US012387151B2

(12) United States Patent
Menon et al.

(10) Patent No.: US 12,387,151 B2
(45) Date of Patent: Aug. 12, 2025

(54) **PREDICTING SUSTAINABILITY ACTION PLAN PERFORMANCE OVER TIME**

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(73) Assignee: **Schlumberger Technology Corporation**, Sugar Land, TX (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(21) Appl. No.: **18/733,951**

(22) Filed: **Jun. 5, 2024**

(65) **Prior Publication Data**

US 2024/0403778 A1 Dec. 5, 2024

Related U.S. Application Data

(60) Provisional application No. 63/471,174, filed on Jun. 5, 2023.

(51) **Int. Cl.**
G06Q 10/06 (2023.01)
G06Q 10/063 (2023.01)
(Continued)

(52) **U.S. Cl.**
CPC ***G06Q 10/063*** (2013.01); ***G06Q 10/06315*** (2013.01); ***G06Q 10/0633*** (2013.01);
(Continued)

(58) **Field of Classification Search**
CPC G06Q 10/06
See application file for complete search history.

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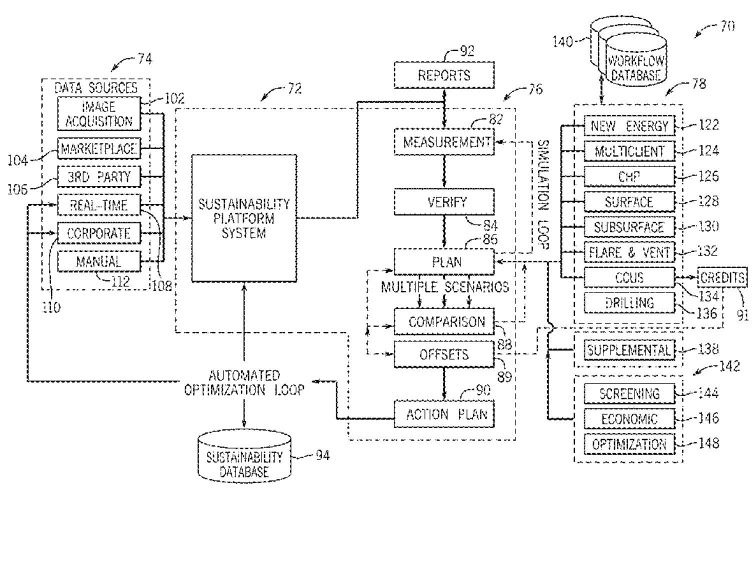
Primary Examiner — Kurtis Gills
(74) *Attorney, Agent, or Firm* — Michael Guthrie

(57) **ABSTRACT**

An enterprise system may include one or more devices with sensors that measure operational parameters of the devices. The enterprise system may also include a sustainability platform system that obtains a sustainability model representative of a state of operations of the enterprise based on the measured operational parameters and receives sustainability target data that includes one or more threshold limits, one or more ranges, or both for one or more sustainability parameters. The sustainability platform system may also obtain one or more action plans for adjusting respective operations of the devices based on the sustainability model
(Continued)



and the sustainability target data, simulate a performance of the action plans over a period of time relative to the sustainability parameters, and determine whether the simulated performance of the action plans is effective.

20 Claims, 12 Drawing Sheets

(51) **Int. Cl.**

G06Q 10/0631	(2023.01)
G06Q 10/0633	(2023.01)
G06Q 10/0637	(2023.01)
G06Q 10/0639	(2023.01)
G06Q 10/067	(2023.01)
G06Q 50/02	(2012.01)

(52) **U.S. Cl.**

CPC ***G06Q 10/0637*** (2013.01); ***G06Q 10/0639*** (2013.01); ***G06Q 10/067*** (2013.01); ***G06Q 50/02*** (2013.01)

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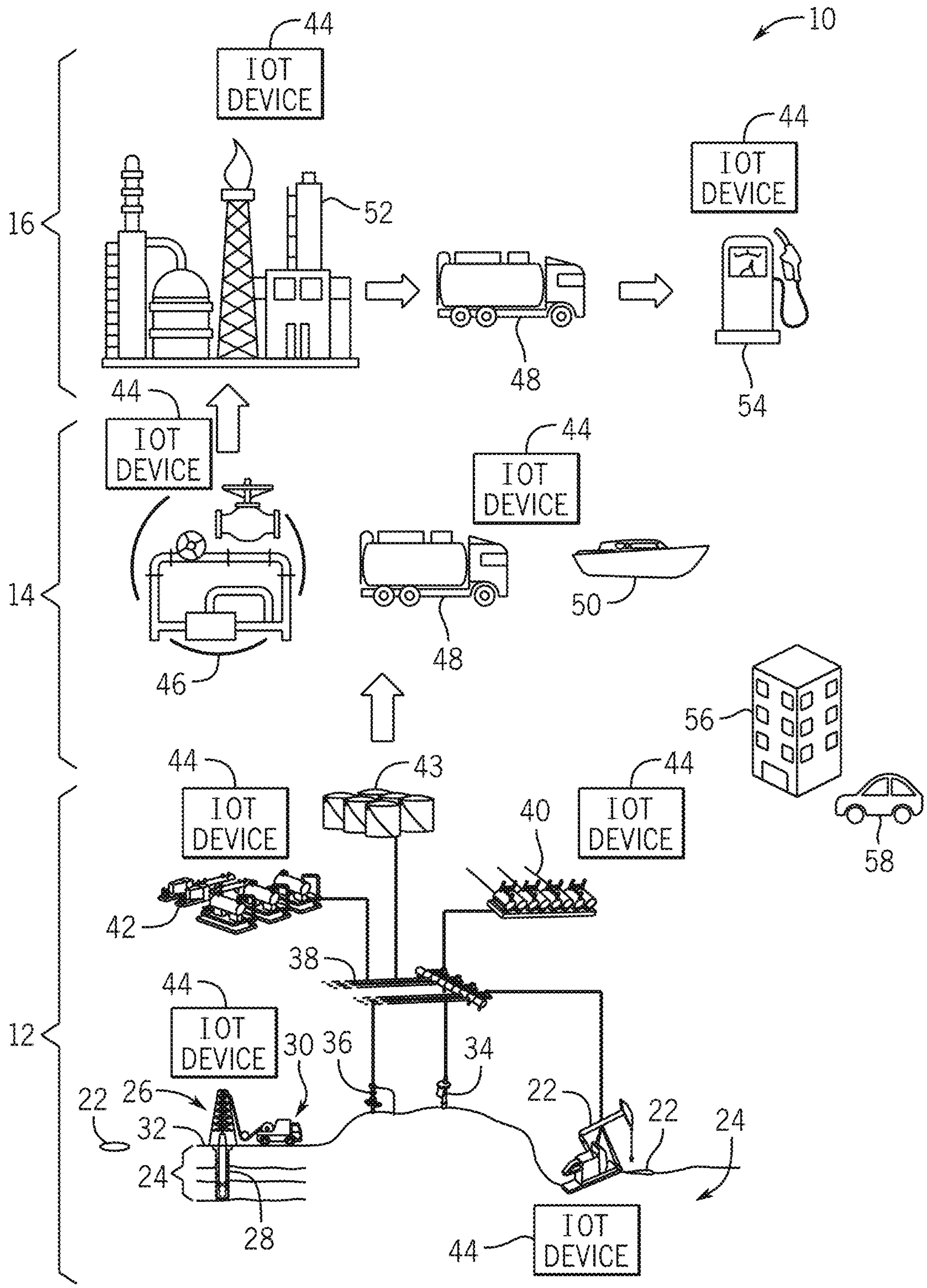
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44
IOT DEVICE
52
16
48
54
14
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FIG. 1

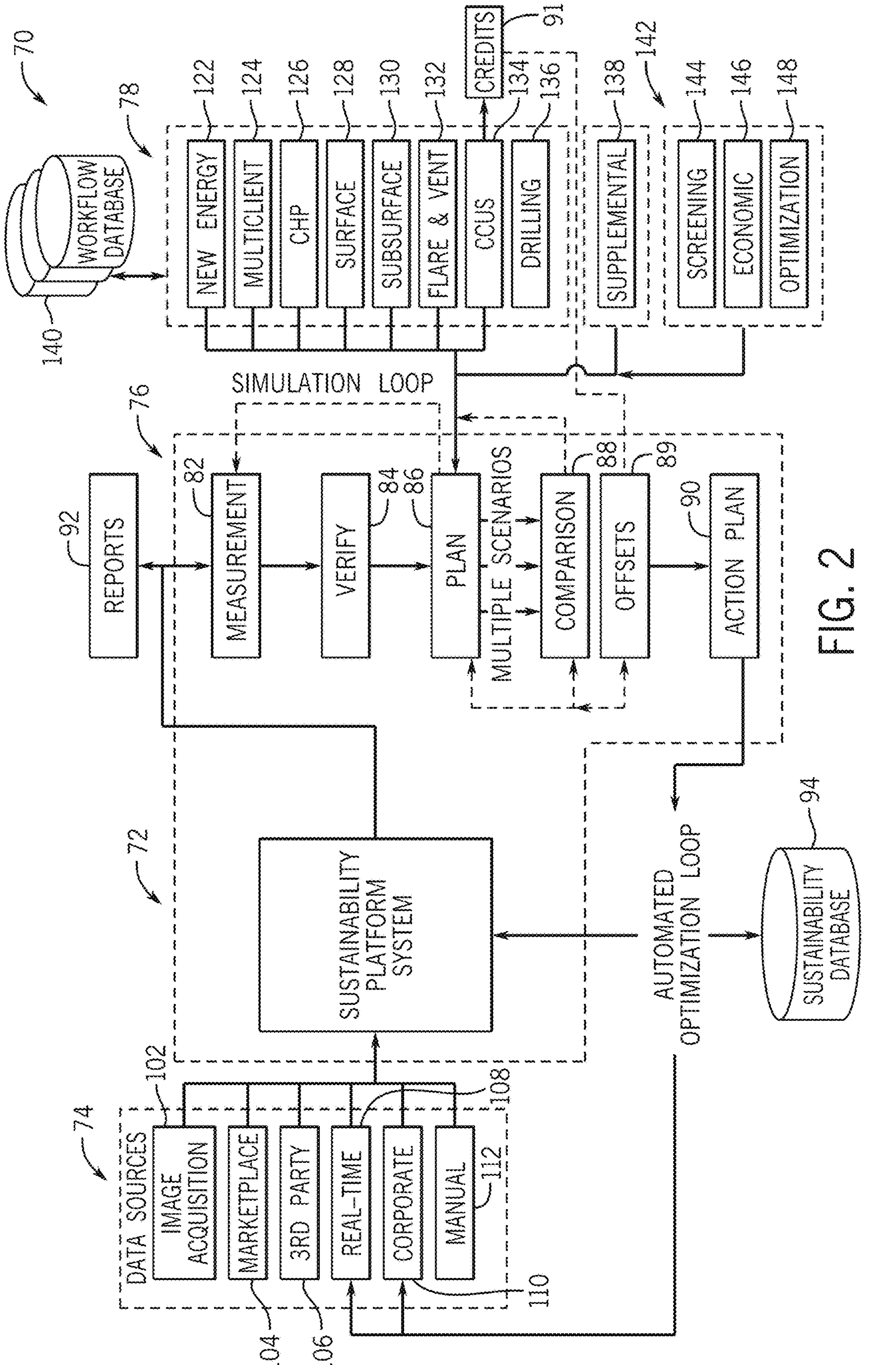

70
WORKFLOW DATABASE
140
78
NEW ENERGY
MULTICLIENT
CHP
SURFACE
SUBSURFACE
FLARE & VENT
CCUS
DRILLING
122
124
126
128
130
132
134
136
CREDITS
91
SUPPLEMENTAL
138
142
SCREENING
ECONOMIC
OPTIMIZATION
144
146
148
SIMULATION LOOP
76
REPORTS
92
MEASUREMENT
82
VERIFY
84
PLAN
86
MULTIPLE SCENARIOS
COMPARISON
88
OFFSETS
89
ACTION PLAN
90
72
SUSTAINABILITY PLATFORM SYSTEM
AUTOMATED OPTIMIZATION LOOP
SUSTAINABILITY DATABASE
94
74
DATA SOURCES
IMAGE ACQUISITION
MARKETPLACE
3RD PARTY
REAL-TIME
CORPORATE
MANUAL
102
104
106
108
110
112

