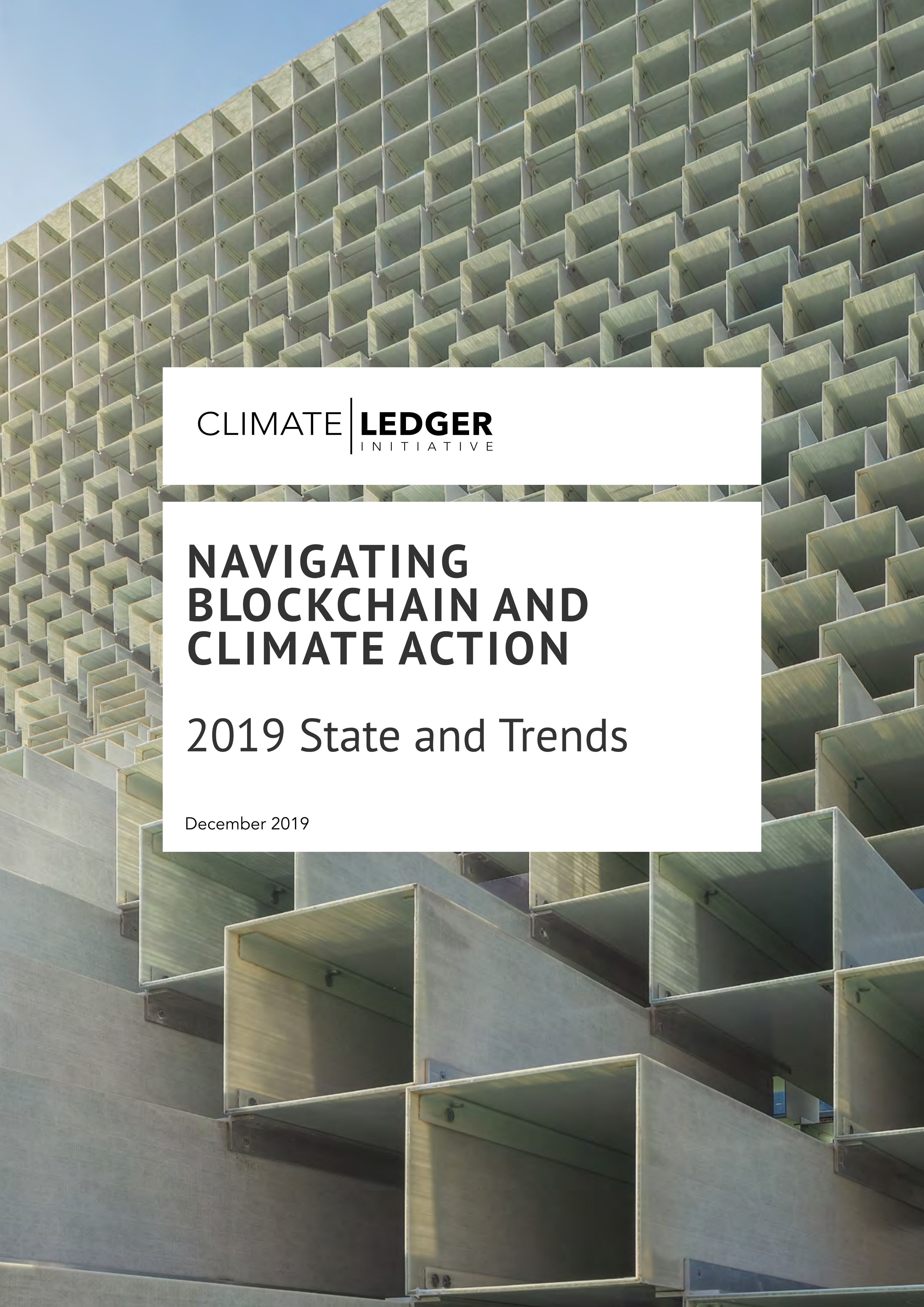

CLIMATE LEDGER INITIATIVE

NAVIGATING BLOCKCHAIN AND CLIMATE ACTION

2019 State and Trends

December 2019

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Preface

This report was prepared by an international team of authors with a diverse set of experiences and insights. It is a knowledge product of the Climate Ledger Initiative (CLI) published on an annual basis to track progress according to latest research and use cases – supporting CLI's role as an international knowledge platform to accelerate climate action through blockchain based innovations.

The Climate Ledger Initiative

The mission of the Climate Ledger Initiative is to accelerate climate action in line with the Paris Climate Agreement and the Sustainable Development Goals (SDGs) through blockchain-based innovation applicable to climate change mitigation, adaptation, and finance.

The Climate Ledger Initiative has been initiated in early 2017 by Nick Beglinger of Cleantech21 and is jointly operated by INFRAS Consulting, Analysis & Research and the Gold Standard Foundation.

In 2019, the Climate Ledger Initiative is financially supported by the Government of Switzerland and by EIT's Climate-KIC. It maintains a platform of donors, partners and collaborators that it is constantly expanding.

For more information, in case of interest in partnerships and collaboration and for registering to our newsletter please visit https://climateledger.org/.

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The Climate Ledger Initiative's second edition of Navigating Blockchain and Climate Action

The mission of the Climate Ledger Initiative (CLI) is to accelerate climate action in line with the Paris Agreement and the Sustainable Development Goals (SDGs) through blockchain-based innovation applicable to climate change mitigation, adaptation, and finance. The initiative sits at the nexus of one of the world's most pressing problems, climate change, with one of the world's most promising technological innovations, blockchain and broader distributed ledger technology. CLI addresses policy and research questions and identifies specific innovation opportunities in the intersection of climate and blockchain. Since the publication of the first Navigating Blockchain and Climate Action Report in 2018, the work has greatly benefited from the discussions and input from participants in over 10 CLI workshops and events and from the support of partner use cases.

In this second edition, we take stock of current state and trends. The report highlights the emerging success stories and bottlenecks in using blockchain for climate action (Chapter 2) and provides a deep-dive into selected crunch issues regarding digitizing MRV (Chapter 3) and tries to make sense of it all in the conclusions.

We are grateful to the diverse range of authors and interview partners who have contributed their vision and real-world learnings. As the findings show, the technologies are developing fast and innovative business are being tested in tangible use phases.

We hope this edition helps practitioners and policymakers alike navigate the quickly evolving field, learn and get inspired from the different experiences in many countries for of using blockchain to achieve the goals of the Paris Agreement.

Summary and key findings

The emergence of the blockchain technology, or more generally Distributed Ledger Technology (DLT), introduces new and innovative form of decentralized database that enables a secure exchange and storage of data and digital assets, primarily designed for peer-to-peer transaction platforms. Blockchain holds the most potential to accelerate climate action in three main areas based on the unique needs of the Paris Agreement (see also CLI 2018 Navigating Report[1]):

- Next-generation registries and tracking systems
- Digitizing Measuring, Reporting and Verification (MRV)
- Decentralized access to clean energy and finance

Blockchain technology has matured during the last 12 months since the first edition of this report. In 2019 blockchain has proven to be more than a passing fad, demonstrating that it can serve as a pragmatic solution to business problems across industries. The increasing diversification of use cases for blockchain and removal of key barriers to adoption suggest further signs of maturation, including for climate action.

The key insights from the report are summarized below.

Carbon pricing and interoperability of carbon markets (2.1)

- Interoperability of emission reduction registries with other databases, such as for example GHG inventories, will be crucial to unleash global mitigation activities. Linking of databases will also be important to avoid double counting of reductions (eg, by automating corresponding adjustments).
- Interoperability is also the precondition to functionalities provided by the World Bank's Climate Warehouse which is a decentralized technology approach to connect climate markets systems and to offer access to international finance. Various real world mitigation activities, such as the generation of climate assets from renewable generation in Chile or the tokenized services provided by EcoRegistry in Colombia are already considering interaction with the Climate Warehouse.

1 https://www.climateledger.org

— Combining carbon credits with carbon taxes is another trend that can be observed in various countries, in particular in Latin America. Linking these domestic carbon pricing mechanisms may be a promising use case for future blockchain protocols and eventually the first step towards a next generation of linked carbon markets.

Digitizing Measuring, Reporting and Verification (2.2)

— Bottom-up development of technology and practices reveal a fragmented landscape but themes emerge around integration of different approaches and win/win scenarios where MRV is improved but analytics also lead to a positive impact on good project design.

— Key barriers to adoption include:

  — Finance – It's difficult to scale up a new technology as a lone proponent; public and private investment is needed.

  — Standards adoption – Standards need to adapt to make sure that they can allow for new approaches.

Choosing digital MRV approaches (3.1)

— Data collection use cases are falling into three potential categories that should integrate and if done well can deliver major positive feedback benefits:

  — Access to existing data sets/data set aggregation to support projects at a larger scale

  — Direct capture of information at impact source

  — Remote sensing of data related to a specific project

— Combinations of the above allow for both reduced cost of access but also a shift towards real time monitoring of key issues which can:

  — Help identify and respond to problems quicker (eg, reacting to illegal logging in real time)

  — Increase value of assets (eg, by avoiding old vintages of carbon credits)

- Standards systems like Gold Standard or the UN CDM or in-house due diligence requirements such as within Green Climate Fund need to:
  - Keep flexible – Avoid prescribing a specific tech over another, rather allow for multiple approaches assessed against core principles.
  - Make sure not to leave anyone behind – Many users will be shut out if only new approaches are allowed due to capacity limitations.

Blockchain for corporate climate and sustainability (2.3)

Supply chain action is a major driver to deliver on ambitious climate commitments. Blockchain has the potential to tackle pressing supply management issues and the new challenges posed by customers' growing expectations for transparency. Improved data management and traceability solutions combined with internet of things (IoT) and artificial intelligence can break down data silos, create significant business value and incentivize climate action at scale.

- Corporate uses of blockchain technology focus on supply chain management across three main themes: traceability, collaborative logistics and product information.
- The question of trust is at the center of a debate on public vs private blockchains. Some experts argue that private blockchains like Hyperledger provide insufficient decentralization for security and trust. On the other hand, private blockchains are usually faster and more efficient because they can circumvent the need for proof-of-work / proof-of-stake and the role of validators. Consortium blockchains allow for hybrid approaches that combine benefits from both.
- The field is very dynamic. The technology has developed incredibly fast over the last two years and issues like energy consumption are being solved faster than anticipated. The current issues with scaling likely have more to do with the maturity of the market than with the maturity of the technology, although scaling on a technical level is often still a challenge.

Decentralized access to clean energy and finance (2.4)

- The increasing capabilities provided by digitalization, in particular blockchain and IoT, have triggered the next level of renewable energy management. IoT and blockchain technology already started to extend financing opportunities of renewable energy deployment as shown by use cases from Puerto Rico and Singapore in this report.
- Blockchain helps mobilize corporate demand and respective finance

— for renewable energy and opens new market segments that are currently not supported by domestic renewable energy certificate systems. With users paying each other directly, many traditional market roles may shift or disappear, including distribution system operators, retailers, suppliers, metering point operators and more.

Conclusions and outlook – It's all about governance

In 2019, we have seen a very fast development of blockchain and related technologies by start-ups but also by many large corporations eager to benefit from the new technologies in their supply chains, processes and sustainability systems. At the same time, not many of the multiple well-meaning climate related "XY-coins" that started in 2017 or 2018 seem to be particularly successful.

Many governments and regulation struggle to keep pace with the technical developments.

In 2019 it is still challenging to replace paper contracts by blockchain-based smart contracts, to pay through the blockchain for climate services and transactions, let alone to interact with governmental registries and databases.

Progress in governance and regulation is also too slow in climate negotiations. In late 2019, UNFCCC negotiators have still not agreed on the "rulebook" detailing the rules for the Paris Agreement's market mechanisms under Article 6.

This underscores the need to inform and engage policymakers in co-shaping the future systems of blockchain based credits and value transfer. The Climate Ledger Initiative will continue to engage and bring together practitioners, technology proponents, government officials and researchers to overcome hurdles and allow full utilization of the potential of blockchain and related innovative technologies for urgently needed acceleration of climate action.

If you want to be part of this, contact us;
we are happy to partner with you.

Abbreviations

- — AI - Artificial intelligence
- — BC - Blockchain
- — BLOB - Binary Large Object
- — BNDES - Brazilian Development Bank
- — CER - Certified Emissions Reduction
- — CDM - Clean Development Mechanism
- — CITL - EU Community Independent Transaction Log
- — CLI - Climate Ledger Initiative
- — COP - Conference of the Parties
- — CORSIA - Carbon Offsetting and Reduction Scheme for International Aviation
- — CTF - Common tabular format
- — DLT - Distributed ledger technology
- — EBRD - European Bank of Reconstruction and Development
- — ETS - Emissions Trading System
- — EWS - Early Warning System
- — GCCI/USA - Global Climate Change Initiative
- — GEF - Global Environment Facility
- — GHG - Greenhouse gas
- — GIZ - Gesellschaft für Internationale Zusammenarbeit
- — GMA - Grocery Manufacturers Association
- — ICF/UK - UK's International Climate Finance
- — ICO - Initial Coin Offerings
- — IKI/Germany - International Climate Initiative
- — IoT - Internet of things
- — ITL - International Transaction Log
- — ITMO - Internationally transferred mitigation outcomes
- — IRENA - International Renewable Energy Agency
- — KfW - Kreditanstalt für Wiederaufbau
- — LIDAR - Light Detection and Ranging
- — LFG - Landfill Gas
- — MO - Mitigation Outcome
- — MRV - Measuring Reporting and Verification
- — NAMA - Nationally Appropriate Mitigation Actions
- — NCIFI/Norway - Norway's International Climate and Forest Initiative
- — NDC - Nationally Determined Contributions
- — PMR - Partnership for Market Readiness
- — PV - Photovoltaic
- — RADAR - Radio Detection and Ranging
- — REC - Renewable Energy Certificates
- — REDD+ - Reducing Emissions from Deforestation and Forest Degradation
- — RFID - Radio Frequency Identification
- — SDC - Swiss Agency for Development and Cooperation
- — SDG - Sustainable Development Goals
- — SKU - Stock-keeping Unit
- — UNDP - United Nations Development Programme
- — UNFCCC - United Nations Framework Convention on Climate Change
- — UNSAID - United States Agency for International Development
- — WTP - Wood Tracking Protocol

1

Blockchain and digital MRV for climate action – moving towards implementation

1

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Implementing the Paris Agreement

According to the Intergovernmental Panel on Climate Change, if we are to limit warming to 1.5°C we will need to lower our CO2 emissions by about 45% by 2030 (compared to 2010 levels). Even limiting global warming to 2°C will require nothing less than transitioning to a carbon-neutral economy by the middle of this century – only several decades from now.

The UNDP/UNFCCC's Global Outlook Report 2019[1] provides an analysis of countries' stated pledges to reduce greenhouse gas emissions. While climate action has accelerated since the Paris Agreement was reached in 2015, it still falls far short of an unprecedented transformation needed to limit impacts of climate change. One of the most critical limiting factors in developing countries is access to finance, according to the joint UNDP/UNFCCC analysis, representing a key entry point for blockchain technology.

Maturing blockchain technology and nexus to climate action

At COP24 in Katowice 2018, delegates completed negotiations on most implementation guidelines to ensure transparency and fairness, respecting the different capabilities and socio-economic realities of each country while providing the foundation for ever-increasing ambition.

The emergence of the blockchain technology, or more generally Distributed Ledger Technology (DLT), introduces new and innovative form of decentralized database that enables a secure exchange and storage of data and digital assets, primarily designed for peer-to-peer transaction platforms.

Blockchain holds the most potential to accelerate climate action in three main areas based on the unique needs of the Paris Agreement (see also CLI 2018 Navigating Blockchain and Climate Action Report [2]):

— **Next-generation registries and tracking systems**: The decentralized nature of the Paris Agreement and its governance structure requires new approaches to registries and tracking systems to handle heterogeneous rulesets for accounting and reporting and to allow for trusted, networked carbon markets.

— **Digitizing Measuring, Reporting and Verification (MRV)**: Blockchain is part of an ecosystem of digital technologies including remote sensors, internet of things, big data and artificial intelligence. The combined use of these new technologies unlocks new, more accurate ways to measure, report and verify climate outcomes at lower transaction costs. Digitization of MRV also allows the coding of methodologies and processes in the form of smart contracts for the automated

1 https://www.undp.org/content/undp/en/home/librarypage/environment-energy/climate_change/ndc-global-outlook-report-2019.html
2 https://www.climateledger.org

issuance, transfer and payment of climate outcomes. Digital MRV can facilitate access to carbon markets or other results-based finance schemes for private sector players, in particular in weaker regulatory frameworks – including for climate finance and adaptation. It can also transform corporate supply chains towards more transparency and accuracy on climate and sustainability impacts of goods produced and sourced.

— **Decentralized access to clean energy and finance**: Blockchain systems emerge as the backbone of new decentralized markets for clean energy where individual "prosumers" are empowered to produce and store their own renewable energy and trade with their neighbors. More generally, blockchain technology combined with new fingerprint, iris or face recognition technology allows individuals who lack identity documents or bank accounts to access climate finance in the form of micro credits, subsidy schemes of payments for mitigation or adaptation action.

Blockchain technology has matured during the last 12 months since the first edition of this report. In 2019 blockchain has proven to be more than a passing fad, demonstrating that it can serve as a pragmatic solution to business problems across industries [3]. According to the Deloitte Global Blockchain Survey 2019, the question for executives is no longer, "Will blockchain work?" but, "How can we make blockchain work for us?". After the financial technology sector was among the leaders in blockchain development, many other sectors are expanding and diversifying their blockchain initiatives, such as technology, media, telecommunications, life sciences, health care and governments. The increasing diversification of use cases for blockchain and removal of key barriers to adoption suggest further signs of maturation, including for climate action.

