Smart contracts using blockchain technology:
a better way to deliver construction projects

EY

Building a better working world

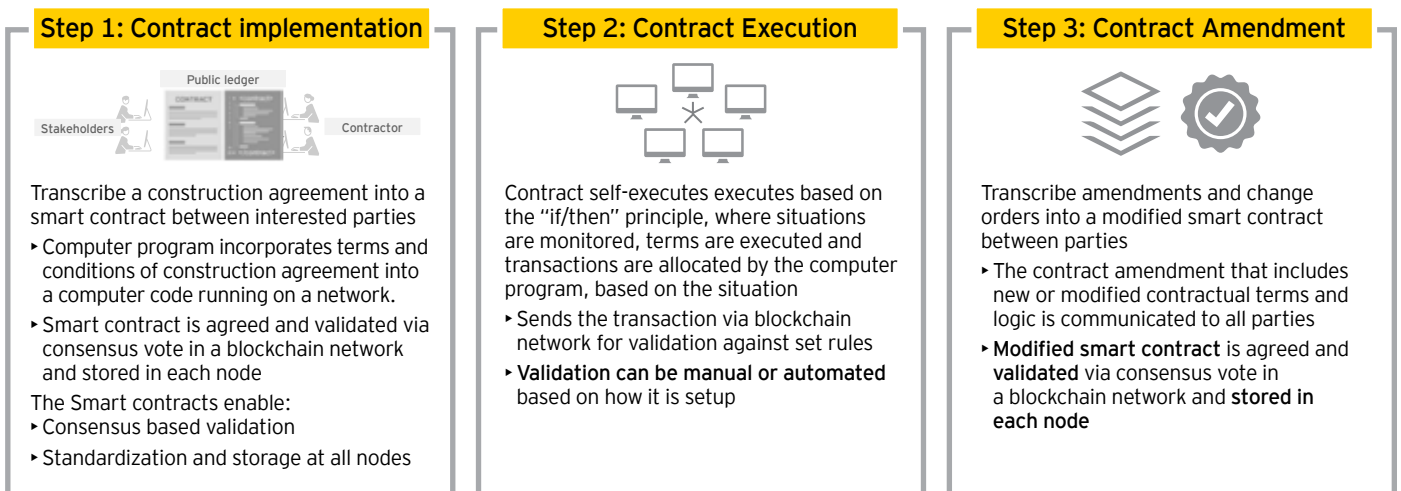# The foundation of a successful construction project is a strong construction contract.

A contract enables the completion of work, the delivery of materials and the transfer of payments to contractors and subcontractors. It also provides indirect project value as a facilitator of collaboration between interested parties and a tracker of key performance indicators.

Technology has reached a point where it can significantly benefit construction projects through the implementation of smart contracts. Historically, construction projects face commercial challenges resulting from the lack of alignment between contract terms, contractor performance and owners' expectations. The inherent properties of smart contracts using blockchain – traceable, immutable and secure – can provide a more collaborative, open working environment between project stakeholders and contractors, ultimately decreasing commercial disputes and providing greater alignment between project stakeholders.

What is a smart contract?

A smart contract is essentially a computer program that incorporates the terms and conditions of a contract into computer code working on a network.[1] The contract self-executes based on the "if/then" principle, where a situation is monitored and certain terms are executed by the computer program, based on the situation. See figure below for a detailed overview of smart contract applications.

| Step 1: Contract implementation | Step 2: Contract Execution | Step 3: Contract Amendment |

Transcribe a construction agreement into a smart contract between interested parties

- Computer program incorporates terms and conditions of construction agreement into a computer code running on a network.
- Smart contract is agreed and validated via consensus vote in a blockchain network and stored in each node

The Smart contracts enable:
- Consensus based validation
- Standardization and storage at all nodes

Contract self-executes executes based on the "if/then" principle, where situations are monitored, terms are executed and transactions are allocated by the computer program, based on the situation

- Sends the transaction via blockchain network for validation against set rules
- **Validation can be manual or automated** based on how it is setup

Transcribe amendments and change orders into a modified smart contract between parties

- The contract amendment that includes new or modified contractual terms and logic is communicated to all parties
- **Modified smart contract** is agreed and **validated** via consensus vote in a blockchain network and **stored in each node**

