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BLOCKCHAIN AND SMART CONTRACT FOR PEER-TO-PEER ENERGY TRADING PLATFORM: LEGAL OBSTACLES AND REGULATORY SOLUTIONS

JOSEPH LEE AND VERE MARIE KHAN

ABSTRACT

This paper discusses the implications of smart contracts in energy trading for the protection of consumer and individual rights. It examines the legal risks and regulatory solutions for a peer-to-peer energy trading platform (P2P-ETP) in creating a sustainable energy ecosystem. Part I discusses the conceptual framework of P2P-ETP, which enables consumers to become energy 'producers' and traders. Smart technologies—smart contracts, smart meters, and distributed ledger technology (DLT) platforms, are the main components of this platform. The study examines the legal basis for these components. Part II analyzes the legal uncertainty of the smart contract, such as its enforceability, and the inadequate protection for consumers and their individual rights through price manipulation, violation of rights to privacy, and data breaches. Part III discusses the potential policy implementations and the principles behind a legal and regulatory framework for establishing a trusted peer-to-peer energy trading platform.

Keywords: Peer-to-peer; energy trading; sustainability; tokenisation; smart technologies; blockchain

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JOSEPH LEE AND VERE MARIE KHAN*

I. INTRODUCTION

Smart technology is the inspiration of the Fourth Industrial Revolution; it simultaneously embodies the concept of the shared economy and consumer awareness. Environmental and research evidence on this type of economy shows that consumer awareness of energy usage helps lower carbon emissions. However, as the most recent industrial revolution demonstrated, consumer confidence in smart technology is low because of legal uncertainties regarding smart algorithmic contracts and the unfamiliarity of their impact on privacy. Societal priorities are shifting towards a more sustainable ecosystem, and smart technologies, such as smart contracts, have been claimed to empower consumers and encourage energy efficiency through peer-to-peer energy trading. Research into the application of smart contracts within energy trading shows the risks of third-party influence through market manipulation, violation of privacy rights, and potential misuse of data. This paper discusses the implications of smart contracts in energy trading for the protection of the individual rights of consumers. Part I shall discuss the conceptual framework of P2P-ETP, which enables consumers to become energy 'producers' and traders. Part II will analyze the legal uncertainty of the smart contract, such as its enforceability, and the inadequate protection for consumer rights through price manipulation, violation of rights to privacy, and data breaches. Part III discusses the potential policy implementations and the principles behind a legal and regulatory framework for a peer-to-peer energy trading platform.

II. PEER-TO-PEER ENERGY TRADING

A. *Smart Technology*

Smart technology is described as the marriage between enhanced data processing and internet-based communication to facilitate effortless access to information and

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enable control over complex systems in both physical and digital spaces.¹ Peer-to-Peer Energy Trading Platform ('P2P-ETP') is a system that encompasses the technologies of smart grids, smart meters and blockchain-based smart contracts. Thus, P2P-ETPs correspond directly with the growth of smart cities² as envisioned by the United Nation's New Urban Agenda³ which coincides with the United Kingdom's focus on developing sustainable cities.⁴ Smart grids allow access to detailed information on electricity production (with renewable energy appliances) and consumption to improve the reliability of the service, reduce costs, and introduce renewable energy sources into a nation's energy portfolio.⁵ The purpose of a smart grid is to ensure that consumers can establish real-time situational awareness over vast stretches of energy systems, as well as their production and consumption. In doing so, these smart technologies collect, aggregate, and report detailed energy production and consumption data from individual households.⁶

Smart grids rely on the installation of smart meters to achieve these goals of greater consumer awareness and participation—producing, consuming, and trading energy. Therefore, it is necessary to identify all the necessary components of the P2P-ETP network to understand how smart technologies, such as smart contract, can assist with greater consumer protection in the promising P2P-ETP industry. Traditional energy trading is mostly unilateral, as it flows from producers to consumers through a centralized grid. P2P-ETP disrupts this model by promoting multi-directional trading without a central body transmitting energy unilaterally.⁷ Hence, it removes the role of a monopolist grid. This is because of the peer-to-peer aspect, which relies on a decentralized system. Within this decentralized system, smart contracts serve as the digital medium and form a reliable and secure foundation for peer-to-peer energy trading.⁸

Smart meters are the initial step towards smart electricity grids and lay the foundation for further implementation of renewable energy production and consumption.⁹ Smart meters are communication devices, similar to a messaging service, which correspond to the electricity usage of in-house appliances of the

¹ John R. Forbush, *Regulating the Use and Sharing of Energy Consumption Data: Assessing California's SB 1476 Smart Meter Privacy Statute*, 75 ALB. L. REV. 341, 341 (2012).

² DEP'T FOR BUS. INNOVATION & SKILLS, SMART CITIES: BACKGROUND PAPER 11 (2013), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/246019/bis-13-1209-smart-cities-background-paper-digital.pdf.

³ G.A. Res. 70/1, ¶ 18 (Oct. 21, 2015) [hereinafter *U.N. Resolution*].

⁴ GREATER LONDON AUTHORITY, SMARTER LONDON TOGETHER 30 (June 2018), https://www.london.gov.uk/sites/default/files/smarter_london_together_v1.66_-_published.pdf.

⁵ A. Brown et al., *Smart Grid Issues in State law and Regulations* 30 (Galvin Elec. Initiative, Galvin White Paper 2010), [http://galvinpower.org/sites/default/files/SmartGridIssuesInStateLawAndRegulation_Whitepaper_Final\(1\).pdf](http://galvinpower.org/sites/default/files/SmartGridIssuesInStateLawAndRegulation_Whitepaper_Final(1).pdf).

⁶ Elias Leake Quinn, *Smart Metering And Privacy: Existing Laws And Competing Policies* 18 (May 9, 2009) (unpublished manuscript), https://papers.ssrn.com/sol3/papers.cfm?abstract_id=1462285.

⁷ Ning Wang et al., *Peer-To-Peer Energy Trading Among Microgrids with Multidimensional Willingness*, 11 ENERGIES 3312 (Nov. 27, 2018) (manuscript at 2), <https://doi.org/10.3390/en11123312>.

⁸ *Id.*

⁹ Nancy J. King & Pernille W. Jessen, *Smart Metering Systems and Data Sharing: Why Getting a Smart Meter Should Also Mean Getting Strong Information Privacy Controls to Manage Data Sharing*, 22 INT'L J. OF L. AND INFO. TECH. 215, 215-53 (2014).

consumer and external providers. Smart meters provide a detailed breakdown of usage, including peak consumption and other relevant energy regulatory data.¹⁰ A crucial difference between smart meters and traditional meters is the smart meter's ability to communicate immediately with the household and energy providers—who may also be the consumer if renewable energy appliances are installed in the household. Traditional meters only give current usage of the household, and an accurate breakdown of usage is inaccessible to the individual consumer. Conversely, smart meters can communicate usage to consumers and other parties, such as utility companies, in real time.¹¹ In P2P-ETP applications, smart meters are vital to the tracking, trading, and allocation of energy of the participants in the network. Energy trading will operate through the P2P network, with transactions verified through blockchain-based smart contracts.

These contracts will operate on blockchain, a distributed ledger technology, which shall serve as the infrastructure of the platform. It uses cryptographic security combined with a consensus mechanism¹² so that the transaction activities are transparent and immutable. The decentralized nature of the technology enables each meter (or node on the blockchain) to have access to the record of the transactions on the platform. The nodes represent energy consumers that operate on the same chain and detail all transactions via the copy that each consumer possesses.¹³ Consumers can be either consumers or prosumers, based on their specific keys. Within the P2P-ETP ecosystem, users interact with the blockchain via private or public keys depending on the accessibility of the chain itself. Private keys give access solely to the individual's personal transactions, while public keys create access to the network transactions. The dual system works as an 'asymmetric cryptography,'¹⁴ which brings authentication and integrity to the dealings on the network.¹⁵ Each block is identified by its cryptographic lock and references the block that came before it.¹⁶ This creates the immutability of the technology because the data and prior blocks cannot be deleted, but only copied—while more information can be added to the following blocks. Blockchain blends several existing technologies alongside P2P networking. As outlined earlier, these include public and private keys, which are protected through cryptography, and consensus mechanisms that create a highly resilient and immutable ledger.¹⁷ The networks are not centrally managed but operate collectively.¹⁸ However, because of the personal data stored on the P2P-ETP, it is submitted that a private chain, with a central operator, would likely be required. It is envisaged that, in the future with more advanced automated technology, no central operator would be

¹⁰ Kevin L. Doran, *Climate Change and The Future of Energy: Privacy and Smart Grid: When Progress and Privacy Collide*, 41 THE U. OF TOL. L. REV. 909, 910 (2011).

¹¹ King & Jessen, *supra* note 9, at 222.

¹² Jiani Wu & Nguyen Khoi Tran, *Application of Blockchain Technology in Sustainable Energy Systems: An Overview*, 10 SUSTAINABILITY 3067 (Aug. 28, 2018) (manuscript at 3), <https://doi.org/10.3390/su10093067>.

¹³ *Id.*

¹⁴ *Id.* at 6.

¹⁵ *Id.*

¹⁶ PRIMAVERA DE FILIPPI & AARON WRIGHT, BLOCKCHAIN AND THE LAW: THE RULE OF CODE 35-36 (2019).