Note that for simplicity, the term "blockchain" is used to represent broader distributed ledger technologies.

3 Deloitte Global Blockchain Survey 2019 : https://www2.deloitte.com/content/dam/deloitte/se/Documents/risk/DI_2019-global-blockchain-survey.pdf

2

State and trends of blockchain and other innovative digital technologies for climate action

Sven Braden
Programme Manager
Climate Ledger Initiative

2.1 Carbon pricing and interoperability of carbon markets

While the Kyoto Protocol relied on centralized, internationally-governed approaches to carbon pricing, Article 6 of the Paris Agreement recognizes that Parties may engage in decentralized, bilateral cooperative approaches, including the use of internationally transferred mitigation outcomes (ITMOs), to achieve their Nationally Determined Contributions (NDCs). Heterogeneous approaches to carbon pricing introduces trading in different units, with different governance rules, and different technological systems. However, robust and trusted accounting is the backbone to environmental accounting and crucial to trust and credibility of market mechanisms[1]. Thus, consistent with the bottom-up ethos of the Paris Agreement, a decentralized IT approach can link carbon pricing approaches and respective registry systems in a peer-to-peer arrangement.

Carbon pricing curbs greenhouse gas emissions (GHG) by placing a fee on emitting and/or offering an incentive for emitting less. The price signal creates shifts in consumption and investment patterns, making economic development compatible with climate protection. The most common methods of carbon pricing, emissions trading systems (ETS) and carbon taxes.

An ETS caps the total level of greenhouse gas emissions and allows those industries with low emissions to sell their unused allowances to larger emitters. By creating supply and demand for emissions allowances, an ETS establishes a market price for greenhouse gas emissions. The cap helps ensure that the required emission reductions will take place to keep the emitters (in aggregate) within their preallocated carbon budget. A carbon tax directly sets a price on carbon by defining a tax rate on GHG emissions. It is different from an ETS in that the emission reduction outcome of a carbon tax is not predefined but the carbon price is.

Both instruments must operate and interact with special registries or online databases that issue, record, or track the carbon units exchanged within these market mechanisms.

Experience indicates that linking registries of existing carbon pricing schemes has enormous potential to facilitate GHG reductions. It was the successful connection of the UN's International Transaction Log (ITL)[2] with the EU Community Independent Transaction Log (CITL)[3] in 2008 that brought together the demand for the EU ETS with the Clean Development Mechanism (CDM). The eligibility of Certified Emission Reductions (CERs) from the CDM for compliance purposes under the EU ETS led to larger demand for units and tremendous growth of the CDM market, paving the way for the large-scale introduction of low carbon technologies in

1 See e.g.: https://www.infras.ch/en/projects/gestaltung-der-neuen-klimaschutz-marktmechanismen-nach-2020/

2 The ITL is a database that registers and records transaction of Certified Emission Reductions originating from the Clean Devel-opment Mechanism of the Kyoto Protocol

3 From 2008 to 2012 the CITL administered the transactions within the ETS and between 26 EU registries.

many developing countries[4]. However, the CDM and the EU ETS are managing the transactions of their units via centralized registry administrations, which may not be assumed anymore for future markets under Article 6 of the Paris Agreement.

To achieve the necessary GHG reductions to meet the ambition of the Paris Agreement, it will be crucial that the next generation of registries for carbon pricing are interoperable with other registries and databases, such as national GHG inventories. Policy developments at the World Bank, in Colombia and Chile suggest that this next generation of registries is emerging.

USE CASE

World Bank simulation for decentralized Climate Warehouse

Information provided by
Susan David Carevic, Stephanie Rogers and Rachel Chi Kiu Mok,
World Bank

Exploring the potential of a decentralized Climate Warehouse

Information about climate assets is currently collected in a variety of repositories including spreadsheets, databases reflecting pipeline activities, and registries at the country, regional, or institutional level for issued assets. The differences in these processes and systems constrain market integration and add to the complexity of conducting transactions. A new architecture is therefore needed to enhance transparency across different systems while ensuring the integrity of trades.

The Kyoto Protocol utilized an International Transaction Log (ITL), operated by the UNFCCC, to facilitate communication between registries. Under this framework, the UNFCCC had a clear mandate to carry out the centralized function, including a clearance process for transactions. Under the Paris Agreement, which relies on a decentralized approach to markets, climate negotiators are still determining whether a centralized infrastructure should continue, the functions it could perform, and to which market mechanisms or transactions it would apply. Consistent with the bottom-up ethos of the Paris Agreement, there is value in demonstrating a decentralized IT approach to link registry systems in a peer-to-peer arrangement.

The World Bank's Carbon Markets and Innovation team (CMI) is exploring a Climate Warehouse ecosystem to demonstrate a decentralized information technology approach to connect climate markets systems. This meta-registry system would connect to country, regional, and institutional databases and registries to surface publicly-available information on mitigation outcomes (MOs) and record status changes to provide information on how MOs are used. The objective is to enhance transparency and trust among market participants and enable tracking of MOs across jurisdictions and test blockchain technology for this purpose.

4 See e.g. High-level panel's final report on the CDM policy dialogue https://www.cdmpolicydialogue.org/

In spring 2019, the ITS Technology and Innovation (ITSTI) Lab conducted international testing to explore the potential of using blockchain technology to bring together information from various climate markets registry systems. The internal testing comprised of a series of use case specifications to define the meta-registry actors, preliminary data fields, and process flows. These were used as a basis to recommend an architecture and functionality of the prototype.

EXPERIENCES AND FUTURE CHALLENGES

The internal testing demonstrated that blockchain can simplify data sharing amongst diverse registries within the climate ecosystem, so that all participants can account for their MOs in an immutable structure. The decentralized and immutable nature of the system provides resilience against attacks and confidence that asset information has not been tampered with. Since each participant can hold their own decentralized node, the node architecture and access rights can be determined by each participating entity according to the regulations of each country. Blockchain also ensures that MOs can be traceable from their origin to their eventual retirement.

However, blockchain is not a suitable repository for storing large amounts of attribute information about climate actions and MOs. The MRV processes needed to verify project and MO information currently rely on extensive use of audit reports, detailed project information, and imagery. Therefore, more extensive information and attributes of the mitigation outcomes should reside within conventional data storage component.

Blockchains were built to ensure that digital assets are not double spent. However, they do not provide capabilities to ensure that duplicative information is not entered into a blockchain. It is possible for different entities to surface climate assets pertaining to the same climate project into the meta-registry. This problem can be minimized through governance processes that dictate the format of information and its flow into the meta-registry. Other tools, such as artificial intelligence could be utilized to identify information that could be related to the same project. If duplication does occur, at the very least, blockchain provides a record of the occurrence, and corrections will be fully traceable amongst participating parties.

Stakeholder testing will be important to ensure a smooth transition to a decentralized approach to connect climate markets systems. The Climate Warehouse has the potential to change the role of actors and eliminate systems present within the ecosystem supporting the Kyoto Protocol. Since the Warehouse is a new concept, it is recommended that even though the potential exists, the functioning of the Warehouse ecosystem has much to gain by further piloting and co-existence with current systems. This will allow time to build understanding amongst stakeholders during the operationalizing of the prototype and minimize unintended consequences.

OUTLOOK

World Bank is planning a simulation of the meta-registry concept that will link with partner institutions' systems to surface publicly-available information on MOs and enable learnings about the opportunities of this type of decentralized meta-registry system.

Neeraj Prasad

Practice Manager, Carbon Markets and Innovation Practice, World Bank Group

"Continued challenges in international negotiations on climate markets mean that piloting efforts are now more important than ever to enable learning-by-doing. The World Bank is well-placed to demonstrate innovative solutions to address key challenges and build client capacities through collaborative pilots. Moving forward, the World Bank hopes to continue to facilitate regular exchange with Governments, the private sector and other expert groups to explore opportunities to leverage emerging technologies, such as blockchain, for post-2020 climate markets".

USE CASE

Combining a Blockchain-based platform with a registry for mitigation actions in Chile

Information provided by

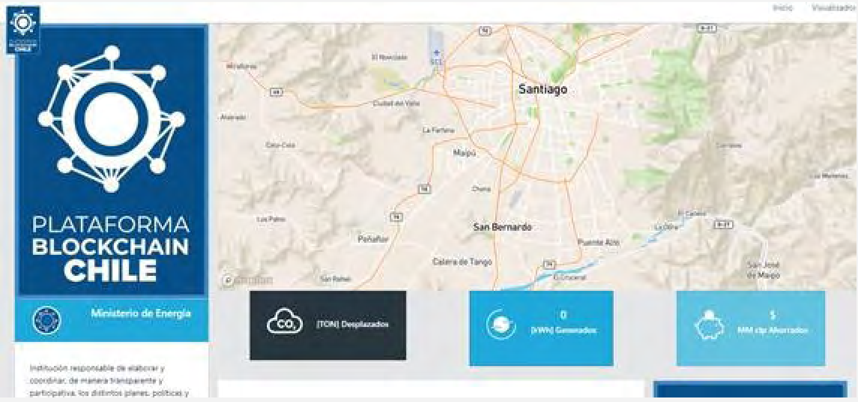
Francisco Dall'Orso León

Climate Change Professional, Ministry of Energy, Chile

The Ministry of Energy, Chile is conducting a pilot project that combines a blockchain platform with a registry for mitigation action. In a first phase the project focuses on the generation of climate assets from renewable energy generation. This can be extended to assets originated from other sources such as energy efficiency activities, the retirement or conversion of coal-fired power plants or e-mobility projects. These assets will be registered mitigation outcomes in the World Bank's Climate Warehouse. (See Use Case above.)

According to the Ministry of Energy, the project will create the supply of mitigation outcomes while operating on the national infrastructure to record and track transfers which can mobilize additional finance to low-emission energy activities.

The pilot phase was developed using the existing Public Solar Roofs Program facilities. Ten solar photovoltaic (PV) installations for self-consumption in public buildings rooftops were selected in different cities of Chile.



Source: Courtesy of the author

"The pilot seeks to explore the potential of blockchain for the development of the carbon market as well as for the reporting of commitments under the Paris Agreement, namely to automatically certify and validate relevant data and protecting it in a distributed way".

Francisco Dall'Orso León

Climate Change Professional

Ministry of Energy, Chile

Automated certification and validation of data

The pilot explores the potential for blockchain for the development of the carbon market as well as for the reporting of commitments under the Paris Agreement, namely to automatically certify and validate relevant data and protect it in a distributed way. Pilot activities aim to ensure robustness and transparency using real field data.

EXPERIENCES AND CHALLENGES

The main challenge was to define the governance of the creation of mitigation outcomes and the MRV protocol. To develop a robust process, the initiators worked in coordination between technical teams of the Ministry of Energy, the World Bank and IT consultants. For monitoring and reporting the challenge was in the extraction and registration of information between different platforms, the blockchain platform, the registry of mitigation actions of the energy sector and the Climate Warehouse. For the validation, the primary challenge was to crosscheck with an independent monitoring station installed in each PV generation plant.

The key will be to improve the understanding and support of blockchain solutions in key institutions like the Electrical System Coordinator to have relatable and secured data of the large-scale generators, or the Superintendence of Environment.

OUTLOOK

It is hoped that the Paris Agreement and Chile's national carbon tax reform – that gives flexibility to the instrument allowing taxed entities to compensate part of their emissions with complementary offsets schemes – will create new markets for mitigation outcomes in the near future. For example, Chile's actual carbon tax covers around 40 million CO2 tons that could be compensated. Technology solutions like these provide needed data security for these markets.

Source: Courtesy of the author

USE CASE

A registry platform for emission reduction projects in Colombia

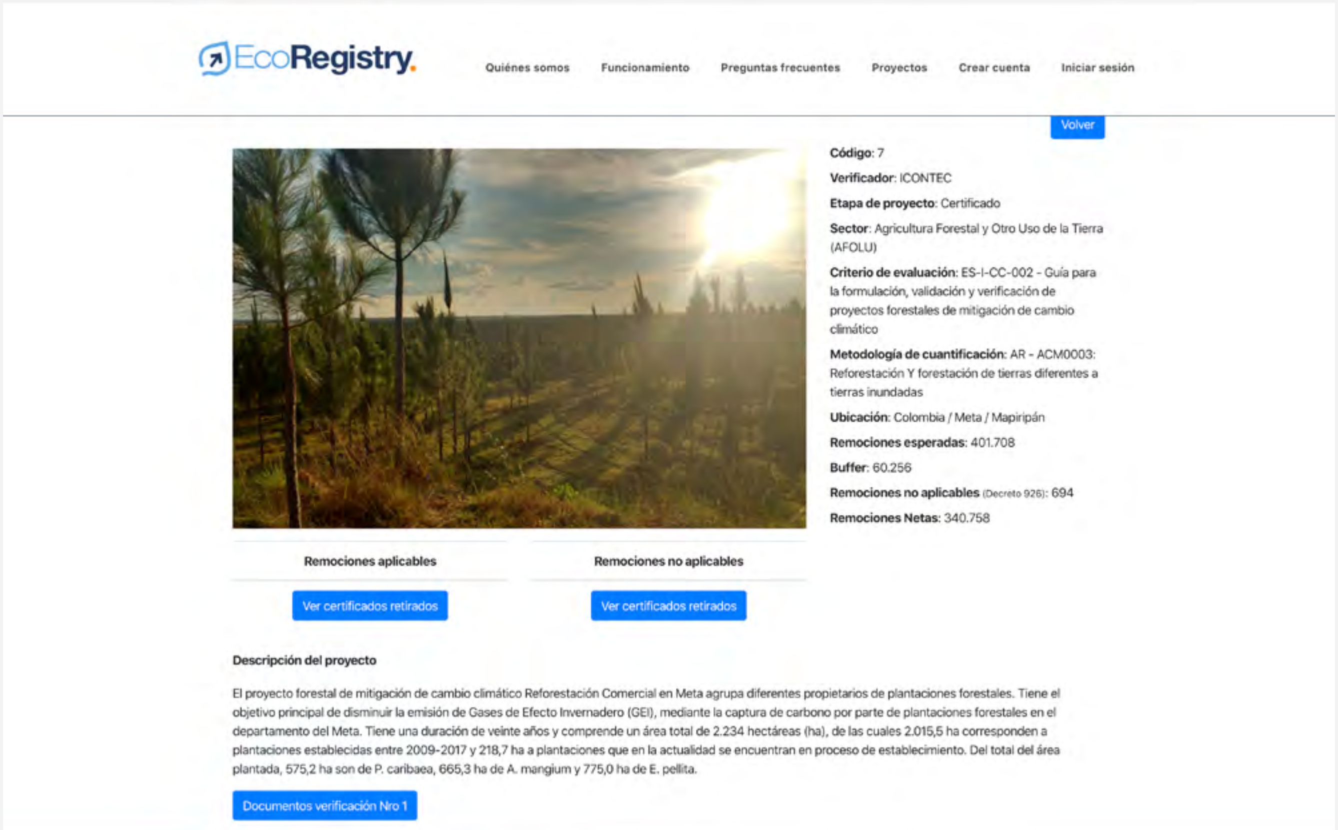
Information provided by

Juan David Durán Hernández

Project Lead, EcoRegistry at XM

EcoRegistry provides a platform for emissions reduction projects to certify, transfer and retire carbon credits. EcoRegistry uses blockchain to increase traceability between the generation and retirement of carbon credits and to safeguard the information of mitigation projects or activities that generated the credits. EcoRegistry runs on a permissioned blockchain that works as a private blockchain and may be scaled in the future to enable any eligible participant to operate a node.

Validation and verification bodies and representatives of certification programs document their work in the EcoRegistry process using digital signature procedures.This process achieves redundancy and validation of the information associated with the different projects. EcoRegistry uses blockchain technology to (1) tokenize each ton of CO2 reduced, (2) publicly stream project relevant data for auditing purposes and (3) "burn" or retire the tokens to avoid double counting of CO2 reductions.



Source: Courtesy of the author

Combining carbon market and carbon taxation

The voluntary carbon market grew considerably in Colombia due to the government's decision to allow for the use of domestic carbon credits towards tax obligations under the Colombian carbon tax (No causación del impuesto al carbono). The EcoRegistry platform aims to ensure transparency, traceability and confidence in the Colombian carbon market by securely tracking carbon credits.

EXPERIENCES AND CHALLENGES

A challenge was the limited flexibility of blockchain systems initially used, limiting the ability to reflect needed changes in the types of users, permissions, and key parameters such as amount of emission reductions.

Another major challenge in the future will be the integration of other registry systems, like the National Emissions Reduction Registry System (RENARE). To ensure efficient information management, EcoRegistry plans to interoperate with the national registry that will register all eligible emission reductions of the country. The objective is that EcoRegistry will be able to feed the databases of different governmental entities, avoiding double work and inefficiencies in information management.

The interoperation of different systems and different kind of markets, like tax-based markets and emissions trading systems, is another major challenge. Here it is important to start standardizing means to exchange data and find common approaches for tangible outputs such as tokenized tons of CO_2 emissions or reductions.