Benefits of smart contracts

1. **Reduced or complete avoidance** of intermediary and overall project costs
2. **Maximized transparency** of cost, time and scope of project
3. **Limited complexity**, enabling informed decision-making
4. **Efficient resolution** of contractual grey areas

Figure 1. Implementation of smart contracts[2]

Blockchain forms the foundation for smart contract applications. The computer code that underpins the contract logic is stored on the blockchain ledger, and consensus algorithms are used to validate the addition of new contract terms and transactions, which ensures only one true version of the contract is being distributed across the project team. There are multiple consensus algorithms, but the most appropriate consensus type for smart contracts is proof of stake (PoS). The PoS method allows validators to propose changes and vote on the next block (e.g., contract terms, transactions) based on their economic stake in the project.[3]

</> When should you implement a smart contract?

The time to invest in smart contract and blockchain technology is now. Smart contracts are legally binding in some US states, while other regions are in the process of passing laws and regulations to make smart contracts and blockchain legally binding in all industrial sectors. Furthermore, Canadian Government sectors have begun to adopt blockchain technology. The National Research Council of Canada recently launched a trial of Ethereum blockchain to administer government contracts.[4] With increasing government support for blockchain, mainstream adoption of blockchain-based smart contracts is expected in the next five years.[5] The numerous benefits of smart contracts and blockchain technology can be applied to many sectors in the construction industry.

Here we explore real-life examples of how smart contracts can be used to improve construction projects in these sectors' project execution, from both the owner's and contractor's perspective. These case studies are based on real projects we've worked on. Additionally, we identify considerations for the construction industry to prepare for this foundational change to the way owner and contractor interact.

1 Example 1: Subcontractor management

Project/Situation

A leading North American energy infrastructure company was building a power generation plant. The company assumed the role of the prime contractor and subcontracted major portions of the work as time and material subcontracts. These contractors further subcontracted portions of the work to other parties.
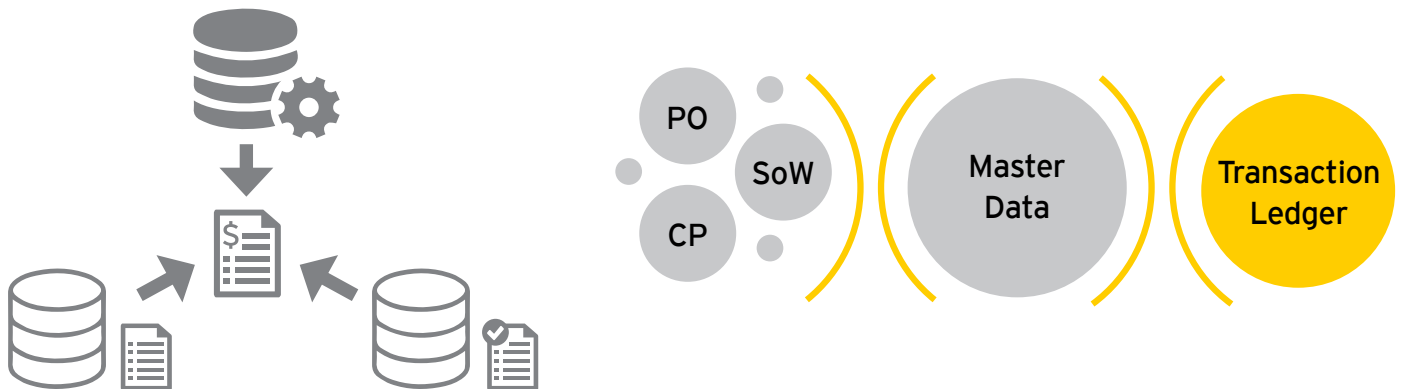

Figure 2. Automated three-way matching for invoice verification (left); Intersection between contract, invoice verification and payment processes (right).

Problem

The project team spent significant time and effort reviewing invoices and supporting documents submitted by the contractors and subcontractors. Due to the cost and the nature of the contract, the company relied on its major contractors to accurately and truthfully submit the correct subcontract amounts.

