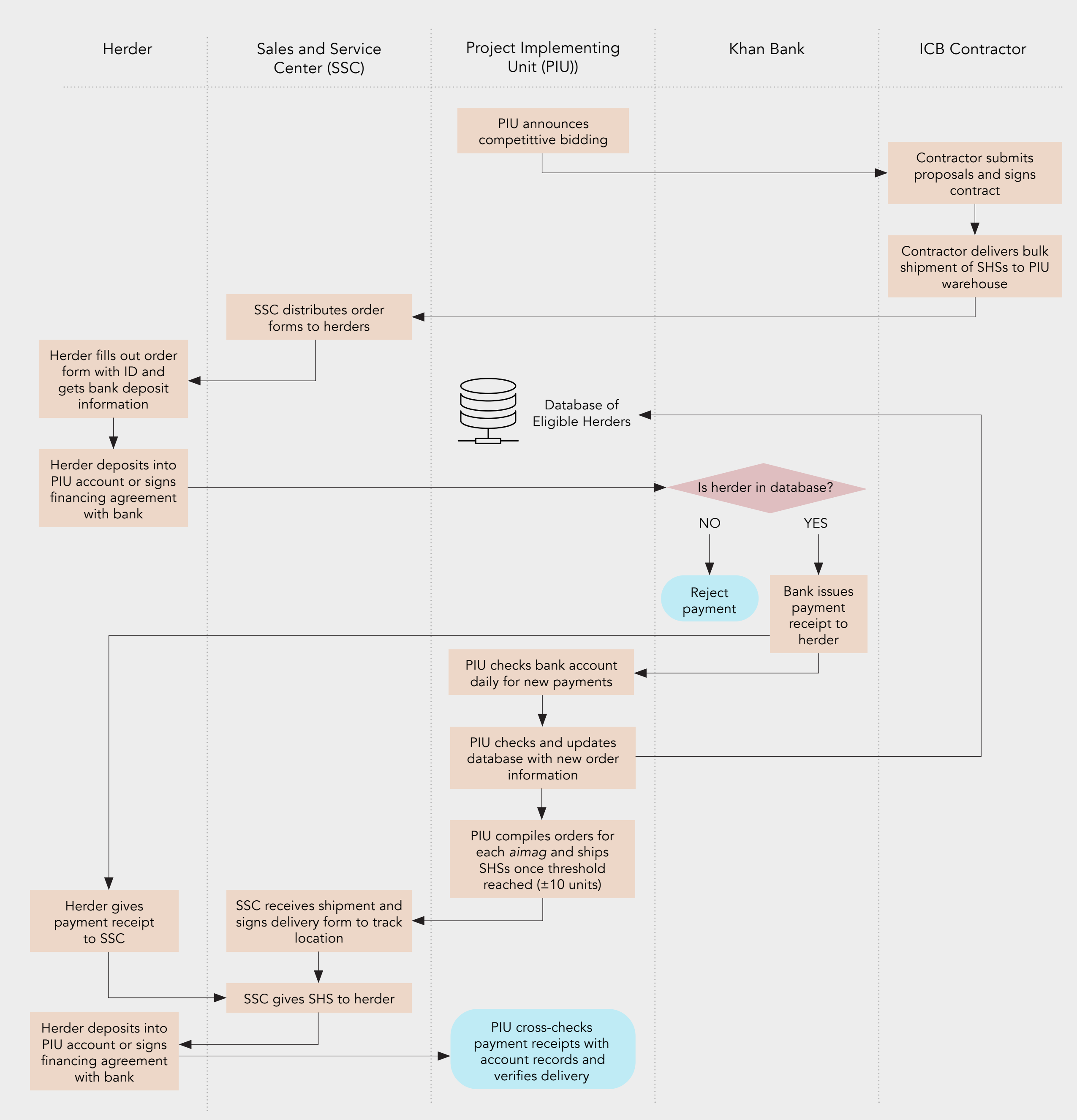
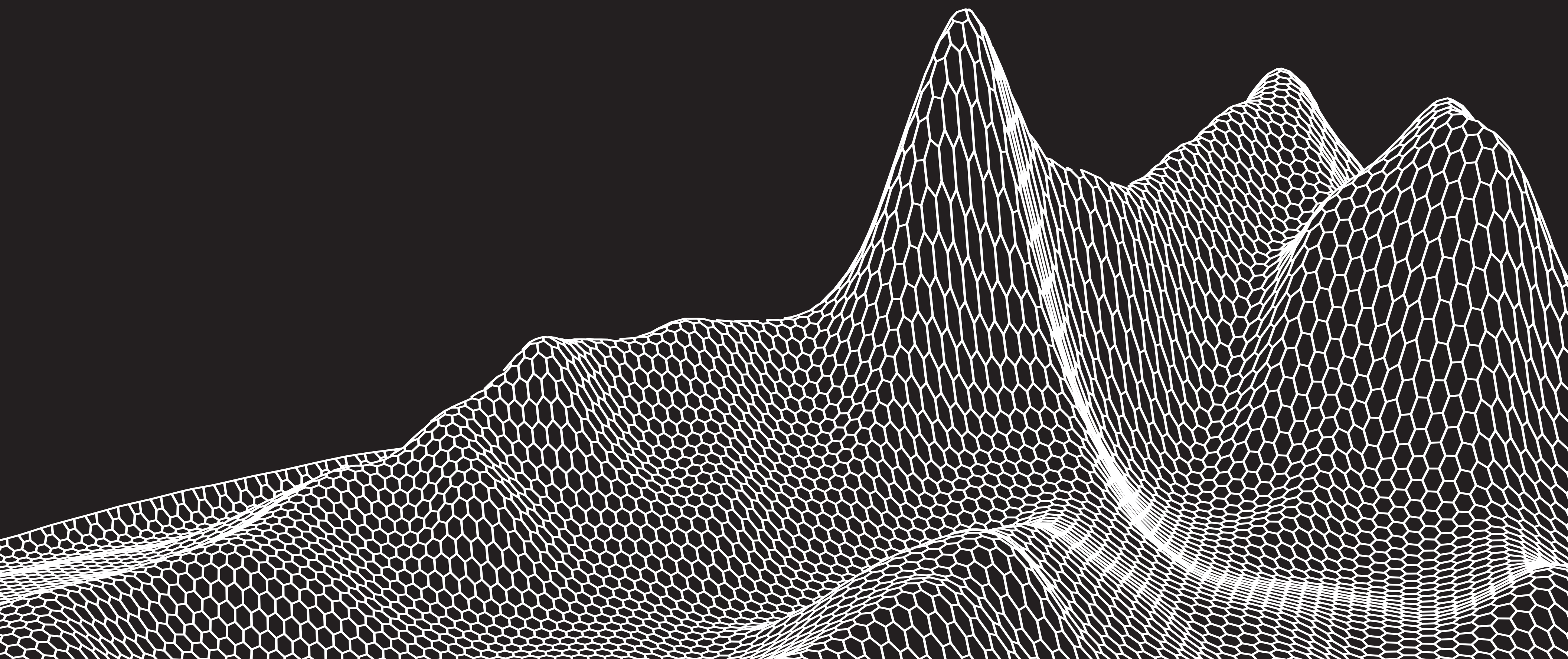



FIGURE 4. Delivery process of public channel under REAP

electricity. To address these challenges, the World Bank became involved to establish REAP which aimed to improve the efficiency of the 100,000 Solar Ger Program and support the government in reaching its rural electrification goals. In restructuring the program, the World Bank prioritized the program's affordability for herders by streamlining the procurement to include an international competitive bidding process and sold the SHSs with a 50 percent subsidy. A limit of one subsidized unit per household was set to maximize the program's reach. The program maintained a database of eligible herders, checked and verified by an independent project implementation unit to enforce this limit.

To encourage market development, the World Bank aimed to facilitate private-sector involvement by allowing private dealers to independently source and sell SHS units with a 50 percent subsidy. Initially, REAP intended to transition away from government procurement and utilize private-sector dealers as part of their own distribution network. However, because the government's bulk procurement process made the units affordable, many dealers opted to distribute government-procured units. REAP further sought to engage members of the private sector by establishing two sales and services centers (SSCs) in each *aimag*. SSCs were owned and operated by local business owners and oversaw the distribution of the SHS units from the *aimag* to the *soums*, offered panel-maintenance services, and sold products complementary to the SHS units. The establishment of SSCs improved the efficiency of SHS distribution, supported local businesses, and promoted access to localized technical support for herder families.