OUTLOOK

Although EcoRegistry was born as a response to the needs of the voluntary carbon market in Colombia, its objective in the medium term is to ensure transparency and traceability in CORSIA and the emerging carbon markets of the Latin American continent, registering mitigation outcomes that cover different sectors certified by various standards. Furthermore, EcoRegistry aims to be interoperable with different national registration platforms and tools such as the World Bank's Climate Warehouse. EcoRegistry is also preparing to feed its information systems with MRV platforms for emission reduction projects based on technologies such as IoT and blockchain to ensure transparent and automatic processes of emission reduction calculations and carbon credit issuance.

EcoRegistry is run by Medellin-based companies XM and Latin Checkout. XM manages the country's wholesale energy market and operates the national power system. Latin Checkout is a company specialized in data analytics. EcoRegistry was officially launched in May 2019. Since then, 13 forestry projects have been registered with the capacity to reduce two million of CO_2e.

Learn more: www.ecoregistry.io

Juan David Durán Hernández

Project Lead,

EcoRegistry at XM

"EcoRegistry serves as an ally of the national government and the emissions reduction projects to keep track of the carbon offsets that applied to the non-causation of the carbon tax".

Summary learnings and outlook

A closer look at the development of next generation GHG registries as currently pursued by various public and private sector activities confirms the path towards interoperability. The World Bank's Climate Warehouse seeks to establish an international platform for commodified emission reductions thereby providing interested (buyer and seller) countries access to the international market. Countries such as Chile or private sector actors such as EcoRegistry in Columbia plan to use their own platforms to generate and transact GHG reductions with the Climate Warehouse.

A closer look at the development of next generation GHG registries confirms the path towards interoperability.

Interoperability is not limited to connecting GHG databases. Next generation registries may also link different carbon pricing approaches. Submitting certified emission reductions to achieve a tax reduction is part of the services offered by EcoRegistry from Colombia. Similar potential to combine carbon credits and carbon taxes via blockchain based approaches exist in other jurisdictions of the region. Mexico and Chile also introduced carbon taxes that may be paid through the submission of certified emission reductions. The approach may also be of interest to South Africa, which aims at combining carbon taxes with domestic crediting systems. The similarities of combining carbon pricing mechanisms in a growing number of countries may provide an interesting environment for decentralized registry approaches in the near future.

Owen Hewlett
Chief Technical Director
Gold Standard

2.2 Digitizing Measuring, Reporting and Verification (MRV)

Measuring, reporting and verification (MRV) plays an essential role to ensure credibility of project outcomes and therefore the broader integrity of the Paris Agreement. A wide range of potential technologies can dramatically enhance MRV, including internet of things (IoT), artificial intelligence (AI), mobile and web applications and Distributed Ledger Technology (DLT) in two key ways:

- **Trust**: Increasing credibility through robust, accurate and consistent data sources, collection, reporting and verification approaches
- **Efficiency**: Reducing time, complexity and costs through automated data collection or sourcing that can be verified in or near real time as possible

Table 1 outlines the four key elements that make up robust MRV with implications and examples of how technology can enhance the process.

TABLE 1 — Today's barriers to MRV

MRV Element	Key stakeholders/proponents impacted	Example issues
Data collection	Proponents of climate action (project implementers, project developers)	— Data reliability and security — Affordability of technology and capacity to apply it at scale — Obtaining funder or standards buy-in to apply the technology
Impact quantification and reporting	Standards operators, funding agencies and project proponents	— Standard processes to flexibly adapt, assess and approve — Allowing for plural approaches
Verification	Standards operators, funding agencies, project proponents and verifiers	— Deviating from established verification timelines and processes — Capacity and resource of verifiers — Perceived threat to verifier business model
Carbon credit issuance	Standards operators, funding agencies and registries	— Trusted issuance to recognized registry system

While fragmented, there are emerging initiatives that impact all four of these elements. This chapter explores trends in data collection and how standards systems are adapting to change.

Digital technology for data collection

To date, MRV of climate action has required manual collection and reporting of data, such as collection of household survey information for community projects or tree surveys in forestry. While these means of data collection are well established, issues remain related to time and cost required, precision of data, and even potential corruption.

The twin issues of trust and efficiency are inseparable; without credible data, automation is irrelevant. Without removal of manual elements, trust will continue to be compromised. New MRV systems that feature automatic capture and reporting of data that is either verified in advance or in real time can be transformational.

Defining trends in the application of new technology in practice can be challenging with the variety of new systems. Two key themes and a number of challenges are emerging. The first concerns integration of solutions that operate at different scales/types of data collection. The second theme concerns reflective learning, where the data generated is used to create a feedback loop that improves the design and implementation of the action being undertaken.

USE CASE

Stairway to Scale – the distribution of efficient cookstoves

Information provided by

Tara Ramanathan

Nexleaf Analytics

In many rural households in developing countries, household cooking takes place on ‘three stone’ open fires, releasing greenhouse gases and other short lived climate pollutants like black carbon, also known as soot or particulate matter. Providing clean cooking solutions to households reduces indoor air pollution and mitigates both climate and health impacts.

EXPERIENCE AND CHALLENGES

The sector is challenging, with barriers to wide scale adoption of new technology as well as reliability and robustness of the clean cooking solutions themselves. Two of the biggest challenges in clean cooking are driving adoption (specific clean cooking technologies either may not be durable or may not be well suited to a family’s typical usage or cultural context) and the monitoring of key parameters related to usage (which can be expensive and unreliable due to their distributed nature). When these two challenges combine it can be difficult to accurately assess true adoption rates.

"Stairway to Scale" is Nexleaf's methodological approach to resolving these issues. It uses direct data capture technology and sophisticated analysis to evaluate and responsibly scale the cleanest and most appropriate clean cooking solutions. Stairway to Scale is therefore an example of how technology, coupled with development best practice can be mutually enhancing through design feedback. The methodology seeks to ensure wide, sustainable adoption of stove technology while overcoming the trust and efficiency issues that are most acutely felt in MRV for the clean cooking sector.

Use cases from rural villages in India and Nigeria showcase the following approach:

— Clean cooking solutions are methodically and responsibly scaled by ensuring the chosen technology is fit for the intended purpose, hence driving up adoption rates. This includes the testing of clean cooking solutions in small groups – beginning with a cohort of 10 households – and incrementally increasing scale once the equipment and/or fuels have met an agreed standard of adoption.

— Sensor devices are applied to the stoves and supported by data analytics tools used to then monitor household cooking activity to measure adoption.

— With the incremental, data-led analysis approach, Nexleaf can identify the obstacles to clean cooking adoption, such as design flaws, supply chain inefficiencies, or improper after-sales service.

OUTLOOK

This use case demonstrates the potential not only to improve trust and efficiency of MRV but also to create a positive feedback loop to further improve the project design and drive sustained adoption. Further challenges to address include:

— Lack of standardization of methodologies and terminology, leading to a broad range of terminology being applied, for example the definition of adoption may vary.

— Improved validation and verification of impacts is required to ensure the adoption of technologies. Wider use of technologies such as on-stove monitors will also ultimately reduce the cost of the individual units and increase the capacity of verifiers to assess.

— Robustness of technology (both stove and sensor) remain an issue for project longevity.

Learn more: https://nexleaf.org/reports/joint-learning-series/beyond-monitoring-and-evaluation.pdf

Impact reporting and quantification: Adapting standards for digital approaches

Standards for MRV may be third-party schemes serving carbon markets, for example the UN Clean Development Mechanism or Gold Standard. They may also inform the investment decision making of climate finance agencies, typically through 'in-house' standards. Good standards schemes include two key elements:

1. Requirements against which potential programs are assessed to ensure robustness
2. Assurance processes through which programs are assessed to confirm conformity to requirements and provide certainty of outcomes

Traditional standards provide clear, concise 'top-down' requirements for project development. The introduction of alternative, 'bottom-up' technology solutions can therefore be challenging, as data collection techniques may deviate from the standards' approach. Instead of prescribing specific technologies, standards could rather ensure that newly approved approaches are consistent with quality expectations.

It is important for standards to recognize that there may be limited access for proponents that do not have capacity to implement technology solutions. Impact verifiers must also be considered to ensure that they are suitably equipped to assess new approaches. Beyond sufficient access and training, verifiers may perceive a threat to their business models as new technology approaches may automate parts or all of the MRV process, which could create resistance to adoption.

New processes in development can help standards operators adapt in way that allows flexibility for their users. CLI's own 'Next Generation MRV' programme is focused on these issues.

USE CASE

The Wood Tracking Protocol – combining the benefits of blockchain with the capacities of mobile devices in Peru

Information provided by

Martin Jaggi
Head of Cooperation in the Andes Region, Swiss Agency for Development and Cooperation (SDC), Peru

With more than half of its territory covered by forests (about 72 million hectares) Peru continues to face significant deforestation, estimated at 143'000 hectares in 2017 for the Amazon region. Wood extraction through illegal logging is an important driver in the degradation of Peruvian forests. Deforestation and logging in the Amazon are characterized by illegality and informality. Corruption plays a central role in the sector, which often influences the granting of concessions and titles of property, as well as illegal logging. Most of the wood exported or sold on the domestic market is illegally sourced. The collusion of public and private actors along the wood processing chain often leads to the counterfeiting of forest inventories or the creation of false data. By purchasing wood accompanied by legal documents, even if it is established on the basis of falsified information, processing and exporting companies may claim to have bought in good faith wood that seems legal. Only a system based on robust field verification allows the forest authorities, as well as intermediates and the final buyers, to verify the legality and traceability of the wood.

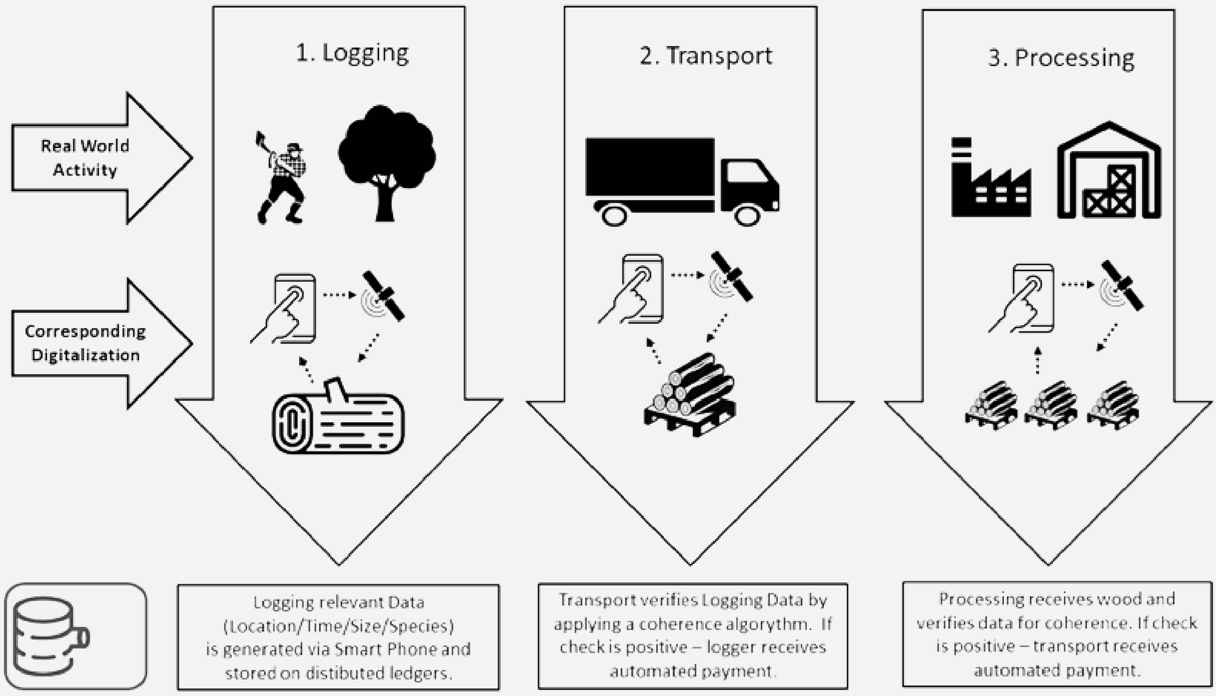
"WTP will allow its users to document their work using photos, GPS data and other features on a mobile device and to store this information in a sequenced and tamper proofed way on a blockchain".

Martin Jaggi

Head of Cooperation in the Andes Region, Swiss Agency for Development and Cooperation

Digitizing the paper trails of wood processing operations in the Amazon region

In 2018 the Swiss Agency for Development and Cooperation (SDC) launched the Wood Tracking Protocol (WTP), featuring a proof of concept and an IT prototype to demonstrate how features provided by mobile devices and blockchain technology can combine to support traceability of wood in the Peruvian Amazon region. WTP includes an application to gather relevant forest data (user information) and a platform to manage and process that data. WTP user information may include geographical parameters of a logging licences, data on the species or size of a tree to be logged or a picture embedded with timestamp and GPS data showing an operation along the wood processing chain. Users of the application connect to the WTP Platform where ID validation via phone number verification takes place. Once users are validated by WTP, they gain access to the blockchain gateway where user information is sent to the blockchain network. This is how the application allows users to document their work (using photos, GPS data and mobile device features) and store this information in a sequenced and tamper-proofed manner. The project complements real world tracking by associating a unique digital history, in particular GPS route and time, to one tree or to one load of wood. In this way, WTP may lower the risk that the same tree or load of wood is double counted along the paper trail.



Source: Courtesy of the author

Linking data gathering tools with other technologies applied in forest initiatives

The WTP plans to digitize and automate parts of the traditional procedures. Ultimately, WTP aims to decentralize procedural responsibilities enabled by a computer protocol to prevent collusion of public and private actors in the wood processing chain. The WTP will maintain flexibility to accommodate future developments and will be developed open source – allowing the software to be used by other stakeholders. Linking data gathering tools, such as WTP, with other technologies applied in forest initiatives, such as image processing or satellite remote sensing monitoring could lead to a win-win situation for the Amazon and their communities.

Source: Courtesy of the author

EXPERIENCES AND CHALLENGES

The application must address the limited internet access in the Amazon region and enable offline operation and safe data storage on the device with subsequent background synchronization. Challenges related to scalability, latency and high energy demand must be addressed. The WTP needs to ensure a positive user experience in the field, which may require capacity building with potential users of WTP (public authorities, logging companies, NGOs). Integrating a payment system into WTP could increase the attractiveness and help ensure sustainable operation. An associated challenge is to define government involvement as administrator of the platform or only as user, as well as broader governance.

OUTLOOK

Piloting in the Peruvian Amazon

WTP is currently preparing for a piloting phase in 2020 in the Peruvian Amazon region to examine viability and scalability. All lessons learned from that phase will be made publicly available.

Learn more: www.wtp-project.com, www.cooperacionsuiza.pe

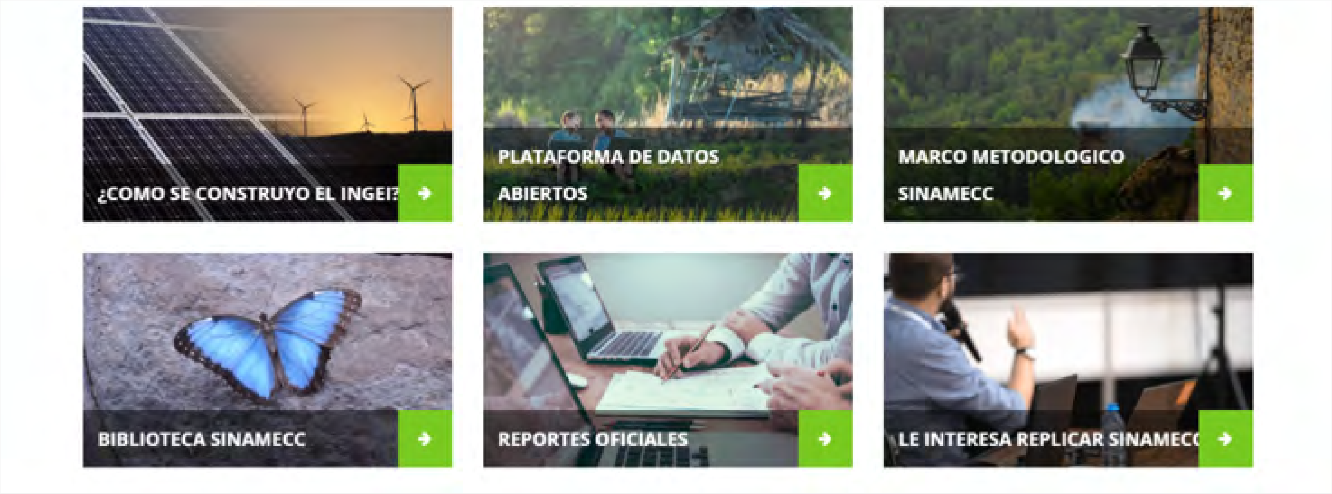
USE CASE

SINAMECC – The national climate change metrics system, Costa Rica

Information provided by

Ana Lucía Moya Mora
Project Manager SINAMECC, Costa Rica

The National Climate Change Metrics System (SINAMECC from its Spanish acronym) is a tool to facilitate the transition of Costa Rica to the Enhanced Transparency Framework reporting process and to improve data-based decision making to address the climate crisis. The system has been built as open-source software with the explicit goal of sharing it with other countries, which can then work together to maintain and improve the system, saving resources and improving South-South collaboration. SINAMECC has an important impact on GHG in two areas: Enhancing capabilities of MRV and improving the knowledge base for decision making.



Source: Courtesy of the author

By providing a process and platform for accounting of mitigation actions and their relationship to GHG and to NDC accounting, including the use of market based mechanisms, SINAMECC enhances MRV capabilities. By improving data availability and providing links for and to modelling and visualization tools, SINAMECC facilitates the use of data which strengthens the knowledgebase for decision making.