The main contractors may have been incented to overstate subcontract amounts, since it would increase the amount of markup the vendor could charge. Overstating amounts can occur in a number of different ways, such as:

▶ Incorrectly recording the sub amount

▶ Incorrectly applying margin

▶ Incorrectly applying tax, union fees, living allowances, CPP, etc.

▶ Incorrectly applying tax or other statutory charges e.g. CPP

▶ Incorrectly applying other markups or fees (e.g., union fees, living allowances)

The manual effort required to verify subcontractor amounts, coupled with poorly defined contract requirements for cost acceptance, causes delays in invoice processing. Also, the large number of pending change requests affects the project's overall progress.

Use case for smart contracts

Smart contracts could be used to automate the invoice verification process. A three-way match of the invoice to the purchase order/scope of work, certified progress and the master data can be performed in real time. These three sources would reside in the blockchain database, improving the overall transparency of the process.

Purchase order/Scope of work: This contains the list of activities contracted to the subcontractor by the owner/major contractor. Matching with the invoice validates that the invoiced work was approved by appropriate owner representatives.

Certified Progress: This contains activities completed by the subcontractor and certified by the inspector/supervisor designated by the owner or prime contractor. Matching with the invoice ensures that invoiced work has been appropriately demonstrated as completed.

Master data: Contains the basis of the invoice. This includes the rate list, activity code list, markup list and acceptable operations ratios such as:

- ▶ Operator cost to equipment cost
- ▶ Overhead cost to labour cost
- ▶ Logistic cost to overall cost
- ▶ Standby cost to invoice value

Matching with the invoice validates that the contractual details are represented correctly, and that cost limits and operational ratios are within set parameters.

The transaction of invoice submission would occur using blockchain technology. This technology enables the transaction to contain all the aspects of the contract and the invoice, allowing smart contracts to monitor and administer any changes in the scope of work, master data and certified progress. Any change to the contract or the invoice is visible to the owner, the prime contractor and the subcontractor at the same time.

Benefits

The use of smart contracts could potentially provide the following benefits:

- Reduce non-compliant spend, which results in significant savings in large complex builds.
- Reduce overall spend by highlighting inefficiencies. Some work is compliant to the contract but is not optimized. The smart contract would be embedded with pre-agreed operating ratios for each activity and, in the case of any noncompliance, an automatic alert would be triggered to the owner, the prime contractor and the subcontractor. Smart contracts could give better and faster visibility to these issues.
- Allow the company to reallocate resources to perform front-end inspection work by automating invoice verification. Additional inspection resources would result in higher-quality subcontractor work, which would potentially reduce schedule delays and cost overruns caused by rework of mistakes.
- Reduce the ambiguities in the scope of work through the implementation of well-defined smart contracts, which would help in swift resolution of change orders and claims.
- Improve transparency and trust among all stakeholders through the automatic sharing of corrections to time and material databases.

2 Example 2: Earthworks

Project description

A steel producing company developed a 3 million-ton greenfield facility comprising a coke oven plant, sinter plant, blast furnace, iron plant and a steel workshop. Each unit was subcontracted to a project company for execution. The project had a significant quantity of earthworks that was required to be completed before commencement of structural, mechanical or electrical works. The owner employed a project management consultant (PMC) for weekly work certification.

Project situation

The project faced significant delays due to slow work certification. Each month, the progress recorded by the subcontractors was certified by the PMC with an average delay of 10 days. Due to this delay, at the end of the month the subcontractors billed the company for certified work along with a portion of work in progress, causing delays in the invoice verification.