# Local Administrative Networks



Despite herders' nearly textbook-definition unreachability, Mongolia's local networks ensure that none are cut off from the essentials. No matter how isolated, herders are never so far that they are cut off from periodic access to social services and necessary supplies, owing to the systems that were honed long before the Renewable Energy for Rural Access Project (REAP) started. REAP, and the 100,00 Solar Ger Project that preceded it, was designed to leverage well-established administrative structures to reach the last mile. Rather than overhauling existing structures, REAP adapted these structures to facilitate the diffusion of solar home systems (SHSs).

## TRACKING AND REGISTERING HERDERS

A common barrier to development projects' reach is registration and tracking of intended beneficiaries. Without records of herders' existence, location, and socioeconomic status, it is logistically difficult to locate and deliver services over such a vast and sparsely populated area. Trusted and complete registration data prevent herders from being excluded from the special social services they're entitled to. In the case of REAP, it was important to have processes in place to differentiate herders from nonherders to ensure that subsidized SHSs were being delivered to the intended beneficiaries.

Mongolia has achieved nearly universal registration of herders, with greater than 99 percent birth registration completeness—even in the most rural areas. An official from an *aimag* governor's office detailed a sophisticated census/statistical program administered biannually which collects data on each citizen's occupation, *soum/bagh* of residence, dependents in their family, and other relevant details. The *aimag* government holds a list of all herders in each *soum* and their dependents. As herders relocate, they are required to inform the local *soum* or *bagh* administration of their location. At any given time, the *aimag* government can verify a household as a herder family.

The universal registration and tracking of all herders was the most basic foundation that enabled REAP's delivery network. The information on herder status and family dependents allowed the project implementing unit (PIU) to create the database of households that were eligible to receive a subsidized SHS. Herders' registration numbers were used as trusted proof of identity at the time of purchase.

## GEOGRAPHIC COVERAGE

The *aimag-soum-bagh* subdivisions are uniquely suited to reaching populations across a vast and thinly populated countryside. A common reason that rural populations are often the hardest to reach is the great distances they must travel to access social services. The only major urban center in Mongolia is Ulaanbaatar (which is several days' drive from most outer provinces). The overwhelming majority of herder families would be unable to make frequent trips to the distant city because of the cost and time constraints of transportation to the capital. Even *aimag* centers are often too far for frequent herder access.

However, because the lowest-level administrative unit provided in *soums* is designed to cover a small geographic area, most herders rarely need to travel far to access necessary social services. Since herders are already a mobile population, they have access to transportation methods (cars, horses, etc.) to travel the short distances to these centers. The geographic coverage offered by the *soums* creates a far more feasible "last mile" end point to which services must be delivered.

REAP used the *soum* network as the end point of the delivery chain. Herders visit these centers frequently enough (typically once a month at a minimum) to see advertisements of the REAP project and learn how to purchase a solar home system (SHS) (shown in Figure 5). The herder can perform all necessary actions to receive the subsidized SHS at the *soum* center since they are equipped with all basic institutions/services. Organizing shipments to *soum* centers instead of individual households created some degree of scale, reducing transportation complexity. With herders moving often, it would not be possible to make individual deliveries, since it would result in exorbitant transportation costs, and the driver would need to know the exact location of each herder who, by definition, has no permanent address. Herders, on the other hand, know where the *soum* center is and have the capacity to travel there.

## HIERARCHY OF "HUBS"

The country's administrative system can be thought of as a hierarchy of "hubs" (Figure 6) connected by "spokes" (interactions between levels of the hierarchy). The hubs hierarchy can be simplified into three tiers, beginning with the top-most administrative tier in Ulaanbaatar (where high-level decisions are made and country-wide policies are put into place). A spoke runs from Ulaanbaatar to the capital of each *aimag* (i.e., the second tier of the hub hierarchy). Each *aimag* center is then connected to each *soum* center (the third tier) in that *aimag*.

In general, there is limited interaction between hubs of the same tier (i.e., *aimag* centers are not involved with administering policy or development in other *aimag*s, and *soum* centers do not take a role in other *soums*). Defining hubs' responsibility in the same tier significantly simplifies distribution networks. Each *aimag* is responsible for only their

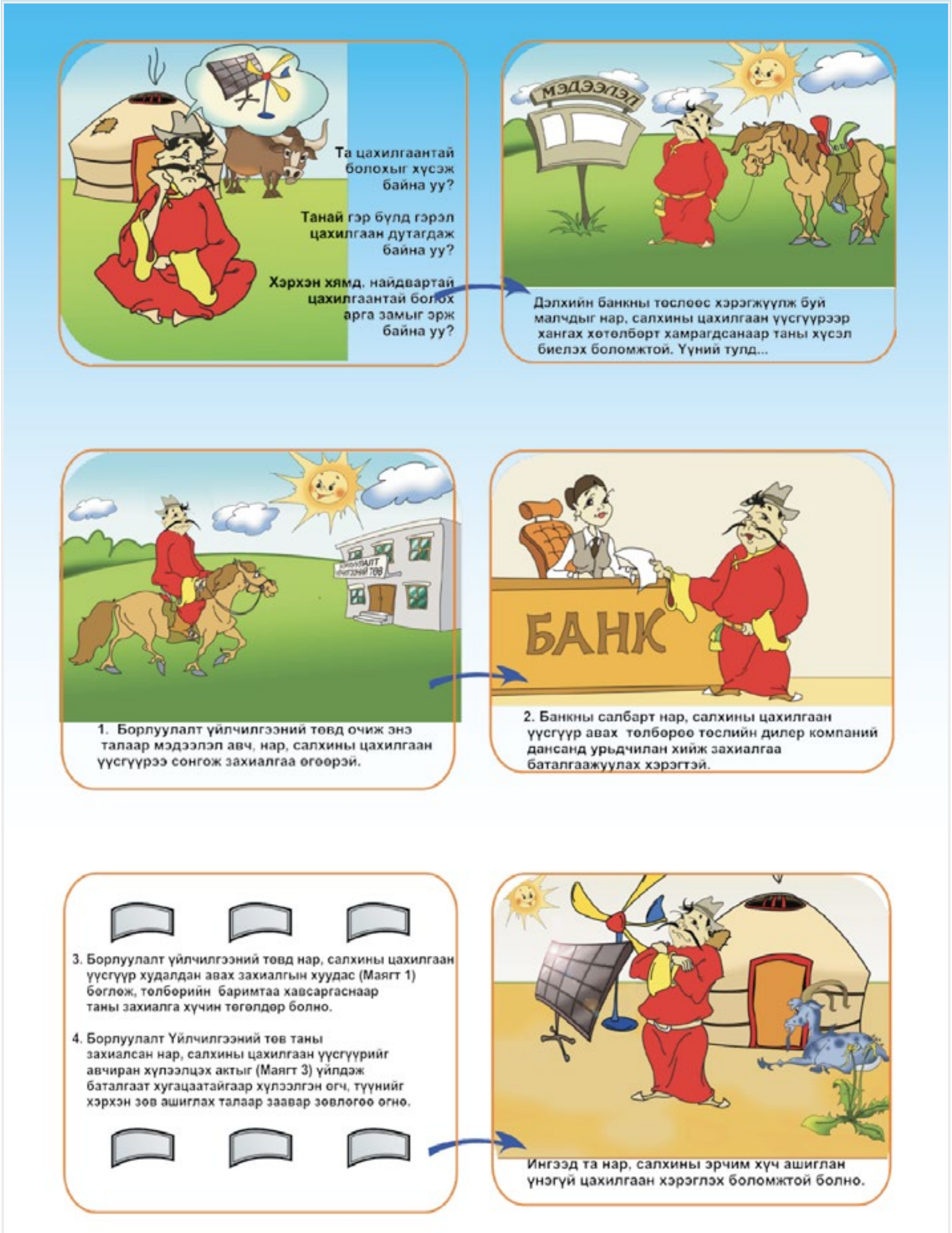



FIGURE 5. Sample advertisement that herders would see in a soum center

population, and they deal only with Ulaanbaatar. There is no confusion over which hub is responsible for which population or who is responsible for what decisions. Instead of a massive web of spokes, supply flows downstream in one direction from the central hub.

REAP followed the same general structure. The overarching project decisions were made by the PIU in Ulaanbaatar, which shipped inventory to each *aimag* center directly. From the *aimag* center, inventory was shipped to each *soum* center only within that *aimag*. The advantage of this structure is that the "last mile" *soum* centers were not required to manage inventory flow or deal directly with anyone except the *aimag* center hub immediately above them. The hierarchy of hubs led to clear decision-making authority and oversight throughout the entire supply chain.