¹⁷ Konstantinos Christidis & Michael Devetsikiotis, *Blockchains and Smart Contracts for the Internet of Things*, 4 IEEE ACCESS 2292, 2292-303 (2016).

¹⁸ DE FILIPPI & WRIGHT, *supra* note 16, at 37.

required to manage P2P-ETPs. The transition towards a truly decentralized peer-to-peer network would initially need to integrate the current regulatory systems¹⁹ with smart technologies.

Case studies show that the chief advantage of implementing P2P-ETP systems is the merging of communicative-metering infrastructures, such as smart meters and the decentralized computing aspect of energy trading.²⁰ The technologies operate through physical and digital media to facilitate the new energy trading model. As discussed, energy trading would run on the P2P system to facilitate bilateral transactions between consumers and those producing energy. Therefore, the P2P-ETP system is self-organized and is able to execute certain transactions autonomously, i.e. the delivery of energy versus payment in an automated manner.

The P2P-ETP system for energy trading follows five consistent criteria.²¹ First, the transactions will be handled chronologically. Second, the specially designed smart meters measure the energy surplus after gauging the energy usage of the household. Third, tokens are used to represent the energy produced ('tokenisation'), which can be stored in a personal digital wallet and connected to the smart meter. Fourth, the energy tokens can be traded on the platform. Lastly, users of the grid can filter and indicate preferred price ranges and the amount of energy desired for specific times. After the energy token has been traded and utilized, it ceases to exist.

The model of a shared economy requires the partnership of private, governmental, and public networks to facilitate access rather than ownership. It relies on the concept of a social contract among the participating parties.²² In the interest of vulnerable and low-income consumers, those who may fail to gain access to such a system that requires significant immediate financial investment, government offices or an independently regulated controller should handle the maintenance and control of the physical infrastructure. Finally, billing and transactions within the P2P-ETP system require accountable coordination, relying on the data gathered by smart meters that are facilitated through smart contacts. Accountability in the P2P-ETP system is established through its transparency and immutability. When transaction information is entered into the shared blockchain network, it would be difficult to manipulate or change the information. This technology increases the resilience of the power system itself, whereby each peer in the network would retain a copy for records and billing to ensure mutual accountability.

According to the United Kingdom Government Office for Science, effective governance and regulation are vital to the success of implementing DLT.²³ It also brings to light the need for proper legal frameworks for regulating the technology in the interest of consumer protection. As of January 2020, the United Kingdom has implemented a deadline for energy companies to become users of data communications companies and to take all reasonable measures to introduce smart meters to their

¹⁹ Wu & Tran, *supra* note 12, at 16.

²⁰ *Id.*

²¹ Wang et al., *supra* note 7, at 2-5.

²² *Id.*

²³ GOV'T OFFICE FOR SCIENCE, DISTRIBUTED LEDGER TECHNOLOGY: BEYOND BLOCK CHAIN 11, 15, 47 (2016), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf.

domestic and small business consumers.²⁴ The deadline for nine major energy suppliers in the United Kingdom to become data communication companies (“DCC”) was March 31, 2020.²⁵ This will benefit consumers and producers by enforcing trust and transparency. To achieve this, a viable option for exploration is the application of automated smart contracts for transactions.

B. *Smart Contracts*

A smart contract is described as a digital agreement which executes automated instructions and utilizes immutable technology, such as DLT, to ensure validity and accountability.²⁶ A basic smart contract process on the P2P-ETP has three steps. First, parties must agree upon a transaction for energy. Second, once the requirements are met for the transaction to proceed, the first ‘block’ unlocks and distributes energy via the encoded instructions. Third, if these requirements are not met, the block will remain locked and nothing will be distributed. Smart contracts have been known for the trading of crypto-currencies such as Bitcoin and Ethereum. In the proposed P2P-ETP, smart contracts shall be used to trade units of energy represented by tokens (‘tokenisation’). These tokens will be stored on digital wallets as dematerialized certificates representing the energy commodity on the P2P-ETP to be traded with the smart contracts.

Digital wallets are software applications that facilitate the storing and safe-keeping of these energy tokens.²⁷ These tokens are subsequently assigned value based on the context of trading and stored within the digital wallet of the consumer. For example, a single token can represent one kilowatt, or an hour of power, and consumers can use these tokens to trade energy²⁸ along smart grids via the smart meters installed in their households.

To execute a smart contract, the parties must negotiate terms until a ‘meeting of the minds’²⁹ occurs, and the parties enter a legally binding contract. After this relationship is established, the smart contract is subsequently encoded to contain the requirements and instructions following the agreed upon terms and conditions of the legal contract. If an energy consumer does not pay, as required by their contractual obligations, the smart contract will not transfer the energy to that consumer. This

²⁴ OFFICE OF GAS AND ELEC. MKT, STATUTORY CONSULTATION ON THE POST-2020 SMART METER ROLLOUT REPORTING REQUIREMENTS 4 (Oct. 1, 2019), https://www.ofgem.gov.uk/system/files/docs/2019/10/statutory_consultation_on_the_post-2020_smart_meter_rollout_reporting_requirements_0.pdf.

²⁵ *Ofgem Orders Nine Energy Suppliers To Become DCC Users*, OFGEM (Jan. 10, 2020), <https://www.ofgem.gov.uk/publications-and-updates/ofgem-orders-nine-energy-suppliers-become-dcc-users>.

²⁶ Florian Möslein, *Legal Boundaries Of Blockchain Technologies: Smart Contracts As Self-Help*, U. OF OXFORD (Jan. 09, 2019), <https://www.law.ox.ac.uk/business-law-blog/blog/2019/01/legal-boundaries-blockchain-technologies-smart-contracts-self-help>.

²⁷ Adam J. Levitin, *Pandora’s Digital Box: The Promise And Perils Of Digital Wallets*, 166 U. PA. L. REV. 305, 307 (2018).

²⁸ Merlinda Andoni et al., *Blockchain Technology In The Energy Sector: A Systematic Review Of Challenges And Opportunities*, 100 RENEWABLE AND SUSTAINABLE ENERGY REVIEWS 143, 143-74 (2019).

²⁹ *Carlill v. Carbolic Smoke Ball Co.* [1893] 1 QB 256 at 266.

scenario demonstrates the use of software to manage contractual performance without human interpretation or intervention.³⁰ However, the performance instructions of the smart contract are not specifically written in standard legal prose or layman language but outlined and executed in a coded programming language stored on the blockchain. Unlike traditional contracts, a smart contract applies a command-oriented language designed for computer automation and comprehension, and it is not written in an accessible language that can be read by an attorney without the specific IT skills. The command-oriented language is derived from the code behind the smart contracts themselves. Typically, smart contracts on the blockchain are coded in programming-based languages such as C++ and JavaScript.³¹ This requires specialized knowledge of computer languages and programming to integrate the operation of a smart contract on the P2P-ETP fully. Computer languages function as executable clauses, and conditions that must be satisfied before delivering the tokens and the units of energy to the intended energy consumer or producer. Therefore, while anyone literate can read traditional contracts, only those who can read specific coding languages can read smart contracts. This is the main disparity between traditional contracts—those drafted for comprehension by people—and automated smart contracts—those executed and written in a computer-oriented language.³²

The contractual terms in the smart contract are confirmed prior to the trading of energy through a traditional contract negotiation. However, the act of energy trading will be through automation with smart contracts. Therefore, it is necessary to consider the contract law issues around smart contracts prior to the automated implementation. Smart contracts execute legal agreements and create digital commercial arrangements.³³ However, they are not themselves legally enforceable because of the decentralized nature of the blockchain, where no single party controls it. Therefore, the autonomous nature of smart contracts make them potentially riskier than traditional legal agreements in terms of consumer protection. To make a smart contract legally enforceable, it is feasible to have a hybrid system of contracts. For example, context-sensitive legal prose, such as good faith or warranty provisions, can be governed by traditional written contracts, while more time-dependent actions, such as payment dates, can be governed by smart contracts.³⁴

This hybrid system of contract is achievable as most coding programs allow clauses, also known as DocStrings, to explain the purpose of the code. DocStrings exist between the lines of code to allow the programmer or readers to understand the functions of the program. Smart contracts operate on similar coding platforms backed by typical computer programming. DocStrings allows for written explanations for the functions of the code in the interest of applying them alongside traditional legal contracts. This system creates the foundation for a hybrid styled smart contract that

³⁰ DE FILIPPI & WRIGHT, *supra* note 16, at 72.

³¹ Maria Konash, *9 Key Tools And Technologies To Develop And Test Blockchain Applications*, COINSPEAKER, <https://www.coinspeaker.com/tools-technologies-blockchain-applications/> (last updated Jan. 23, 2020, 10:38 UTC).

³² Nick Szabo, *Formalizing and Securing Relationships on Public Networks*, NICK SZABO'S HOMEPAGE (1994), <https://www.fon.hum.uva.nl/rob/Courses/InformationInSpeech/CDROM/Literature/LOTwinterschool2006/szabo.best.vwh.net/formalize.html>.

³³ DE FILIPPI & WRIGHT, *supra* note 16, at 73-74.