FIG. 2

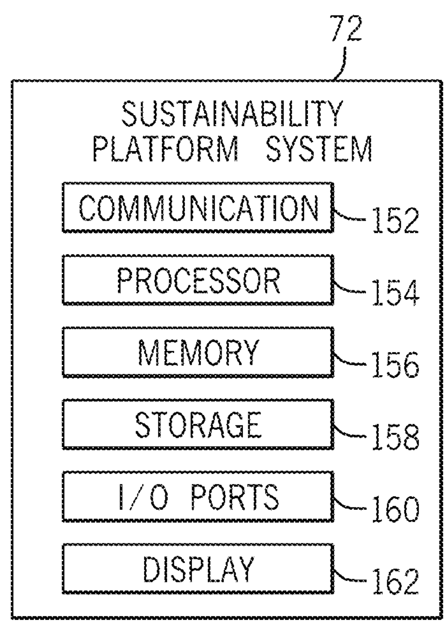
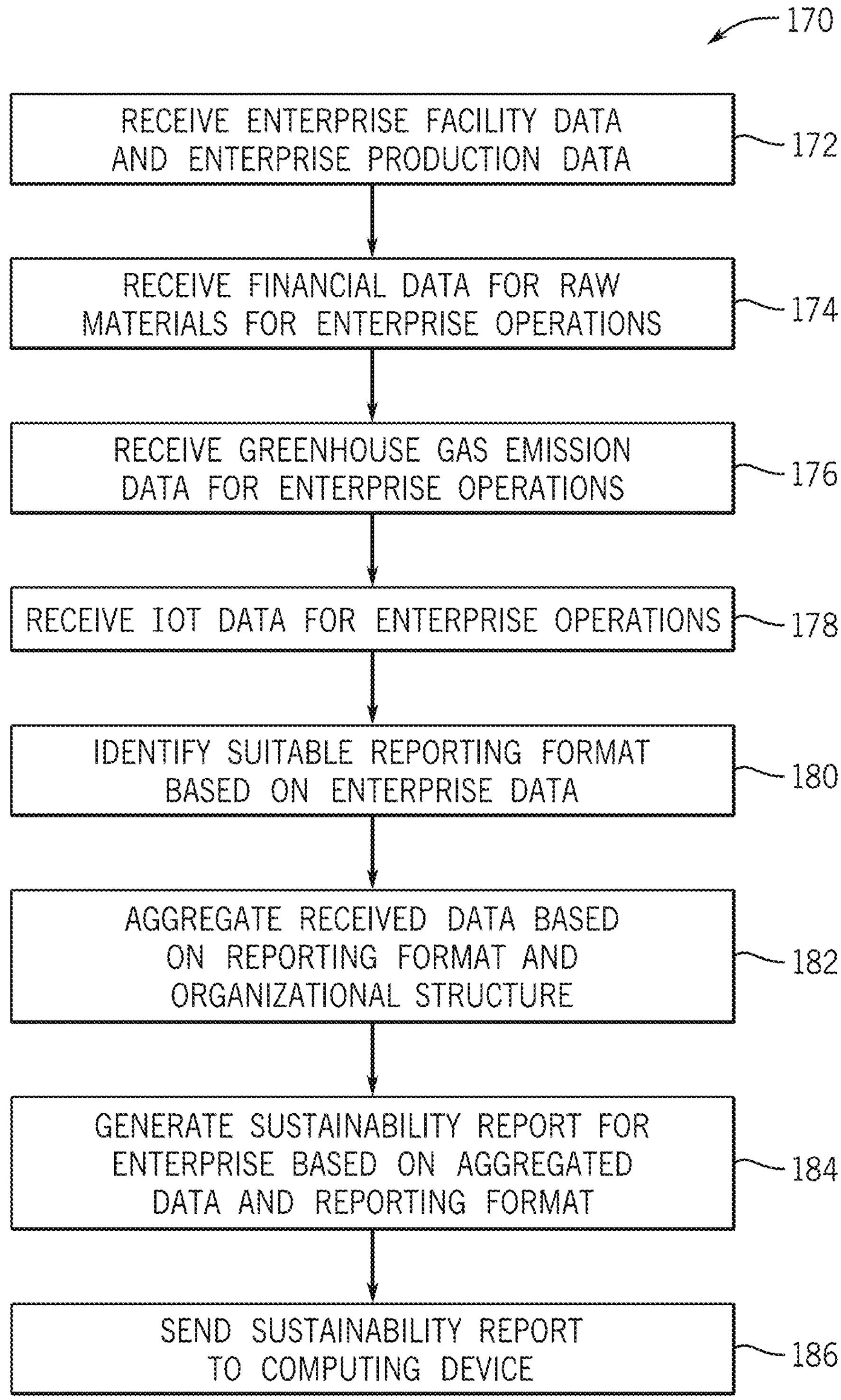

72
SUSTAINABILITY PLATFORM SYSTEM
COMMUNICATION
152
PROCESSOR
154
MEMORY
156
STORAGE
158
I/O PORTS
160
DISPLAY
162

FIG. 3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RECEIVE ENTERPRISE FACILITY DATA AND ENTERPRISE PRODUCTION DATA
172
RECEIVE FINANCIAL DATA FOR RAW MATERIALS FOR ENTERPRISE OPERATIONS
174
RECEIVE GREENHOUSE GAS EMISSION DATA FOR ENTERPRISE OPERATIONS
176
RECEIVE IOT DATA FOR ENTERPRISE OPERATIONS
178
IDENTIFY SUITABLE REPORTING FORMAT BASED ON ENTERPRISE DATA
180
AGGREGATE RECEIVED DATA BASED ON REPORTING FORMAT AND ORGANIZATIONAL STRUCTURE
182
GENERATE SUSTAINABILITY REPORT FOR ENTERPRISE BASED ON AGGREGATED DATA AND REPORTING FORMAT
184
SEND SUSTAINABILITY REPORT TO COMPUTING DEVICE
186

FIG. 4

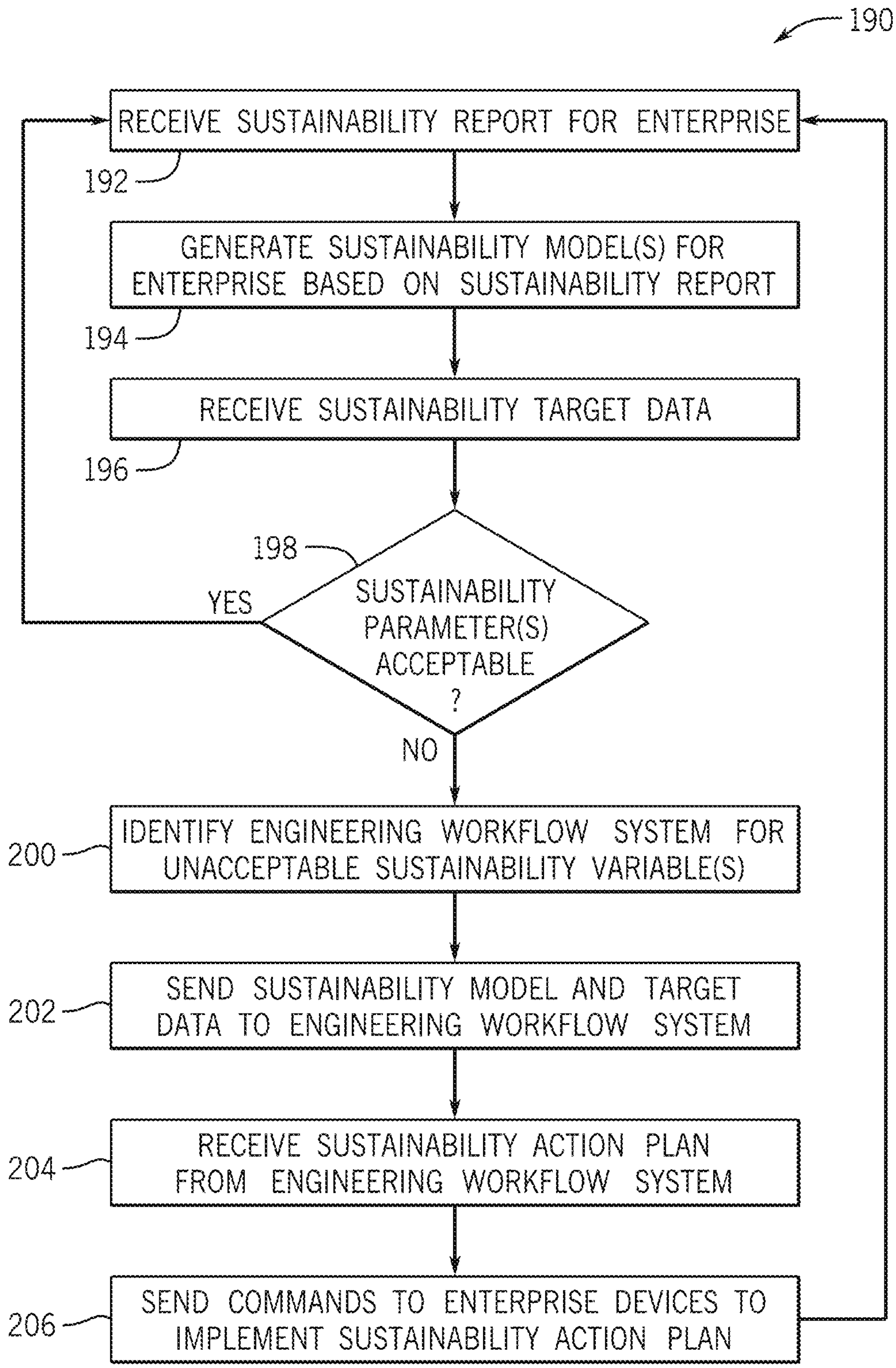
190
RECEIVE SUSTAINABILITY REPORT FOR ENTERPRISE
192
GENERATE SUSTAINABILITY MODEL(S) FOR ENTERPRISE BASED ON SUSTAINABILITY REPORT
194
RECEIVE SUSTAINABILITY TARGET DATA
196
198
SUSTAINABILITY PARAMETER(S) ACCEPTABLE ?
YES
NO
200
IDENTIFY ENGINEERING WORKFLOW SYSTEM FOR UNACCEPTABLE SUSTAINABILITY VARIABLE(S)
202
SEND SUSTAINABILITY MODEL AND TARGET DATA TO ENGINEERING WORKFLOW SYSTEM
204
RECEIVE SUSTAINABILITY ACTION PLAN FROM ENGINEERING WORKFLOW SYSTEM
206
SEND COMMANDS TO ENTERPRISE DEVICES TO IMPLEMENT SUSTAINABILITY ACTION PLAN