## DEMARCATED RESPONSIBILITY

The delivery of SHSs involved an exceptionally long supply chain, starting with a large urban center in Ulaanbaatar, traveling across the country to provincial centers, and finally arriving at remote *soum* centers. Because Mongolia is a large country made up of diverse biomes, ethnic groups, and cultures, successful delivery requires adaptation to local contexts. Considering the 331 *soums* in the country, it would be impossible for a person or group administering a project to build in local adaptations for each one, since a single administrator cannot be intimately familiar with them all.

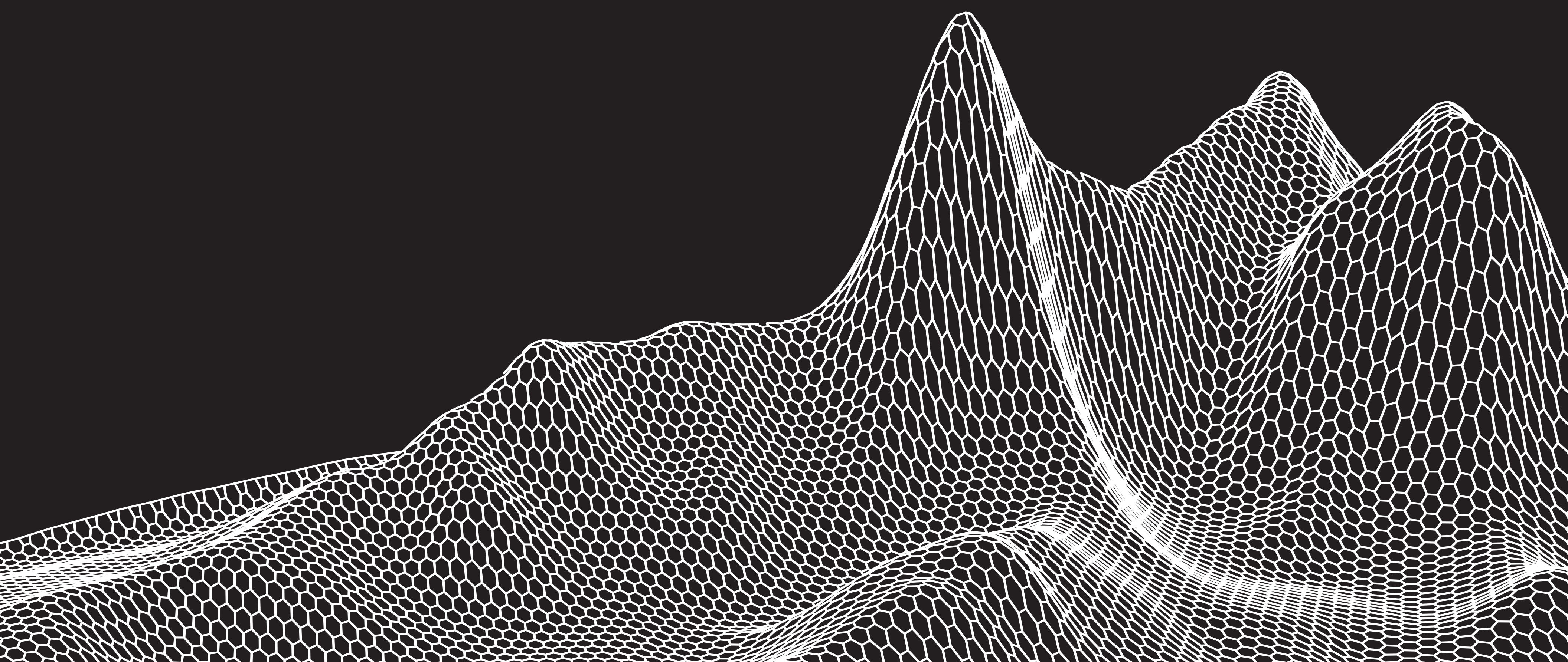
The solution to this issue of adaptation involves local experts as key members of the implementation group. Local leaders are most familiar with the culture and environment of their region and are often respected community members. REAP had enough flexibility to fully hand off responsibility for delivery to those agents as the SHSs moved through the distribution network. The PIU always began the process by organizing shipment of the correct number of SHSs to *aimag* centers. From there, *aimag* administrators or SSCs would organize shipment to *soums* as they saw fit without the PIU's direct involvement. If there was further shipping required, a *soum* administrator or SSC would arrange it in similar fashion. In this way, each delivery agent operated within a range along the chain that they were already familiar with and took control of their leg of the delivery. *Aimag* administrators often had to organize transportation or delivery to and from *soum* centers for other supplies, and knew the best routes, shipping companies, or drivers. Similarly, SSCs were existing businesses who had experience delivering products to herder families in various *soums*. It was both easier and more efficient to outsource the decision making to local experts, rather than having a central body administer the entire process from beginning to last mile.

SUMMARY

Mongolia's unique administrative structure laid the groundwork for the successful delivery mechanisms of REAP. Nearly 100 percent of herders are registered and tracked to a given *soum* at all times, and this registration data made it possible to determine eligibility for subsidized panels. The *aimag-soum-bagh* subdivisions are able to cover Mongolia's vast landscape and create a more feasible "last mile" to reach. The hub-and-spoke model of Mongolian government led to clear hierarchy and decision making in REAP's implementation, and demarcated responsibility ensured that each actor along the distribution chain was fully responsible for only what they were best suited to organize.


FIGURE 6. Simplified hub-and-spoke structure of administrative hierarchy

# Quality and Standards



Before the Renewable Energy for Rural Access Project (REAP), the majority of herders had access to electricity in only *soum* or *aimag* centers when they encamped there for the winter. Outside of this, some may have had small diesel generators to power lights and small appliances, but most used kerosene lamps or candles for their daily energy use. The introduction of portable solar power was a highly promising development that seemed poised to change herder families' lives. To convince herders to willingly part with a large portion of their yearly income for this unproven technology (40% of herders have a yearly income lower than USD 450 and the subsidized panel costs USD 240)[2] it was crucial for REAP to put measures in place to guarantee the SHSs' quality.[3] An official from 100,000 Solar Ger and World Bank representatives told us that well-cared-for systems can last for a long time (up to twenty years for the panel and five years for the battery), which would contribute to the project's sustainability.

## ESTABLISHING STANDARDS

In the late 1990s and early 2000s, the first SHS units were distributed to herders. These systems were often donated or manufactured in Ulaanbaatar and, as an official from 100,000 Solar Ger explained, because the technology was still in its infancy they were not as reliable as current systems. The panels were not manufactured to standards and systems suffered breakdowns at a higher rate. This was harmful to the technology's reputation and caused many herders to remain unconvinced that it was a worthwhile investment.

REAP recognized that a lack of trust in the technology would be difficult to overcome. To combat this potential mistrust they established quality standards for SHSs specifying required testing procedures and system requirements. An excerpt from the standards can be seen in Figure 7.

Under the government channel, it was relatively easy to ensure compliance with standards, since the PIU was directly involved in procuring panels. However, encouraging the adoption of quality standards among private dealers proved to be more challenging. Lower-quality and lower-cost systems would allow private dealers to have a higher profit margin. A "smart" subsidy system was put in place by the PIU as an incentive for private-sector adoption of the standards laid out by the project. In this method, private dealers would collect the subsidized amount from herders (50 percent of the total cost), and then collect the balance from the PIU. To get the balance, they would need to show proof of compliance with the standards for each system sold. In this way, consistent quality was guaranteed across the project's public and private channels. Since the herders themselves had to pay only 50 percent of the cost of a high-quality SHS under the REAP subsidy, there was no financial incentive for them to choose a cheaper, lower-quality system on the market. The combination of the subsidy and the quality standards helped improve the SHSs' reputation and pushed unreliable systems out of the market.

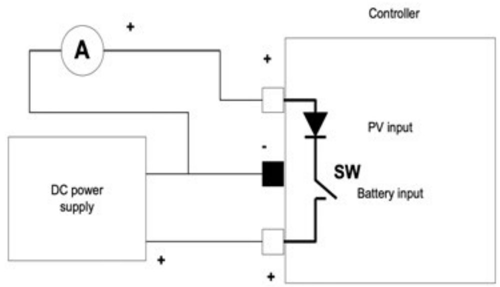
## ACCESS TO AFTER-SALES SERVICE

Small repairs were sometimes needed to fix minor electrical faults to ensure the distributed SHSs did not fail prematurely. These repairs needed to be as accessible to herders as the initial purchase was so that they could reliably repair systems quickly. To address this need, sales and service centers (SSCs) were developed. At these SSCs herders were informed about how to get access to repairs and servicing at the time of purchase. Since there were at least two SSCs in each *aimag* (each responsible for half of the *soums*) herders had reasonable access to someone who could diagnose problems and fix them.