³⁴ *Id.*

accommodates both smart contract developers and lawyers. Consequently, in the P2P-ETP models that would utilize smart contracts, the contractual agreements between the parties would be enforced through the transparency of the automated smart contract, while they would also be legally protected through the terms and applicable body of law governing the the traditional contract. Therefore, when parties are in dispute, they may either renegotiate or seek traditional legal routes, such as court ordered compensation, to resolve the dispute. Judge Steven Morris QC specified in *Armstrong DLW GmbH v. Winnington Networks Ltd*³⁵ that tradable carbon emission credits constitute an intangible property³⁶ in English law. This forms the legal basis for trading ‘tokenised energy’ as an intangible property via smart contracts on P2P-ETP.

C. Benefits of the P2P Model

There are numerous academic assessments of the potential beneficial and negative attributes of P2P-ETPs, which promotes sustainability³⁷ by removing the intermediaries and allowing consumers to trade energy on their own terms. The P2P-ETP satisfies many of the United Nations Sustainable Development Goals (“SDGs”) for the 2030 Agenda for Sustainable Development.³⁸ Most notably, SDGs 7, 9, 11, and 13, which all touch upon access to affordable sustainable energy and building infrastructure that combats climate change.³⁹ These goals are also reflected in the Third Energy Package for the European Union (EU) and the Smart Meter Act 2018 in the United Kingdom. The legislation encourages allocating government investment into infrastructure and incentivizing consumer energy awareness. The P2P-ETP system itself is vital for sustainable application as it impacts the physical functioning of the domestic energy sector. Smart grids and P2P-ETP systems encourage consumers to create their own renewable energy, such as solar energy, using installed solar panels.⁴⁰ Smart meters, which can track and observe the exact amount of energy produced and spent, would promote greater consumer consciousness while ensuring control over the energy they directly produce, consume, and trade.⁴¹

Smart contracts, working in tandem with these technologies, operate as an accountability measure to fight against the potential consequences of depleting common resources. In a situation of shared resources, self-interest leads to the

³⁵ *Armstrong DLW GmbH v. Winnington Networks Ltd* [2012] EWHC (Ch) 10 [52]-[54], [2013] Ch 156.

³⁶ *Official Receiver (as liquidator of Celtic Extraction Ltd and Bluestone Chemicals Ltd) v. Environment Agency* [2001] Ch 475.

³⁷ *Id.*

³⁸ *U.N. Resolution, supra* note 3, at 14.

³⁹ *See id.* SGD 7 reads to “[e]nsure access to affordable, reliable, sustainable and modern energy for all.” SGD 9 reads to “[b]uild resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation.” SGD 11 reads to “[m]ake cities and human settlements inclusive, safe, resilient and sustainable.” SGD 13 reads to “[t]ake urgent action to combat climate change and its impact.”

⁴⁰ Rafael Leal-Arcas, Feja Lesniewska, & Filippas Proedrou, *Smart Grids In The European Union: Assessing Energy Security, Regulation & Social And Ethical Considerations*, 24 COLUMBIA J. OF EUR. L. 291, 291-389 (2018).

⁴¹ *Id.* at 323.

depletion and eventual destruction of the collective; in this scenario, the collective are connected energy consumers. In the past, this situation in the energy sector highlighted the contribution of excessive energy consumption to severe carbon emissions. However, consumers are unable to track their direct consumption and therefore may not be aware of their consumption levels. The introduction of smart contracts to the P2P-ETP system will empower consumers by allowing them to regulate their own energy consumption.⁴² Now, more and more consumers are desiring responsible energy consumption as more scientific research comes out detailing the severity of the climate change emergency.⁴³

To empower consumers, it must be acknowledged that energy consumers are unique individuals with different preferences in terms of environmental concerns, financial burdens, and levels of trust towards emerging technology. Therefore, smart contracts introduce a market mechanism suited to individual consumers' concerns within their control. P2P-ETP systems enable such consumer empowerment by using smart contracts to facilitate bilateral energy transactions within specific demand periods. Consumers are given the ability to negotiate price dynamics through supply and demand models. In embedding smart contracts within P2P-ETPs, the pricing would be flexible and automated based on pre-set conditions and demand. Consumers would be able to personalize their own ceiling cap for purchasing, and therefore, avoid potential overcharge or overconsumption of energy. This dynamic style would assist the energy consumer's ability to negotiate in conjunction with complex tariff structures. Consequently, by enabling energy trading throughout a period of fluctuating pricing, demand at peak times would be lowered as energy will be purchased at will by the individual consumer prior to use or when necessary.⁴⁴

As a result of these dynamics, P2P-ETPs facilitate management of energy supply through this shared economy model with smart grids and smart meters.⁴⁵ Energy consumers can actively manage their household energy usage and cost through the accessibility of their data.⁴⁶ Research on this application is outlined in the cost-benefit analysis issued by the UK Government. The real-time awareness of usage and cost will encourage consumers to reduce demand and contribute to lower energy bills.⁴⁷ A real-world example of this structure is the Brooklyn Microgrid Project⁴⁸ in the United States, where participants generate their own energy and resell to consumers who need it, at a cheaper rate.⁴⁹

⁴² *Id.* at 324.

⁴³ William J. Ripple et al., *World Scientists' Warning Of A Climate Emergency*, 70 *BIOSCIENCE* 8, 8-12 (2019).

⁴⁴ Claire Henly et al., *Energizing the Future with Blockchain*, 39 *THE ENERGY BAR ASS'N ENERGY L. J.* 197, 197-232 (2018).

⁴⁵ Hilary E. Brown, Siddharth Suryanarayanan, & Gerald T. Heydt, *Some Characteristics Of Emerging Distribution Systems Considering The Smart Grid Initiative*, 23 *THE ELEC. J.* 64, 64-75 (2010).

⁴⁶ Sonia McNeil, *Privacy and the Modern Grid*, 25 *HARVARD J. OF L. AND TECH.* 199, 199-224 (2011).

⁴⁷ DEP'T OF BUS., ENERGY AND INDUS. STRATEGY, *SMART METER ROLL-OUT COST-BENEFIT ANALYSIS 1*, 35 (Sept. 16, 2019), <https://www.gov.uk/government/publications/smart-meter-roll-out-cost-benefit-analysis-2019>.

⁴⁸ Andoni, *supra* note 28, at 155-56.

⁴⁹ *About*, BROOKLYN MICROGRID, <https://www.brooklyn.energy/bmg-101> (last visited June 29, 2019).

Several P2P-ETP projects are being tested worldwide.⁵⁰ For example, in the United Kingdom, Piclo was established as a collaboration between the technology company Open Utility⁵¹ and the renewable energy supplier Good Energy.⁵² Piclo's system matches consumption preference to generators depending on locality and demand, while providing consumers with data analytics through smart meters.⁵³ This is an example of how P2P-ETPs integrate data consisting of pricing and consumer preference information to match demand based on consumer selection. While these systems are being rolled out slowly, limited research is currently available on the impact of smart contracts and P2P-ETPs.

While these examples are still new, they demonstrate that P2P-ETPs can engage consumers in a more dynamic energy market. Feedback of energy consumption is especially useful for consumers, as it has been shown to change behaviors dramatically. Darby⁵⁴ and Fischer⁵⁵ note that energy feedback could reduce energy consumption by 10%.⁵⁶ The European Smart Metering Industry Group (ESMIG), after a review of 100 beta-testing pilots and 460 samples over 450,000 consumers, suggested savings from around 5-6% without real-time readings compared to an average of 8.7% with real-time readings.⁵⁷ Other trials in the EU provided similar results.⁵⁸ Interestingly, an ancillary, yet positive outcome from these trials is that the energy bills for many of the participants are lower than usual.

The cost for suppliers and utility companies will also be positively affected by the implementation of smart meters. Traditional meters only allow for a simple record of energy consumption and require manual reading, such as on-site meter visits or requiring consumers to send in meter readings. With the implementation of smart meters, the labor necessary for these antiquated methods would no longer be required. Conclusively, the Early Learning Project found in its 2015 report—on behalf of the United Kingdom Department of Energy and Climate Change—that consumers with smart meters were better able to budget for expenditure as a result of the real-time meter, and therefore, were more satisfied than those with traditional ones.⁵⁹ Within the energy market's proliferating smart technologies, the implementation of DLT is

⁵⁰ Thomas Morstyn et al., *Using Peer-to-Peer Energy-Trading Platforms to Incentivize Prosumers to Form Federated Power Plants*, 3 NATURE ENERGY 94, 94-101 (2018).

⁵¹ *About*, PICLO.ENERGY, <https://piclo.energy/about> (last visited June 29, 2019).

⁵² *Id.*

⁵³ *Id.*

⁵⁴ Sarah Darby, *The Effectiveness of Feedback on Energy Consumption: A Review for DEFRA of the Literature on Metering, Billing, and Direct Displays* 3 (Env'tl. Change Insti. At U. of Oxford, April 2006), <https://www.eci.ox.ac.uk/research/energy/downloads/smart-metering-report.pdf>.

⁵⁵ Corinna Fischer, *Feedback On Household Electricity Consumption: A Tool For Saving Energy?*, 1 ENERGY EFFICIENCY 79, 79-104 (2008).

⁵⁶ *Id.*

⁵⁷ Jessica Stromback et al., *The Potential of Smart Meter Enabled Programs to Increase Energy and Systems Efficiency: A Mass Pilot Comparison 2* (vaasa ett 2011), https://esmig.eu/sites/default/files/2011.10.12_empower_demand_report_final.pdf.