FIG. 5

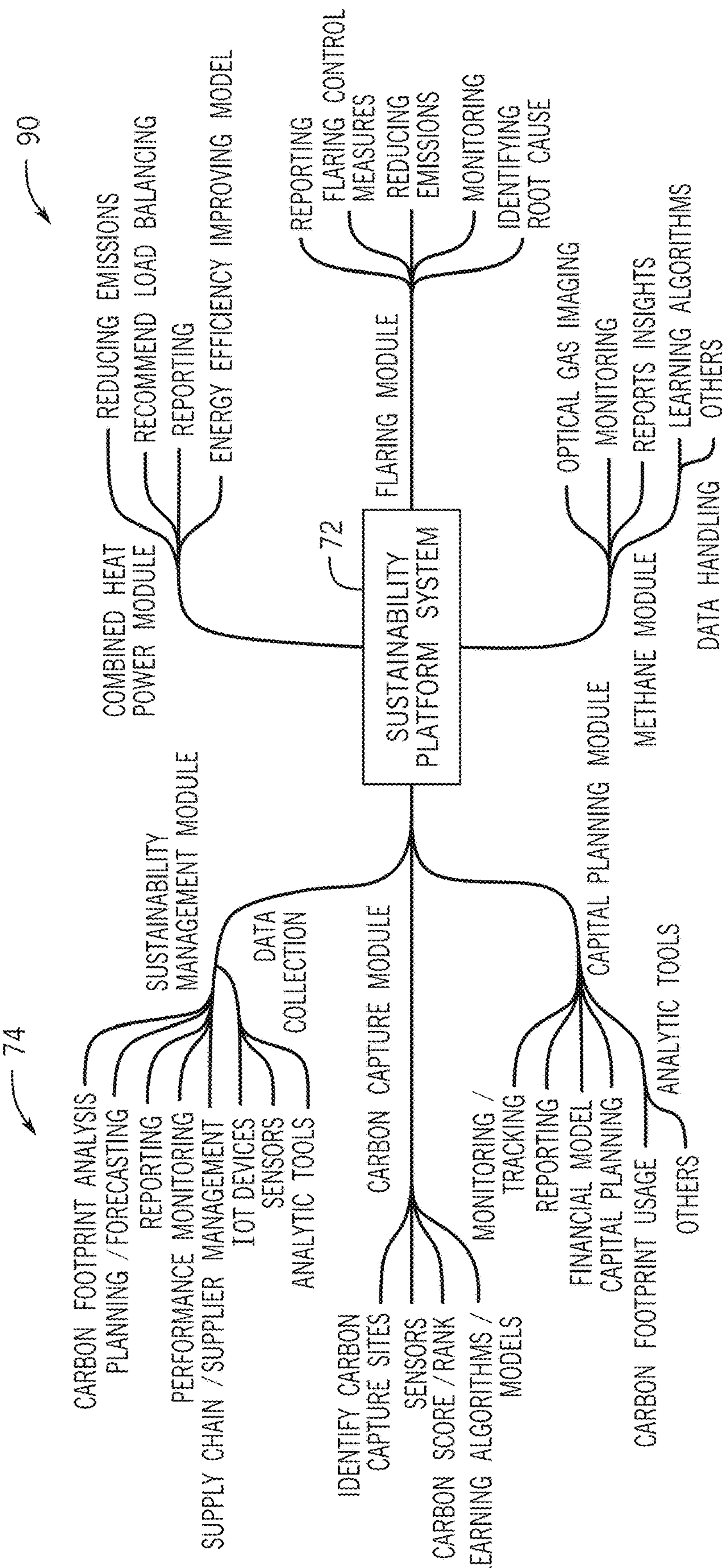
90
72
SUSTAINABILITY PLATFORM SYSTEM
COMBINED HEAT POWER MODULE
REDUCING EMISSIONS
RECOMMEND LOAD BALANCING
REPORTING
ENERGY EFFICIENCY IMPROVING MODEL
FLARING MODULE
REPORTING
FLARING CONTROL MEASURES
REDUCING EMISSIONS
MONITORING
IDENTIFYING ROOT CAUSE
METHANE MODULE
OPTICAL GAS IMAGING
MONITORING
REPORTS INSIGHTS
LEARNING ALGORITHMS
OTHERS
DATA HANDLING
74
SUSTAINABILITY MANAGEMENT MODULE
DATA COLLECTION
CARBON FOOTPRINT ANALYSIS
PLANNING / FORECASTING
REPORTING
PERFORMANCE MONITORING
SUPPLY CHAIN / SUPPLIER MANAGEMENT
IOT DEVICES
SENSORS
ANALYTIC TOOLS
CARBON CAPTURE MODULE
IDENTIFY CARBON CAPTURE SITES
SENSORS
CARBON SCORE / RANK
LEARNING ALGORITHMS / MODELS
CAPITAL PLANNING MODULE
ANALYTIC TOOLS
MONITORING / TRACKING
REPORTING
FINANCIAL MODEL
CAPITAL PLANNING
CARBON FOOTPRINT USAGE
OTHERS

FIG. 6

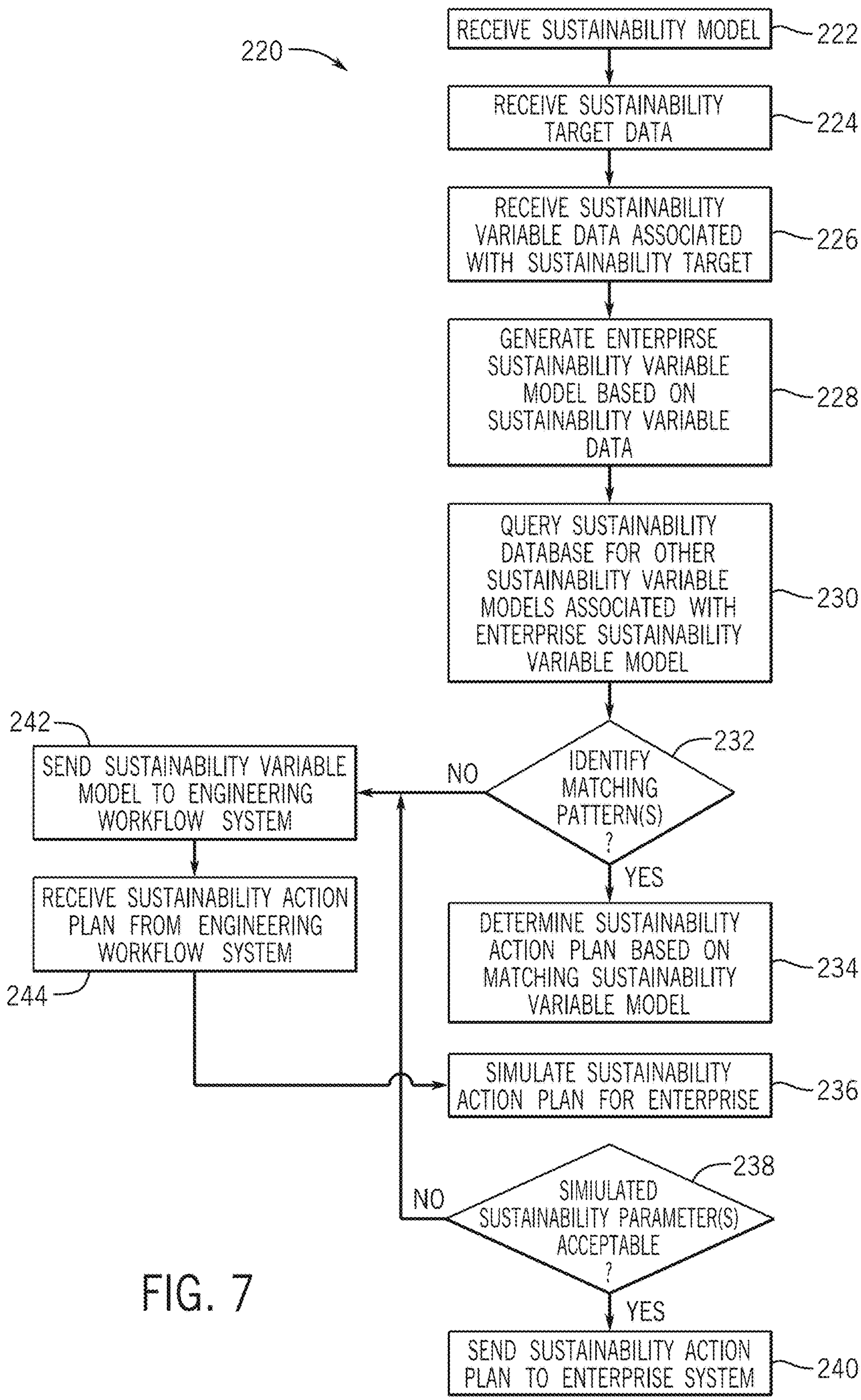
220
RECEIVE SUSTAINABILITY MODEL
222
RECEIVE SUSTAINABILITY TARGET DATA
224
RECEIVE SUSTAINABILITY VARIABLE DATA ASSOCIATED WITH SUSTAINABILITY TARGET
226
GENERATE ENTERPIRSE SUSTAINABILITY VARIABLE MODEL BASED ON SUSTAINABILITY VARIABLE DATA
228
QUERY SUSTAINABILITY DATABASE FOR OTHER SUSTAINABILITY VARIABLE MODELS ASSOCIATED WITH ENTERPRISE SUSTAINABILITY VARIABLE MODEL
230
IDENTIFY MATCHING PATTERN(S) ?
232
NO
YES
SEND SUSTAINABILITY VARIABLE MODEL TO ENGINEERING WORKFLOW SYSTEM
242
RECEIVE SUSTAINABILITY ACTION PLAN FROM ENGINEERING WORKFLOW SYSTEM
244
DETERMINE SUSTAINABILITY ACTION PLAN BASED ON MATCHING SUSTAINABILITY VARIABLE MODEL
234
SIMULATE SUSTAINABILITY ACTION PLAN FOR ENTERPRISE
236
SIMIULATED SUSTAINABILITY PARAMETER(S) ACCEPTABLE ?
238
NO
YES
SEND SUSTAINABILITY ACTION PLAN TO ENTERPRISE SYSTEM
240