REAP organized extensive recruitment and training processes for SSCs to guarantee their ability to diagnose and repair issues with SHSs. The people chosen to run the centers were recruited based on past experience in related fields (electronics, engineering, etc.). This pool of experienced applicants were then given training specific to SHSs. There were three training sessions in Ulaanbaatar hosted by REAP that these applicants were required to attend to be a certified SSC. Transportation and room and board were covered for the training sessions to incentivize attendance and remove access barriers for rural business owners. There was no limit to the number or location of participants, as long as they were able to attend the sessions in the city. All necessary tools for repairs and diagnostics were given to the applicants for free. With these tools and the training provided by the PIU, SSCs were equipped to perform almost all necessary maintenance on the herders' systems.

SSCs would make a small profit from repair services, which was their motivation to attend training and certification. In the event that a repair was outside the scope of their skill set, systems could be sent to Ulaanbaatar where the PIU would repair them. Costs of repairs were covered under warranty for the first year, after which the herder would pay for repairs. After many years of use, if significant breakdowns of SHSs occurred, repair

[2] *Project Performance Assessment Report 127225, Mongolia—Renewable Energy for Rural Access Project*, Independent Evaluation Group (Washington DC: World Bank, 2018).
[3] PIU Director, National Renewable Energy Council, Mongolia, in discussion with the authors, 20 May 2019.




**Firgure 9 Battery reverse discharge protection test**

**7.9.4 Reverse polarity protection**

Connect a DC power supply to the controller's battery input terminals in reverse polarity, and check if there is any damage on controller or power supply.

**7.9.5 Lightning protection**

Visually check the lightning protection components, verify that their type and ratings can absorb the shocking energy.

**7.9.6 Over voltage endurance**

Connect a DC power supply to the controller's PV input terminals. Apply 1.25 times Voc for 1hr. Examine to be certain there is no damage to the controller.

**7.9.7 Over current endurance**

Connect a DC power supply to the controller's PV input terminals, and a variable resistor to battery input terminals. Adjust the resistor so that the charging current reaches 1.25 times Isc, maintaining it for 1hr. Examine to be certain there is no damage to the controller.

**7.10 Battery state of charge indicator**

The system should provide an indicator to show the battery state of charges:

a) Fully charged indicator: battery is fully charged, the charge current from PV array is reduced or disconnected;

b) Low voltage indicator: battery voltage is low and should start to reduce power consumption;

c) Load disconnect indicator: battery voltage is below LVD and load has been disconnected.

The indicators can be LEDs, analog needle meters, digital meters or audible alarms. These indicators should be clear and self-explaining, so the user can understand the battery state of charge without reference to the user manual.

FIGURE 7. Excerpt from SHS quality standards document (Source: NREC)

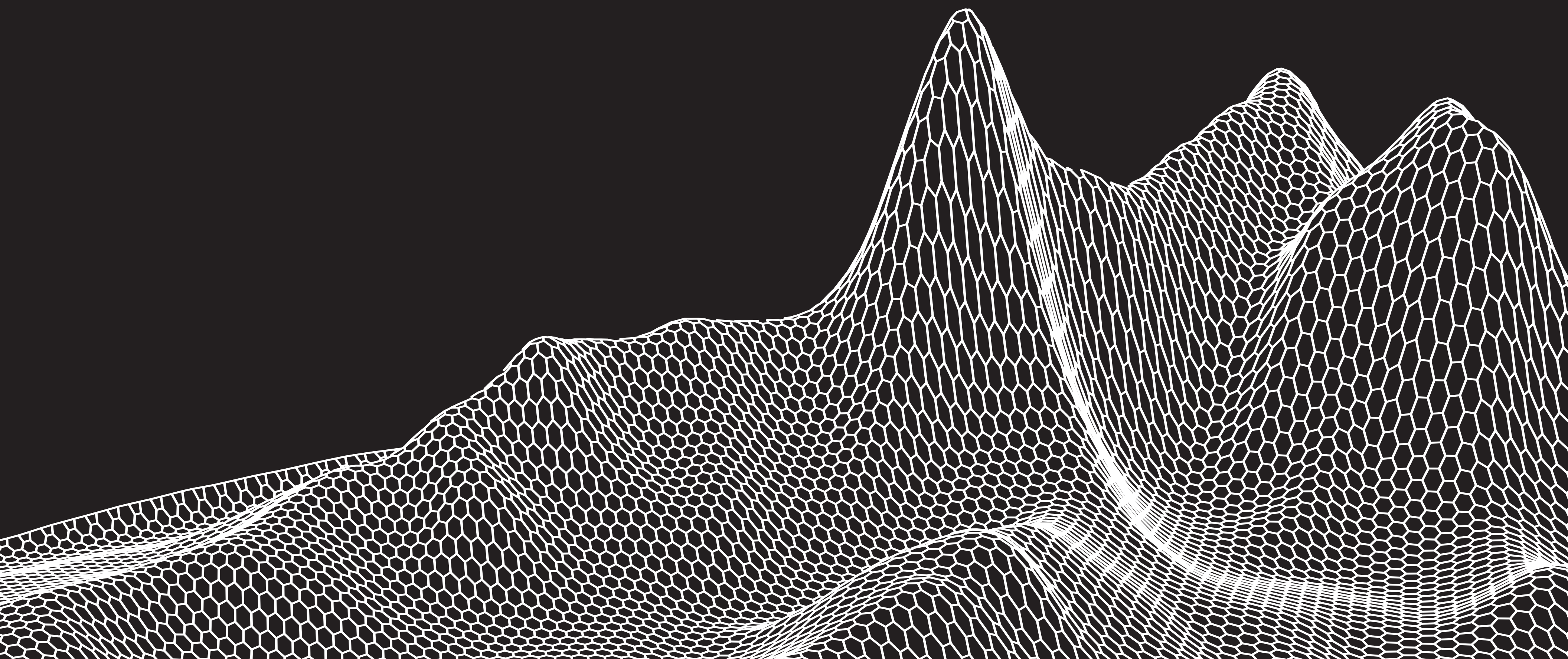
costs could be prohibitive for herders and they might opt to stop using the SHS entirely. Again, this was a motivating factor for the implementation of strict standards to reduce the likelihood of these occurrences.

A private SSC dealer involved with REAP and a National Renewable Energy Center (NREC) official both explained that, during the project's lifespan and in the following years of evaluation, the standards were effective in preventing breakdowns. Few herders needed access to repairs. In the few cases where they did, it was typically minor issues caused from improper usage or assembly. Quick and easy access to repair services, even for these minor issues, helped maintain the technology's reputational integrity and encouraged its further adoption among herders.

## SUMMARY

SHS technology was still nascent at the beginning of REAP and it was challenging to convince herders to part with a large portion of their yearly income without assurances that the systems were built to last. To overcome these challenges, extensive quality standards were introduced and accountable processes were put in place to ensure compliance with standards across both government and private dealer channels. The establishment of a trained after-sales service network in the SSCs gave herders the confidence that they would be able to fix minor issues without needing to travel to urban centers.

# Private Sector Participation



Prior to the Renewable Energy for Rural Access Project (REAP), solar home systems (SHSs) were exclusively procured by the Ministry of Energy and distributed through government administration channels. This approach required constant government oversight to maintain a market for SHSs and failed to create a sustainable market for SHSs post-project because of issues of price affordability for herders. Additionally, the limited access to servicing outlets meant that herders were unable to maintain their systems. The government also had to develop a distribution network for the sale of appliances that could be used with the SHSs. To continue the project would push any nascent private-sector SHS and appliance distributors out of business because they would not be able to compete with subsidized government products. Therefore, in the interest of creating a sustainable market that could continue post-REAP, the country needed a private-sector market for SHSs.

PRIVATE DEALERS

The project implementation unit (PIU) facilitated links between private dealers and Chinese manufacturers, which proved to be effective in the project's initial stages. The dealers worked with manufacturers but were unable to procure panels in bulk without greater capital, leading to reallocation in the project budget. The reallocated money went toward bulk procurement of panels that the government then distributed through sales and service centers (SSCs) (bypassing private dealers), however, dealers were given the choice of distributing independently procured panels or panels procured by the ICB process. This restructuring did not have an adverse effect on private dealers' participation. The profit margin on the sale of the SHS was very thin so the primary incentive for dealers to sell SHSs was to create a market for the high-profit-margin appliances (such as lights, TVs, and refrigerators) where they made most of their profits. With the restructuring, the government was helping to rapidly expand the market for these appliances, while alleviating the cumbersome task of sourcing and distributing the SHSs.