⁵⁸ *Electricity Smart metering Customer Behaviour Trials (CBT) Findings Report* 1-146 (Comm'n for Energy Reg., May 16, 2011), <https://www.cru.ie/wp-content/uploads/2011/07/cer11080ai.pdf>.

⁵⁹ DEPT OF ENERGY AND CLIMATE CHANGE, SMART METERING EARLY LEARNING PROJECT: SYNTHESIS REPORT 32 (2015), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/407568/8_Synthesis_FINAL_25feb15.pdf.

already being considered for the next step for smart meters, grids,⁶⁰ and eventually a cohesive P2P-ETP.

III. LEGAL OBSTACLES

A. *Limitation of Smart Contracts in P2P Trading*

Smart contracts are computer-based software. The regulatory challenge is to embed smart contracts into the current contract law framework.⁶¹ Otherwise, the creation of a separate regulatory legislation will become a necessity in the future legal structure of P2P-ETPs.

1. *Black Box Smart Contracts*

While not written entirely in a programmed-coded format, the form of expression in smart contracts differs greatly from traditional contracts.⁶² An understanding of computer languages is necessary to draft, understand, and implement the code within them. While the code facilitating the smart contracts might be correct, unspecified directions for the instructions or requirements can result in unintentional consequences and in liabilities to either party. A notable issue with smart contracts is rooted in the fixed format and protection of what has been previously agreed and programmed into the code.⁶³ While this is helpful for accountability, it can lead to potential issues in consumer protection and contractual liability if smart contracts are recognized as legally enforceable contracts. Should they be recognized as legal contracts, it would be difficult to verify that they are appropriately coded and protected.⁶⁴ Consumers and businesses would have to rely on the qualifications of those drafting the computer language behind them and ensure that they are legally enforceable.⁶⁵ On P2P-ETPs, smart contracts are considered to function as intended by the developer.⁶⁶ Thus, the smart contract, if not properly executed, can result in malfunctions. For example, an attack on the DAO, a digital decentralized autonomous organization that operated as an investor-directed venture capital fund on the Ethereum blockchain, led to over 60 million US dollars being moved into an incorrect

⁶⁰ Commission Rolling Plan for ICT Standardisation, <https://joinup.ec.europa.eu/collection/rolling-plan-ict-standardisation/smart-grids-and-smart-metering> (last updated July. 1, 2020).

⁶¹ Jake Goldenfein & Andrea Leiter, *Legal Engineering On the Blockchain: 'Smart Contracts' as Legal Conduct* 29 L. AND CRITIQUE 141, 144 (2018).

⁶² Guido Governatori et al., *On Legal Contracts, Imperative And Declarative Smart Contracts, And Blockchain Systems* 26 ARTIFICIAL INTELLIGENCE AND L. 377, 377-409 (2018).

⁶³ Governatori et al., *supra* note 62, at 9-13.

⁶⁴ *Id.* at 14-15.

⁶⁵ Kristin Silverberg et al., *Getting Smart: Contracts On The Blockchain* 9 (Inst. of Int'l Finance, May 2016), https://www.iif.com/portals/0/Files/private/32370132_smartcontracts_report_may_2016_vf.pdf.

⁶⁶ Maher Alharby & Aad van Moorsel, *A Systematic Mapping Study On Current Research Topics In Smart Contracts*, 9 INT'L J. OF COMPUTER SCIENCE AND INFO. TECH. 151, 151-64 (2017).

account.⁶⁷ This resulted in a legal controversy regarding the automation and ownership of these tokenised funds on the blockchain. To avoid this risk with P2P-ETP systems, an established and accredited standard for trustworthy professionals on the back end of the technology is necessary. Consumer contracts must be clearly and unambiguously understood⁶⁸; therefore, the development of smart contracts as legal contracts would create a hurdle for those who are not technologically inclined. Placing trust in a contract that an average person cannot read or understand opens a technological ‘pandora’s box’ of litigation and misunderstanding.

2. Systemic Risk Due to Errors in Coding

A systematic chain reaction stemming from errors within the smart contract would severely impact both parties involved with the contract.⁶⁹ For example, an error in the contract's application and execution would create a crisis of time-restricted consequences. The contract's intricate system of immutability to editing and retracting on the blockchain would be a negative characteristic. There is a risk of using niche languages with smart contract coding, and even if there is an error within the code of the smart contract, the program itself could potentially still run without indication of error.⁷⁰ However, it would run incorrectly. For example, errors in the execution of smart contracts could lead to incorrect billing, malfunctions between transactions, and loss of potential or purchased energy units. This is avoidable once all codified terms and clauses of smart contracts perform as intended, relying on the guarantee that the contract is coded correctly. Smart contracts rely on trusting the computer programmers behind them. This trust also depends on the resilience to tampering once adequately coded. Due to the difficulty of changing the underlying blockchain code, the narrow opportunities for anyone to access or change the contract without preceding agreements can also represent a risk of errors in coding.⁷¹

Blockchain technology and smart contracts should assist consumers in understanding the risks and terms better before agreeing.⁷² Trust can be reinforced by requiring the consumer to digitally check marked terms and clauses indicating acceptance, or by enabling a feature that tracks how long someone spends on a page to guarantee that the consumer has properly read all the terms and conditions. It is also symbiotically beneficial to companies, such as the controllers of the private blockchain network, that rely on consumer acknowledgement for their legal protection. Clauses should be drafted in the traditional contract to include legal accountability through the consumer protection legislation for any breach or errors in service.

⁶⁷ Fan Zhang et al., *Town Crier: An Authenticated Data Feed for Smart Contracts*, CCS'16: 2016 ACM SIGSAC CONF. ON COMPUTER AND COMM'N SEC. 270, 270-82 (Oct. 2016), <http://dx.doi.org/10.1145/2976749.2978326>.

⁶⁸ WRM Group Ltd v Wood [1997] Lexis Citation 4581.

⁶⁹ Goldenfein, *supra* note 61, at 147.

⁷⁰ Christian Chessman, *A 'Source' Of Error: Computer Code, Criminal Defendants, And The Constitution*, 105 CAL. L. REV. 179, 179-228 (2017).

⁷¹ Maher Alharby & Aad van Moorsel, *Blockchain Based Smart Contracts: A Systematic Mapping Study*, FOURTH INT'L CONF. ON COMPUTER SCIENCE AND INFO. TECH. 125, 125-40 (2017).

⁷² Goldenfein, *supra* note 61, at 143.

Consumer knowledge, trust, and understanding are vital to the contractual agreements between consumers and energy producers. However, 60% of domestic consumers within the United Kingdom, who are on default tariffs, are not currently benefitting from this model.⁷³ This indicates that most domestic consumers in the energy market fail to meet their needs. An example of this was demonstrated by OVO Energy in January 2020, where consumers were extraordinarily overcharged and issued incorrect energy usage information.⁷⁴ It is submitted that the implementation of P2P-ETPs would ensure greater consumer protection and company compliance through transparency and accountability. P2P-ETPs would enable consumers to access their own energy data (produced, consumed, purchased, stored in the custody of the wallet, and traded) and avoid a disastrous billing system. The platform can also ensure a cap on energy expenditure based on the amount of energy produced and used within the household. With the collected data from smart meters, consumers would know the precise amount of energy produced⁷⁵ and used while utilizing smart contracts for their legal protection and billing.⁷⁶

The P2P-ETP smart contract trading for energy detailed above is exemplified through a cyclical ecosystem. Smart meters are the medium to regulate energy consumption and production. As discussed, the consumer has agreed to energy tariffs and contracts, and the smart contract enforces accountability and price arrangement. When the terms and conditions of trading have been agreed to, the information is encoded into the smart contract as an automated system. To avoid overbilling, a cap can be introduced into the smart contract transaction to ensure that the consumer does not consume or pay for more than stipulated. Options for additional purchases may be presented if the consumer is reaching close to their limit. The consumer can use the smart meter to enforce their smart contract with the energy company. The smart meter requires no direct regulation and functions autonomously using its own data, ensuring that the consumer is receiving the agreed amount of energy. In turn, the smart contract also ensures that the energy company is receiving payment at the specified time and date, as agreed in the hybrid contract. This limits the potential of energy being cut off during colder times of the year and protects vulnerable consumers from sudden heating cuts. Therefore, this example of a smart contract in the P2P-ETP would not require any additional regulation outside of traditional contract law and application, as it utilizes pre-determined conditions in a traditional contract as protection.

B. Consumer Protection

Consumers are empowered through P2P-ETPs by having more control over their energy usage. Although, technological infrastructure should be regulated in the interest of consumers and there is evidence that this is beginning to take shape. For

⁷³ OFFICE OF GAS AND ELEC. MKT, FORWARD WORK PROGRAMME 2018-2019 6 (2018), https://www.ofgem.gov.uk/system/files/docs/2018/03/forward_work_programme_2018-19_0.pdf.

⁷⁴ *Ovo Energy To Pay £8.9M For Overcharging Customers*, BBC NEWS (Jan. 29, 2020), <https://www.bbc.co.uk/news/business-51292695>.

⁷⁵ *AXA Launches Ethereum Smart Contract Insurance Product for Flight Delays*, TRUSTNODES (June 18, 2018, 4:42 PM), <https://www.trustnodes.com/2018/06/18/axa-launches-ethereum-smart-contract-insurance-product-flight-delays>.