Combining data management, climate reporting and decision making

Transparency is the backbone of the Paris Agreement and the transparency framework is one of the main mechanisms to inform the global stocktake. The set of rules that countries have to follow under new transparency regime include a stronger reporting of the progress to achieve the NDC targets and better accountability of the mitigation actions and its outcomes. In this context, developing countries face an important challenge, since they must build or strengthen their MRV systems and arrangements to comply with biennial reporting requirements.

SINAMECC seeks to address that challenge. The system considers automatization and process improvements for data collection for GHG inventories, calculation and publication through open data standards, a registry for mitigation actions along with a national carbon asset registry designed to be used with blockchain technology, a climate finance registry, and modelling and scenario-building tools.

Source: Courtesy of the author

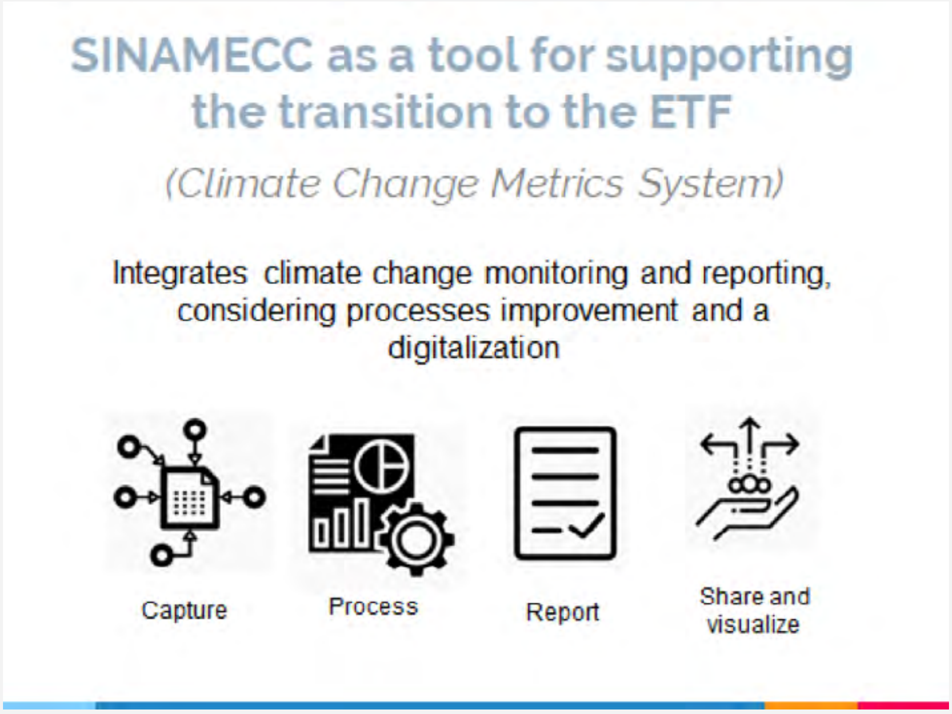
EXPERIENCES AND CHALLENGES

The design of SINAMECC began five years ago. Considering the development of transparency rules under the UNFCCC until today, it has been crucial to design SINAMECC in a way that is flexible enough to evolve and adapt quickly without deviating from its original concept and objective so it can constantly grow. The system has had important growth since 2018, mainly on the programming and standardization of processes to develop its first operative version. The first version of the SINAMECC platform will include most of its mitigation tools. These tools can be replicated by other countries.

"SINAMECC provides an innovative approach by combining data management, climate reporting and decision making, publication and opening data. And by sharing its developed tools and structure it enables for exchanging lessons learned with other countries".

Ana Lucía Moya Mora

Project Manager SINAMECC, Costa Rica



Source: Courtesy of the author

The implementation process depends on the use and appropriation of key stakeholders, such as data providers, report compilers and policy makers. This represents a challenge, considering that the digitalization and technological improvements processes usually come with an adaptation period before realizing full benefits. A future challenge will be governing SINAMECC as it is envisaged to be extended through multiple countries. This requires a strong structure to maintain and improve SINAMECC while providing support, capacity building and advisory to users and respective countries.

Another challenge is a considerable gap of IT knowledge within most of the people implementing climate action. This reduces the possibilities of innovation and in some cases enhances change resistance. Therefore it is crucial to extend technical capacity building within the climate change community in the future. Finally, it is also important to conduct more applied research, eg, using real world problems as input for cutting edge IT innovation.

OUTLOOK

In five years SINAMECC open tools will have been implemented in several countries, establishing a network between countries to improve its metrics, share experiences to meet the Biennial Transparency Report (BRT) requirements, and improve and maintain SINAMECC's tools collectively. This common framework will also promote dialogue and collaboration opportunities between countries. It is projected that in five years SINAMECC will include tools and processes to account for:

- Co-benefits related to sustainable development and transformational change, functionalities that are already being conceptualized and designed with first pilots soon to begin
- Adaptation and implementation means, with a first focus on finance
- Mitigation actions registry and outcomes using blockchain and communicating efficiently with other registries

The system will be profiled as an international model to improve transparency and decision making in an efficient and collective way.

Learn more: sinamecc.go.cr

USE CASE

Integrated and innovative MRV platform to track NAMAs in energy and transport in Peru

Information provided by

Daniella Rough
Project Coordinator[1],
Ministry of Energy Peru (MINEM)

The Project "Nationally Appropriate Mitigation Actions (NAMA) in the power generation sectors and its final use in Peru" has developed four Energy NAMAs which include (1) universal access to sustainable energy, (2) energy efficiency in the public and private sectors, (3) promoting grid-connected non-conventional renewable energy, and (4) electric transport. The four NAMAs comprise a total of 12 mitigation measures that are formally included in Peru's NDC. These measures are reported in a digital MRV platform, which also monitors and evaluates the situational state of the rural population's energy needs and advances of the national programs. To ensure a transparent, traceable and credible tracking process for each of the mitigation measures, the project is currently evaluating the use of blockchain technology in the MRV protocols.

Allowing the replication and up scaling of mitigation activities

An important component of the Universal Access to Sustainable Energy NAMA is the continuous evaluation of the population's energy access and needs. Therefore, the project has developed a census to evaluate the energy access and needs in rural populations, which consists of a geo-referenced survey developed for mobile devices to enable data collection and determine gaps more efficiently and economically. The census collects data in real time on a web platform, which enables online monitoring of information collected in the field by government entities, as well as a limited version that the project is developing for the public. This helps to improve the accuracy of national programs and planning at the national level via the provision of detailed information on the energy needs of the target population.

All progress within the four NAMAs and their 12 associated mitigation measures will be registered in the MRV platform with the aim to eventually integrate the remaining mitigation measures in the energy sector and other sectors. A structured monitoring process foresees validation and annual reporting of the results. This approach allows the replication and up-scaling of future related activities in other sectors. The potential integration of blockchain technology in the MRV systems will allow for greater transparency and traceability of emissions avoided by GHG mitigation projects, lowering the risk of double counting of emission reductions.

1 Coordinator for the UNDP/GEF Project "Nationally Appropriate Mitigation Measures (NAMA) in the power generation sectors and its final use in Peru", based in the General Directorate of Energy Efficiency, Peruvian Ministry of Energy and Mines (MINEM)

Source: Courtesy of the author

EXPERIENCES AND CHALLENGES

The primary stakeholders of the NAMA Project are the Peruvian public and international cooperation organizations such as UNDP. The public awareness of these activities grows every day with the further project promotion through a web page, new pilots, events, and workshops.

Data integrity and security are fundamental aspects of good governance, since public institutions have an obligation to protect sensitive and personal data of their citizens. The loss, inappropriate use, confidentiality breaches, and/or concealment of data are continuous risks. At the same time, free access to information is essential to maintain public confidence in government transparency. Therefore, processes must be to established to allow proper flow of data between citizens and the state. Experiences show that such flows need to be aligned with transparent practices (eg, using standards such as the ISO 27001 standard for information security, ISO IEC/12207 – NTP for managing the Life-Cycle of the Software, and ISO IEC 15504 or Capability Maturity Model Integration).

The geographical and cultural diversity of Peru creates challenging conditions for the implementation of new technologies. Many projects, especially in rural areas with difficult access, require unique social and technological solutions to achieve full acceptance and participation of the diverse target populations. Another technical challenge is the implementation of blockchain technology and interoperability within the MRV platform, through web services, service-oriented architecture (SOA) and representational state transfer (REST). The massification of the Internet and the 5G network will be a fundamental axis for the implementation and monitoring of innovative sustainable energy technologies in rural areas such as photovoltaic installations, as well as the promotion of new energy systems such as smart grids, electric transport and integrated energy management systems.

"The potential integration of blockchain technology in the MRV systems will allow for greater transparency and traceability of emissions avoided by GHG mitigation projects, lowering the risk of double-counting of emission reductions".

Daniella Rough

Project Coordinator, Ministry of Energy Peru (MINEM)

OUTLOOK

Over the next five years, the strategies regarding technological innovation and support will be applied throughout the country's public and private institutions. Accordingly, NDCs will be updated with new and more ambitious goals, with proven, improved and innovative MRV systems.

Learn more: www.minem.gob.pe, http://namasenergia.minem.gob.pe

Summary – The need to connect the dots in a dynamic but fragmented environment

Between the MRV elements of data collection, impact quantification and reporting and verification there remains a highly fragmented landscape of innovation, albeit with key themes emerging. While it remains clear that the opportunities afforded by digital approaches in driving trust and efficiency are great, there are also key challenges and barriers to overcome:

— Finance and capacity are the main barriers to scale. While individual project proponents and technology come forward with single or limited application opportunities, for most it remains too expensive and not a high enough value to invest in change. Funding is required to assist with the acceleration, implementation and testing of digital approaches.

— Digital approaches may initially impose higher transaction costs for proponents, particularly for first adopters. Conversely, others may be unable to access new approaches due to capacity or access issues related to their specific contexts. Funding should be extended to not only support use cases but also to grow capacity and understanding in the sector.

— A lack of standardization of approaches makes it challenging for technology developers to establish protocols that can align with climate policy and standards. It may be that for certain technologies it is not yet cheaper to apply a digital approach and will not be until sufficient usage is in place to benefit from economies of scale, which in turn is limited by standards adoption.

— Digital approaches, particularly those that automatically capture data, may also require enhanced safety, privacy, security and fraud protocols that are beyond the reach of individual proponents to provide.

— Scaling solutions relies on critical mass adoption to reduce cost of technology, which in turn requires adoption by key organisations and standards. It is challenging for standards operators to provide the flexibility and efficiency of decision making needed to support the introduction of new approaches whilst also maintaining access for those that may not be ready to adopt them. Standards should develop flexible decision making and adaptation approaches to allow for innovation without prescribing or limiting to individual technology solutions.

It is important that capacity across proponents/technology providers, standards and verifiers are grown together in a holistic way. To overcome issues of early adopter risk, cost of technology and comparative studies and cost-benefit discrepancy this will require large scale funding to support. It is clear though that the potential benefits associated with improving trust and efficiency are worth the investment of time and resources to unlock.

Marion Verles
Chief Executive Officer
SustainCERT

2.3 Blockchain for sustainable supply chains

Taking climate action in supply chains is the key for many companies to deliver on ambitious climate commitments. At the time of writing, 683 [1] companies have committed to reduce their emissions in line with what science says is required to stay below two degrees; and most of them have identified their supply chains as a priority lever to drive emissions reductions at scale.

Blockchain has the potential to tackle pressing supply chain management issues and the new challenges posed by customers' growing expectations for transparency. Improved data management and traceability solutions combined with internet of things and artificial intelligence can break down data silos, create significant business value and incentivize climate action at scale.

Companies are increasingly leveraging blockchain to advance their supply chain management and sustainability challenges. For incumbents, widespread adoption of the technology in supply chains is expected to generate significant costs savings and greenhouse gas emission reductions; for new entrants, the technology is often seen as a vehicle to drive a deep transformation of food systems through radical transparency. The technology is rapidly maturing and barriers to scale are now primarily ecosystem related rather than technology related.

Blockchain for sustainable supply chains

Adoption of blockchain technology by corporates is driven by a combination of supply chain management and sustainability goals across three main themes: traceability, collaborative logistics and product information.

From a supply chain management perspective, the technology is expected to drive efficiencies in supply chains that are inherently complex. Ons Sassi, Innovation Project Manager at GS1, a global retail and healthcare distribution industry association known for launching standards for bar codes, cites goods tracking and load / unload appointment management as two areas where the technology can unlock significant efficiencies. In these two examples, blockchain helps overcome the challenge of data silos by connecting separate platforms to allow the sharing of data and the transferring of value without the need for assurance from a third party. For example, in a situation where a transporter is late and another one early, predefined automated smart contracts can transfer an appointment from one transporter to the other, thereby avoiding late fees for one and downtime for the other whilst ensuring value is transferred safely and commercially sensitive data is protected. A study by GS1 and Mines ParisTech estimates that blockchain-based interoperability between load / unload appointment management platforms could save 9% of CO_2 emissions and 15% of transport costs.

1 Science-based targets website

From a sustainability perspective, the technology is used to deliver against the need to give customers accurate information on origin, quality and impact of products. Because it offers traceability, trust and efficient payment solutions, the technology is seen by many as a promising delivery vehicle for sustainability strategies. Initiatives that were either at concept or early stage a year ago have now largely moved to pilot implementation. Others have experienced severe difficulties and stopped operating, whilst several new entrants have joined the movement.

Box 1 below provides an overview of key players using blockchain for sustainable supply chains in the agri-food sector.

New digital ecosystems including blockchain can break down data silos, create business value and incentivize climate action at scale in corporate supply chains.

Box 1 –

Key players in the blockchain for sustainable supply chain agri-food sector

Incumbents are typically large fast moving consumer goods companies or established technology players planning to use blockchain to future-proof supply chains and their business models. Selected examples include:

— Carrefour - The French retail company has set the goal to use blockchain for all its Quality Line Product by 2022. After a first use-case on the Ethereum platform, Carrefour has now joined the IBM Food Trust Consortium.

— Unilever - The sustainability leader started engaging with the technology back in 2017 with a year-long pilot on the tea supply chain with Provenance. It has now joined the IBM Food Trust Consortium.

— Wal-Mart - In September 2018, the retail giant claimed to be able to trace 25 products from 5 different suppliers using a system powered by the Hyperledger Fabric.

— IBM - With its Blockchain as a Service, IBM Food Trust Consortium is clearly a dominant player in the sector. It started in 2015 with the Hyperledger project launched by Linux Foundation and funded by Accenture, Cisco, Intel, JP Morgan and IBM. IBM Food Trust provides several functionalities including traceability, management of certifications and insights into supply chain efficiencies for a monthly price starting at $100 for small businesses.

New entrants are newly established consumer brands or technology providers planning to leverage the technology to disrupt the sector by providing radical transparency and a sense of purpose to customers. Whilst some of them are using the IBM Food Trust Consortium, others have opted for different technology providers, often with a preference for public blockchains.

— Moyee coffee - The world's first FairChain coffee is planning to use the technology to fix what they call a broken coffee supply chain by driving value to farmers and giving them access to credit.

— Open SC - The joint venture between conservation non-profit WWF and consultancy firm BCG Digital Ventures, backed by Humanity United and Working Capital, seeks to transform supply chains by providing traceability, impact verification and information sharing solutions.

— Farmer Connect - A Swiss start-up created in 2019, it provides a blockchain enterprise platform, a digital ID for farmers and a consumer app (Thank My Farmer) with the objective to create an ecosystem for digital connectivity from farmer to consumer and everyone in between.

From delivering trusted data to driving behaviour change

Corporate motivations to engage with the technology for sustainability purposes are to provide transparent, credible and relevant data to customers. There is, however, a significant difference in the way the technology is used by some new entrants planning to leverage blockchain to empower customers and producers to change their behaviours. Whilst the IBM Food Trust private blockchain solution appears to be the dominant player, newly established technology providers (eg, OpenSC, Farmer Connect) and consumer brands (eg, Moyee Coffee) are hoping to transform the sector by providing radical transparency and a new set of incentives. In this context, the technology can become a vehicle to achieve a rapid transformation of the food system that currently fails to serve either the people or the planet, empowering customers and producers to drive this change.

The trust that comes with a public, decentralized blockchain is 'critical to drive behaviour change' explains Markus Mutz, CEO of OpenSC, adding 'our vision is to provide database transparency so you don't have to trust OpenSC'. The vision to use the technology to drive changes in customer behavior is shared by the FairChain Foundation whose experiment with The Other Bar turns customers into change agents by giving them the opportunity to finance the purchase of cocoa trees. Similarly, FarmerConnect also hopes to create a virtuous ecosystem where consumers are provided a safe and transparent channel to transfer value to coffee producers.

Private vs public blockchains

The question of trust is at the center of a debate on public vs private blockchains. Some experts argue that private blockchains like Hyperledger on which IBM Food Trust is built do not provide sufficient decentralization to create security and trust. On the other hand, the benefit of private blockchains is that they are usually faster and more efficient because they can circumvent the need for proof-of-work / proof-of-stake and the role of validators. Consortium blockchains allow for hybrid approaches that combine the benefit from both. Table 2 provides an overview of the features of private and public blockchains.

TABLE 2 — Private or Public?