Eventually, the private dealers expanded their operations and managed to distribute several thousand SHSs by the end of REAP. After the project concluded, SHS sales dropped drastically as a result of the lack of subsidy and relative saturation of the market, but many private dealers were able to keep selling, according to one of the largest private dealers active under REAP. Despite slow expansion of the private dealer network, the approach to include the private sector succeeded in creating a self-sustaining project.

SALES AND SERVICE CENTERS

REAP's last-mile delivery was performed largely by SSCs. The project's sustainability would depend on their continued involvement as essential members of the delivery chain in sales and repairs after the project concluded. With this in mind, REAP chose to recruit only local private-sector actors as SSCs, and only those who already had established businesses. These SSCs would not depend on the PIU for funding.

The recruitment of SSCs required incentivizing private businesses to become distributors for the PIU. REAP did not want to provide commissions or profits on the sale of SHSs because this cash flow would end with the project. The loss of commissions could have presented operational challenges for SSCs after project close. Instead, the incentive for businesses to become SSCs was the opportunity to sell appliances and make repairs on systems, which herders would directly pay for. This also incentivized SSCs to deliver as many SHSs as possible to expand their potential appliance market, even though they made no commission on the SHS itself.

OVERSEEING THE PRIVATE SECTOR

The inclusion of the private sector in a public project creates complications with accountability. The public sector is subject to constant oversight and has well-established checks to prevent mismanagement of assets, but the private sector is often not subject to the same level of scrutiny. The introduction of the private sector necessitated the adoption of uniform verification processes across both public and private distribution channels.

A paper trail of documentation was required of private dealers and SSCs for each stage of the delivery process. Dealers were required to provide documents (Figure 8) certifying the SHSs' compliance with standards to the PIU with proof of the panel/battery type and manufacturer. Each individual system's serial number was recorded. Each time the systems changed hands during transport (between the drivers, *aimag/soum* administrators, and SSCs) the person receiving the shipment had to sign off on the list of SHSs they were accountable for, listed with the serial numbers. Their contact information, location, and even license number (for delivery drivers) was noted on the form.

These forms were sent back up the chain to the PIU, who would verify the delivery and make sure no systems were missing (or if systems were missing they could identify who was responsible). At the end of the chain, herders were required to provide a bank receipt showing the correct subsidized payment amount and account number of the dealer they paid to. The PIU cross-checked

FORM 1

**ORDER FORM**
**OF SOLAR HOME SYSTEM WITH US$ 160 SUBSIDIZED PRICES**
**"RENEWABLE ENERGY AND RURAL ELECTRICITY ACCESS PROJECT"**

| Dealer № | SSC № | Order № |
|---|---|---|
| | | |

| **1. INFORMATION OF HERDER** | | |
|---|---|---|
| Povince | Soum | Bag |
| | | |
| Last name | First name | Register number |
| | | |

| **2. INFORMATION OF PROVIDER** | |
|---|---|
| Name of Dealer | |
| Name of SSC | |
| Address of SSC | |
| Name of Soum Administration | |

| **3. INFORMATION OF SOLAR HOME SYSTEM** | | |
|---|---|---|
| Serial number of PV module | | |
| Price of Solar home system | | |
| Component | Unit | Manufacturer |
| PV module | | |
| Battery | | |
| Power box with charge controller | | |
| Light | | |
| Power cables | | |
| PV module support structure | | |
| Operation manual | | |

**4. VERIFICATION OF ORDER**

1. Herders who received SHS by subsidized price between 2003-2005 under Japan Government and Government of People's Republic of China are not qualified
2. Herders who received SHS by subsidized price between 2007-2009 under the "100000 solar ger program"
3. The number of SHS to be delivered to each soum center will be limited by number of herder mentioned in the Census data published by Statistical Office of Mongolia
4. For the payment made by the herder who is not qualified the above Article 1-3 the PIU not responsible.
5. The integrated order form will be valid only with payment receipts.

| Stamp | ................ Province ........................ Soum center ...................... Bag center .................... Last name .................... First name<br>Hereby we confirm that the herder have right to receive SHS.<br>Governor of Soum center and Bag /........................... / Signature Name /<br>Date: 20..... Year .... Month .... Day |
|---|---|

If you need more information, please contact following address.

Project impleminting unit
Energy authority
Ulaanbaatar, Khan-uul District, Chingis avenue,
Post box 527, Ulaanbaatar-210136, Phone: 342375, 342691 Fax: 342375
E-Mail: info@reap.mn, www.reap.mn

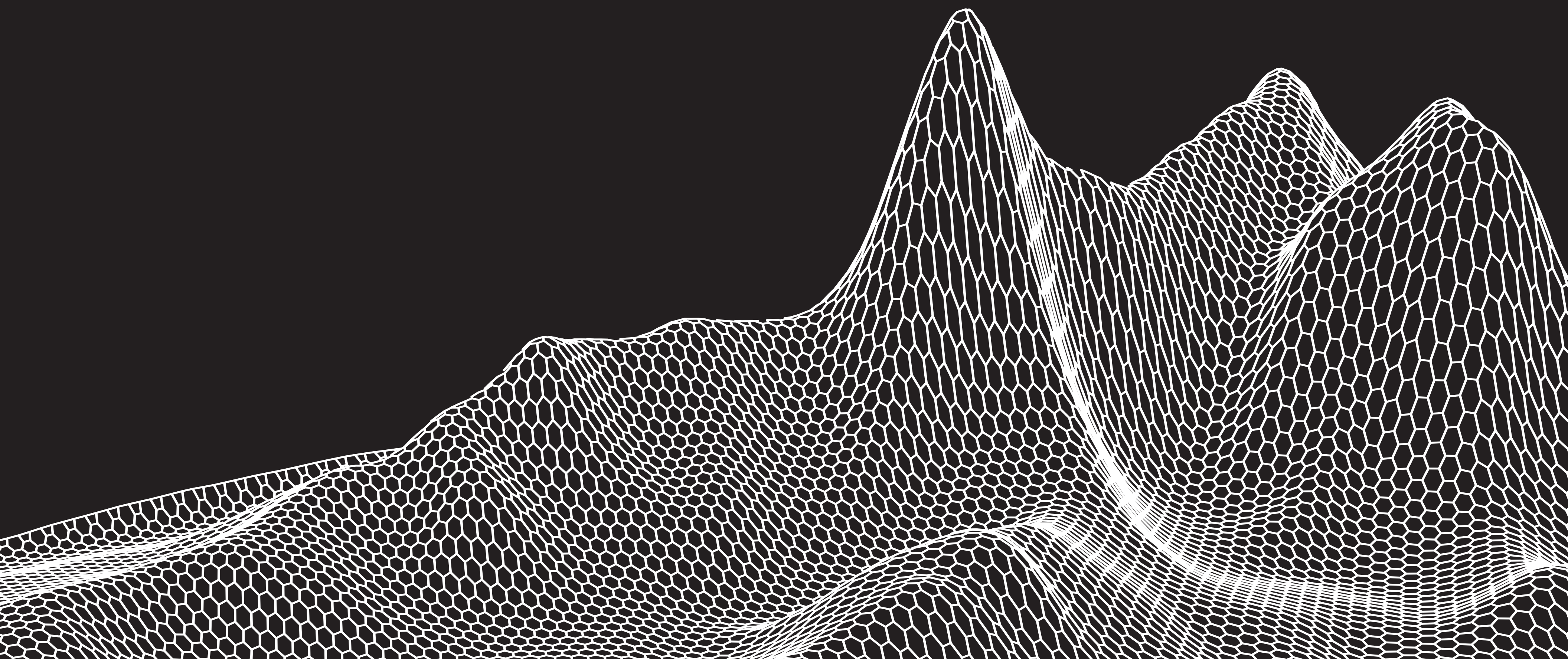
FIGURE 8. Order form used in overseeing private dealers

receipts (along with proof-of-delivery forms signed by the herder) with bank records. Once these verifications were completed by the PIU, the subsidy would be deposited to the private dealer's account. The PIU was deliberate in choosing to release the subsidy post-verification of sale, rather than at point of sale or sooner. In doing so, it ensured that private dealers complied with project protocols if they wanted to recover 50 percent of their costs through the subsidy.

## SUMMARY

Existing SHS initiatives relied on the government's continued involvement and could not survive without direct management. Additionally, the cost of SHS systems at unsubsidized prices was prohibitive for nearly all herder families. This necessitated a private-sector market for SHSs that could continue independently post-REAP. The PIU helped establish a supply chain between Chinese manufacturers and private-sector dealers in Mongolia. Despite these dealers' limited early success, they were distributing large numbers of systems by the project's close. The "last mile" delivery was performed mostly by sales and service centers. These SSCs were local business owners who were recruited and given training to repair systems. The subsidy system required constant oversight of the private sector during REAP. This oversight included a comprehensive paper trail to trace SHSs at all stages of the delivery process.