⁷⁶ Zhang, *supra* note 67, at 271, 274-76.

example, for P2P-ETPs, the Renewable Energy Directive states that the infrastructure of smart technology and regulatory instruments should embed consumer protection. The Directive indicates that an applicable regulatory framework should be established to empower renewables for self-consumers (consumers and prosumers) without disproportionate burdens.⁷⁷ Thus, the foundation for consumer protection, while consuming and generating energy, has been enshrined in this legislation for the encouragement of P2P-ETPs. Discussions throughout this paper indicate that smart contract obligations on the P2P-ETP can be regulated through traditional contract law via hybrid contractual arrangements. Other legislative measures can also be applied to blockchain-based smart contracts depending on the legal recognition of smart contract. Furthermore, the transparent model also raises legal issues around security, individual privacy, and data protection.⁷⁸

1. *Smart Contracts as Software*

P2P-ETP systems are an amalgamation of multiple smart technologies. Smart contracts, as discussed, operate as the functioning medium for billing and financial transactions. However, they may not be legally enforceable because they are comprised of code. Therefore, smart contracts can be considered software as digital content under the Consumer Rights Act of 2015. Digital content is data produced and supplied in digital form.⁷⁹ Therefore, P2P-ETPs can be considered the devices on which smart contracts—the digital content in this context—operate. Smart contracts are enforced by the blockchain, which is also considered a ‘digital good’. Therefore, consumer protection against software and product liability in P2P-ETP systems can fall under the Consumer Rights Act of 2015. Other legislative measures can be applied to smart contracts on the blockchain. For example, the Digital Economy Act of 2017⁸⁰ states that Schedule 9 extends to the Banking Act of 2009 which oversees the Bank of England’s inter-bank payment system,⁸¹ to connect to other payment systems. The Digital Economy Act makes consequential provisions to facilitate digital transactions. Therefore, digital transactions are not a new activity that need to be regulated and monitored outside of existing legislation.

⁷⁷ Directive 2018/2001, of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources, recital 66.

⁷⁸ N. King & P. Jessen, *For privacy's sake: Consumer "opt-outs" for smart meters*, 30 *COMPUTER L. AND SEC. REV.* 530, 530-539 (2014).

⁷⁹ Consumer Rights Act 2015, c. 1, § 2(9) (Eng.).

⁸⁰ Digital Economy Act 2017, c. 30, § 113 (Eng.).

⁸¹ BANK OF ENGLAND, THE BANK OF ENGLAND’S OVERSIGHT OF INTERBANK PAYMENT SYSTEMS UNDER THE BANKING ACT 2009 1 (2009), <https://www.bankofengland.co.uk/-/media/boe/files/news/2009/september/the-boes-oversight-of-interbank-payment-systems-under-the-banking-act-2009.pdf>.

2. Software and Product Liability

With reference to the potential dangers discussed above, highlighting potential flaws and vulnerabilities⁸² within coded products, there is a precedent for large-scale software being susceptible to failures.⁸³ Failures tend to be costly, and many dangerous malfunctions have led to products and services being recalled. However, potential flaws within software are an inevitable reality,⁸⁴ and it has even been argued that strict product liability regulation would result in stifling the creative and entrepreneurial spirit of software development.⁸⁵ Arguments against regulation include how the high cost of meeting a specified standard could potentially drive smaller software companies out of business, and thus, create an unfair monopoly⁸⁶ to the point of delaying or stifling innovation.⁸⁷ From this perspective, software liability and redress are still developing areas of law for consumer protection with regard to defence and obligation.⁸⁸

Software failure on the P2P-ETP can cause losses to consumers due to resulted blackout or billing errors. Thus far, there is no clear legal standard of care for consumers applied to software developers.⁸⁹ Hence, a universal standard is necessary to demonstrate software liability.⁹⁰ This standard must establish that no reasonable software developer would commit such an act.⁹¹ Software development is a subjective field in terms of creation and application; however, a line must be drawn between the proper function of software and the unreasonable failure in delivering that function.

The United Kingdom's case of *The Software Incubator Ltd v Computer Associates Ltd*⁹² extended the meaning of goods to include software supplied electronically within The Commercial Agents Regulations Act 1993.⁹³ This case features the argument that if a company produces and distributes software (goods) through commercial agents, they must pay compensation to the commercial agents upon the termination of agency agreements.⁹⁴ This is specific to English law and can be applied even if the controller operates internationally. Therefore, applying this to the application of smart contracts,

⁸² Mehul Srivastava, *Whatsapp Voice Calls Used To Inject Israeli Spyware On Phones*, FINANCIAL TIMES (May 13, 2019), <https://www.ft.com/content/4da1117e-756c-11e9-be7d-6d846537acab>.

⁸³ Shuai Wang, Chengyu Zhang & Zhendong Su, *Detecting Nondeterministic Payment Bugs In Ethereum Smart Contracts*, 189 PROCEEDINGS OF THE ACM ON PROGRAMMING LANGUAGES 1, 1-29 (2019).

⁸⁴ Jonathan G. Rohr, *Smart Contracts and Traditional Contract Law, or: The Law of the Vending Machine*, 67 CLEV. ST. L. REV. 67, 71 (2019).

⁸⁵ Rohr, *supra* note 84, at 71.

⁸⁶ *Id.*

⁸⁷ Ning Wang et al., *Peer-To-Peer Energy Trading Among Microgrids with Multidimensional Willingness*, 11 ENERGIES 3312 (2018) (manuscript at 1-22), <https://www.mdpi.com/1996-1073/11/12/3312>.

⁸⁸ Carol Dick & Aaron Praktijnjo, *Blockchain Technology And Electricity Wholesale Markets: Expert Insights On Potentials And Challenges For OTC Trading In Europe*, 12 ENERGIES 832 (2019) (manuscript at 1-25), <https://www.mdpi.com/1996-1073/12/5/832>.

⁸⁹ Dick & Praktijnjo, *supra* note 88, at 9.

⁹⁰ Horst Treiblmaier, *Toward More Rigorous Blockchain Research: Recommendations For Writing Blockchain Case Studies*, 2 FRONTIERS IN BLOCKCHAIN 1, 1-15 (2019).

⁹¹ Treiblmaier, *supra* note 90, at 10-13.

⁹² *The Software Incubator Ltd. v Computer Associates Ltd.*, [2016] EWHC (QB) 1587 at 36 (Eng.).

⁹³ The Commercial Agents (Council Directive) Regulations 1993, p. 1, § 2(1).

⁹⁴ Treiblmaier, *supra* note 90, at 7, 10, 13.

which is a digital software provided electronically, there is a strong argument for software liability to be considered under the same scope as a digital good failing to produce its intended function. An opposing argument is that software should be treated like electricity, which itself is specifically covered by Article 2 of the Regulation⁹⁵ and the Consumer Protection Act 1987 in Section 1(2). This opposing argument stands for the idea that software is essentially compiled from the energy that is material in the scientific sense. However, this is a dated argument, as modern definitions of software have placed it as a product of the information age. The case of *St Albans City and District Council v International Computers Ltd*⁹⁶ emphasizes that software should be classified as a product versus electricity and enables redress under standard consumer protection legislation.

C. Consumer Rights and P2P-ETP

Software, as a commercial good and product, is also covered under Part 1 and Part 3 of the Consumer Rights Act 2015 with regard to faults in digital content or products. The Act defines digital content as, ‘data which is produced and supplied in digital form’⁹⁷ and was assumed from the Consumer Rights Directive. However, this would be difficult to apply to smart contracts within the P2P-ETP system because of the context and nature of the software. On P2P-ETP, the smart contract operates as a facilitator for transactions instead of a purchased product. The product being purchased is energy and not the smart contract itself. Therefore, under the Consumer Rights Act 2015, it is difficult to separate the smart contract, because of its facilitating nature, from the entire P2P-ETP itself.

This issue is substantial with regard to consumer protection if trading goes wrong due to the smart contract. In this situation, the question is if a consumer would be able to obtain legal redress against the smart contract designer or the platform provider. It can be interpreted that smart contracts are part and parcel of the P2P-ETP network, and therefore, the standards under the Consumer Rights Act 2015 could apply. The code operating the smart contract is the mechanism that controls the automation of billing and transactions. The parties involved in the transactions on the P2P-ETP are consumers and the smart grid operator. This analysis considers traditional contract law concerning the relationship between the consumer and the smart grid operator that maintains the infrastructure physically and digitally. As previously discussed, the Consumer Rights Act 2015 recognizes the consumers’ rights in situations of digital content. These are situations where it is either supplied for free in conjunction with paid goods and services or digital content that is inaccessible without payment.⁹⁸

In this case, the digital content is a part of the overall contract for such goods and services, and the prescribed standards will apply. Therefore, assuming the definition of digital content in the Consumer Rights Act 2015 Act applies to smart contracts, the designers of the smart contracts would be held to the standard set out in the

⁹⁵ The Commercial Agents (Council Directive) Regulations 1993, p. 1, § 2(1).

⁹⁶ *St. Albans City and District Council v Int'l Computers Ltd.*, [1996] 4 All ER 481 [493] (Eng.).

⁹⁷ Consumer Rights Act 2015, c. 1, § 2(9) (Eng.).