FIG. 7

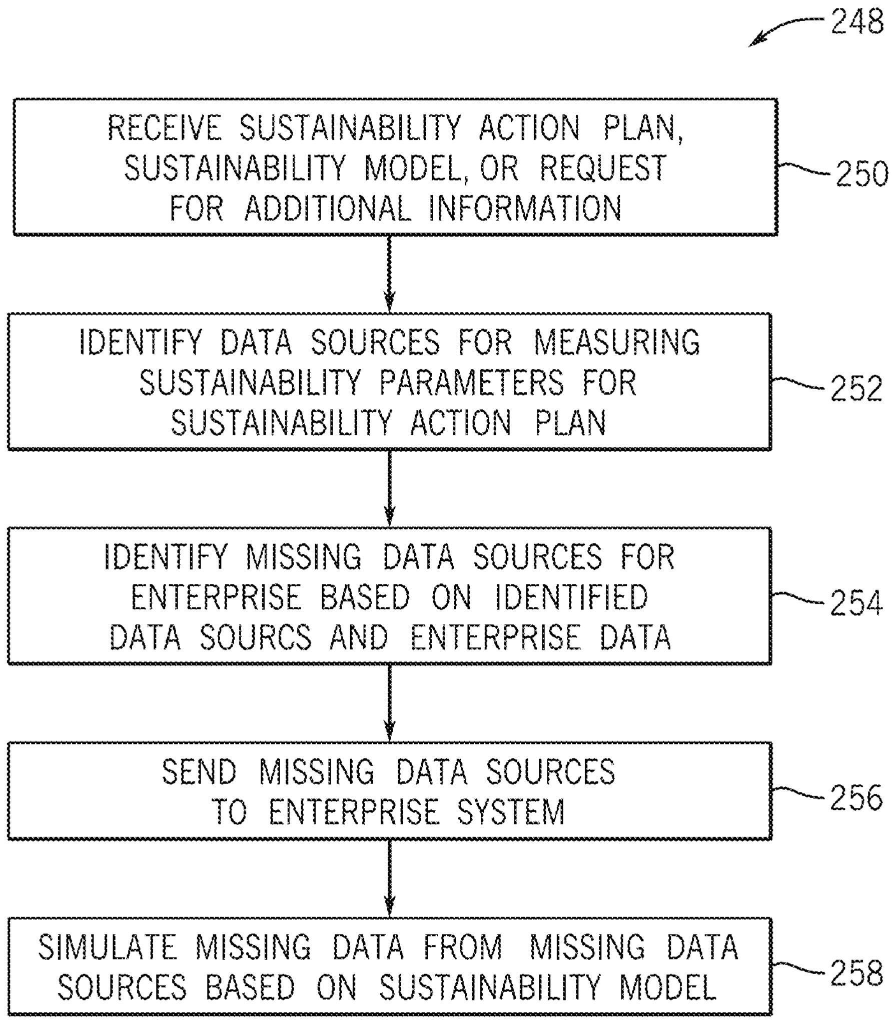
248
RECEIVE SUSTAINABILITY ACTION PLAN, SUSTAINABILITY MODEL, OR REQUEST FOR ADDITIONAL INFORMATION
250
IDENTIFY DATA SOURCES FOR MEASURING SUSTAINABILITY PARAMETERS FOR SUSTAINABILITY ACTION PLAN
252
IDENTIFY MISSING DATA SOURCES FOR ENTERPRISE BASED ON IDENTIFIED DATA SOURCS AND ENTERPRISE DATA
254
SEND MISSING DATA SOURCES TO ENTERPRISE SYSTEM
256
SIMULATE MISSING DATA FROM MISSING DATA SOURCES BASED ON SUSTAINABILITY MODEL
258

FIG. 8

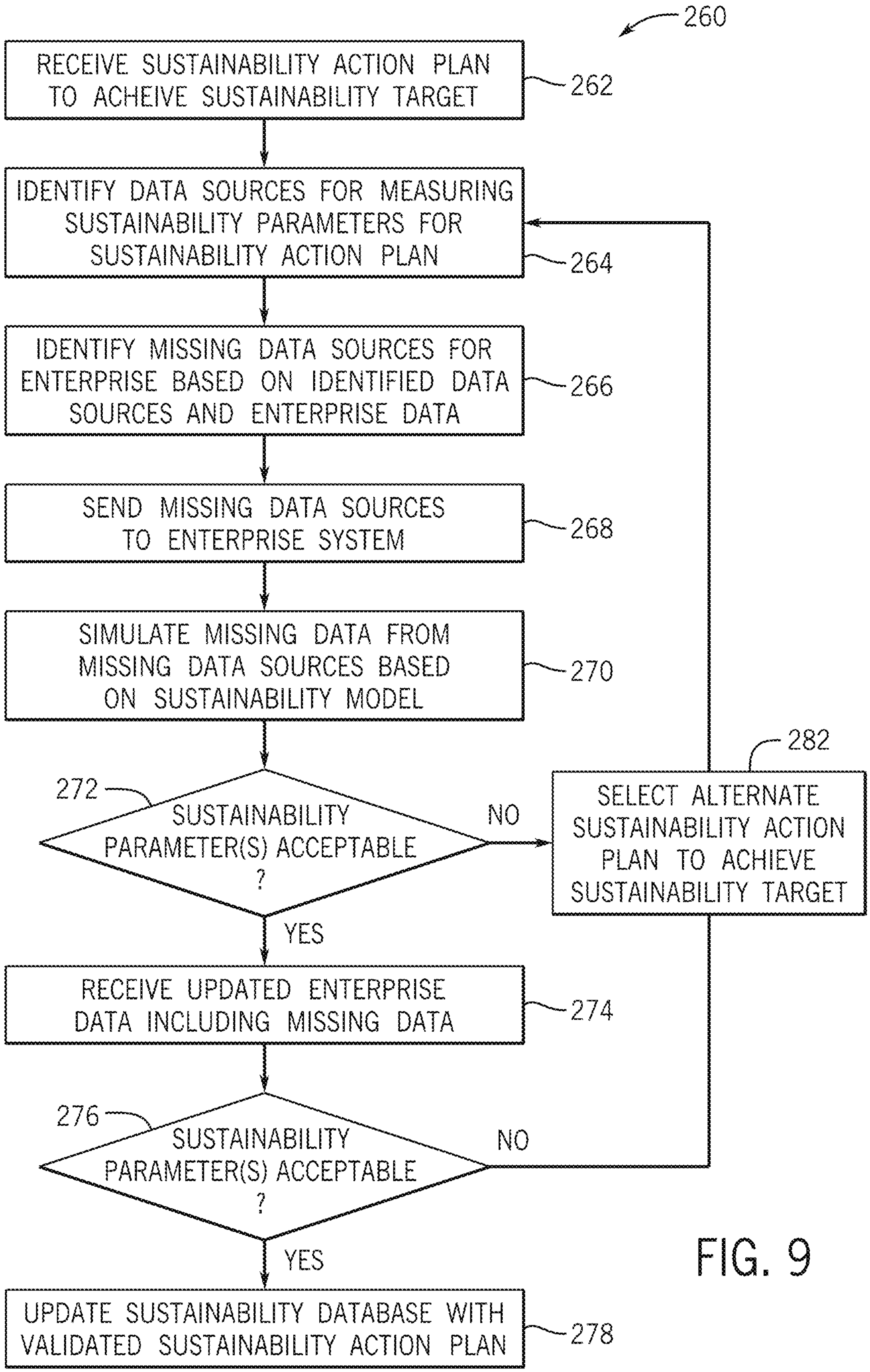
260
RECEIVE SUSTAINABILITY ACTION PLAN TO ACHEIVE SUSTAINABILITY TARGET
262
IDENTIFY DATA SOURCES FOR MEASURING SUSTAINABILITY PARAMETERS FOR SUSTAINABILITY ACTION PLAN
264
IDENTIFY MISSING DATA SOURCES FOR ENTERPRISE BASED ON IDENTIFIED DATA SOURCES AND ENTERPRISE DATA
266
SEND MISSING DATA SOURCES TO ENTERPRISE SYSTEM
268
SIMULATE MISSING DATA FROM MISSING DATA SOURCES BASED ON SUSTAINABILITY MODEL
270
272
SUSTAINABILITY PARAMETER(S) ACCEPTABLE ?
NO
YES
282
SELECT ALTERNATE SUSTAINABILITY ACTION PLAN TO ACHIEVE SUSTAINABILITY TARGET
RECEIVE UPDATED ENTERPRISE DATA INCLUDING MISSING DATA
274
276
SUSTAINABILITY PARAMETER(S) ACCEPTABLE ?
NO
YES
UPDATE SUSTAINABILITY DATABASE WITH VALIDATED SUSTAINABILITY ACTION PLAN
278

FIG. 9

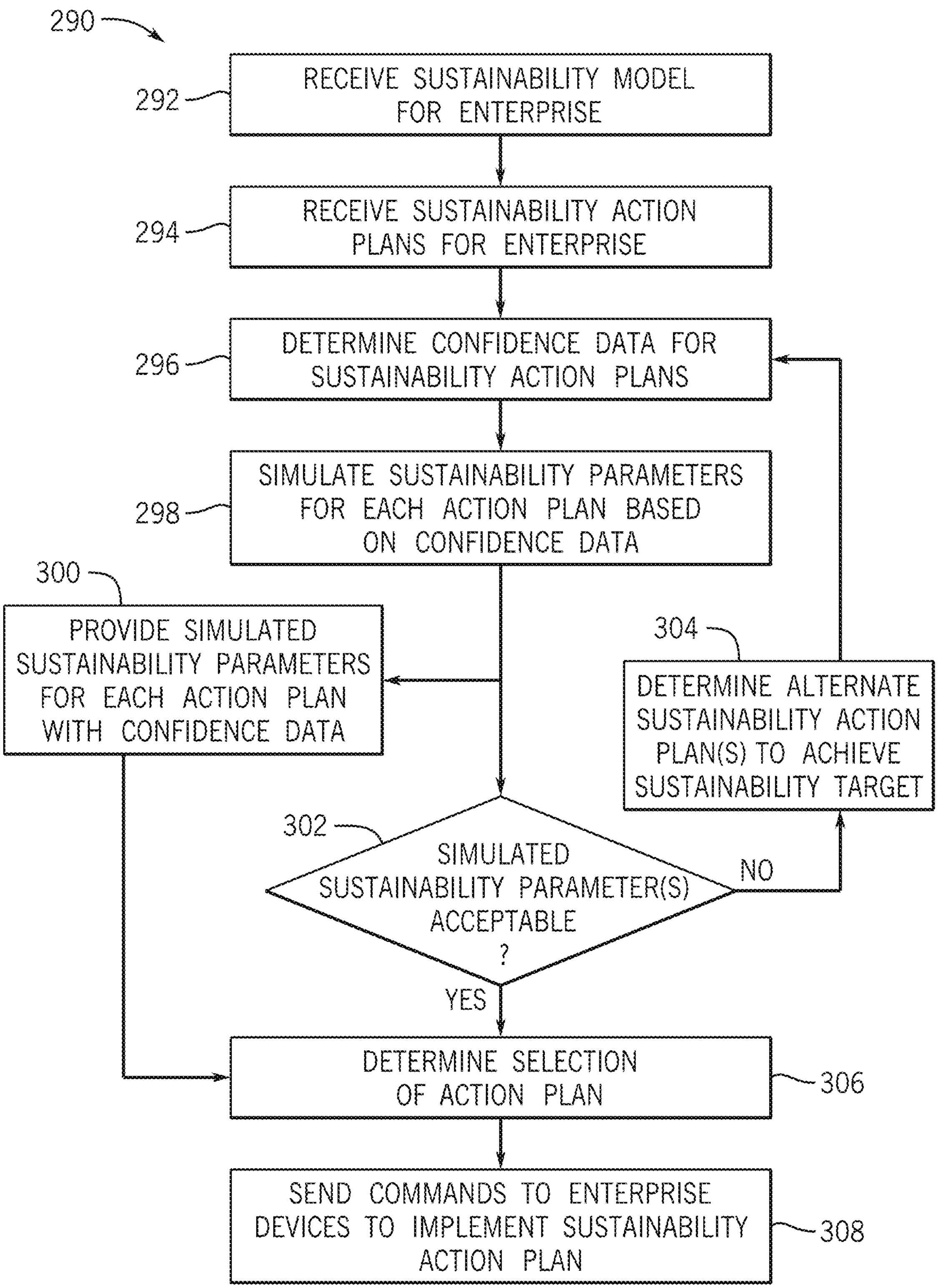
290
292
RECEIVE SUSTAINABILITY MODEL FOR ENTERPRISE
294
RECEIVE SUSTAINABILITY ACTION PLANS FOR ENTERPRISE
296
DETERMINE CONFIDENCE DATA FOR SUSTAINABILITY ACTION PLANS
298
SIMULATE SUSTAINABILITY PARAMETERS FOR EACH ACTION PLAN BASED ON CONFIDENCE DATA
300
PROVIDE SIMULATED SUSTAINABILITY PARAMETERS FOR EACH ACTION PLAN WITH CONFIDENCE DATA
304
DETERMINE ALTERNATE SUSTAINABILITY ACTION PLAN(S) TO ACHIEVE SUSTAINABILITY TARGET
302
SIMULATED SUSTAINABILITY PARAMETER(S) ACCEPTABLE ?
NO
YES
DETERMINE SELECTION OF ACTION PLAN
306
SEND COMMANDS TO ENTERPRISE DEVICES TO IMPLEMENT SUSTAINABILITY ACTION PLAN
308