# Cost and Financing



Previous iterations of the Renewable Energy for Rural Access Project (REAP) relied on grants from bilateral donors to finance the purchase and distribution of solar home systems (SHSs). The lack of a reliable source of funding hindered the program's ability to expand its delivery channels and resulted in program instability. This led to the development of key financial strategies that focused on keeping costs affordable for herders while maintaining cost-recovery mechanisms to sustain program operations. REAP was funded by the World Bank, including grants from the International Development Association, Global Environment Facility, the government of Netherlands, and contributions from the government of Mongolia.

## INTERNATIONAL COMPETITIVE BIDDING

During the initial stages of the 100,000 Solar Ger program, panels were either gifted by donors, or purchased from various manufacturers, leading to disparity in system durability and efficacy. A key REAP innovation was to introduce international competitive bidding in the procurement process. International manufacturers that met REAP's quality standards submitted their bid to an evaluation committee, which was overseen by the National Renewable Energy Center (NREC). The bidding process benefited the program in two ways. First, it allowed distributors to source the cheapest panels, which in turn translated to cheaper prices, and second, it ensured the distribution of standardized panels because all SHS panels were sourced from the winning contractor.

In addition to purchasing SHSs through a competitive bidding processes, the program purchased panels in bulk to take advantage of economies of scale. Payments for bulk purchases were made in installments, with careful consideration to cash flow needs. A government of Netherlands grant was used to settle the upfront advance needed to secure the bulk purchase agreement. From there, outgoing payments to contractors were aligned with incoming payments from the sales of SHSs. This process allowed the project implementation unit (PIU) to maintain sufficient cash in hand to make new bulk purchases while covering operation costs. It was the combined introduction of bulk procurement along with the competitive international bidding that enabled suppliers to drive down their costs and lead to more affordable panels. Bulk procurement combined with international bidding enabled suppliers to drive down their costs, leading to more affordable panels.

## BALANCE BETWEEN AFFORDABILITY AND COST RECOVERY

Given that the majority of a herder's wealth is held in livestock, and that their income is highly seasonal, herders would need some sort of discount if they were going to adopt SHSs. Distributing the panels free of cost would solve issues of affordability, but the lack of a cost-recovery mechanism would render the project financially unsustainable in the long term. There is also evidence to suggest that when herders make partial payments to purchase SHSs, their sense of ownership for the product makes them value it more. This can lead to better care of the systems, contributing to the project's overall sustainability.

The retail price of a good-quality 50-Wp SHS is approximately USD 400, which is unaffordable for most herders ( nearly 40 percent of herders have an income less than USD 450/year). In response, REAP introduced a fixed subsidy of USD 160, which was jointly financed by the government of Mongolia and a grant from the Netherlands. The subsidy, which was set to cover approximately 50 percent of panel cost, not only led to more affordable panels, but also allowed the program to recover funds from the sale of SHSs, thereby ensuring a continuous flow of cash to finance scale-up operations.

## ECONOMIC CAPACITY OF THE PRIVATE SECTOR

Under REAP, ten private dealers were certified to sell SHSs and were eligible for a subsidy buy-back. It was envisioned that these private dealers would self-finance SHSs through bulk procurement and distribute the panels through their established distribution networks. It was assumed that the private dealer network would be more efficient than public channels given their incentive to drive efficiency in return for profit. However, due to their limited financial capacity, private dealers could buy SHSs only in small quantities and were not able to take advantage of wholesale prices. Most private dealers were concentrated in Ulaanbaatar, which also meant reaching herders in remote areas would lead to higher transportation and logistic costs. Despite barely breaking even on the sale of the SHS itself, private dealers were motivated to expand SHS sales to profit on the sale of complementary appliances and after-sales services.

Bulk purchasing through the government channel proved to be more effective because access to additional sources of funding (from the government of Netherlands) enabled them to take advantage of economies of scale. Utilizing the capacity of the SSCs, the government channel achieved significantly more "reach" than many private dealer networks. The private sector, while slow to take off, played an important role in supporting the diffusion of SHSs, particularly following the discontinuation of the subsidy. Prior to REAP and the World Bank's involvement, the market for SHSs was at a nascent stage. Adopting quality standards and introducing a subsidy helped expand the demand for a relatively unfamiliar (and expensive) technology. While the majority of SHSs under REAP were purchased and distributed through government channels, private dealers gradually began to expand their operations in the SHS market. The success of REAP lies in the fact that it was able to develop a market for SHSs, such that market demand remained even after the subsidy's discontinuation. This was essential because it provided long-term business opportunities for the private sector in Mongolia. In particular, following the subsidy's discontinuation, the private sector drove market growth. Since REAP was effective in setting market expectations in terms of price and quality, the private sector had to continue to compete on quality and price, which benefited the end user. Ultimately, it was the combination of public and private channels, running simulta-neously, that was critical to the program's success.

## ALTERNATE SOURCES OF FINANCING

Despite the subsidy, many herders needed access to additional financing. A cooperation with Khan Bank, an established Mongolian bank with branches in every soum center, was developed to provide additional financing for herders. While Khan Bank was the project's official bank, several alternative financing options began to develop for herders who were unable to secure a formal bank loan. This included micro-financing and collectives. While not managed by REAP, these alternatives helped expand the reach of the program, and collectively, provided a range of different options that catered to the herders' financial circumstances. Although affordability was a key consideration in the design of REAP, today, many herders are heavily indebted. The initial purchase of SHS and subsequent system upgrades have invariably had implications for their financial health.

## INCENTIVIZING THE ADOPTION OF NEW TECHNOLOGY

The introduction of a subsidy not only led to more affordable systems but also helped incentivize the adoption of a new technology. The diffusion curve, which groups customers according to how quickly they adopt a product, is useful in understanding how the diffusion of SHSs reached a critical mass. Innovators and early adopters, while well-informed risk takers, require an incentive to purchase SHSs. The subsidy was intended to be the "push" needed to incentivize early users to adopt a relatively unfamiliar technology. Over the course of REAP, as the number of users grew to a late majority, price became less of a consideration for potential buyers. Instead, the system's perceived benefits and high standards became important drivers in incentivizing new buyers. Therefore, despite the discontinuation of the subsidy, SHS sales continued to grow.