⁹⁸ Consumer Rights Act 2015, c. 2, § 33(3) (Eng.).

legislation.⁹⁹ These requirements include that the digital content is an appropriate fit for the intended purpose, is free from minor defects, and is safe and durable.¹⁰⁰ However, Section 38 of Part 3 of the 2015 Act also enforces that unless expressed in the contractual agreement, there are no further requirements in addition to the above. Finally, the 2015 Act also provides additional¹⁰¹ remedies in situations of digital content, such as being able to claim damages in specific circumstances. Because of the ambiguity of software liability, as discussed earlier in this paper, the definition of smart contracts as a good or product would have to be handled on a case-by-case basis. This highlights a legal risk with smart contracts operating on P2P-ETP.

1. *Consumer Protection Act*

Consumer protection legislation has a long history of regulating consumer rights in commercial aspects. In the past, the Consumer Protection Act 1987 enshrined the concept of product liability as part of the law of the United Kingdom for over a decade. The effect of the Consumer Protection Act 1987 was to create liability, even without fault, on the part of the producer of a defective product, which causes death, personal injury, or any loss or damage to property, including land.

Consumers are at the heart of the P2P-ETP's purpose, and consumer rights include the right to information and the right to fair and responsible marketing.¹⁰² These are to encourage responsible and informed consumer choices and behavior.¹⁰³ When an energy supplier agrees to supply gas or electricity, it is a legally binding contract covered by the Consumer Rights Act 2015. For the consumer's benefit, it is necessary to have features for metering and informative billing of energy consumption.¹⁰⁴ This is to make consumers aware of and provide them competitively priced individual meters that accurately reflect their energy data (production, consumption, trading, and ownership). The smart metering system, in the P2P-ETP model, communicates with other energy suppliers or network operators and they use systems that allow collection, measurement, and analysis of energy for grid management and billing purposes.

In the European Union, smart meters are being rolled because of a piece of legislation called the Third Energy Package.¹⁰⁵ This led to the establishment of the Agency for the Co-operation of Energy Regulators (ACER), which is an EU body with a legal personality to monitor developments in European energy markets.¹⁰⁶ The Third Energy Package states that member states should replace at least 80% of the traditional meters with smart meters by 2020.¹⁰⁷ To accomplish this, the EU has a directive that requires member states to provide citizens with smart meters.¹⁰⁸ In the

⁹⁹ Consumer Rights Act 2015, c. 3, §§ 33-36 (Eng.).

¹⁰⁰ *Id.*

¹⁰¹ Consumer Rights Act 2015, c. 3, § 42(6) (Eng.).

¹⁰² *Id.*

¹⁰³ *Id.*

¹⁰⁴ Council Directive 2006/32, art. 13(1), 2006 O.J. (L 114) 72 (EC).

¹⁰⁵ Council Directive 2009/72, art. 9, 2009 O.J. (L 211) 68 (EC).

¹⁰⁶ Council Regulation 713/2009, 2009 O.J. (L 211) 1 (EC).

¹⁰⁷ Council Directive 2009/72, annex 1(2), 2009 O.J. (L 211) (EC) ¶ 4.

¹⁰⁸ Council Directive 2006/32, art. 13(1), 2006 O.J. (L 114) para 2 (EC).

United Kingdom, this promise is regulated by the Electricity and Gas (Internal Markets) Regulations 2011. The legislative push for smart meters is fuelled by governmental targets for reducing greenhouse gas emissions by increasing renewable energy¹⁰⁹ and infrastructure for future P2P-ETPs.

2. EU: P2P-ETPs and Renewable Energy

Early energy legislation in the European Union did not consider P2P-ETP's high regulatory burdens. As of December 2018, the European Union places consumers at the center of the energy market transition, with a clear and concise right to produce their own renewable energy. The Renewable Energy Directive defined P2P-ETP systems as the bartering of renewable energy between market consumers through pre-determined, automated conditioned contracts.¹¹⁰ Understanding and defining P2P-ETPs is the first step in creating legislation, which allows consumers to regulate their systems and benefit from consumer protection mechanisms. Section 72 of the Renewable Energy Directive¹¹¹ enforces valid consumer protection in situations of energy trading on P2P-ETP, where energy consumers and communities participate in the self-consumption of renewable energy. This section specifically states that consumers shall maintain their rights, including those involving contractual agreements with suppliers of their choice.¹¹² Therefore, according to this recent legislation, consumer protection in the European Union for P2P-ETPs, within reason, would fall under traditional consumer contract law. The nature of smart contracts running on DLT is still young. Therefore, a case-by-case assessment is necessary to establish accurate jurisdictional legislation to apply for consumer protection, especially in situations of applying contract law for consumer litigation in circumstances of service failure or error.

D. Infrastructure

1. Privacy and Data Protection

The EU's General Data Protection Regulation (GDPR) expanded the scope of the European Union's data protection to encompass the powers of those determining the purpose and means of processing personal data¹¹³, data controllers¹¹⁴, and the parties collecting and processing¹¹⁵ the data for the controller.¹¹⁶ It is irrelevant if the

¹⁰⁹ Energy and Climate Change Committee, *The Energy Revolution and Future Challenges for UK Energy and Climate Change Policy* (Third Report of Session 2016-17), 2016, HC 705, ¶ 76-78 (UK).

¹¹⁰ Council Directive 2018/2001, art. 18, 2018 O.J. (L 328) 117 (EC).

¹¹¹ Council Directive 2018/2001, 2018 O.J. (L 328) 93, § 72 (EC).

¹¹² *Id.*

¹¹³ Council Regulation 2016/679, General Data Protection Regulation, art. 4(1), 2016 O.J. (L 119) 33 (EC) [hereinafter General Data Protection Regulation].

¹¹⁴ General Data Protection Regulation, *supra* note 111, art. 4(7).

¹¹⁵ *Id.* art. 4(2).

¹¹⁶ *Id.* art. 4(8).

processing of actual data occurs in that location.¹¹⁷ Consequently, as P2P-ETPs fall under the definition of a data controller by determining the means and purpose of processing energy data of consumers within the EU, it is subject to the GDPR. Once the data is related to the offering of goods or services, regulatory bodies can track the trading or usage behavior of consumers within the EU.¹¹⁸ However, for the application of EU data protection law, the data stored on the blockchain must meet the criteria of personal data under Article 4(1).¹¹⁹ This criterion requires the data to be related to a natural person.¹²⁰ This also coincides with Article 2(a) of the Data Protection Directive 95/46, and thus, it can be applied to smart technologies affecting identifiable individuals operating on P2P-ETPs.¹²¹ While smart contracts running on DLT will typically be encrypted, and consequently, can only be accessed with specific keys and authorized parties, this will not remove the personal data from the scope of data protection legislation.¹²²

The levels of encryption are used as a measure for determining the level of data security needed to meet the protection requirements. Energy consumption data in the past did not raise many privacy concerns, as traditional electric meters previously required a physical assessment to gauge output.¹²³ Traditional meters recorded usage over extended periods and were not specific to appliance or activity. In addition, in traditional business models for energy data, utility companies did not have the means to share energy consumption data with third parties. With the digitization of energy data on P2P-ETPs, it is much easier to acquire and transfer data from smart meters.¹²⁴ This raises issues around lack of transactional privacy and data privacy of P2P-ETP.¹²⁵ In DLT systems, all transactions are publicly available to be viewed if allowed by pre-determined parameters within the terms and conditions and the security level of the network, especially if on the public chain network. This lack of privacy could limit the adoption of P2P-ETPs, as individual consumers usually consider their data and financial transactions as personal and confidential. However, privacy-preserving smart contracts can encrypt the code to ensure that only participants in the transaction can access the content on the chain.¹²⁶

Information privacy is a major concern with regard to DLT, and therefore, P2P-ETPs. The primary purpose of using smart meter data is to ensure that consumers can take advantage of the opportunity to access their households' energy data (i.e. production and usage) and make smarter choices to conserve and trade energy while potentially saving money on their energy bills.¹²⁷ Access to more detailed energy-use

¹¹⁷ *Id.* art. 3.

¹¹⁸ *Id.*

¹¹⁹ *Id.*

¹²⁰ General Data Protection Regulation, *supra* note 113, art. 4(1).

¹²¹ Matthias Berberich & Malgorzata Steiner, *Practitioner's Corner · Blockchain Technology and The GDPR – How to Reconcile Privacy and Distributed Ledgers?*, 2 EDPL 422, 423 (2016).

¹²² General Data Protection Regulation, *supra* note 113, art. 32.

¹²³ *Guide to Energy Meters*, OVO ENERGY, <https://www.ovoenergy.com/guides/energy-guides/energy-meters.html> (last visited Feb. 2, 2019).

¹²⁴ King & Jessen, *supra* note 9, at 231.

¹²⁵ David Wright et al., *Sorting out smart surveillance*, 26 COMP. L. & SEC. REV. 343, 6, 12, 14 (2010).

¹²⁶ Shan Zhou & Marilyn Brown, *Smart meter deployment in Europe: A comparative case study on the impacts of national policy schemes*, 144 J. OF CLEANER PRODUCTION 22, 26-28 (2017).