FIG. 10

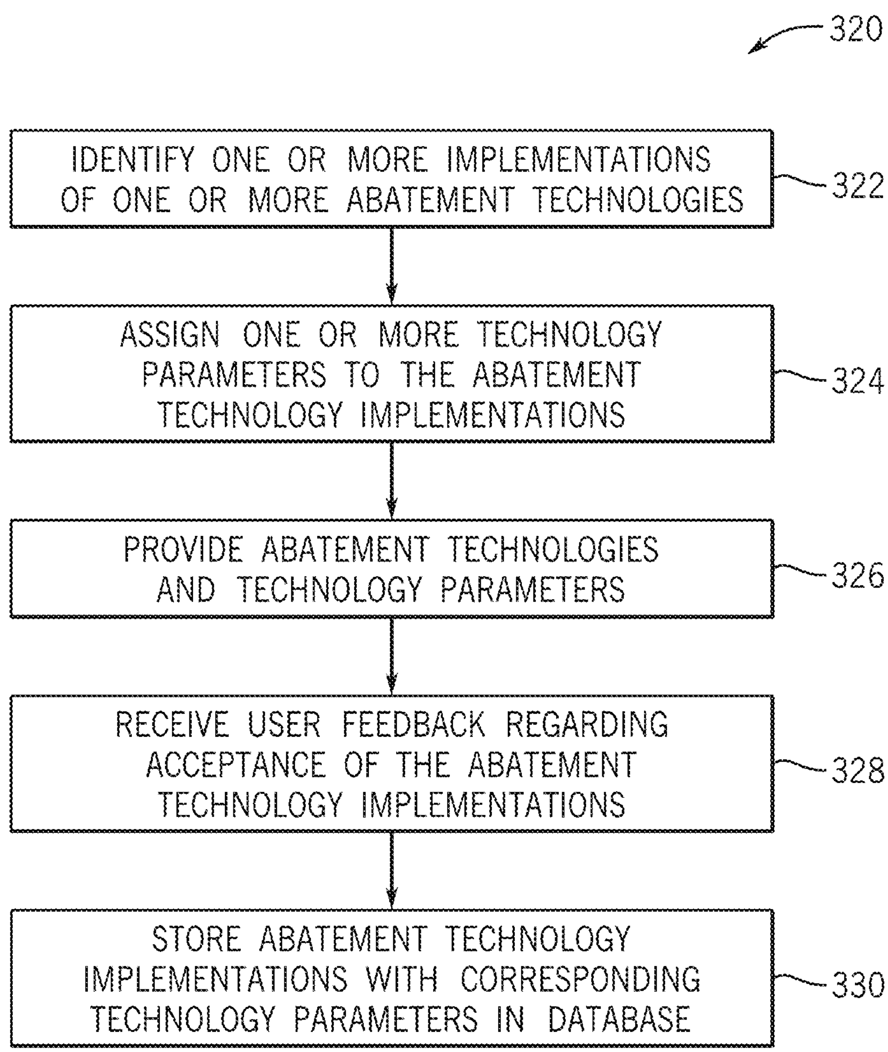
320
IDENTIFY ONE OR MORE IMPLEMENTATIONS OF ONE OR MORE ABATEMENT TECHNOLOGIES
322
ASSIGN ONE OR MORE TECHNOLOGY PARAMETERS TO THE ABATEMENT TECHNOLOGY IMPLEMENTATIONS
324
PROVIDE ABATEMENT TECHNOLOGIES AND TECHNOLOGY PARAMETERS
326
RECEIVE USER FEEDBACK REGARDING ACCEPTANCE OF THE ABATEMENT TECHNOLOGY IMPLEMENTATIONS
328
STORE ABATEMENT TECHNOLOGY IMPLEMENTATIONS WITH CORRESPONDING TECHNOLOGY PARAMETERS IN DATABASE
330

FIG. 11

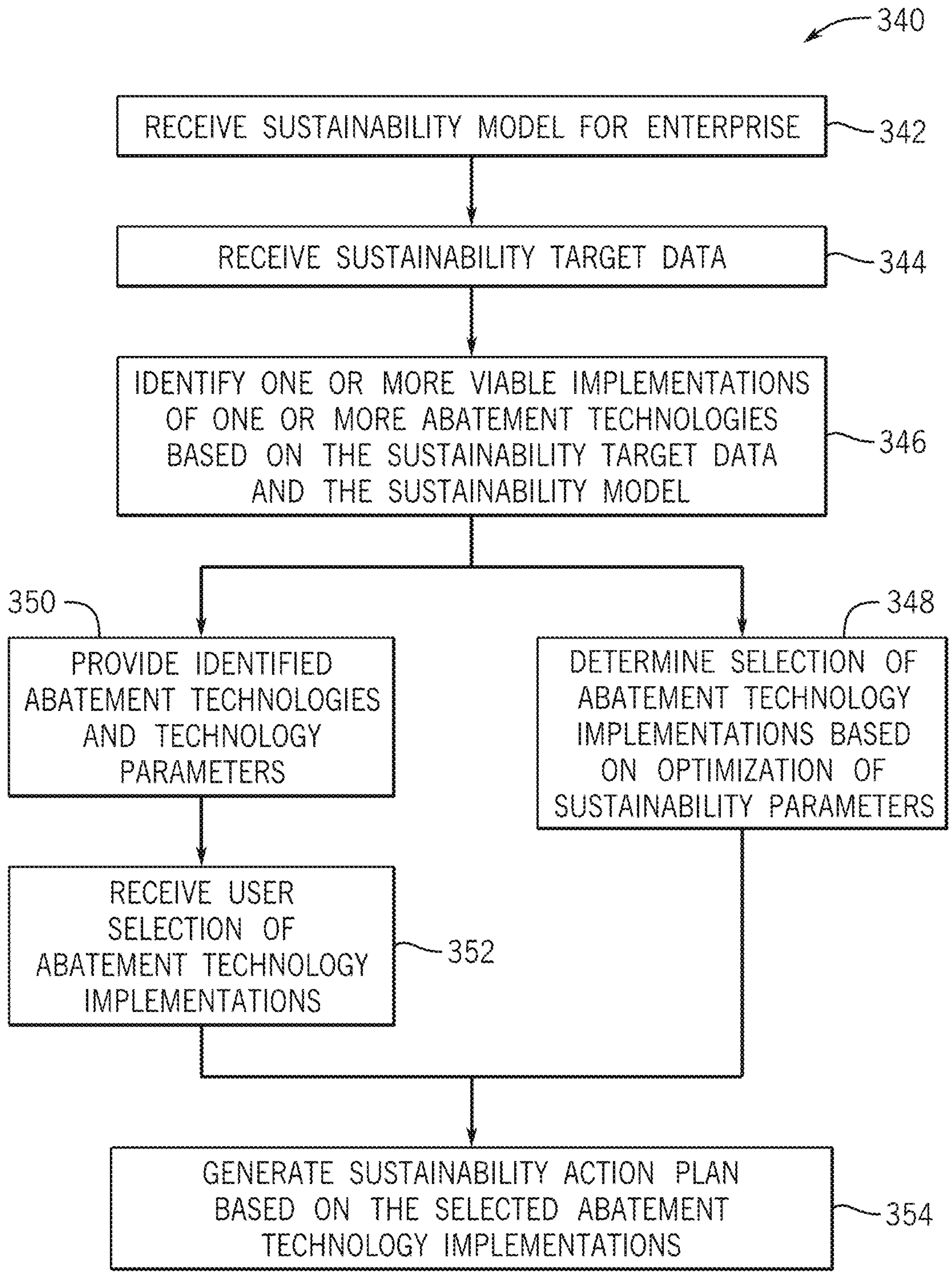
340
RECEIVE SUSTAINABILITY MODEL FOR ENTERPRISE
342
RECEIVE SUSTAINABILITY TARGET DATA
344
IDENTIFY ONE OR MORE VIABLE IMPLEMENTATIONS OF ONE OR MORE ABATEMENT TECHNOLOGIES BASED ON THE SUSTAINABILITY TARGET DATA AND THE SUSTAINABILITY MODEL
346
350
PROVIDE IDENTIFIED ABATEMENT TECHNOLOGIES AND TECHNOLOGY PARAMETERS
348
DETERMINE SELECTION OF ABATEMENT TECHNOLOGY IMPLEMENTATIONS BASED ON OPTIMIZATION OF SUSTAINABILITY PARAMETERS
RECEIVE USER SELECTION OF ABATEMENT TECHNOLOGY IMPLEMENTATIONS
352
GENERATE SUSTAINABILITY ACTION PLAN BASED ON THE SELECTED ABATEMENT TECHNOLOGY IMPLEMENTATIONS
354

FIG. 12

PREDICTING SUSTAINABILITY ACTION PLAN PERFORMANCE OVER TIME

CROSS-REFERENCE TO RELATED APPLICATIONS

This application claims priority to U.S. Provisional Application No. 63/471,174, filed Jun. 5, 2023, and entitled "SUSTAINABILITY PLATFORM FOR IMPROVING SUSTAINABILITY PARAMETERS ACROSS ENTERPRISE OPERATIONS," which is incorporated herein by reference.

Additionally, this application is related to U.S. Ser. No. 18/734,079 filed Jun. 5, 2025, entitled, "UPDATING SUSTAINABILITY ACTION PLANS FOR AN ENTERPRISE BASED ON DETECTED CHANGE IN INPUT DATA"; U.S. Ser. No. 18/734,238, filed Jun. 5, 2025, entitled, "OPTIMIZING SUSTAINABILITY PARAMETERS WITH ACTION PLANS FOR AN ENTERPRISE"; U.S. Ser. No. 18/733,939, filed Jun. 5, 2025, entitled, "MANAGING FACILITY AND PRODUCTION OPERATIONS ACROSS ENTERPRISE OPERATIONS TO ACHIEVE SUSTAINABILITY GOALS"; and U.S. Ser. No. 18/734,289, filed Jun. 5, 2025, entitled, "UPDATING SUSTAINABILITY ACTION PLANS BASED ON THIRD PARTY DATA," each of which is incorporated herein by reference.

BACKGROUND

This disclosure relates generally to providing plans, workflows, and recommendations for improving sustainability parameters across enterprise operations.

As hydrocarbons are extracted from hydrocarbon reservoirs via hydrocarbon wells in oil and/or gas fields, the extracted hydrocarbons may be transported to various types of equipment, tanks, processing facilities, and the like via transport vehicles, a network of pipelines, and the like. For example, the hydrocarbons may be extracted from the reservoirs via the hydrocarbon wells and may then be transported, via the network of pipelines, from the wells to various processing stations that may perform various phases of hydrocarbon processing to make the produced hydrocarbons available for use or transport.