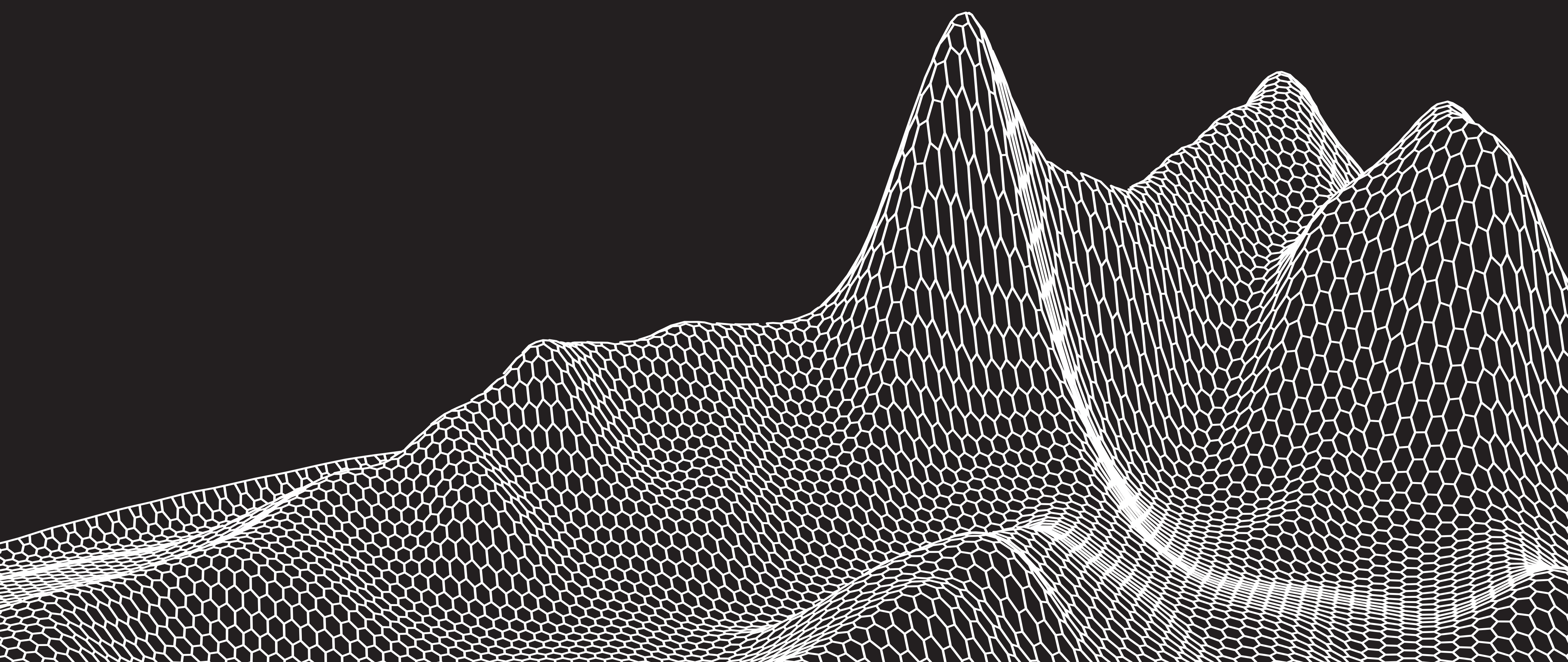
## CURRENT COSTS ON THE DECLINE

Photovoltaic costs have been rapidly declining over the past several years and are translating to more affordable systems. A thriving private market that is characterized by competitive pricing, high-quality products, and ample consumer choices allows herders the choice and flexibility to purchase SHSs without the need for a subsidy. REAP thus succeeded in developing a self-sustaining market for SHSs. However, increasingly, there is a demand for higher-capacity systems as herders' aspirations and lifestyles change. These systems, which are sold at a higher price point, lie beyond the affordability of most herders, and often come at the expense of high loans. In these circumstances, the market, and more specifically, SHS sellers, may need to develop innovative financing mechanisms to support the purchase of more expensive products.

## SUMMARY

A combination of financial strategies supported the broader diffusion of SHSs by breaking down the barriers of cost and price. This included establishing a competitive bidding process for the procurement of panels, developing a subsidy that balanced affordability with cost recovery, and leveraging the economic capacity of the private sector to support public funds.

# Checks and Balances



## INDEPENDENT PIU

The National Renewable Energy Centre (NREC), a government of Mongolia agency, was key to the implementation of the 100,000 Solar Ger Program. However, its lack of autonomy meant that program operations were affected by existing government practices, including a lack of uniformity in processes and poor cross-validation measures. Under the 100,000 Solar Ger Program, contracts for panel procurement were sometimes awarded to close connections, thereby diluting any competition on quality or price. Financing that was earmarked for the project was at times used for other government projects, leading to a greater gap between funding needs and availability.

In response to these implementation gaps, the World Bank reorganized agency duties. Most notably, REAP's steering committee established a project implementation unit (PIU), an independent agency that took over the National Renewable Energy Center's responsibilities for day-to-day management of the project. Although staff were retained, the establishment of a completely autonomous unit allowed the PIU to manage REAP's implementation independently, and introduce processes that emphasized transparency and accountability. This included establishing more rigorous data collection processes to strengthen SHS distribution and sales, introducing the private sector to drive efficiencies in sales and servicing, and developing cross-validation measures to ensure project funds were being disbursed accurately.

## INTRODUCING NEW ACTORS

Another key REAP innovation was to streamline the distribution chain by introducing the private sector and reducing the number of government intermediaries. Prior to REAP, the 100,000 Solar Ger Program relied solely on government agencies to procure and distribute SHSs. Maintaining this single channel led to inefficiencies, particularly because the administrative processes were ad hoc. The program did briefly introduce a cost-recovery component through a partial subsidy. However, there was a significant shortfall in the amount of money that was recovered through the subsidy. This was in part a result of the lack of verification and accountability measures implemented through the government administrative channels. Without adopting standardized verification processes, panels were misplaced, money went missing, and funds did not flow to the intended channels. The decision to include the private sector, in the form of SSCs and the private dealer network, encouraged the program to create a comprehensive verification process and streamline operations because private actors are incentivized to drive efficiency in return for profit.

## PAPER TRAIL

Streamlining the distribution chain also involved establishing an extensive paper trail. REAP introduced a relatively easy-to-use documentation process that included a verification step at every nodal point in the delivery chain (every point where the SHS transferred hands) (Figure 9). This allowed the PIU to track the location, time, and status of every SHS, and allowed them to make more informed decisions about subsidy allocation, delivery disbursement, and funding. Maintaining a paper trail also importantly allowed the PIU to hold each intermediary along the supply chain accountable, despite the demarcation of responsibility. The standardized documentation process also served to denote differences in operational information between the private dealer network and the government distribution channel.

## DATABASE OF HERDERS

To ensure that herders were not receiving multiple subsidies, the PIU kept an online database of herders who had received the subsidy. The database, an off-shoot of the national database of herders, was maintained and updated after each SHS sale. As part of its information-sharing efforts, the database was shared with Khan Bank to ensure that the bank would accept payments from only those herders who were eligible to purchase a panel under REAP. This information sharing across different implementation units was critical to the program's success.

## SUMMARY

Maintaining accountability and transparency was key to ensuring smooth program implementation. This was achieved through several program design innovations, including establishing an independent PIU to oversee implementation, developing a comprehensive paper trail to track SHS deployment, and introducing new private actors to hold public actors accountable.

RENEWABLE ENERGY AND RURAL ELECTRICITY ACCESS PROJECT

TRANSPORTATION FORM ¹ ...

| I. INFORMATION OF RECEIVER | | | |
|---|---|---|---|
| Organization | Posiotion | Last and First name | Phone number |
| | | | |
| II. INFORMATION OF TRANPORTER | | | |
| Name of transportation company | Car<br>Title number | Driver's name | Phone number |
| | | | |

| III. QUANTITY OF RECEIVED MATERIALS | | | | | | |
|---|---|---|---|---|---|---|
| | SHS | Model | technical specification | Unit | Price of unit | Amount |
| 1 | Solar panel | | | | | |
| 2 | Battery | | | | | |
| 3 | Power box with charge controller | | | | | |
| 4 | Light | | | | | |
| 5 | Power cables – Panel | | (15m) 2X2.5 mm² | | | |
| | Power cables – Light | | (5m)2 X 1.5 mm² | | | |
| | Power cables – Battery | | (2m)2 X 2.5 mm² | | | |
| 6 | PV module support structure | | | | | |
| 7 | Operatian manual | | | | | |
| | Total amount | | | | | |

Given by:
Name:
Signature
(Storeman)

Received by:
Name:
Signature

Verified by:

Executive derictor of PIU..............................

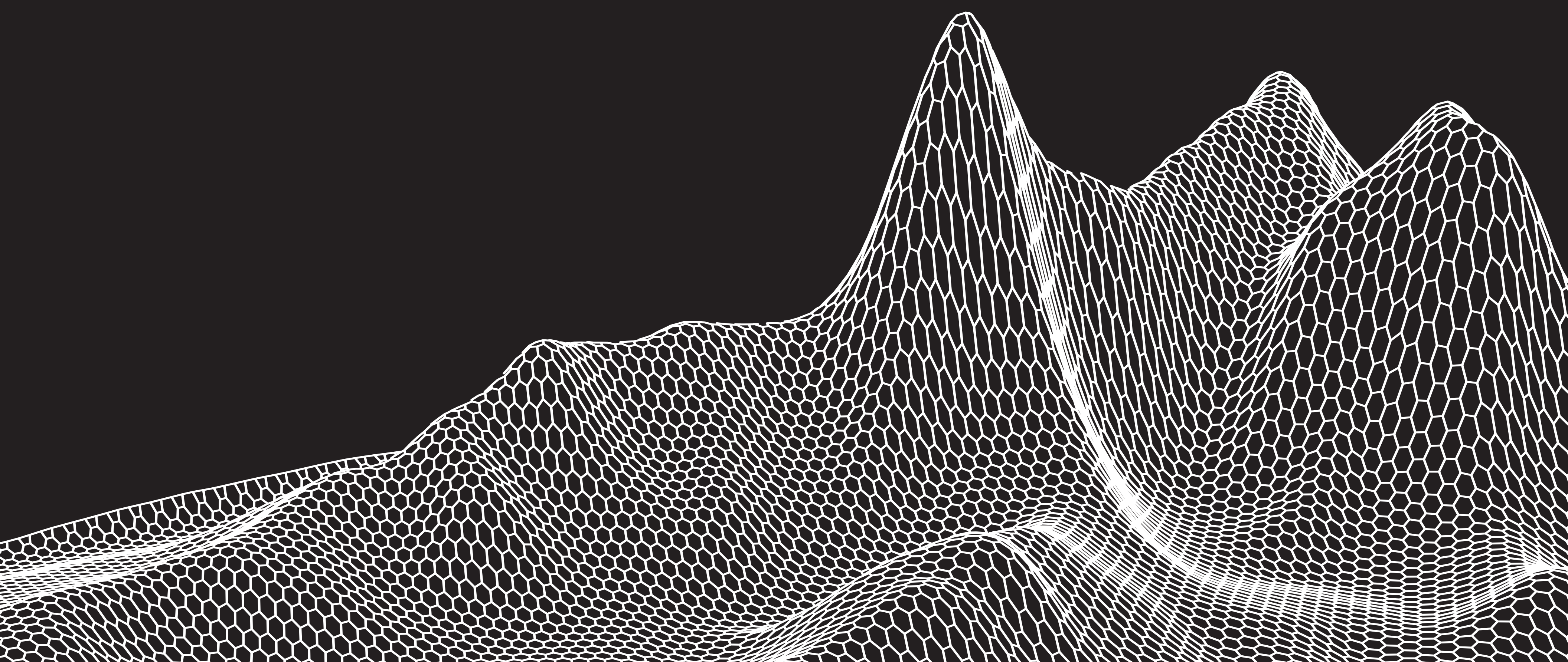
Accountant. ...............