Use case for smart contracts

The use of smart contracts for earthworks would help reduce delays in the invoice verification process. Post-work certification, the payments can be made to the subcontractors in real time.
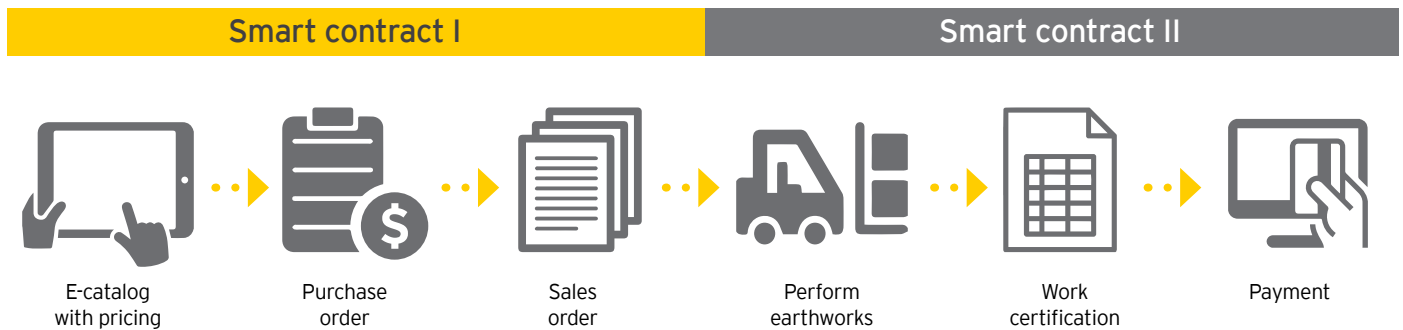

Smart contract I	Smart contract II

E-catalog with pricing → Purchase order → Sales order → Perform earthworks → Work certification → Payment

Figure 3. Use of smart contracts to optimize the "procure to pay" process

Benefits

The use of smart contracts could potentially provide the following benefits:

- All transactions between the construction company and the earthworks contractor are:
  - Executed in real time, eliminating the role of the bank and reducing the transaction cost and working capital cost
  - Available in the private, distributed ledger, thereby reducing the cost of arbitration and enforcement
- The identities of the construction company and the contractors are verified, thereby reducing the risk of fraud losses

3 Example 3:
Public-private partnerships (P3) operations

Project description

A provincial government was building a community hospital that would offer a comprehensive range of services. This project was structured as a P3 deal, with multiple long-term operations contracts awarded to project companies.

Project/Situation

The process of contract administration for long-term operations contracts is time consuming, as it requires the administrator to verify each invoice with operations log, scope of services defined in the contract and the log of services provided. Also, due to lack of trust between the stakeholders, there are disputes on penalties charges.

Use case for smart contracts

A smart contract could be established to govern all elevator operations agreements. The clause on service level agreements (SLAs) would provide guidelines for expected performance of the elevators throughout the life of the contract. The smart contract would be programmed to execute the following transactions as per the identified operating scenarios.
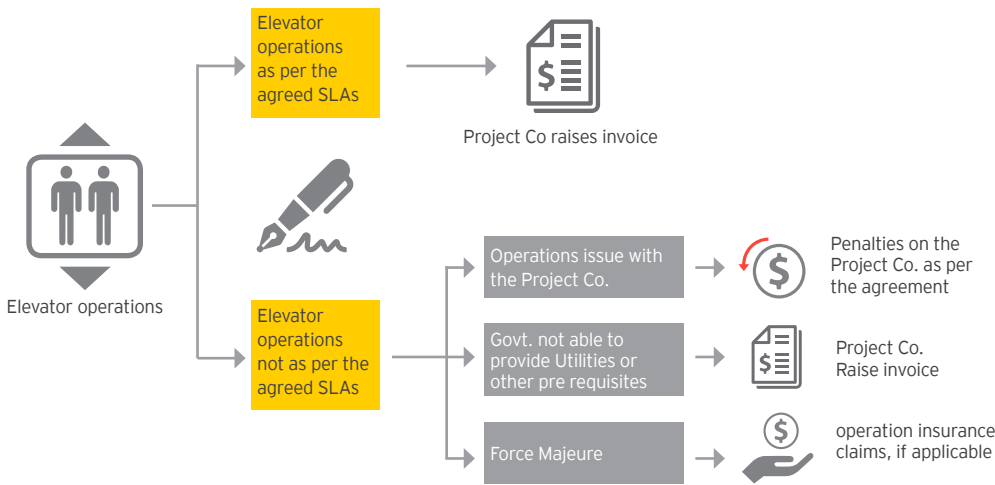

Figure 4. Typical operating scenarios programmed in the smart contract

Benefits

The use of smart contracts could potentially provide the following benefits:

- ✓ The operating scenarios programmed in the smart contract would increase transparency in the contract administration and reduce disputes and litigations
- ✓ The auto executing smart contracts would reduce the need for a full-time contract administrator to verify the invoice as per the terms of the contract.