	Private Blockchain	Consortium Blockchain	Public Blockchain
MAIN FEATURES	— Permissioned blockchain — By invitation only — Privacy guaranteed — Only selected nodes can read and write	— Hybrid model, semi-decentralized — Managed by a group of organizations or individuals — Pre-selected set of nodes controls the consensus process	— Permission-less blockchain — Anyone can join — Anonymity guaranteed — Any node can read and write — Security achieved via consensus mechanism (proof of work, proof of stake)
EXAMPLES	— Hyperledger — IBM Food Trust — Farmer Connect	— Energy Web Foundation — Banking sector blockchain platforms	— Ethereum — Bitcoin — OpenSC
BENEFITS	— Protecting IP and commercially sensitive information	— Combine efficiencies and privacy benefits of private blockchains with de-centralised governance of public ones	— Security — Full transparency
LIMITATIONS	— Security		— Speed

Two main categories of challenges remain in reaching scale: technology-related challenges and ecosystem-related challenges.

Scalability is often hindered by the limited interoperability between platforms. This means that scale may not come in the form of one platform getting to scale but rather in the form of multiple platforms working together at scale. Another challenge with scale comes from the 'realities of the production systems we are dealing with' explains Markus Mutz. Whilst 'algorithm design is very well catered to scale', other solutions like sensors can become prohibitive at scale. Hence the need to design for scale at the outset.

Ons Sassi is confident about the technology's capacity to scale, she explains 'the technology has developed incredibly fast over the last two years. Issues like energy consumption for example are being solved faster than we thought'. She adds 'the issue with scaling has probably more to do with the maturity of the market than with the maturity of the technology'. This is particularly true for private blockchains which scale more easily; public blockchains, however, still face limitations.

Technology developments continue to progress with speed – much faster than anticipated a year ago. It is clear that an enabling environment in the form of a conducive ecosystem are keys to scale. This includes fit-for-purpose regulations on critical issues such as digital identity or monetary transfers, the persistent knowledge gap on the side of the users or the perceived high risk associated with the technology. This is where progressive policies and forward looking governments can change the game.

Sven Braden
Programme Manager
Climate Ledger Initiative

2.4 Decentralized access to clean energy and finance

The generation and distribution of renewable energy is one of the most important means to achieve the objectives of the Paris Agreement. Blockchain technology allows for transparent peer-to-peer energy transactions and may help to disrupt traditional ways to generate and distribute energy. Decentralization plays an important role. The growing use of small renewable energy installations, such as rooftop solar panels, can create stress on electricity grids that were designed with large, centralized power plants in mind. By allowing peer-to-peer energy trading and incentivizing local consumption at the time of production, blockchains can help stabilize electricity grids and further decentralize energy production. Moreover, blockchain technology has already started to extend financing opportunities of renewable energy deployment.

Until recently, environmental commodities such as renewable energy certificates (RECs) or carbon credits have been certified through inefficient bureaucratic processes. Trading mainly occurred via over-the-counter intermediaries. The administrative system was and still is cumbersome, expensive, slow, and centralized. It creates numerous barriers to market access, especially for smaller market participants. Developers of clean energy are usually required to pay upfront fees to participate, making it cost-prohibitive for many smaller companies. Buyers generally source these credits through intermediaries, requiring administrative efforts and costs that often lead to a decrease of economic attrac-tiveness of the market for environmental commodities in general. Buyers also remain wary of the legitimacy of these credits because of the opacity of the market, with some bad actors manipulating data at the expense of the long-term credibility of the market.

Blockchain technology supports the monetization of impacts from renewable energy generation, eg, via tokenization of carbon reduction units or RECs, which may further lower future costs of the energy transition. Real world activities conducted by Yale University and MIT Media Lab in Puerto Rico or the Reneum Institute in Singapore are al-ready testing the possibilities of financing and managing decentralized energy generation of the future.

Blockchain technology can help lower future costs of the clean energy transition.

USE CASE

Contractual automation and crowd securitized crowd-investments in renewable energy project finance: Puerto Rico pilot

Information provided by

Martin E. Wainstein
PhD Yale Openlab, Yale University,
Digital Currency Initiative, MIT Media Lab

One and a half years after hurricane Maria hit Puerto Rico— taking down the centralized electric grid into total blackout— communities were still relying on a high-carbon energy system vulnerable to climate impacts. Groups at MIT and Yale began engaging with the school communities to evaluate how research and development efforts in the intersection between emerging digital technologies and renewable energy could best help with their pressing needs.

The clear option for providing energy resilience for the island was the financing of locally owned solar energy and the creation of community-based microgrids. But the main problem and opportunity was not the lack of technology nor the need for blockchain in the transactive nature of microgrids, but the lack of viable financing options to deploy the upfront hardware costs. There are many options for financing solar energy in the United States. However, most traditional mechanisms such as long-term power purchase agreements (PPA), lease-to-own models and the monetization of federal tax benefits and green attribute credits are cumbersome and require economies of scale to be affordable; aspects not available for community initiatives.

Bringing contractual automation and fintech to the 'pay-to-own' model so that solar assets are eventually owned and managed by the local communities was the solution. In early 2018 Yale and MIT began building the OpenSolar platform, which leverages blockchain and Internet of Things (IoT)-based smart contracts for disintermediations and automations designed to streamline the flow of securitized crowd-based funds (eg, municipal bonds and equity) to finance the deployment of solar assets. The platform's smart contract allows end-users to own these resources after a payback period through regular utility-like payments driven by energy generation and consumption IoT-based data[1].

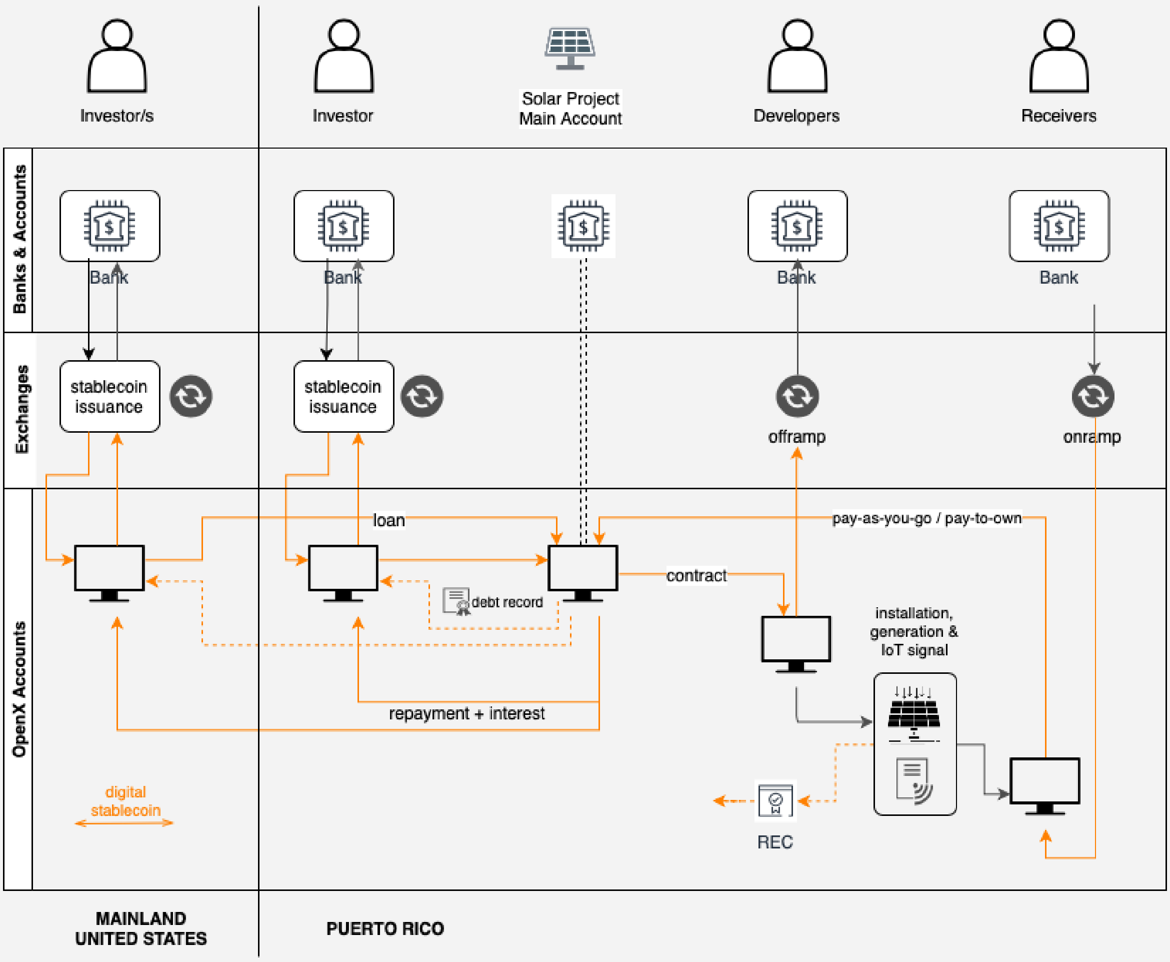
An investor in Munich could contribute to a pool of loans that provides affordable funding to a microgrid in Vieques, Puerto Rico, and know that the rights to the power generated are being managed equitably. If repayments aren't fulfilled, consumer connections could be limited or disconnected and surplus production supplied to a reservoir of storage and other paying users, all within a system in which neither the borrower nor the lender can manipulate the result. Research points to a decentralized system of property rights, one that bypasses official property registries and inefficient legal proceedings to protect the rights of all parties to a financial contract.

1 See also Martin E. Wainstein (2019): Blockchains as Enablers of Participatory Smart Grids, Technologyl Architecture + Design, 3:2, 131-136

The OpenSolar platform is in its full beta version. It is built on the Stellar blockchain, uses stable US dollars as main internal currency and holds integrations to the Swytch platform for the management of blockchain-based renewable energy certificates (RECs), which in turn act as green attestations for impact investors. Pilot projects have been deployed in public schools and community centres in the rural areas of Puerto Rico.

The core mechanism of the platform integrates IoT data with a project-specific smart contracts, whereby energy generation data (in kWh) triggers three key processes. The first involves the generation of a REC, a digital record that 1 MWh of clean energy was generated, which has economic value, can be traded between parties, and is important to certify green attributes for impact investors or for specific climate finance instruments like green bonds. The second automated process facilitates service utility payments and investment clearing and settlements. Using a blockchain-based banking network and payment channels, regular bills are self-executed between the energy offtakers and the projects main escrow account. Inflows from energy payments cover operational costs, interest to investors, and accruements to repay the initial projects' capital cost. The third key process is the transfer of asset ownership, from investors to end-users as their payments accrue to cover the system's cost.

To ensure smart contracts are correctly executed from validated data, machine learning, artificial intelligence (AI) or other statistical computations are used as part of what are called 'oracles,' computer agents that cross-reference actions and perform verifications before smart contracts are executed. Other automations facilitated by the platform involve processes to de-risk the investor position in the case of payment breach, such as in blended finance mechanisms where an 'impact-first' guarantor can ensure first-losses throughout the project.



Source: Courtesy of the authors

This creates disintermediation and contractual automation for:

- Low cost solar financing: High trust and peer-to-peer transactions using security instruments (equity and bonds)
- Digitized Power Purchase Agreements: IoT-driven payment from offtakers to investors with associated ownership changes and tariffs anchored to local values using independent oracles
- Breach response: Contract execution of hardware overrides, and guarantor (blended capital) flows
- Environmental and social impact certification: Attestation of events, packed into data rich non-fungible tokens that replace the analog version of the REC

EXPERIENCE AND CHALLENGES

The first prototype was built using Ethereum smart contracts. However, at that time, the Ethereum ecosystem did not offer significant tools for financial technology, such as stable coins, high throughput in payments and low transaction cost, leading the project to the Stellar blockchain. Since then, the Ethereum decentralized finance ecosystem has evolved significantly offering many possibilities that could outperform Stellar given that is holds on-chain smart contracts. However, different pros and cons are still being evaluated, and in the meantime all measurements to keep the platform ecosystem-agnostic have been made.

The biggest challenge the project faces is the lack of compatible regulation to be able to operate the platform with regulated securities, particularly in the United States. After several ICO (Initial Coin Offerings) frauds, financial regulators still don't accept distributed ledger technologies to be adopted for the management of bonds and equity. The project hopes this work can inform and provide valuable research for regulator to revise their position on DLTs.

OUTLOOK

After the final end-to-end pilot, projected for Q1 2020, the project will take on two parallel tracks as next steps. First involves a strategic and regulatory analysis on how to deploy the solution at scale within the United States, using mechanisms approved by the Security Exchange Commission whilst ensuring a sustainable business model. The second includes the exploration of the platform for the management of climate bonds in cross-border investments for projects that also use the IoT data and blockchain records to certify mitigation outcomes, which could be eventually eligible for their international transfer, as per Article 6 of the Paris Agreement.

Martin E. Wainstein

Yale Open Innovation Lab

"The Climate Ledger Initiative has been providing immense value in summarizing a very complex landscape so that policy makers, climate experts and technologist can understand the true value in the climate and blockchain intersection. The second navigation report goes even deeper and provides concrete examples that will help further the advance the whole emerging field".

USE CASE

Digitizing and democratizing renewable energy, Reneum Institute, Singapore

Information provided by

Brianna L. Welsh
Vice President, Asia at Sindicatum Blockchain Technologies, Singapore

Founded in 2018 by institutional clean energy investor and developer Sindicatum Sustainable Resources, the Reneum Institute was incorporated as a not-for-profit based in Singapore, aiming to stimulate investment into climate finance and green energy. Reneum replaces the traditionally paper-backed tradable REC commodities with tokens, issuing "Reneums" to clean energy projects (free-of-charge) for every 1 MWh of energy generated, to help them attract new capital investment and increase bankability.

Source: Courtesy of the authors

Verifying authenticity the energy source before it enters the market

The technical architecture facilitates automated certification, verifying authenticity of the energy source before it enters the market, adding a layer of market security. Through digitally stamped 'smart contracts', an automated match-making mechanism simplifies global trades, minimizing time and costly transaction fees in a fully transparent and secure manner. Progressive multinational companies buy Reneum tokens to 'green' their energy consumption, to then remove the tokens from circulation permanently through a process of 'burning'.

Sindicatum officially launched the platform in April 2019 and have since registered 20 solar and wind projects across 9 markets in Asia and the Middle East. They are in discussions with several RE100 buyers as well to procure tokens by early 2020 and expect to conduct first transactions by the end of Q1.

"Reneum's blockchain platform automates certification and transactions, maintaining independence and transparency that enables the global market scope for environmental commodities".

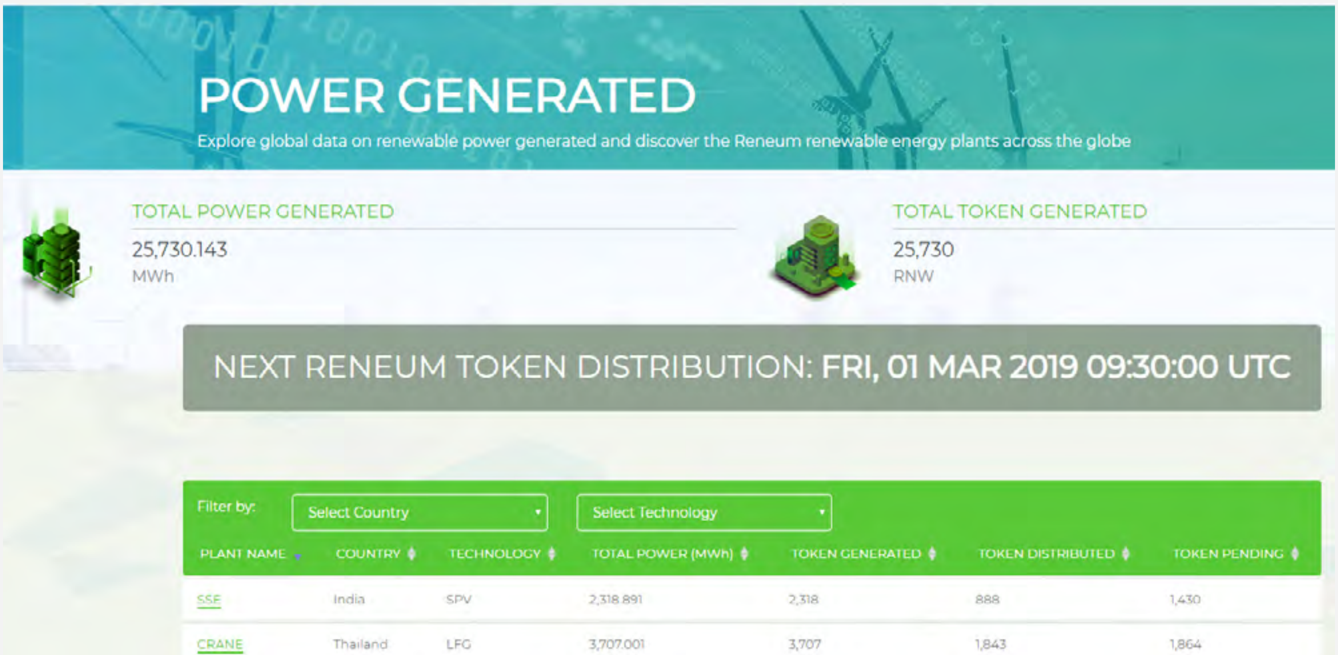
Brianna L Welsh
Vice President, Asia, Sindicatum Blockchain Technologies, Singapore

Helping project developers to realize a new revenue stream

Reneum was conceived as a solution to the challenge of renewable energy development in emerging markets. With declining government subsidies, the scaling back of feed-in-tariffs, and waning (or non-existent) political support, the financing hurdles faced by project developers pose existential threats. By stimulating this global market, Reneum helps project developers realize a new revenue stream, providing project bankability and encouraging new developers to enter the market. As developers, Sindicatum recognized the value of a reliable revenue stream like these environmental commodities and wanted to develop a tool to facilitate the transactions of these instruments.