The transported hydrocarbons may be processed or refined into suitable hydrocarbon products and ultimately distributed to end consumers. Overall, the hydrocarbon enterprise may be characterized as encompassing upstream, midstream, and downstream stages. At each of these stages, sustainability parameters such as energy, carbon, waste, water, and the like may be consumed or used. As enterprises move towards becoming more sustainable organizations, it may be challenging to track sustainability parameters while simultaneously identifying opportunities for improving sustainability parameters associated with the enterprise.

This section is intended to introduce the reader to various aspects of art that may be related to various aspects of the present techniques, which are described and/or claimed below. This discussion is believed to be helpful in providing the reader with background information to facilitate a better understanding of the various aspects of this disclosure. Accordingly, it should be understood that these statements are to be read in this light, and not as admissions of prior art.

SUMMARY

A summary of certain embodiments disclosed herein is set forth below. It should be understood that these aspects are presented merely to provide the reader with a brief summary of these certain embodiments and that these aspects are not intended to limit the scope of this disclosure. Indeed, this disclosure may encompass a variety of aspects that may not be set forth below.

In some embodiments, an enterprise system may include one or more devices with sensors that measure operational parameters of the devices. The enterprise system may also include a sustainability platform system that obtains a sustainability model representative of a state of operations of the enterprise based on the measured operational parameters and receives sustainability target data that includes one or more threshold limits, one or more ranges, or both for one or more sustainability parameters. The sustainability platform system may also obtain one or more action plans for adjusting respective operations of the devices based on the sustainability model and the sustainability target data, simulate a performance of the action plans over a period of time relative to the sustainability parameters, and determine whether the simulated performance of the action plans is effective.

Various refinements of the features noted above may be made in relation to various aspects of this disclosure. Further features may also be incorporated in these various aspects as well. These refinements and additional features may be made individually or in any combination. For instance, various features discussed below in relation to one or more of the illustrated embodiments may be incorporated into any of the above-described aspects of this disclosure alone or in any combination. The brief summary presented above is intended only to familiarize the reader with certain aspects and contexts of embodiments of this disclosure without limitation to the claimed subject matter.

For clarity and simplicity of description, not all combinations of elements provided in the aspects of the invention recited above have been set forth expressly. Notwithstanding this, the skilled person will directly and unambiguously recognize that unless it is not technically possible, or it is explicitly stated to the contrary, the consistory clauses referring to one aspect of the embodiments described herein are intended to apply mutatis mutandis as optional features of every other aspect of the invention to which those consistory clauses could possibly relate.

BRIEF DESCRIPTION OF THE DRAWINGS

Various features, aspects, and advantages of this disclosure will become better understood when the following detailed description is read with reference to the accompanying figures in which like characters represent like parts throughout the figures, wherein:

FIG. **1** illustrates a schematic diagram of example hydrocarbon production system that may include operations undertaken by an enterprise to produce, process, and distribute hydrocarbon products, according to one or more embodiments of this disclosure;

FIG. **2** is a data flow diagram in which inputs from data sources are used to generate workflow plans to adjust operations and/or procedures within an enterprise to improve sustainability parameters, according to one or more embodiments of this disclosure;

FIG. **3** is a block diagram of components that may be part of the sustainability platform system, according to one or more embodiments of this disclosure;

FIG. **4** is a flow chart of a method for generating sustainability reports for enterprise operations employing the sustainability platform system of FIG. 3, according to one or more embodiments of this disclosure;

FIG. 5 is a flow chart of a method for generating sustainability action plans for enterprise operations employing the sustainability platform system of FIG. 3, according to one or more embodiments of this disclosure;

FIG. 6 illustrates a data diagram of various types of data that may be analyzed for determining plans and workflows to improve sustainability parameters for the enterprise operations, according to one or more embodiments of this disclosure;

FIG. 7 is a flow chart of a method which the sustainability platform system may simulate sustainability action plans over a period of time for analysis, in accordance with embodiments herein.

FIG. 8 is a flow chart of a method for identifying missing data sources and simulating missing data, according to one or more embodiments of this disclosure;

FIG. 9 is a flow chart of a method for identifying missing data sources to validate effectiveness of sustainability action plans, according to one or more embodiments of this disclosure;

FIG. 10 is a flow chart of a method for updating sustainability action plans based on confidence data, according to one or more embodiments of this disclosure;

FIG. 11 is a flow chart of a method for adding abatement technologies with corresponding technology parameters to a database, according to one or more embodiments of this disclosure; and

FIG. 12 is a flow chart of a method for selecting abatement technology implementations for use in a sustainability action plan, according to one or more embodiments of this disclosure.

DETAILED DESCRIPTION

One or more specific embodiments will be described below. In an effort to provide a concise description of these embodiments, not all features of an actual implementation are described in the specification. It should be appreciated that in the development of any such actual implementation, as in any engineering or design project, numerous implementation-specific decisions must be made to achieve the developers' specific goals, such as compliance with system-related and business-related constraints, which may vary from one implementation to another. Moreover, it should be appreciated that such a development effort might be complex and time consuming, but would nevertheless be a routine undertaking of design, fabrication, and manufacture for those of ordinary skill having the benefit of this disclosure.

The drawing figures are not necessarily to scale. Certain features of the embodiments may be shown exaggerated in scale or in somewhat schematic form, and some details of conventional elements may not be shown in the interest of clarity and conciseness. Although one or more embodiments may be preferred, the embodiments disclosed should not be interpreted, or otherwise used, as limiting the scope of the disclosure, including the claims. It is to be fully recognized that the different teachings of the embodiments discussed may be employed separately or in any suitable combination to produce desired results. In addition, one skilled in the art will understand that the description has broad application, and the discussion of any embodiment is meant only to be exemplary of that embodiment, and not intended to intimate that the scope of the disclosure, including the claims, is limited to that embodiment.

When introducing elements of various embodiments of this disclosure, the articles "a," "an," and "the" are intended to mean that there are one or more of the elements. The terms "including" and "having" are used in an open-ended fashion, and thus should be interpreted to mean "including, but not limited to . . . ." Any use of any form of the terms "couple," or any other term describing an interaction between elements is intended to mean either an indirect or a direct interaction between the elements described.

Certain terms are used throughout the description and claims to refer to particular features or components. As one skilled in the art will appreciate, different persons may refer to the same feature or component by different names. This document does not intend to distinguish between components or features that differ in name but not function, unless specifically stated.

Hydrocarbon sites may include a number of components that facilitates the extraction, processing, and distribution of hydrocarbons (e.g., oil) from a well or well site. A hydrocarbon extraction site may include different types of facilities and equipment including extraction tools, pipelines, and the like. The operations related to the extraction of the hydrocarbons may often be referred to as upstream operations. After the hydrocarbons are extracted, the raw hydrocarbons may be transported via automobile vehicles, railways, barges, pipelines, or any suitable component to storage containers, processing centers, and the like. In some cases, the raw hydrocarbons may be treated (e.g., waste removed, compressed) prior to being transported to other facilities. These operations are often referred to as midstream operations. Finally, the hydrocarbons may be processed (e.g., refined) and distributed to end consumers, thereby covering downstream operations.

At each stage of operations, a certain amount of greenhouse gas emissions may be produced when performing various tasks associated with each stage. As industries move to providing a net zero carbon enterprise, the greenhouse gas emissions produced during these stages may be removed from the atmosphere. A number of action plans may be related to removing carbon from the atmosphere including afforestation, reforestation, soil carbon sequestration, carbon capture and storage technology, direct air capture technology, ocean fertilization, reducing emissions at the source, switching to sustainable power sources, reusing previously discarded resources, and the like. In addition to net zero carbon operations, industries are working to achieve improved sustainability parameters that reduce waste, conserve resources, and reduce the effects that their respective operations have on the environment.

In order to prepare action plans to achieve net zero operations, organizations may first determine baseline sustainability variable values (e.g., carbon, waste, water) that reflect the current operations of the entire organization or enterprise. That is, the organization may employ a sustainability platform system to collect data related to sustainability parameters from across the entire organization. By way of example, hydrocarbon enterprises may include a number of operations related to the manufacturing, processing, or production of hydrocarbon products. Indeed, hydrocarbon enterprises may involve operations related to upstream, midstream, and downstream operations. As such, to determine the baseline sustainability parameters, the sustainability platform system may collect data from sensors, forecasting models, reports, internet-of-things (IOT) devices, image data (e.g., optical gas imaging), flaring control measurements, and other suitable data sources. Using the collected data over time, the sustainability platform system may determine baseline sustainability parameters (e.g., carbon footprint, waste levels, water usage) for the entire operational flow of the enterprise over a period of time (e.g., days, weeks, months, years).

Based on the macro outlook of future sustainability goals as provided by a user, the sustainability platform system may then employ a planning module to determine action plans to determine a number of sustainability operations to employ to cause the baseline sustainability parameters to trend towards net zero operations. The planning operations employed by the sustainability platform system may involve reviewing digital models, empirical models, or insights received from previous operations at facilities other than the respective enterprise to determine operational changes to operations performed within the enterprise, additional operations (e.g., install carbon capture technology) to add to the enterprise, and/or other suitable action plans to cause the enterprise operations to improve sustainability parameters.

The action plans may thus be related to facility level operations that optimize sustainability efficiencies at a facility level that may involve modifying certain processes (e.g., order of operations and/or timing for performing tasks based on a sustainable energy source schedule). The facilities of an enterprise may be related to buildings in which engineers and office personnel visit, as well as structures that support industrial operations such as production or refining operations. By evaluating the sustainability parameters with respect to the facility level, the sustainability platform system may provide action plans to coordinate facility operations (e.g., work from home days, lighting operations, operational task schedules, tool selections, equipment operating parameters) to improve sustainability efficiencies.

In addition, enterprises may perform certain operations to produce or manufacture a product. The sustainability platform system may also evaluate these product level operations to identify different processes, equipment, or devices to use to improve sustainability parameters related to the operations that correspond to the operations involved in producing or manufacturing a product. By way of example, a product carbon footprint (PCF) may be generated based on the techniques described herein to illustrate a total of the greenhouse emissions generated by a product over the different stages of its life cycle. For instance, a cradle-grave PCF may include greenhouse emissions from operations related to extraction of raw materials to operations related to the end-of-life of the product.

With the foregoing in mind, the sustainability platform system may measure the sustainability parameters for the enterprise at various levels, provide reports related to the measured values, and verify the measurements to ensure that a developed action plan, when implemented, may improve sustainability efficiencies within the enterprise operations. It should be noted that the measured sustainability parameters may also be sourced or estimated as provided by certain data sources, such as emissions databases provided by EPA, IEA, and the like. In some embodiments, the sustainability platform system may collect the measured and verified data to provide reports for meeting certain governmental reporting regulations. Further, the sustainability platform system may model the determined action plans to predict the effects to the measured sustainability parameters over a period of time to determine whether the sustainability parameters will achieve desired values or ranges.

After generating the action plan, the enterprise operations may implement the outlined actions of the action plan by adjusting the operations of facilities, the operations of the production services, or the like. As the action plan takes effect, the sustainability platform system may continue to measure, validate, and report the sustainability parameters that were previously collected to perform feedback analysis to determine the effectiveness of the action plan. The results may be stored in a database or other suitable storage component to serve as empirical data for assisting other enterprises achieve their sustainability goals. Further, the feedback may be provided to the models used to generate the action plans to better calibrate certain machine learning parameters or coefficients, such that the models may more accurately reflect the actual measurements.