¹²⁷ *Id.* at 24, 29.

information, increased control over households' energy use and costs, the ability to transfer data to others, and personal involvement in energy conservation are all potential benefits to consumers with access to P2P-ETPs. These considerations justify treating consumers' access to smart meter data as a primary purpose of P2P-ETP.¹²⁸ However, there are privacy risks in terms of transferring such important data to third parties. For example, energy usage patterns and profiles based on smart meter data can be used for many secondary purposes. Such purposes include generating targeted and personalized advertising in online and mobile frameworks.¹²⁹ Under the Data Protection Act 2018, it is an offence to disclose personal data without consent.¹³⁰ It would be necessary to include such consents in the traditional contractual terms and obligations prior to enabling P2P-ETPs access to household data.

Another risk in terms of data sharing on a transparent model of P2P-ETP is the fear of individual data tracking. Consumer interest includes an individual's legal right to be free of unreasonable surveillance¹³¹ and other types of intrusions into their homes and personal lives.¹³² There is potential to apply data-mining technologies to energy usage data produced by P2P-ETPs and use the information for primary and secondary commercial purposes, including many purposes that have not yet been identified in the evolving digital economy.¹³³ Parties involved in data sharing with P2P-ETPs include direct consumers, energy suppliers, and other third parties.¹³⁴ These third parties would include energy service management companies with whom the consumer's energy data has been shared, or marketing entities that rely on consumer data for product advertising and profiling. Data sharing on P2P-ETP may be carried out by the consumer or their energy supplier. Data that could potentially be shared by third parties includes the amount of automated transfers of smart meter data.¹³⁵

Data sharing is often necessary to achieve the benefits of P2P-ETPs, and that data can trickle down to secondary purposes. For example, energy companies may utilize the consumer's smart meter data with a third-party advertising company to earn advertising revenue.¹³⁶ These distinctions between the parties and purposes of sharing are the foundation of the transparent P2P-ETP model. An example can be taken from the United States, where significant progress has been made for consumer privacy concerns with regard to smart meter data. The US Department of Energy enacted a

¹²⁸ King & Jessen, *supra* note 9, at 229.

¹²⁹ *Opinion of the European Data Protection Supervisor on the "Commission Recommendation on preparations for the Roll-out of Smart Metering Systems,"* at 5-6, ¶ 20, https://edps.europa.eu/sites/edp/files/publication/12-06-08_smart_metering_en.pdf.

¹³⁰ Data Protection Act 2018, c. 6, § 170(1) (Eng.).

¹³¹ King & Jessen, *supra* note 78, at 533.

¹³² Wright, *supra* note 125, at 3-4.

¹³³ Omer Tene & Jules Polonetsky, *Privacy in the Age of Big Data: A Time for Big Decisions*, 64 STAN. L. REV. 63, 63 (2012).

¹³⁴ King & Jessen, *supra* note 9, at 251.

¹³⁵ DEPT. FOR BUS., ENERGY & INDUST. STRATEGY, SMART METERING IMPLEMENTATION PROGRAMME 14 (April 2018), https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/700382/SMETS1_maximising_interoperability_enrolment_mandate_consultation_.pdf [hereinafter SMART METERING IMPLEMENTATION PROGRAMME].

¹³⁶ King & Jessen, *supra* note 9, at 235-36.

task force¹³⁷ specifically focused on addressing the issue.¹³⁸ Currently, their key responsibility is to craft a voluntary smart grid code of conduct specific to privacy.¹³⁹ Another development is the construction of a voluntary ‘smart grid privacy seal program’¹⁴⁰ aimed at companies that utilize consumer energy data.¹⁴¹ Policy and legislation play major roles in assisting consumer protection while implementing smart technologies in everyday life. For example, in the United Kingdom, consumer protection for privacy and personal data is included in the suppliers’ licensing terms.¹⁴² Under these terms, a P2P-ETP supplier may collect monthly meter readings for billing and regulation purposes without the need for consumer consent. Furthermore, it would be possible to collect daily meter readings with an option for opting out at the consumer’s consent, or half-hourly meter readings solely with consumer consent for opting in.¹⁴³

Balancing consumers fundamental human rights to privacy and data protection with the beneficial interests of society and the environment is an obvious challenge. However, with P2P-ETP’s smart metering systems, accountable smart contracts, and legislative protection, it is becoming a realistic objective.¹⁴⁴ The European Court of Justice delivered a preliminary ruling¹⁴⁵ in 2010, where they assessed the validity of the Data Retention Directive.¹⁴⁶ In light of Article 7 of the Charter of Fundamental Rights,¹⁴⁷ the issue was whether the service provider could retain the data of registered users and if the Directive adequately met the requirement of personal data protection.¹⁴⁸ It was held that the retention of data for a particular purpose of the Directive was of general public interest. This can prove to be problematic to consumer privacy, as P2P-ETPs utilize and store consumer energy usage. This data is particularly sensitive, as it can be used to track consumer habits and lifestyles.¹⁴⁹ However, Article 52(1) of the Directive states that the application of the principle of proportionality should be enforced, and only data that is necessary for general interest should be retained.¹⁵⁰ Operating this against Articles 7 and 8 emphasizes that it is

¹³⁷ See 42 U.S.C. § 17336 (2018).

¹³⁸ U.S. DEPT. OF ENERGY, VOLUNTARY CODE OF CONDUCT (VCC) FINAL CONCEPTS AND PRINCIPLES 1 (Jan. 12, 2015), https://www.energy.gov/sites/prod/files/2015/01/f19/VCC%20Concepts%20and%20Principles%202015_01_08%20FINAL.pdf.

¹³⁹ Angelique Carson, *Stakeholders Aim to Craft Smart Grid Privacy Code of Conduct*, IAPP (Feb. 27, 2013), <https://iapp.org/news/a/2013-02-27-stakeholders-aim-to-craft-smart-grid-privacy-code-of-conduct/>.

¹⁴⁰ King & Jessen, *supra* note 78, at 537.

¹⁴¹ Eleanor, *Privacy Risk Summit Preview: Privacy by Design for IoT*, TRUSTARC (May 23, 2016), <https://www.trustarc.com/blog/2016/05/23/privacy-risk-summit-preview-privacy-design-iot/>.

¹⁴² OFFICE OF GAS AND ELEC. MKT., SUPPLY LICENCE GUIDE: SMART METERING 2-6, https://www.ofgem.gov.uk/system/files/docs/2017/11/smart_metering.pdf (last updated Nov. 16, 2017).

¹⁴³ SMART METERING IMPLEMENTATION PROGRAMME, *supra* note 135, at 11-15.

¹⁴⁴ Wright, *supra* note 125, at 13.

¹⁴⁵ Joined Cases C-293/12C-594/12 *Digital Rights Ireland Ltd v Minister for Communications, Marine and Natural Resources*, 2014 E.C.R. 775.

¹⁴⁶ See generally Council Directive 2006/24/EC, 2006 O.J. (L 105/54).

¹⁴⁷ Charter of Fundamental Rights of the European Union: 2012 O.J. (C326) 391, title II, art. 7.

¹⁴⁸ *Id.* at title II, art. 8.

¹⁴⁹ King & Jessen, *supra* note 78, at 537.

¹⁵⁰ Charter of Fundamental Rights of the European Union: 2012 O.J. (C326) 391, Title VII, Article 52(1).

possible to balance installing P2P-ETPs with adequate consumer privacy; however, in the spirit of the EU's principle of proportionality, consumers should not be penalized with excessive opting-out fees in order to exercise their fundamental right to privacy.¹⁵¹

This ruling should be considered in the context of the United Kingdom's laws, as the United Kingdom is not exempt from complying with the provisions of the Charter of Human Rights.¹⁵² Further legislation is required to address privacy concerns surrounding data sharing and retention. In this context, smart contracts deal with the financial and energy trading aspects of P2P-ETPs, and therefore, will contain and hold consumers' data on the underlying blockchain. Hence, it is reasonable to apply the previous analysis of data retention to P2P-ETPs, as their function in this model facilitates the exchange of data. Therefore, consumers are protected by overarching principles within the EU for their right to privacy when trading energy and recording energy usage. However, these rights are also subject to general interest and potential future regulations for third-party commercial uses.

2. Security

The security of the infrastructure is vital to the trust consumers need to operate on a P2P based platform. As previously discussed, the security of P2P-ETPs is embedded in the strength of the DLT coding behind it. In the past, the lack of secure technology in smart meters has led to hacking of consumer devices. These attacks have resulted in hackers controlling their billing, tracking their electronics, and even causing fires¹⁵³ and explosions.¹⁵⁴ Once a hacker gains access to the meter and the software, the consequences can be dire. In 2013, a town of nearly 40,000 consumers in the south of Germany almost lost all power, water, and gas.¹⁵⁵ This situation was a test of the system's security but highlighted a gap in the encryption protection for retail market devices. A report from the University of Cambridge stated that smart meters raised certain serious security issues.¹⁵⁶ These issues included fraud through manipulated meter readings, threats of power outages through cyber-attacks, and other misuses of private customer data.¹⁵⁷ A cyber-attack that can shut down a household's access to heat can be detrimental during winter in the United Kingdom.

¹⁵¹ King & Jessen, *supra* note 78, at 537.

¹⁵² 2012 O.J. (C-411/10 & C-493/10).

¹⁵³ *SaskPower To Remove 105,000 Smart Meters Following Fires*, CBC NEWS (July 30, 2014, 2:53 PM), <https://www.cbc.ca/news/canada/saskatchewan/saskpower-to-remove-105-000-smart-meters-following-fires-1.2723046>.