Reneum's blockchain platform automates certification and transactions, maintaining independence and transparency that enables the global market scope for environmental commodities. Reneum's entirely public database lends credibility and legitimacy, buoying the market through a trusted database.

Thanks to the decentralized and public nature of the blockchain, tokens are easily audited and include full traceability. Through the use of digitally stamped and secured contracts called 'smart contracts', the issuance of the tokens will be executed automatically once a set of predefined parameters has been satisfied, minimizing transaction costs in executing trades and decentralizing the market. With no central regulator, trades can be made globally, offering the first "one-stop-shop" for buyers. And each token is issued a unique ID code, storing generation data that is valuable to buyers to provide comfort of authenticity, preventing fraud and reducing the due diligence process required by buyers.



Source: Courtesy of the author

EXPERIENCES AND CHALLENGES

Before initiating development, Sindicatum conducted a commercial analysis and industry diagnostic to identify the key components of the platform. Having understood the commercial applications to be straightforward and the blockchain to be the ideal solution, upon building the application, they realized there were functional gaps in the choice of a decentralized database, and halfway through development, opted to rewrite the program to integrate a different database entirely. This delayed launch by nearly 6 months but ultimately benefitted the end product due to increased security and functionalities. They also selected a program believed to be highly scalable at the outset, but upon user acceptance testing, realized it may not be as efficient as expected. A new program and server was needed to ensure both scalability and stability in the event of a cyberattack.

Since inception, several other renewable energy certificate platforms have launched, prompting identification of areas to collaborate rather than compete. Since the objective of the market is to attract investment into new renewable markets, Sindicatum believes it is in the broader industry's best interest to partner and approach different markets or types of projects. They are currently evaluating the best approach for this objective and hope to help direct climate finance into new markets and to less advanced companies to help with bankability.

Regarding governance and data security, since data flows are unilateral (they only receive three data points from developers and do not share or receive any commercially sensitive data), risk for data breach is reduced.

One of the biggest challenges facing the climate sector is fragmentation and opacity of data. Without clear and uniform metrics for data analysis, housed in a single and easily accessible database, research and action tends to get lost. There are many policy and environmental associations actively engaged on positive climate initiatives, but until they speak to each other and communicate with the private sector in an open forum, climate action will continue to face obstacles in mass adoption.

OUTLOOK

Sindicatum plans to broaden the marketplace to emerging markets in Asia, the Middle East, Africa and Latin America, and expect to have more than 200 projects registered and trading credits with international buyers. They are also exploring listing project power purchase agreements on the platform to facilitate a greater material impact for project financing.

Learn more: www.reneum.com

According to information provided by IRENA more than a quarter of primary energy in Latin America comes from renewables, twice the global average. Power sectors in the region are characterized by a high dependence on hydropower. Exploiting the complementarity between hydropower and variable renewable energy sources is a key leveraging factor for all renewables in Latin America.[1]

1 IRENA 2016, 'Renewable Energy Market Analysis: Latin America'. IRENA, Abu Dhabi

In contrast, Asia Pacific accounts for more than half of global energy consumption with 85% of that regional consumption coming from fossil fuels[2]. Demand for energy is rising thanks to rapid urbanization and industrialization, and considerable opportunities exist to avoid long-term lock-in with carbon-based energy technologies. Decentralizing the generation as well as the distribution of energy using modern IT means, such as blockchain technology will become important contributions in the energy transition of these regions.

USE CASE

Observation on developments of renewable energy and blockchain technology in Latin America and Asia Pacific

Interview with

Christian Huebner
Director of the Regional Programme Energy Security and Climate Change Asia-Pacific, Konrad Adenauer Foundation, Hong Kong

What are the trends you have observed in terms of Blockchain and Renewable Energy in Latin America and Asia?

In both regions, blockchain or DLT is dominated by the public perception of crypto currency. Its potential for renewable energy is only considered by specialised start-ups, think tanks and working groups within multilateral organisations. Bigger established energy companies are hesitating to use blockchain. But I see in both regions a rising awareness especially in terms of the benefits of decentralised energy approaches.

Christian Huebner
Director of the Regional Programme Energy Security and Climate Change Asia-Pacific, Konrad Adenauer Foundation, Hong Kong

"In Latin America difficult access in the Andean mountains or islands in Southeast Asia could be a good starting point to use the advantages of decentralised renewable energy systems".

2 IRENA 2018, https://www.irena.org/asiapacific

Where do you locate room for improvements to drive decentralized access to Energy in Latin America and Asia?

Many countries in both regions would like to have more access to renewable energy to ensure energy security. But a lack of technology and perhaps a lack of knowledge on how to use decentralized energy supply systems is a burden. In Latin America difficult access in the Andean mountains or islands in Southeast Asia could be a good starting point to use the advantages of decentralized renewable energy systems.

What kind of support is missing at the crossroads of digitalization and climate action?

I think renewable energy supply systems are a starting point for many digitalization approaches in the sustainability universe. Smart metering is a classic example for Internet of things, improving the match between energy supply and demand with artificial intelligence or using DLT to facilitate whole decentralized renewable energy supply chains are the first real world experiments. Carbon pricing could be the next big thing for digitalization, especially when it comes to the regional connection of national emission trading systems. DLT could be the missing technology to implement standardized MRV in a cross border context. Nevertheless, that needs a common global framework. Hopefully the next COP will solve this.

Summary and outlook

Greater penetration of IoT technologies like smart meters will be critical to increase energy efficiency and self-supply generation measurements. The definition of governance and rules of operation of the national offsets scheme and the Paris Agreement are fundamental to develop national carbon market infrastructure. Finally, more capacity building across sectors, from government institutions to private organizations is necessary to promote IT innovation. Clearer policy signals are needed from digital government initiatives to climate change regulations, and these signals should not only come from the central government but from international bodies.

> **Technology penetration, standardized governance, capacity building and clear policy signals are needed to enable new technologies to help scale renewable energy.**

3

Focus topic: Crunch issues in digitizing MRV

Owen Hewlett
Chief Technical Officer
Gold Standard

3.1 Development and adoption of digital MRV approaches

This chapter considers illustrative examples of the trends and challenges associated with digital approaches for data collection and adoption outlined in Chapter 2.2.

Data collection, impact quantification and reporting by project developers

Data collection innovation can typically be categorized into three areas:

1 — Solutions to automate shared access and enhancement of data sets (not activity specific, remote capture): These include solutions targeting the use of 3rd party data in lieu of direct measurement 'on site', to automate aspects of MRV. Verification then focuses on the data itself, reducing the need for individual verification.

2 — Solutions that capture data directly from source (activity specific, direct capture): These involve direct capture of data on site through technology in place of manual effort, typically using Internet of Things (IoT) and cloud-based technologies to automate data collection.

3 — Solutions that capture data remotely (activity specific, remote capture): Remote sensing technologies, LIDAR, RADAR or even drone capture, applied in the land-use sector are common examples.

Solution 1 – Automating shared access and enhancement of data sets: MRV approaches, such as those used in the carbon markets, include parameters that use existing, 3rd party data that can be relied upon to calculate climate impact. Examples include Non-Renewable Biomass fractions for clean cooking solutions or deforestation rates in REDD+. Challenges with reliance on third party data are:

- Costly to obtain and assess/integrate
- Significant reconciliation required for specific application context
- Transparency, limitations and assumptions that can impact verifiers' ability to assess
- Limited user and verifier capacity to assess and apply the data accurately

For example, an afforestation project collects baseline data via direct survey to justify conditions prior to the project. This may not be always be feasible because projects could commence work on tree planting immediately without the opportunity to retroactively survey the site. In this case, it may be possible to purchase pre-existing data sets and satellite imagery to define baseline conditions. However, the data purchased may not perfectly reflect the specific need, for example, if there are different spatial or temporal scales, data gaps or levels of certainty that differ from the methodological requirements. This may make it challenging to integrate and interpret compared to having a data set collected and compiled for the purpose of supporting the project.

USE CASE

The REDDChain Platform using cutting edge remote sensing and AI for sustainable forests

Information provided by

Patrick Bürgi
Co-Founder / Director Public Sector
South Pole

REDD+ schemes are typically national standards that are designed to issue carbon credits for the climate benefit of avoided deforestation (i.e. the avoidance of releasing sequestered carbon in woody biomass through illegal logging and burning). It is critical that the scheme can rely upon credible, robust data concerning deforestation rates, since these form the baseline from which deforestation is reduced and hence emissions release is avoided.

The REDDChain Platform (RCP) is an initiative that employs a range of digital and technology solutions to better inform, enable and facilitate the MRV of REDD+ schemes by improving both trust and efficiency. RCP seeks to resolve issues associated with deforestation and degradation by linking users to data sets and by crowd-sourcing and improving those data sets to the benefit of all.

RCP thus acts as a system with which countries and regions can publish and administer forest data through a DLT application. This in turn allows a global land use data exchange to emerge (with no central party) to the betterment of access, trust and credibility. In the future each participant can be incentivized towards data sharing, as this is specifically rewarded with better access to finance and higher transparency.

OUTLOOK

REDDChain is currently under development with piloting activities taking place in 2019 and 2020 and beyond.

Learn more: http://cleantech21.org/fileadmin/content/NBE/C21_H4C_REDD-Chain_Sum082018_v04.pdf

Solution 2 – Direct data capture: While the first solution offers the opportunity to automate large parts of the MRV process, in the case of many climate actions it is not possible to refer to national or subnational data sets for all required monitoring parameters. This is particularly prevalent in community or household projects where local contexts such as domestic habits, family structure, demographics, climate and economics are all highly context specific and have a great bearing on the impacts achieved.

Technology level monitoring through IoT applications can address this. As described in Chapter 2.2, Nexleaf Analytics demonstrates that by designing new and improved approaches to MRV it is possible to also address development issues, in this case how to ensure households undergo sustained adoption of clean cooking technology. A further use case, provided below, considers the use of lightweight palettes equipped with IoT devices, developed by Lightning Technologies to improve food security.

USE CASE

Lightning Technologies Smart Pallets with RFID based tracking for food supply chains

Information provided by

Rich MacDonald
Chief sustainability and client solutions officer, President
Lightning Technologies, Canada

The transportation and logistics system for supply chains results in significant GHG emissions globally. Innovative technologies provide cost-effective solutions that also reduce GHG emissions. The average commodity pooled pallet weighs about 35kg and lasts, with repairs up to 11 turns or about 2.5 - 3 years.

Lightning Technologies has invented a smart Grocery Manufacturers Association (GMA) multi-trip and sustainable pallet that meets or exceeds all industry standards (such as food safety) and is lightweight at 21.8 kg, manufactured from sustainable fast-growing crop trees and encased in a proprietary ExobondTM coating to be longer lasting (10 years, 120 trips). It is equipped with the latest Bluetooth Low Energy IoT devices.

GHG emissions can be substantially reduced, less forests will be cut down, less cargo (eg, food) will be wasted, particularly in the delivery of cold chain products, (eg, produce, protein, and pharmaceuticals) and all activities, for each pallet, can be monitored in real time.

Lightning Technologies uses an Intelligent active Bluetooth Low Energy device to track pallets with unique IDs (eg, radio-frequency identification or RFID) for location, temperature, humidity, vibration and shock – in real time and/or store and forward, as well as monitor goods by Stock Keeping Unit (SKU), lot, date/time packaged, location, and carrier. The Lightning Technologies software application enables data mining, messaging to responsible parties when the product metrics start to trend outside of the prescribed limits, as set by the local gateway device in the clients locations, immediate quality assurance reports, customized dashboards, APIs and has double encryption of the data stored in a data cloud.

The Bluetooth Low Energy sensor that is located in the centre leg of the pallet, has minimal latency in reading temperature and humidity, so that readings are both accurate and timely thus improving the quality of the clients loads/SKU readings and improving the metrics around their own transportation supplier quality systems.

Information and data readings are securely communicated through double encryption from the sensor to the gateway and the gateway to the cloud. The cloud database has been designed to be fully flexible, parsible, and permission governed. Data can be updated in real time and provide clients with valuable metrics and insights into the journey of their products, thus improving food quality, safety and maximizing food shelf life.

OUTLOOK

Lightning Technologies is working with ClimateCHECK to develop a methodology with Gold Standard. A next generation digital MRV methodology will be developed that specifies requirements for the additional digital technologies, data system and analytics, including DLT such as the "IOTA Track and Trace", to support more cost-effective MRV with high resolution and assurance.

Learn more: https://lightningtechnologies.com/

Solution 3 - Remote data capture: In some cases, activity-specific data can be captured remotely. In land use activities this could involve the use of remote sensing techniques such as LIDAR or RADAR or drone data. An example of the application of remote sensing to facilitate real-time MRV is provided by SarVision, see Use Case below.

USE CASE

SarVision early warning system for tropical forest degradation

Information provided by

Dirk Hoekmann
ESG researcher,
SarVision

As outlined in the REDDChain use case, the role of forest degradation is of critical importance to forest monitoring, whether for general accounting purposes or for use in markets such as REDD+. Reducing the scale and impact of degradation can prevent the release of stored carbon and protect the ability of the forest to sequester carbon and provide other ecosystem services.

Degradation may occur legally as a result of fire, disease, pests or illegally from logging, clearance, or encroachment. The speed of becoming aware of an issue and the decision to mitigate degradation has a major bearing on its impact, hence tools to provide real-time information to decision makers to act quickly and stop degradation before the damage is done can have a major climate change mitigation benefit. Such systems have not existed historically in most parts of the world and hence by the time authorities are alerted to a degradation event it is often too late.

To overcome these issues SarVision developed in collaboration with WWF an Early Warning System (EWS) that provides an automated, near real-time forest monitoring based on free-of-cost Sentinel1 (European Space Agency) radar images with a change detection frequency of 6-12 days at high resolution (15x15m). This system can provide information to the relevant authorities about degradation in a very early stage, allowing for a rapid response and mitigation of the worst effects. Coupled with a rapid response approach the EWS becomes a very powerful tool.

EXPERIENCES AND CHALLENGES

One of the main challenges that has prevented the use of satellite data for this purpose is the frequent presence of cloud cover that prevents near real time analysis. In tropical rainforests, cloud-free optical images are only available during a couple of days throughout the year. Consequently, for many analytical and practical purposes, monitoring systems based on optical systems are not suitable for tropical rainforests. By contrast, radar images are available continuous every 6-12 days, day and night. Radar also “sees” through clouds, smoke, heavy weather, through tree canopy and vegetation, and can even calculate biomass data of top soil.

Hence this case study demonstrates that for rapid response issues, remote data collection at the activity level may be more effective than more generalized remote sensing. However, it is ultimately the combination of technologies and the linking of direct measurement with remote sensing (such as the REDDChain platform – see previous use case) that may ultimately deliver optimal results in terms of monitoring climate impacts.

Potential applications

1 — EWS for governments that want to monitor their tropical forests to detect (illegal) logging, road and canal development, forest degradation, fire scars and floods.

2 — Use for carbon accounting. As outlined earlier in this chapter, forest degradation is an important parameter in REDD+ schemes but is often hindered by poor quality and misaligned data. With help of the EWS baseline map and EWS output maps degradation can be observed, quantified and related to carbon losses in a more credible way.

3 — EWS can help law enforcement dispatch intervention teams immediately after undesired activities have been detected, such as illegal logging, illegal road and canal development, forest degradation, fire damage (via fire scars).

4 — EWS for plantation owners to monitor their plantations and act in case their plantations are threatened by illegal activities, floods and fires. Historical flood monitoring prevents plantation owners from converting unsuitable parts of forest into plantation area. This not only reduces investment costs significantly but also contributes to the conservation of remaining forest patches.

OUTLOOK

The current availability of regular, frequent and free radar imagery started only recently in 2015 with the launch of the Sentinel1 satellites and will be available for the coming 20 years or more. In June of 2019 the 3 Radarsat Constellation satellites were launched and images will also be available free of cost from the end of this year. It is also further being explored to add a predictive component, using an AI application that could allow for the enhancement and optimisation of activity design and management of risk.

The EWS is already operational for Borneo and can be applied in any part of the world. Additional funding is needed to set up the system in other regions with tropical forest.

Standardization is important for the accreditation of the EWS system and its products. The current EWS system differentiates 10 classes of degradation, but additional field work and some research is needed to define the character and intensity of each degradation class.

Learn more: http://www.sarvision.nl/

Adoption of digital approaches by standards

The highlighted examples of digital approaches to data collection at scales varying from national level to activity specific, remote and non-remote. In all cases these solutions have great potential to improve both trust and efficiency but are hampered by cost and capacity as well as the lack of consistency with and adoption by agencies and standards that may apply them at scale. These issues go hand in hand – driving costs down requires large scale adoption by agencies and standards that can provide finance to them. Adopting emerging MRV approaches will require changes to the way standards operate in terms of certification processes, governance and how environmental commodities are transacted and used. It will invariably spark changes in the roles and business models of involved stakeholders, such as project developers, auditors, standard bodies and brokers/traders.

Enabling these changes while still maintaining access for proponents that may not yet have capacity to benefit from them is a challenge. Standards also must not prescribe a specific technology or restrict further innovation by doing so. Hence this requires flexible decision-making approaches and flexible methodologies.

Several initiatives are emerging to guide further development. Chapter 2.2 highlighted the CLI 'Next Generation MRV' programme that seeks to identify use cases and provide a process to assess and integrate into standards schemes, with examples in the following use cases.