With the foregoing in mind, the present embodiments described herein provide a computationally efficient manner to monitor, track, project, and adjust sustainability parameters associated with operations throughout an enterprise. Indeed, some systems use integrated workflows that become prohibitively expensive with respect to cost and computational processing power by determining recommendations for achieving improved sustainability parameters without incorporating feedback mechanisms, real-time data sources, and updated projections, as described herein. By continuously tracking and updating the sustainability action plans generated for an enterprise based on input data changes detected in real time, the present embodiments may incrementally update portions of a sustainability model without independently regenerating the respective sustainability model for the enterprise. In this way, operation personnel of the enterprise may be notified in a timely manner to adjust operations for ensuring that certain sustainability target goals are achieved over a period of time as circumstances change.

Unlike other sustainability evaluation processes, which may be prohibitively slow with exhaustive sustainability parameters to account for, the present embodiments provide a more efficient analysis that reduces the amount of processing power employed by computing systems tasked to determine the recommended sustainability action plans by employing action plan modules or systems that focus on specific sustainability parameter improvements. In other words, other optimization schemes are limited by certain memory and computational parameters of existing computing systems to provide useful facilities recommendations for hydrocarbon site planning operations. However, by processing of different datasets modularly (e.g., set portions), the present embodiments described herein may allow for the ability to trade computer processing time/resources for precision of the optimal solution.

It should be noted that although the following description of various embodiments for improving sustainability parameters is described with respect to hydrocarbon enterprise operations, it should be understood that the embodiments described herein may be applied to any suitable industry including utilities, cementing operations, steel factories, and the like. Further, although the following description of the various methodologies may be detailed in the context of a particular industry or technology area, it should be noted that the methodologies described herein may be implemented within other suitable areas.

By way of introduction, FIG. **1** illustrates a schematic diagram of an example hydrocarbon production system **10** where hydrocarbon products, such as crude oil and natural gas, may be extracted from the ground, stored, transported, processed, distributed, and the like. The example hydrocarbon production system **10** is provided as an example enterprise that includes a number of different units that coordinate with each other to perform various tasks. For instance, the enterprise may include a collection of equipment, buildings, personnel, raw materials, office buildings, and other components that encompass at least some aspect of the business operations of the enterprise. In the example hydrocarbon production system **10** described below, the enterprise includes all of the processes, employees, operations, buildings, equipment, and other related components that enable the enterprise to produce, transport, and distribute hydrocarbon products. In the same way, the present embodiments described herein may be applied to other enterprises that provide other products and services and should not be limited the hydrocarbon production system **10** described below.

Referring now to FIG. **1**, the hydrocarbon production system **10** may generally include an upstream system **12**, a midstream system **14**, and a downstream system **16**. The upstream system **12** may include a number of components and equipment associated with the exploration and production of hydrocarbons. As such, geological surveys that employ seismic sources (e.g., vibrators, air guns), seismic sensors, and other equipment (e.g., fracking trucks) used for hydrocarbon exploration services may be included in the upstream system **12**, although not illustrated in FIG. **1**.

In addition, the upstream system **12** may include a number of components or facilities that correspond to wells, processing facilities, collection components, distribution networks, and the like. For example, as shown in FIG. **1**, the upstream system **12** may include a number of wells **22** disposed within a geological formation **24**. The wells **22** may include drilling platform **26** that may have performed a drilling operation (e.g., on land or subsea) to drill out a wellbore **28**. Additionally, as used herein, wells **22** may generally refer to physical components such as the drilling platform **26** and wellbore **28** and/or the general area of the reservoir in which extraction is desired (e.g., a reservoir well section). The drilling operations may include drilling the wellbore **28**, injecting drilling fluids into the wellbore **28**, performing casing operations within the wellbore **28**, exploratory operations measuring the viability of the wellbore **28**, extraction operations, and the like. In addition to including the drilling platform **26**, the upstream system **12** may include surface equipment **30** that may carry out certain operations, such as cement installation operation, well logging operations to detect conditions of the wellbore **28**, and the like. As such, the surface equipment **30** may include equipment that store cement slurries, drilling fluids, displacement fluids, spacer fluids, chemical wash fluids, and the like. The surface equipment **30** may include piping and other materials used to transport the various fluids described above into the wellbore **28**. The surface equipment **30** may also include pumps, electric or gas-powered motors, and other equipment (e.g., batch mixers, centrifugal pumps, liquid additive metering systems, tanks, etc.) that may be used with or a part of the interior of a casing string with the fluids discussed above.

In addition to the equipment used for drilling operations, the upstream system **12** may include a number of well devices that may control the flow of hydrocarbons being extracted from the wells **22**. For instance, the well devices in the upstream system **12** may include pumpjacks **32**, submersible pumps **34**, well trees **36**, and the like. The pumpjacks **32** may mechanically lift hydrocarbons (e.g., oil) out of the well **22** when a bottom hole pressure of the well **22** is not sufficient to extract the hydrocarbons to the surface. The submersible pump **34** may be an assembly that may be submerged in a hydrocarbon liquid that may be pumped. As such, the submersible pump **34** may include a hermetically sealed motor, such that liquids may not penetrate the seal into the motor. Further, the hermetically sealed motor may push hydrocarbons from underground areas or the reservoir to the surface. The well trees **36** may be an assembly of valves, spools, and fittings used for natural flowing wells. As such, the well trees **36** may be used for an oil well, gas well, water injection well, water disposal well, gas injection well, condensate well, and the like. By way of reference, the wells **22** may be part of a first hierarchical level and the well devices that extract hydrocarbons from the wells **22** may be part of a second hierarchical level above the first hierarchical level.

After the hydrocarbons are extracted from the surface via the well devices, the extracted hydrocarbons may be distributed to other devices via a network of pipelines **38**. That is, the well devices of the upstream system **12** may be connected together via a network of pipelines **38**. In addition to the well devices described above, the network of pipelines **38** may be connected to other collecting or gathering components, such as wellhead distribution manifolds **40**, separators **42**, storage tanks **43**, and the like.

In some embodiments, the pumpjacks **32**, the submersible pumps **34**, well trees **36**, wellhead distribution manifolds **40**, separators **42**, and storage tanks **43** may be connected together via the network of pipelines **38**. The wellhead distribution manifolds **40** may collect the hydrocarbons that may have been extracted by the pumpjacks **32**, the submersible pumps **34**, and the well trees **36**, such that the collected hydrocarbons may be routed to various hydrocarbon processing or storage areas in the upstream system **12**, the midstream system **14**, or the downstream system **16**. The separator **42** may include a pressure vessel that may separate well fluids produced from oil and gas wells into separate gas and liquid components. For example, the separator **42** may separate hydrocarbons extracted by the pumpjacks **32**, the submersible pumps **34**, or the well trees **36** into oil components, gas components, and water components. After the hydrocarbons have been separated, each separated component may be stored in a particular storage tank **43**. The hydrocarbons stored in the storage tanks **43** may be transported via the pipelines **38** to transport vehicles, refineries, and the like.

In addition to the components described above, internet-of-things (IoT) devices **44** may be distributed throughout the upstream system **12**, the midstream system **14**, and the downstream system **16** and may collect information, perform analysis on data, send data related to a respective component or parameters (e.g., temperature, flow) of a component to a computing system or the like. By way of example, the IoT device **44** may include sensors, actuators, machines, or other equipment that may include a processor that execute computer instructions and performs certain tasks including collecting data, processing data, and communicating data over a network.

Although the hydrocarbon production system **10** is described above with certain components, it should be understood that the hydrocarbon production system **10** may include additional, fewer, or different components. For example, although discussed above in relation to the hydrocarbon production system **10** on land, present embodiments may also apply to off-shore hydrocarbon sites.

After extracting, transporting, and storing the hydrocarbons in the upstream system **12**, the hydrocarbons may be transported and stored in the midstream system **14**. The midstream system **14** may thus include pipeline infrastructure **46** that may move the extracted hydrocarbons across certain terrains and geographic locations to facilities to process, refine, or store the hydrocarbons. The pipeline infrastructure **46** may include similar devices as described in the upstream system **12** such as the separators **42** and storage tanks **43**, as well as other components that may assist in moving the hydrocarbons long distances, such as pumping stations, tank trucks **48**, rail tank cars, barges **50**, and the like. The IoT devices **44** may thus track the flow of the hydrocarbons, the valves for directing the hydrocarbons within the pipelines, the locations of the vehicles used to transport the hydrocarbons, and the like. In some embodiments, the IoT devices **44** may include autonomous control systems to control the operations of the vehicles transporting the hydrocarbons.

The downstream system **16** may include components that may convert the transported hydrocarbons into final petroleum or gas products. The operations performed by the downstream system **16** may include refining the hydrocarbons into different products such as gasoline, diesel, oils, lubricants, petrochemicals, and the like. As such, the downstream system **16** may include a refinery system **52** for processing the hydrocarbons. By way of example, the refinery system **52** may include distillation towers to separate the hydrocarbons, heat exchangers to transfer heat between different fluids, pumps used to move fluids, reactors to perform chemical reactions for processing the hydrocarbons, separators **42**, compressors, storage tanks, and the like. After the hydrocarbons are converted into hydrocarbon products, they may be transported to other locations for distribution via tank trucks **48** or other suitable distribution mechanisms. For instance, the hydrocarbon products (e.g., gasoline) may be distributed to a fuel station to distribute fuel to consumers via a gas pump **54**.

In addition to the upstream system **12**, the midstream system **14**, and the downstream system **16**, the enterprise may include buildings **56**, vehicles **58**, and other objects that are owned, leased, or operated by an organization. These tangential or supplemental objects may be involved in the planning, marketing, accounting, and supplementary business aspects for commercializing the hydrocarbon production system **10**. Although only the buildings **56** and vehicles **58** are depicted as supplementary objects associated with the enterprise in FIG. **1**, it should be understood that other supplementary objects may also be considered part of the enterprise.

Each of the components and subsystems of enterprise described above (e.g., the upstream system **12**, the midstream system **14**, the downstream system **16**, office building **56**) involves the consumption of resources such as energy and water. Further, these systems also produce a certain amount of waste greenhouse gas (GHG) emissions while performing their respective operations. The resource, waste, and emission amounts vary for different portions of each respective system, but the aggregated resource, waste, and emission amounts may include a planning phase (e.g., within building **56**), a construction phase, an operation phase, a decommissioning phase, and the like. In addition, each of these phases at each system level (e.g., upstream, midstream, downstream, office) produces greenhouse gas (GHG) emissions such as carbon dioxide, methane, and the like. The resources, waste, GHG emissions, and other byproducts consumed and produced during these operations may be referred to as sustainability parameters. Enterprises may generally move to improve sustainability parameters by focusing on one or more of increasing energy efficiencies, reducing water usage, curbing GHG emissions, decreasing waste amounts, and the like. The sustainability parameters may be interdependent with each other and the enterprise may reduce the environmental impacts of their operations by coordinating their operations to improve the aggregate sustainability parameters across the enterprise. As shown in FIG. **1**, any type of enterprise may involve a diverse group of equipment, processes, structures, and the like. In accordance with the embodiments described herein, a sustainability platform system may track and monitor sustainability parameters across the variety of levels, operations, and aspects of the enterprise to provide sustainability action plans to revise enterprise operations and structures to improve sustainability parameters. Indeed, as more industries move to achieve net zero compliance in which the enterprise achieves a balance between the amount of GHG emissions produced by the enterprise operations and removed from the atmosphere, efficient generation of efficient action plans for reduced GHG emissions and other sustainability operations may be increasingly important.