IV. APPROVED BY

| Given by | | | Received by | |
|---|---|---|---|---|
| Stamp | Organization | REAP | Name | |
| | Position | | Signature | |
| | Name and signature | | Other | |
| | Phone,Fax | | | |
| | E-mail | | Date: | |

FIGURE 9. Transportation form required to track panels at each stage

# Lessons Learned



The evolution of the 100,00 Solar GER program into the Renewable Energy for Rural Access Project (REAP) reflected the need for a more effective design that integrated financial sustainability with project viability. The World Bank's involvement in the program was crucial in bringing specialized expertise and proven processes to enable the broader diffusion of solar home systems (SHSs). REAP's success ultimately lies in the dedicated engagement of development institutions such as the World Bank, working in coordination with local public and private actors. Through their combined efforts, the program leveraged resources across different public and private channels, reaching even the most remote herders.

While public and private collaboration and co-ordination remained central to REAP's success, there were several key program innovations that contributed:

1. *The administrative structure present in Mongolia.* The effective use of the existing *soum* administrative network to distribute panels enabled the program to use an existing service-delivery channel to expand distribution. The administrative network maintains near-universal birth registration, which allowed the project implementation unit (PIU) to track delivery to the intended recipients. The geographic coverage of this administrative network is vast but the most basic level (the *soum* level) covers a small area that is accessible to nearly all herders. Using this widespread network was a far more feasible "last mile" than reaching herders in their *gers*. Where access was inadequate, the program utilized private-sector capacity to expand reach. It was this unique public-private partnership that was central in distributing SHSs and providing after-sales services. The demarcation of responsibility along the chain gave REAP the flexibility to hand off the delivery process to regional experts and officials, allowing for more efficient and complete distribution of SHSs.
2. *The introduction of quality standards.* By introducing quality standards, REAP could encourage herders to "trust" and adopt a relatively unknown technology. The quality standards not only ensured panel durability but also established market expectations (in terms of price and quality) that remained even after the World Bank's exit from the program. The training of sales and service centers (SSCs) created opportunities for herders to get their systems repaired locally so they could use the systems for their full lifespan. By training private-sector actors (local business owners) to perform these repairs, REAP ensured that herders were able to continually access repairs even after the World Bank ended their involvement.
3. *Financial planning and accountability processes.* Establishing well-designed cost-recovery mechanisms, such as the subsidy, and the international competitive bidding process ensured that affordability remained key in the procurement and sale of SHSs. The introduction of validation processes, such as establishing an autonomous PIU, developing an extensive paper trail, and introducing the local private sector in the supply chain served to close the gap between program design and implementation.

The success of REAP is in large part a result of the introduction of new processes and practices that improved the design and delivery of a rural electrification program. While the introduction of new processes was spearheaded by an external organization, the deliberate use of existing governing structures, distribution channels, and local actors made the program succeed on the ground. These innovations and achievements helped sustainable energy reach hundreds of thousands of Mongolians, improving their quality of life and paving the way for future social development.

# RESEARCH TEAM

**JOSEPH WONG** is the vice provost and associate vice president, International Student Experience, at the University of Toronto. He is also the Ralph and Roz Halbert Professor of Innovation at the Munk School of Global Affairs & Public Policy and a professor of political science. He held the Canada Research Chair in Democratization, Health, and Development for two full terms, ending in 2016. Wong was the director of the Asian Institute at the Munk School from 2005 to 2014.

**AMY BILTON** is the director of the Centre for Global Engineering (CGEN), and an assistant professor of Mechanical Engineering at the University of Toronto. She is the director of the Water and Energy Research Lab (WERL), which focuses on developing innovative water and energy technologies and computer-based design methods. She has worked on development projects in Bangladesh, Vietnam, Nicaragua, and Mexico. She completed her PhD and MS in Aeronautics and Astronautics at MIT and her BASc in Engineering Science, Aerospace Option, from the University of Toronto. Amy has also worked as a systems engineer at Pratt and Whitney Canada and Honeywell Aerospace.

**AHMED MAHMOUD** (P. Eng) is the CGEN's program manager and a research associate with the Water and Energy Research Lab (WERL). Ahmed works with CGEN faculty members and external partners to identify and fund research initiatives in global development at the University of Toronto. He also helps administer CGEN's student engagement opportunities, including its academic courses and extracurricular activities. At WERL, Ahmed is working with Professor Amy Bilton on designing a passive pond aeration system for rural aquaculture in southeast Asia. Ahmed received his master's degree in Mechanical Engineering from the University of Toronto in November 2016.

**TANVI SHETTY** recently graduated from the Master of Global Affairs program at the University of Toronto. She was previously employed at RBC, where she supported corporate portfolio management. With roles held across public, private, and not-for-profit sectors, she has had the opportunity to tackle social challenges using a cross-disciplinary approach, and has worked with a diverse set of stakeholders to drive change.

**HANNAH RUNDLE** is a recent graduate of the Master of Global Affairs program at the University of Toronto. She holds a BSc in environmental biology and has conducted paleoecological research investigating the impact of climate change on algal assemblages in freshwater lakes. Hannah enjoys applying her diverse background to study the nexus of environmental issues, global development, and international security. In her current role, Hannah supports sustainable business strategy in the financial services sector.

**RUSHAY NAIK** is a Human Biology (Global Health) and Peace, Conflict, and Justice student at the University of Toronto. With a particular interest in the intersection of armed conflict and infectious disease, Rushay uses multidisciplinary approaches to interpret urban and global health challenges. Rushay recently completed research fellowships with the University of Toronto's School of Cities, examining efforts by global cities to revitalize their aging urban infrastructures, and with the Center for the Study of the Presidency and the Congress in Washington, DC, focusing on universal healthcare proposals in the United States. He is currently preparing a senior thesis on Geneva, Switzerland, analyzing transitions in the city's interstate peacemaking "infrastructure" amid the growing complexity of contemporary armed conflict.

**BEN SPRENGER** is a Mechanical Engineering student at the University of Toronto with a strong interest in new technologies for the developing world. He is particulalry interested in sustainable energy developments and the role that they play in combatting poverty and climate change. Ben has also worked on autonomous robot development for use in search-and-rescue applications (e.g., in natural disaster zones). An avid motorsports fan, he currently works for Williams Advanced Engineering on designing Formula E electric race cars in an effort to push cutting-edge sustainable energy technology into the mainstream.

# REACH PROJECT

Development is about delivery—the will and ability to deliver interventions to very poor and vulnerable people to help improve their lives. The development "space" is filled with great ideas and innovative solutions, from technological interventions to new policy initiatives. But the effects of these potentially game-changing ideas are severely mitigated if they do not actually get to the people they are intended to benefit. We think of this challenge in terms of "reach." Solutions can solve problems only if they reach those who need them most.

The Reach Project focuses on the delivery of services and interventions to those who are hardest to reach. We are a research initiative supported by a partnership between the Munk School of Global Affairs & Public Policy at the University of Toronto and the Mastercard Center for Inclusive Growth. The Reach Project is led by Professor Joseph Wong. The commitment of student researchers and faculty mentors from across the University of Toronto drives our work. Together, we examine the delivery of services and interventions to those who are hardest to reach in countries around the world.

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