¹⁵⁴ Alex Hern, *Smart Electricity Meters Can Be Dangerously Insecure, Warns Expert*, THE GUARDIAN (Dec. 29, 2016), <https://www.theguardian.com/technology/2016/dec/29/smart-electricity-meters-dangerously-insecure-hackers>.

¹⁵⁵ Christoph Steitz & Harro Ten Wolde, *'Smart' Technology Could Make Utilities More Vulnerable To Hackers*, REUTERS (July 15, 2014, 8:35 PM), <https://www.reuters.com/article/us-utilities-cybersecurity/smart-technology-could-make-utilities-more-vulnerable-to-hackers-idUSKBN0FK1SZ20140716>.

¹⁵⁶ Aoife Haney et al., *Smart Metering And Electricity Demand: Technology, Economics And International Experience* 1, 27-28, 64 (U. of Cambridge, Energy Policy Research Group Working Paper No. 0903, 2009), <https://www.eprg.group.cam.ac.uk/wp-content/uploads/2014/01/binder2.pdf>.

¹⁵⁷ Steitz, *supra* note 155.

The Office for National Statistics reported 50,100 excess deaths¹⁵⁸ in England and Wales in 2017-2018 due to weak health and freezing temperatures.¹⁵⁹ Therefore, the issue with cyber security is more than merely privacy and encompasses consumer safety.

P2P-ETP systems carry a greater guarantee of security because of the nature of DLT underpinning them. The data involved in energy trading can be used to track individual movements and the time spent in their households. Therefore, it is possible for this data to be considered useful by police in criminal or civil cases in verifying individual locations and activities. This information might require search warrants in the same vein for personal cellular devices. Data ownership and its use in policing were demonstrated in *Business Energy Solutions Ltd and others v. Crown Court at Preston*,¹⁶⁰ where it was found that data can be covered under the scope of search warrants, and within reasonable practicality of the case's context, the data can be copied, and the copies kept.¹⁶¹ This is typically applicable to corporate and commercial civil cases where data from a business is a source within an investigation. A more reasonable approach of the law for consumers is necessary if comparing data on P2P-ETP smart meters to those on an individual's cellular device. In this scenario, the data would be regarded with the same privacy considerations. While the United Kingdom does not have specific legislation requiring a warrant for such data searches, current legislation states that it would only occur if there were reasonable grounds.¹⁶² Therefore, the P2P-ETP systems do not fall outside the applicable legislation for security and privacy surrounding data. Furthermore, an energy consumer can lose the access key to the system. In such situations, fail-safe measures should be in place to accommodate consumers in the same way that individuals retrieve lost bank details. Some institutions employ verification via secure, encrypted text messages, or email verifications. Because P2P-ETPs are digitally based, this is the most reliable system of key or password retrieval.

IV. RECOMMENDATIONS

A. Standardization and Certification

One possible recommendation to ensure a stable P2P-ETP network would be a collective consortium of those consuming energy, known as consumers, and those consuming while also producing energy, known as prosumers. The P2P-ETP facilitates

¹⁵⁸ Melissa Bennett, *Excess Winter Mortality In England And Wales: 2017 To 2018 (Provisional) And 2016 To 2017 (Final)*, ONS (Nov. 30, 2018), <https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/bulletins/excesswintermortalityinenglandandwales/2017to2018provisionaland2016to2017final>.

¹⁵⁹ Denis Campbell, *Excess Winter Deaths In England And Wales Highest Since 1976*, THE GUARDIAN (Nov. 30, 2018), <https://www.theguardian.com/society/2018/nov/30/excess-winter-deaths-in-england-and-wales-highest-since-1976>.

¹⁶⁰ *Business Energy Solutions Ltd and others v. Crown Court at Preston*, [2018] All ER (D) (Jun) [2018] EWHC 1534 (Admin).

¹⁶¹ Criminal Justice and Police Act, c. 16, § 53 (2001) (Eng.).

¹⁶² Police and Criminal Evidence Act, c. 60, § 25 (1984) (Eng.).

contracts among consumers, prosumers, and the central operator. Therefore, consumers can form trading coalitions to fulfil a more trustworthy system. Coalition forming is envisaged as being highly automated, undertaken by P2P-ETP users based on preferences and information from connected consumers.¹⁶³ Several mechanisms for forming trading coalitions are possible, including bilateral contract networks.¹⁶⁴ One option for standardization is to have a set range during periods of peak demands.¹⁶⁵ For example, establishing a set price during the evenings where a majority of users would be in their households after work. A ceiling and floor cap should be implemented to deter pricing out more vulnerable consumers. This ensures the protection of the P2P-ETP market against price discrimination or manipulation. With multiple consumers and households on one P2P-ETP, trading between parties would be held in a controlled and certified environment.

As discussed earlier, smart meters are replacing traditional energy meters in households across the United Kingdom. These meters serve as certified nodes on the P2P-ETP's DLT and serve as a physical transmitter for this information. As smart meters are already being encouraged and rolled out across the United Kingdom and the European Union, they are affecting consumer confidence and interest in reviewing energy consumption.¹⁶⁶ Smart technologies on P2P-ETP create a trustworthy arrangement for consumers to track and monitor their energy consumption for billing and carbon emissions. Therefore, proper standardization, regulation, and certification are the first necessities to increase consumer trust in P2P-ETPs. Another possible regulatory initiative would be for the P2P-ETP controller to invest in specific safeguards for their liabilities to the consumers operating on the system itself. In the event of a system failure or error, the controller can produce and send energy to affected households as a backup system. The controller can also establish warranty clauses in traditional contracts to ensure that consumers are aware of each individual step possible for compensation.

Finally, the controller can ensure the functioning capabilities of the technology behind the P2P-ETP system by enlisting certified coders. A regulatory body can oversee the certification of smart contracts and blockchain developers to ensure a standardized level of training and ability before implementation. These examples encourage greater consumer trust, which is vital to the success of implementing P2P-ETPs.

B. Trust System

Consumer trust in P2P-ETPs relies on the social collective's confidence in smart technology. To increase consumer trust, the European Consumer Organisation¹⁶⁷ recommended the creation of transparent mechanisms to track the delivery of

¹⁶³ Woongsup Lee et al., *Direct Electricity Trading In Smart Grid: A Coalitional Game Analysis*, 32 IEEE 1389, 1389 (2014).

¹⁶⁴ *Id.* at 1402.

¹⁶⁵ *Id.* at 1403.

¹⁶⁶ Haney et al., *supra* note 156, at 18.

¹⁶⁷ *Ensuring Consumer Protection in the Platform Economy - Position Paper*, BEUC (Feb. 10, 2010), https://www.beuc.eu/publications/beuc-x-2018-080_ensuring_consumer_protection_in_the_platform_economy.pdf.

renewable energy.¹⁶⁸ Following the recommendations of a standardized consortium of P2P-ETP traders in the prior section, P2P-ETPs have four critical roles in facilitating energy transactions: to help consumers identify complementary preferences of energy utilization, establish prices for transactions, instill a mechanism for accountability through smart contract automation, and provide legally binding contract clauses for coordinating services to execute transactions.

P2P-ETPs are leading various economic and social shifts towards greater decentralized energy systems. Smart contracts, once appropriately coded, should be compatible with the United Kingdom and the European Union's contract laws. While specific energy legislation would depend heavily on the design and construction of P2P-ETP networks, private DLT and blockchain-based smart contracts should be designed to comply with the existing legal structures aimed at protecting consumers.

V. CONCLUSION

This paper discusses the potential benefits and shortcomings of implementing P2P-ETPs for energy trading in the interest of consumer protection, specifically for the United Kingdom. The P2P-ETP ecosystem would allow new market models to emerge for self-sustained energy trading. P2P-ETPs can facilitate energy trading for renewables, while tracking duration and location of energy production, energy storage, and consumption. 'Green Tariffs'¹⁶⁹ have been introduced in the European Union and the United States for retail supply contracts to certify the percentage of renewable sources for consumer interest. This benefit would translate into greater consumer responsibility toward energy consumption and lower carbon emissions by promoting renewable energy use.

However, consumers would be taking on potential risks: including the legal uncertainty surrounding smart contracts, potential violations of privacy rights and data protection, price manipulation, and system failure due to coding deficiencies in smart contracts. It is submitted that smart contracts alone cannot be legally binding and a hybrid system including a traditional contract should continue to be used to mitigate the risk of legal uncertainty. Trust and cooperative groups serve as links between consumers through smart contracts and communication via P2P devices such as smart meters. As technology progresses, the law must adapt. With adequate legislation and coordination, P2P-ETPs can open the gates for consumers to produce, consume, and share (through trading) energy with greater knowledge, accountability, awareness, and protection than the traditionally established energy market arrangement.

While the P2P-ETP system is still in its early stages, stability is essential for smaller-scale community projects, such as the Brooklyn Energy Trading Project.¹⁷⁰ It is suggested that, to maintain consumer trust, these smaller-scale projects should be operated and maintained by an independent body through public funding or yearly consumer payments.

¹⁶⁸ *Id.*

¹⁶⁹ Leila Dagher et al., *Residential Green Power Demand In The United States*, 114 RENEWABLE ENERGY 1062, 1070 (2017).

¹⁷⁰ *Home*, BROOKLYN MICROGRID, <https://www.brooklyn.energy/> (last visited June 29, 2019).