Considerations for implementing smart contracts

Smart contracts using blockchain have the potential to significantly improve cost optimization, reduce commercial disputes and increase collaboration between project stakeholders in the construction industry. The diagram below illustrates the necessary steps and considerations for the implementation of smart contracts.
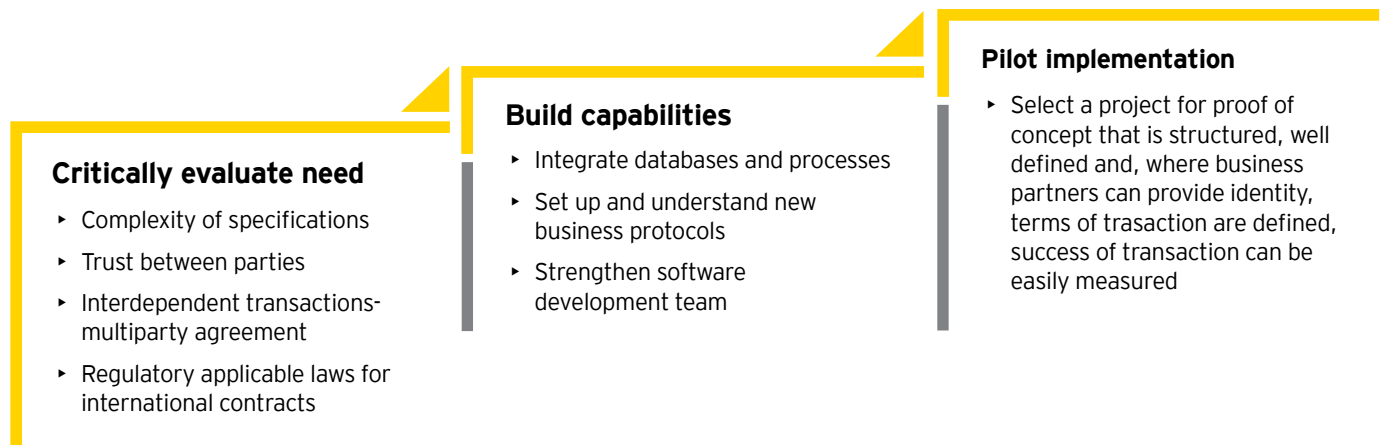
Critically evaluate need

- Complexity of specifications
- Trust between parties
- Interdependent transactions-multiparty agreement
- Regulatory applicable laws for international contracts

Build capabilities

- Integrate databases and processes
- Set up and understand new business protocols
- Strengthen software development team

Pilot implementation

- Select a project for proof of concept that is structured, well defined and, where business partners can provide identity, terms of trasaction are defined, success of transaction can be easily measured

Figure 5. Process diagram for smart contract implementation

To write the smart contract code, a blockchain-based computing platform is required. The contract terms will need to be transcribed into computer code. The nature of computer code requires that the contract terms be explicit, and all possible outcomes of the contract need to be specified. For projects where multiple parties are contributing to the smart contract implementation, there needs to be agreement on the type of code to run, and assurance that the same code is executed across the board. After writing the code, testing procedures will need to be implemented. Most computing platforms have a testing network where the code can be tested to ensure it will function as expected, before deployment on the blockchain.

Large-scale construction projects usually have several project stakeholders, with varying levels of technological capabilities. Some organizations may be lacking the components – servers, IT infrastructure or knowledgeable personnel – required for blockchain usage. To overcome this challenge, companies could enlist the services of subject matter professionals to implement the necessary technological components and train company personnel. Further, the nature of collaborative projects in the construction industry requires confidentiality, privacy and protection of intellectual property. To overcome this challenge, project stakeholders need to implement robust data management strategies with varying levels of transparency for each interested party, based on their amount of involvement in the project.[6]

</> Why should you think about smart contracts now?

Smart contracts have the potential to significantly change how projects are executed. The construction industry has been plagued by the persistent problem of value leakage across the supply chain. The integration of smart contracts in construction projects can improve project stakeholders' ability to deliver a project on time and on budget. Smart contracts provide a means for enhancing commercial controls, providing more accurate performance measurement and aligning contract interpretation.

The time to invest in smart contracts is now.

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Endnotes

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