USE CASE

Chile waste to energy

Information provided by

Tom Baumann
Chief Executive Officer,
ClimateCHECK

To advance progress toward the Paris Agreement, the Government of Canada provides support to developing countries to help them implement their NDCs, including a CAN$7M contribution (2017-2021) to help Chile reduce GHG emissions in its waste sector. The Canada-Chile Reciclo Orgánicos Program is a partnership of the governments of Canada and Chile as well as private sector partners such as Arcadis, ImplementaSur, and ClimateCHECK and includes mitigation measures such as the commissioning of a modern landfill gas (LFG) capture and destruction system at the Copiulemu landfill to cost-effectively reduce GHG emissions. The program has also developed standardized MRV methodologies or protocols to quantify the emission reductions achieved by these mitigation measures.

Standardized methodologies (eg, WCI – Western Climate Initiative) are a key feature of a credible MRV system, since they allow for the generation of comparable mitigation outcomes that are transparently quantified and verified. However, these methodologies are most commonly implemented through activities with high transaction costs, involving manual quantification and reporting processes (eg, going onsite for observations, gathering data files, using Excel calculations), and the engagement of a third-party verifier to verify GHG emission reductions. These processes offer various opportunities for improvement such as, reducing the timeline for MRV activities, improving the provenance transparency, and improving the MRV consistency from an MRV system perspective (eg, tracking the same mitigation outcomes on NDC registries and in climate finance reporting) – critical in the context of the Paris Agreement. A variety of new digital MRV solutions to address the challenges and opportunities noted above are currently being tested around the world with various types of climate actions (eg, forestry, supply chains, renewable power).

Reciclo Orgánicos plans to support a digital MRV pilot, which would start in January 2020 and end in March 2021. The first stage of the pilot would assess the specific LFG site's monitoring system/plan and data systems (eg, LFG collection volumetric flow rates, gas composition analysis, combustion device and operation, combustion efficiency), as well as other relevant information systems (eg, backend capabilities, data availability and quality assurance, IoT connectivity, security, external data sources). In parallel with the assessment of project information and developing the plan to build the digital MRV solution, a "digital MRV smart standard" would be developed that builds off of the existing LFG protocol developed by Reciclo Orgánicos. The digital MRV smart standard would specify the technologies and digitized processes for performing the MRV requirements.

The digital MRV solution featuring DLT-enabled software would incorporate the specifications from the digital MRV smart standard and link the onsite IoT devices and data flows with the DLT-enabled platform and online software tool for MRV. Following the trial and validation phase, activities would continue to assess the performance of the solution relative to conventional GHG MRV practices, refine the solution, and support capacity building of local partners to continue or replicate the digital MRV solution for LFG projects after the pilot ends.

OUTLOOK

Whereas this pilot project focuses specifically on the digital MRV for the mitigation outcomes of the LFG capture and destruction, the project partners hope to explore the future potential in other types of projects, such as bio digestion, and to expand the application of digital solutions to support MRV and climate action accounting more broadly. Examples of a wider LFG application could include using digital solutions to: (1) link the GHG emissions inventory of the landfill reported to the national inventory and the emission reductions mitigation outcomes (whether capture and flare or capture and utilization downstream), (2) link the digital MRV of mitigation outcomes with a carbon credit registry and an online carbon credit marketplace, or (3) track and MRV climate finance associated with various climate actions.

Learn more: https://www.reciclorganicos.com/

— **Decentralized access to clean energy and finance**: Blockchain systems emerge as the backbone of new decentralized markets for clean energy where individual "prosumers" are empowered to produce and store their own renewable energy and trade with their neighbors. More generally, blockchain technology combined with new fingerprint, iris or face recognition technology allows individuals who lack identity documents or bank accounts to access climate finance in the form of micro credits, subsidy schemes of payments for mitigation or adaptation action.

Source: Courtesy of the author

Summary and recommendations

The examples highlighted in this section point to the high potential for technology driven data collection and integration with standards to have a great impact on both trust and efficiency and perhaps equally importantly on the enhanced design of climate action. The main challenges associated with these areas are:

— Aligning data sets with MRV protocols may be challenging, particularly where different geographical coverage or temporal scales exist that may be too onerous for individual users to resolve, hence the need for platforms such as REDDChain.

— Sustainable development and inclusivity matters can be complex for technology to solve. These include stakeholder consultations, which play a critical role in community-based REDD+ projects and assessment of environmental and social safeguards, for example, evaluating potential project impact on the local environment or the well-being of local communities. Nevertheless, digital identities and digital recordings or other digital data from such consultations may help in making consultations more transparent.

— Similarly, the monitoring of co-benefits may be difficult to digitize or, at minimum, may not offer a straight-forward case for digitization from a cost-benefit perspective. This can include monitoring of jobs created directly by a project, health impacts or biodiversity benefits. In some cases, as demonstrated by REDDChain, a combination of remote and indirect data may be applicable.

— Capacity may vary greatly across development settings. National approaches in Least Developed Countries may be limited by lack of finance, capacity and access and therefore require greater funding and options where digital approaches may not be feasible.

It is therefore recommended that standards operators carefully design and integrate digital approaches, paying particular focus to inclusive and open approaches. Standards systems can become modular and flexible digital ecosystems that allow for constant innovation and connectivity to new approaches, applications and services without needing to prescribe or allow individual approaches over another. A focus on principles and requirements can inform technologies and for flexible adjustments based on certainty and alignment of data with circumstances.

Standards systems can become modular and flexible digital ecosystems that allow for constant innovation and connectivity to new approaches

Susan David Carevic
IT Officer, Technology & Innovation
World Bank

Rachel Chi Kiu Mok
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World Bank

3.2 Securing data entering the blockchain – "Last mile issue"

Blockchain technology can provide the infrastructure to transparently and securely store and share data between partners and provide assurance that data within the ledger has not been tampered with. This builds trust between partners or with the public. However, data inputs into the ledger must be accurate, verified and secured. Without these assurances, blockchains will do little more than securely transport data that could be dubious from the start. This problem, sometimes referred to as blockchain's 'last-mile issue', refers to the gap between a physical asset and its digital representation on the chain. The credibility and effectiveness of a blockchain solution critically depend on bridging these two.

The last-mile problem needs to be resolved for every use case that endeavors to tie physical assets to digital assets, so that network users can be assured that the digital and physical assets match at each checkpoint in a tracking system. In supply chain systems, this is done often with barcode sensors, Radio Frequency Identification (RFID), and tamperproof packaging with machine-readable labelling. However, this does not work for many climate projects, where assets like carbon credits or renewable energy certificates do not have a physical form. Conventionally, MRV processes involve entities to monitor and audit project performance to provide assurance that the data used to issue climate assets is reliable. Robust MRV processes can increase the value and desirability of climate assets, but these are also time consuming and expensive to implement.

Digital MRV processes can reduce the time and resources needed to audit projects; however, they must provide the same level of trust and assurances that good data is being used so that climate assets are valued appropriately.

Robust monitoring, reporting and verification (MRV) processes can increase the value and desirability of climate assets.

USE CASE

World Bank's prototype to overcome the last-mile issue with simplified MRV and improved data quality

Information provided by

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The World Bank Carbon Markets and Innovation Practice (CMI) and Technology and Innovation Lab (ITSTI) explored how the MRV process could be simplified, while improving data quality and last-mile assurance through the use of Internet of Things (IoT) and blockchain technology. In particular, the prototype explored:

— How IoT sensors can be used to derive information needed to create mitigation outcomes from climate projects

— How data collected from IoT sensors can securely collected and disseminated with near-perfect security, exploring the role of blockchain technology to protect first-mile data

— What technical components would be needed to scale while keeping the technology as lightweight as possible

The World Bank teams built an internal prototype, which included a solar energy installation using a mini solar panel, IoT sensors to read data and a microcomputer that simulated the data collected from the mini-grid. At a very high level, the simulation took near real-time readings from a sensor connected to the solar panel. At set intervals, these readings were aggregated and simultaneously saved to a simple database and hashed to a blockchain record containing project metadata about the mini-grid.

The prototype assumed that MRV would require aggregated data, such as daily totals, daily average, and daily max readings. The database used to store aggregate information is protected using standard cybersecurity practices. A hash of the aggregate data was simultaneously stored on a blockchain to further ensure that the data had not been tampered with. This enabled those who needed to use the data for MRV processes to take a new hash of the data and check it against the hash stored in the blockchain to ensure that the data had not been manipulated since its initial storage in the database.

Technical details on the components used for the prototype are described below.

IoT-Blockchain Architecture Data Collection

Data collection in the prototype architecture required an IoT device and cloud services available as a subscription through the internet.

The following components were used to build the prototype:

— Raspberry Pi - The IoT device, named Raspberry Pi, is an inexpensive small board computer. The Raspberry Pi can be physically connected to multiple sensors, such as power meters. In the lab prototype, a small power meter measured the power generated from the solar panel, and the IoT device pulled the readings and measurements from the meter. Two messaging protocols were used to securely transmit data between (1) the power meters and the Raspberry Pi (I2S protocol) and (2) the Raspberry Pi and the IoT Hub (MQTT Protocol). MQTT is a machine-to-machine (M2M)/IoT connectivity protocol. It was designed as an extremely lightweight publish/subscribe messaging transport. It is useful for connections with remote locations where a small code foot-print is required and/or network bandwidth is at a premium.

— Cloud-based IoT hub - Data was then transmitted to a cloud provider's IoT Hub, which is a cost-efficient, highly scalable service that supports provisioning, device monitoring and metrics, out-of-the-box security, and codeless integration with other cloud services such as storage, and reporting functions. Through the usage of an IoT Hub, the administrator for a large project can configure and control all IoT devices together or individually.

— BLOB storage - If a project requires a large number of IoT devices and must store readings from thousands of devices, a standard database alone may not provide optimal storage space. The prototype therefore stored raw data in a cheaper alternative called BLOB storage, while storing the aggregated data in a database.

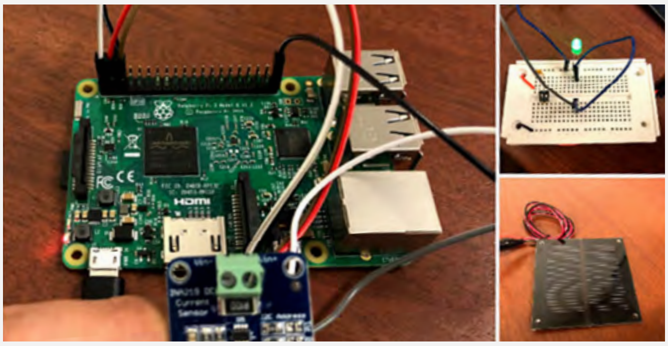
— Blockchain - A private blockchain was used for the prototype to demonstrate what project information would be stored with the hash of aggregated meter data. In an operational scenario, the usage of a public, or public permissioned blockchain should be considered. This architectural decision should be made based on the public nature of the meta data to be stored with the hash.

What is BLOB storage?

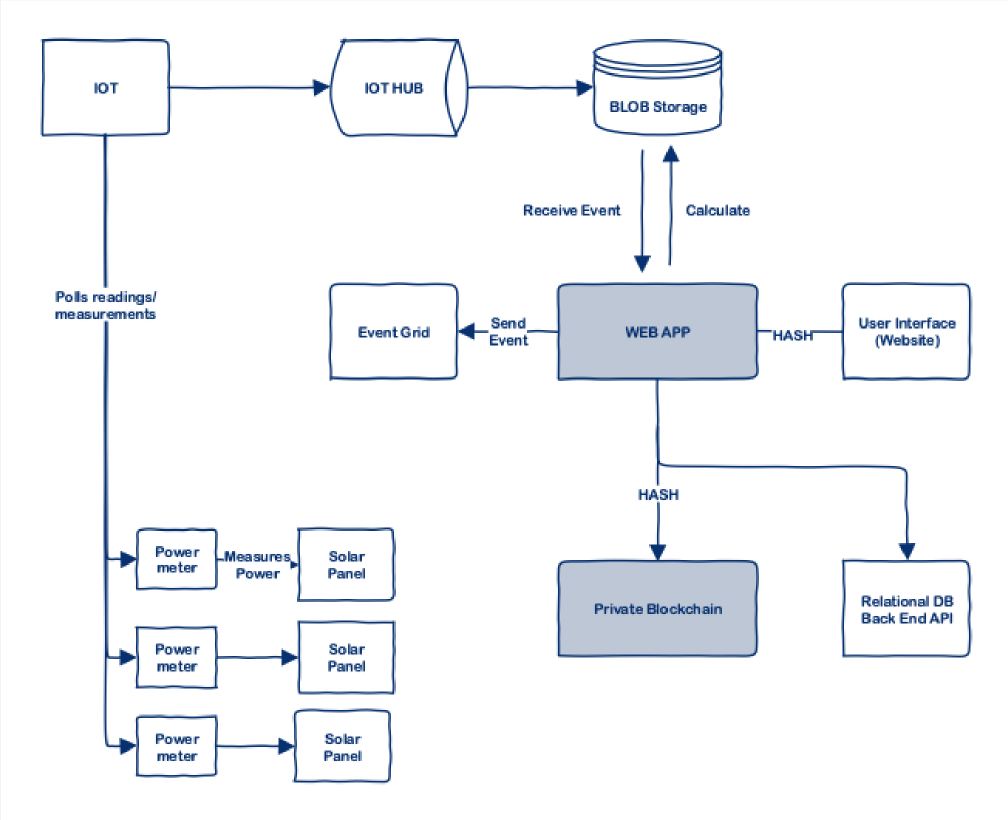
BLOB stands for Binary Large Object. This type of storage is offered from cloud providers to store large files that can have diverse formats, for example, unstructured data files, images or other multimedia. BLOB storage was chosen for this prototype due to its scalability and inexpensive price.

Data process flow -- store, analyze and hash

The figure below shows the high-level component architecture with dataflows. Multiple solar panels and power meetings can be connected to an IoT device. The IoT Hub managed the IoT device(s) and was used to monitor their functioning, switch them on and off in bulk, and push any needed upgrades. A cloud-based event manager managed the functions of the application, including aggregating the data, hashing the data to the blockchain and storage of the data to a database.



Source: World Bank



Source: World Bank

EXPERIENCES AND CHALLENGES

The purpose of utilizing the blockchain for this experiment was not to enable transactions but to ensure the integrity and security of the IoT data. The hash does not provide a backup copy of the data for retrieval if the data has been tampered with or is lost, rather for quality assurance that the aggregated data in the database was not changed.

This prototype demonstrated how part of this problem can potentially be solved through the use of blockchain and IoT, but it is an incomplete solution. The prototype limited the scope to tamper with the data but left the possibility for an individual with access control rights to manipulate data at the aggregation stage before hashing the data to the blockchain. Additionally, for this prototype to be useful, the MRV processes needs to include an automated check of the hash during the audit process. If the automated process determines that the data was altered, because a hash of the stored data does not match the hash on the blockchain, the data should be considered denigrated and not be used. The hashed data to the blockchain offers no protection from data manipulation if the MRV process doesn't compare the aggregate data to the hash for quality control.

It is easy to access a wide range of IT cloud services in a lab environment with ideal connections to the internet. In areas lacking robust internet connectivity, a localized network can be built out to collect data and transmit to an IoT hub. Internet connection would still be needed for hashing data to a blockchain, but by minimizing data requirements and only hashing aggregate information, the connection time and bandwidth needed is low.

The experiment demonstrated that there is potential for improving the MRV model to improve the accuracy of the data, reduce barriers to entry (such as cost, time and capacity) and enhance the credibility and trust in the mitigation outcomes generated. By securing the data and enabling a proof that the data to be used for MRV is reputable, the prototype removes impediments in place through manual data review to increase the frequency of MRV and asset issuance.

"Emerging technologies, such as Internet of Things and blockchain technology can provide new tools to solve problems that were previously difficult to manage. It is important to share learnings on how these technologies can be used alone or in conjunction with more traditional technologies to address challenges, such as improving the collection and traceability of data from climate projects".

Yusuf Karacaoglu

Chief Information Technology Advisor, ITSVP and Director, Technology and Innovation Lab, World Bank Group

OUTLOOK

Moving forward, several issues should be further considered.

1 — Develop a greater understanding of how usage of IoT could alter the MRV process: Existing standards systems rely on a workflow that is designed with manual MRV in mind. Hence, the process flow with the usage of IoT and near real-time data collection needs to be mapped to better understand the points in which digital technologies are needed. Some individual monitoring parameters may be better suited than others for automation. For example, it may be more appropriate for those that involve primary data collection at source and where technology exists to collect it. A further challenge involves the approval of the regulatory/standards body, likely requiring that the digital methodology is proven over a period of time to be as reliable as manual approaches.

2 — Scalability considerations: To operationalize, consideration needs to be given to the volume of data collected over the IoT devices and, from an auditor's perspective, how frequently the data should be aggregated. This will determine the amount of hashing and transactions that need to be recorded to a blockchain. Blockchain platforms will have to be compared to see which ones have a transaction/second ratio that fits project requirements. Another consideration, especially for public blockchains is transaction cost. These two factors vary depending on the consensus mechanism of the blockchain.

3 — Data integrity risks: Utilizing IoT devices and automating data collection cuts down on human error and potential manipulation, but bad data can still seep into the solution if an IoT device malfunctions. To mitigate against data integrity risks, its recommended that data analytics available through an IoT hub be utilized to identify sensor equipment that produces readings that fall outside of an expected range so that they can be turned off. If the MRV process includes an automated check against a hash and the data has been manipulated, a process is needed to exclude that data or revert to other data sources for the missing information.

4 — Role of the verifier: Although verification could be nearly fully automated, there is still an important role for the verifier. For example, site visits for some technology types will remain essential to ensure verification that technology is properly calibrated and preconditioned as well as an ongoing review of those pre-conditions.

5 — Application in least developed countries: While questions around access and capacity are relevant, for technology such as IoT and cloud-based services, there are also potential barriers caused by mobile data and internet limitations. MRV often involves the upload of large amounts of data (eg, mapping) and while access has increased dramatically in recent years, there are still challenges in this area to overcome.

6 — Integration of other technologies, such as artificial intelligence (AI): While the prototype focused on blockchain and IoT, the role of AI should be further explored. AI can potentially provide functions that automate the verification and validation process. AI can be used for verification, for example, in checking that records comply with a specific protocol before entry into a registry, noting that a smart contract may be able to carry out this role in certain cases. In validation AI can be used to cross check other data to validate that what the record states is indeed true.

Sven Braden
Programme Manager
Climate Ledger Initiative

3.3 Improving climate finance

The distribution of climate finance today is considered complex and opaque. A reason is that there is limited international guidance on climate finance. In fact, activities around climate finance have always enjoyed the benefits of flexible and dynamic interpretations by governments. The Paris Agreement reflects this flexibility in its Article 9 (3) when it requests developed countries "to continue to take the lead in mobilizing climate finance from a wide variety of sources, instruments and channels, noting the significant role of public funds, through a variety of actions, including supporting country-driven strategies".

While a flexible and broad interpretation of climate finance may be justified to address different national circumstances, it slows down the evolution of a common understanding. For example, there is no clear definition on the types of climate finance or how results of climate finance may be measured. Climate finance types vary from grants and concessional loans to guarantees and private equity. The type of climate finance not only defines the rights and obligations of involved stakeholders, it can also determine who has to be involved.

In addition to a lack of international guidance, the fact that multiple climate finance providers follow their own internal procedures increases complexity. Several multilateral climate funds provide for various flows of climate finance, including the Green Climate Fund, GEF, CTF or the Partnership for Market Readiness. Many developed countries have also launched specific climate finance initiatives (e.g. GCCI/USA, ICF/UK, IKI/Germany or NCIFI/Norway) or are providing climate finance through bilateral development assistance (e.g. EBRD, USAID, KfW, GIZ, UNDP). Some developing countries have set up regional and national funds and channels to receive climate finance (eg, the Amazon Fund in Brazil). Challenges like administrative inefficiencies, high number of intermediaries or overlapping donors have to be addressed to scale up climate finance.

It comes as no surprise that multilateral funds and climate finance initiatives as well as bilateral development cooperations and national funds show an increasing interest in tracking climate finance. Donor and beneficiaries often lack mutual trust in data. Overall tracking of international funding, including a clear reference to participating donors, will become more important within future climate finance flows. In 2018, German Development Bank KfW teamed up with Brazilian Development Bank BNDES, who runs the countries Amazon Fund, to launch a blockchain-based platform that increases transparency in budget allocations and spending.

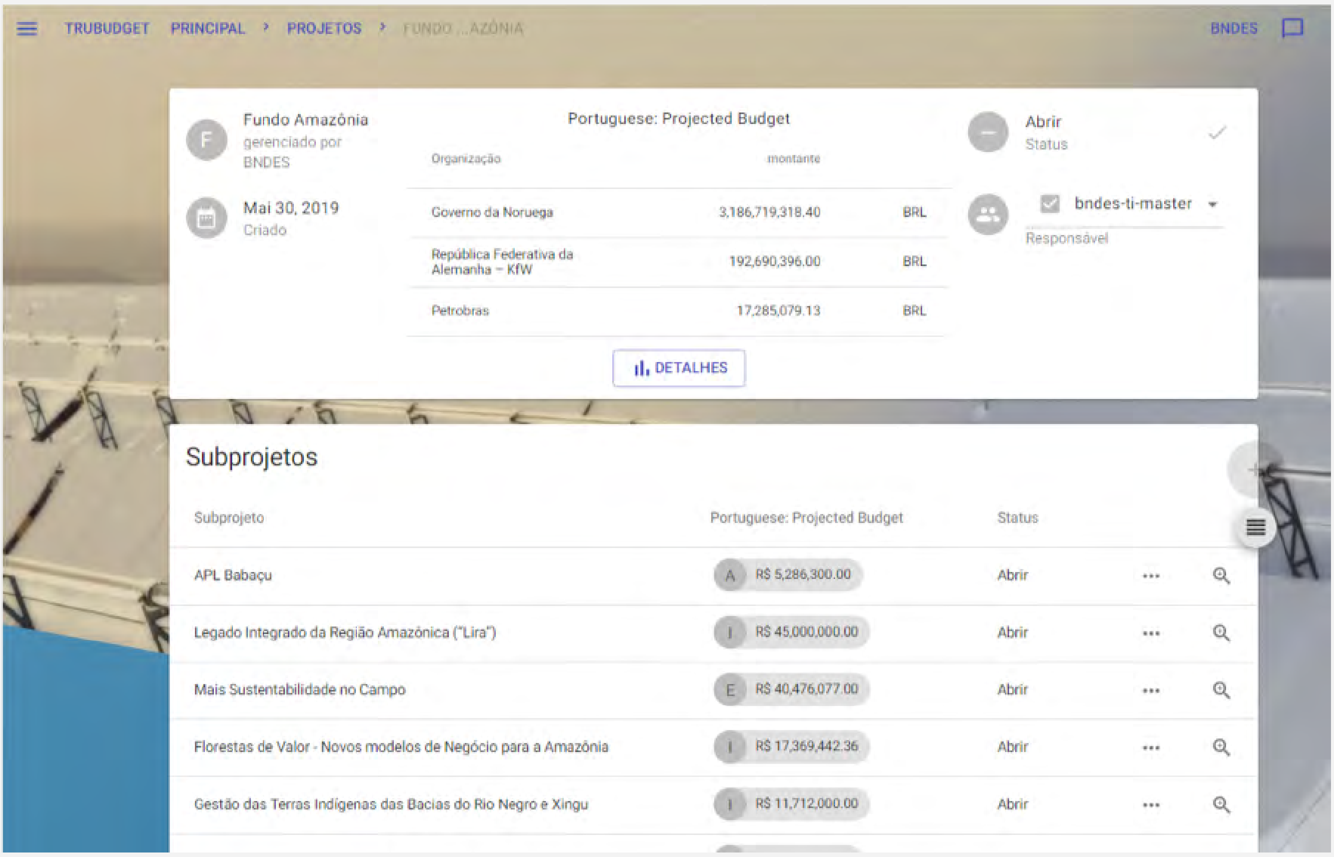
USE CASE

BNDES and TruBudget – Increasing transparency in budget allocation, Amazon Fund, Brazil

Information provided by

Marcio Onodera
Co-founder of BlockchainLab,
Brazilian Development Bank (BNDES)

TruBudget is an open source tool developed by German development bank KfW that records the steps of a workflow in a permissioned blockchain (multichain). The tool improves transparency of information between donors, fund managers and project implementers, using a "logbook" approach. For example, a government ministry can define the budget and the specific executing body can define the workflow, but there can also be built-in checks where donors have the right to approve certain steps before they can be enacted. To sum up, blockchain technology enables an audit-proof record of who completed each step and what the status of the project is.



Source: Courtesy of the author

Marcio Onodera

Co-founder of BlockchainLab,
Brazilian Development Bank (BNDES)

"The project aims to guarantee that funds are being properly applied through the reliable sharing of critical information among the different institutions".

For the Amazon Fund, BNDES uses TruBudget to register an instalment disbursement to clients of the fund such as NGOs, government agencies from national and subnational levels or universities. These clients acknowledge the receipt of those instalments on TruBudget. Currently, both BNDES (fund manager) and KfW (one of the donors) are running nodes of the permissioned blockchain for TruBudget.

Real time access to information about disbursements

The project aims to guarantee that funds are being properly applied through the reliable sharing of critical information among the different institutions. In this case, the effect is similar to the one obtained by the audit technique of circularization letters, where independent auditors send a confirmation letter directly to third parties, which are sources of information external to the audited institution, so that balances and the occurrence of accounting facts can be confirmed. Another highlight is that donors have real time access to information about disbursements.

EXPERIENCES AND CHALLENGES

The TruBudget tool is already on its 4th release in production. BNDES's role is to give permanent feedback to KfW about requirements, functionalities, bugs and other contributions. From the proof of concept phase to piloting, BNDES has reduced the scope of registered procedures to focus on scaling up the most valuable processes to obtain higher benefits at lower costs to all stakeholders. The main barrier to scale up and expand the scope of registered information relates to digital infrastructure and internet access for the providers of products and services of the last mile in the Amazon. They also have been impacted by the European and Brazilian regulations on general data protection, which guide the definitions of what kind of information is saved on the blockchain and also about solutions for managing user's credentials.

OUTLOOK

In the next five years, BNDES would like to involve other levels of the money flow chain using TruBudget. Their vision is that some clients who run "clustering" projects will be able to document processes such public calls, contracts and disbursements that they promote to local institutions as an implementation strategy of their projects. Also, convergence with another BNDES BlockchainLab project called BNDESToken is possible. In this approach, it is not only information that is saved on the blockchain. The project proposes the tokenization of the fiduciary money in a limited ecosystem, where all transactions are processed by the blockchain, from the BNDES disbursement, through clients payments to providers of products and services, which in turn are allowed to redeem the tokens, exchanging them again for fiduciary money. In this way, it is possible to identify agents and track digital asset flow, increasing the level of confidence about how the money is spent on the last mile. This could improve the link between donors and local projects, and also bring consistent and valuable information about impact and effectiveness.

It is clear that TruBudget narrows the gap between donors and beneficiaries of climate funds. Further capacity building is needed for new modalities of fundraising and for beneficiaries to explore the DLT potential to reduce transaction costs and improve compliance.

Learn more: https://www.bndes.gov.br

Another challenge related to climate finance is the high number of intermediaries involved in the disbursement of climate finance. The more intermediaries involved in financing climate projects the higher are transaction costs as well as the risks of fraud and corruption. Digitizing climate-relevant data is key for connecting different platforms; connecting platforms using blockchain technology can in turn eliminate intermediates and lower transaction costs. common standards and aligned protocols need to evolve to set the foundation for platform connection.

In Chile, the Ministry of Energy, supported by the PMR, is conducting a pilot project which explores the generation of emission reductions originating from renewable energy production of solar rooftop installations on public buildings. The project aims to create a direct link to the World Bank's Climate Warehouse platform of using blockchain technology. If successful, the cooperation between Chile and the World Bank could serve as a role model showcasing how domestic renewable energy markets and international carbon markets may interact in the future. In the midterm, this link may provide Chile with access to new climate finance flows that come along faster and with lower transaction costs.

MRV platforms with blockchain technology may facilitate access to climate finance for the energy projects of the future.

Last but not least, combining MRV systems and blockchain technology with the aim to tokenize verified outcomes (eg, GHG reductions or Renewable Energy Certificates) can extend the scope of today's result-based payment approaches. In Peru, for example, the Ministry of Energy and Mines (MINEM), supported by UNDP and GEF, is currently setting up a digital MRV platform to facilitate the monitoring performances of GHG mitigation actions in the energy sectors. The platform accommodates the monitoring data from the generation of renewable energy, for example from measures to increase energy efficiency in rural areas, promotion of grid connected renewables and electrification of renewable energy.

The MRV platform creates an enabling environment for climate finance in the energy sector since it sets the stage for linking ex-post payments to concrete and pre-defined results which can be reflected on the MRV platform. Combined with blockchain technology, such MRV platforms may facilitate the access to climate finance for the energy projects of the future.

The means of digitalization such as data gathering via IoT, applying AI and implementing blockchain technology will become crucial for climate finance in the years to come. It is encouraging to see that this process has already started. In many regions around the world pilot activities that aim at increasing transparency and efficiency are being prepared or have already started.

4

Conclusions and outlook – It's all about governance

4

Juerg Fuessler
Managing Partner
INFRAS

It's all about governance

In 2019, we have seen a very fast development of blockchain and related technologies by start-ups but also by many large corporations eager to benefit from the new technologies in their supply chains, processes and sustainability systems. At the same time, not many of the multiple well-meaning climate related "XY-coins" that started in 2017 or 2018 seem to be particularly successful, even though these start-ups have invested considerably in increasingly sophisticated blockchain systems to acquire and transfer carbon assets.

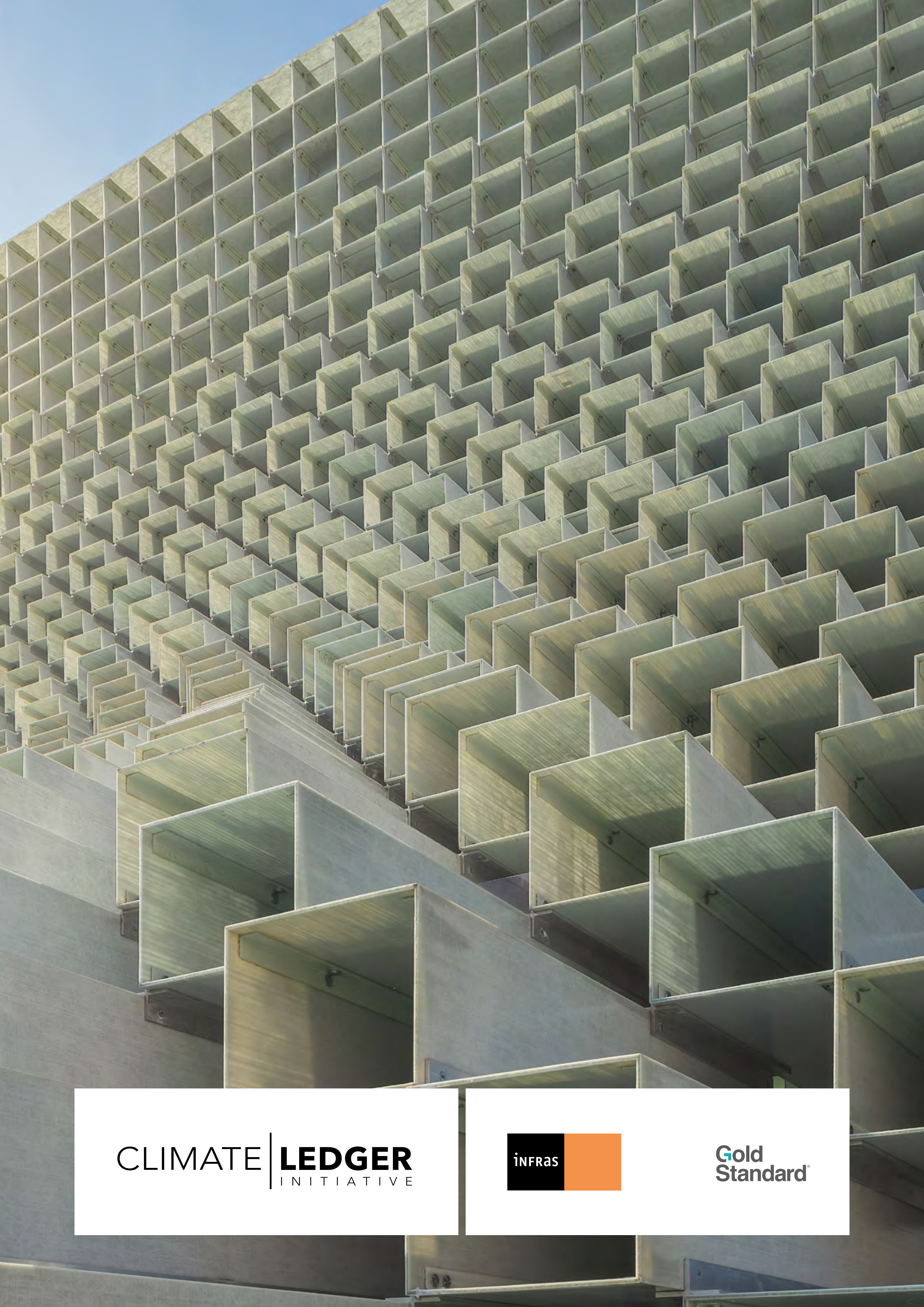
Many governments and regulation struggle to keep pace with the technical developments. To be fair, the blockchain and related technologies open up new disruptive modes for business and carbon instruments that also require new governance models (see section on governance in the Climate Ledger Initiative's 2018 report).

In 2019 it is still challenging to replace paper contracts by blockchain-based smart contracts, to pay through the blockchain for climate services and transactions, let alone to interact with governmental registries and databases. Governance on the blockchain level will need to be advanced further so that the trust not only lies in the blockchain itself, but also in the smart contracts and values that are stored on the blockchain.

Progress in governance and regulation is also too slow in climate negotiations. In late 2019, UNFCCC negotiators have still not agreed on the "rulebook" detailing the rules for the Paris Agreement's market mechanisms under Article 6, which is the necessary regulatory basis for the international transfer of mitigation outcomes.

This underscores the need to inform and engage policymakers in co-shaping the future systems of blockchain based credits and value transfer. The Climate Ledger Initiative will continue to engage and bring together practitioners, technology proponents, government officials and researchers to overcome hurdles and allow full utilization of the potential of blockchain and related innovative technologies for urgently needed acceleration of climate action.

If you want to be part of this, contact us and are happy to partner with you.



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Gold Standard