Keeping this in mind, the present embodiments described herein may include systems and methods for improving sustainability operations across enterprise operations. For example, a data flow diagram **70** of operations performed by a sustainability platform system **72** is presented in FIG. **2**. The data flow diagram **70** may use inputs from data sources to generate sustainability action plans to adjust operations and/or procedures within an enterprise to improve sustainability parameters. Although the data flow diagram **70** illustrates a set of input data sources **74**, a methodology **76**, and a set of engineering workflow systems **78**, it should be noted that the elements illustrated in FIG. **2** do not constitute an exhaustive list of elements that may be part of the data flow diagram **70** and used to perform the methods described herein. Instead, the depicted elements are merely provided as examples to provide context and to supplement the explanation of the embodiments described herein.

Referring now to FIG. **2**, the sustainability platform system **72** may include any suitable computing device, cloud-computing device, or the like and may include various components to perform various analysis operations. By way of operation, the sustainability platform system **72** may receive input data regarding measured sustainability parameters, policies for sustainability programs, and other information from a set of input data sources **74**. Based on the input data, the sustainability platform system **72** may perform certain calculations, analyses, or operations to track sustainability parameters across enterprise operations, report the sustainability parameters with respect to legislative policies or regulations, identify relationships between operational parameters for facilities, devices, and other components that are part of the enterprise and the measured sustainability parameters, and the like.

In some embodiments, the sustainability platform system **72** may implement the methodology **76** that may include a measurement block **82**, a verification block **84**, a planning block **86**, and a comparison block **88**. After receiving input data, analyzing the input data with respect to the engineering workflow systems **78**, the sustainability platform system **72** may generate one or more action plans **90** that may detail operational changes for facilities, machinery, and the like. After the action plans **90** are put in place within the enterprise operations, the sustainability platform system **72** may again receive the input data to determine the effectiveness of the action plans **90**, provide improved action plans **90**, and continuously improve the sustainability parameters across the enterprise operations for the life of the enterprise.

Generally, the measurement block **82** may receive the input data and store the related measurements, values, and other measurable parameters in a storage component, data store, or the like. In some embodiments, the measurement block **82** may prepare or organize the measurement data in accordance with specific protocols or formats, as defined by reports **92**. The reports **92** may include previous reports prepared for different authorities or organizations. As such, the reports **92** may also include metadata related to the format, structure, and type of information presented in the reports **92**. In some embodiments, the reports **92**, the metadata regarding the reports **92**, instructions regarding the preparation or formatting of the reports **92** may also be stored in a database or data storage for access by the sustainability platform system **72**.

The measurement data recorded by the measurement block **82** may be validated by the verification block **84**. That is, the verification block **84** may analyze or query other input data to verify that the recorded measurement data is accurate. For example, the measurement block **82** may receive a measurement from the IoT device **44** regarding some sustainability parameter, such as energy consumption. The verification block **84** may retrieve corporate energy invoices to determine whether the energy consumption measured by the IoT device **44** corresponds to the energy consumed according to the utility providing the energy.

The planning block **86** may use the verified measurement data to query the engineering workflow systems **78** to generate one or more potential action plans or scenarios for improving the sustainability parameters. The engineering workflow systems **78** may include a number of distinct modules or systems that provide recommendations (e.g., equipment recommendation, operational change recommendation) for various portions of the enterprise to improve distinct aspects of sustainability or gain insight to better determine a plan for improving sustainability parameters across the enterprise. For instance, the engineering workflow systems **78** may include a new energy system that tracks new energy sources that may be used to meet the energy requests of various portions of the enterprise. The new energy sources may include renewable energy sources to improve the sustainability parameters for the enterprise operations. As such, the new energy system may determine whether alternative energy sources can be used to replace energy sources that may be less sustainable.

After generating a number of potential plans or scenarios, the comparison block **88** may analyze the collection of potential plans to determine whether plans could be combined, provide comparison data for different sustainability parameters associated with the generated plans, and the like. Additionally, in some embodiments, an offset block **89** may augment the potential plans to form an action plan **90**. For example, carbon credits **91** (e.g., purchased or created via carbon capture) may be factored into the comparison and evaluation of potential plans to achieve goals of an action plan **90**. The comparison data may be presented to a user via an electronic display or any suitable display technology. As should be appreciated, in some embodiments, the comparison block **88** and/or the offset block **89** may be considered part of the plan block **86**. In some embodiments, the plans or comparison data may be sent to user devices (e.g., mobile phone) and may cause the user devices to automatically open or execute an application associated with the sustainability platform system **72**, such that the user device presents visualization related to the determined plans, the comparison data, or the like. In some embodiments, the visualizations may be selectable input fields in which the user may touch or select via an input device (e.g., keyboard, mouse). After receiving a selection or acceptance of an action plan **90**, the sustainability platform system **72** may send the action plan **90** to other user devices, a sustainability database **94**, or other suitable recipient, such that the enterprise may make changes to its operations to implement the recommendations outlined in the action plan **90**. In some embodiments, the sustainability platform system **72** may send commands to equipment (e.g., lights, pumps, wellheads, artificial lifts), such as via IoT devices **44**, to adjust operations based on the recommended action plan **90** to improve the sustainability parameters associated with the enterprise.

Referring now to the input data sources **74**, in some embodiments, the sustainability platform system **72** may receive data from image acquisition sources **102**, marketplace sources **104**, third-party sources **106**, real-time sources **108**, corporate data sources **110**, manual sources **112**, and the like. The image acquisition sources **102** may include devices that may acquire image data (e.g., pictures, video, infrared image) using any suitable image sensor. As such, the devices may include satellites, drones, infrared sensors, cameras, and the like. The image data provided by the image acquisition sources **102** may correspond to heat dissipating from a device, gas leaking from a device, emissions (e.g., fumes, height of fumes) produced by a device, or any other suitable image data that may provide information related to any suitable sustainability parameter. In some embodiments, the sustainability platform system **72** may determine an approximate amount of emissions based on the image data. Although the determined amount may not be precise, the measurement block **82** may use the initial estimate as a data point and use other data points to verify via the verification block **84** using other data.

The marketplace sources **104** may include data provided by analysis software, crowdsourcing systems, and other data sources that may be facilitated by a marketplace such as the Ocean Store provided by Schlumberger and other like sources. That is, the marketplace sources **104** may include data provider sources or services that capture, generate, or simulate certain datasets (e.g., emissions, waste, water usage, energy consumption) for use by the sustainability platform system **72** as ready-made data. For instance, emissions data may be provided by certain marketplace sources **104** that may be able to broadcast or present their available data services for integration with the sustainability platform system **72** via an integration tool, a network location, the sustainability platform system **72** itself, or the like. The supplied data (e.g., emissions data) may be incorporated for calculation purposes, analysis purposes, simulation purposes, or the like. Indeed, the data provided via the marketplace sources **104** may include emission factors from various sources such as IPCC, IEA, EIA, and the like, as well as publicly available frameworks such as TCFD, GHG protocol, and the like. In some cases, the marketplace sources **104** may provide data services for a fee (e.g., subscription) and may coordinate data exchange via the sustainability platform system **72** to enhance the data analysis operations while employing solutions provided by the engineering workflow systems **78** and the like.

As such, different insights with regard to the received data may be determined or gleaned by the sustainability platform system **72** based on the software modules or solutions provided via the marketplace sources **104**. In addition to the examples provided above, the marketplace sources **104** may provide virtual metering data to provide an estimated flow amount for a pump. That is, an application or tool may be provided by the marketplace sources **104** that uses an efficiency of the pump to determine a virtual amount of flow of fluids via the pump based on the amount of time that the pump was operating. Although the present disclosure describes certain exemplary services that may be received via the marketplace sources **104**, it should be understood that the marketplace sources **104** may be provided by any suitable application, data system, or other component that may interact and exchange information with the sustainability platform system **72**.

The third-party sources **106** may include supplier information provided by a manufacturer or other entity regarding a device, system, facility, or the like. Using the pump example mentioned above, the third-party sources **106** may provide a datasheet or operational data that details the efficiency, energy consumption rate, and other information related to the operation of the pump. In addition, third-party sources **106** may correspond to data sources that may be utilized by the sustainability platform system **72** to perform various operations via the planning block **86**, in coordination with the engineering workflow systems **78**, and the like. By way of example, the third-party sources **106** may include data service providers that perform independent research and business intelligence analysis such as Rystad, Gartner, Statista, and the like. In addition, data projections for different organizations may be provided via the marketplace sources **104** as these organizations acquire these data projections (e.g., OPEX/CAPEX) such as historical emission figures, geographies of areas for operation, number of present facilities, number of fields, and the like. Although the present disclosure describes certain exemplary services that may be received via the third-party sources **106**, it should be understood that the third-party sources **106** may be provided by any suitable application, data system, or other component that may interact and exchange information with the sustainability platform system **72**.

The real-time sources **108** may include data provided by sensors, devices, and other data sources via a network connection. As such, the real-time sources **108** may include the IoT devices **44**, as well as any smart component that may be part of the enterprise. In addition, the real-time sources **108** may include routers and other data collection point devices that may receive data (e.g., sensor data) from other systems, computing devices, instruments, and the like.

The corporate data sources **110** may include data provided by corporate entities associated with the enterprise or other organization. For instance, many enterprises may use enterprise resource planning (ERP) software systems to assist in coordinating and tracking business operations such as finance, human resources, field operations, manufacturing, production, supply chain, procurement, customer service, and any other suitable business operation. The corporate sources may also include memorandums, company earning reports, sustainability reports, and other publications provided by the enterprise that may describe various operations, goals, and finances associated with the enterprise. In some embodiments, the corporate data sources **110** may provide a ERP report that details employees that work in a facility, the addresses associated with the employees, the schedules of the employees, the salary information for the employees, the utility invoices for the buildings accessed by the employees, and the like. This information may enable the sustainability platform system **72** to measure emissions related to the enterprise operations to generate insights regarding priorities to address. Further, the information may be used to provide action plans **90** at a facility level, such as recommending changes to work schedules that may encourage work from home days to offset sustainability liabilities in different parts of the enterprise.

The manual sources **112** may include any data manually provide to the sustainability platform system **72** via user input or the like. For instance, the sustainability platform system **72** may provide a user interface that solicits inputs from a user regarding various parts of the enterprise operations. The user input may be provided to the sustainability platform system **72** and used for generating the action plans **90** via the methodology **76**.

Referring now to the engineering workflow systems **78**, the sustainability platform system **72** may employ one or more of the engineering workflow systems **78**, independently or in combination with one or more other systems, to determine recommendations for changing enterprise operations. As used herein, enterprise operations may include any building, operation, task, or activity related to the products and services produced by the enterprise. As such, for example, the enterprise may include any of the activities related to those described above with respect to the hydrocarbon production system **10** from the upstream system to operations related to the function of the building **56**. In this way, the sustainability platform system **72** may holistically evaluate an overall sustainability for the enterprise operations and determine effective and creative solutions to achieve net zero goals.

Each of the engineering workflow systems **78** may perform specific analysis operations to determine solutions for the respective technology areas. That is, the engineering workflow systems **78** may assist with the designing and monitoring of abatement solutions (e.g., emission abatement, waste abatement, etc.). As such, each engineering workflow system **78** may include a separate computing device, cloud system, or the like that independently analyzes data and produces outputs. Each engineering workflow system **78** may thus send queries for information or data to the sustainability platform system **72**, which may serve as data intermediary to assist each engineering workflow system **78** in retrieving relevant information to allow the respective engineering workflow system **78** to perform its analysis. In the same manner, the sustainability platform system **72** may query one or more engineering workflow systems **78** to retrieve solutions, analysis, recommendations, or the like to determine action plans to improve sustainability parameters. Although the following discussion of the types of the engineering workflow systems **78** include a certain number of systems, it should be noted that additional systems may also be part of the engineering workflow systems **78**.

As shown in FIG. **2**, the engineering workflow systems **78** may include a new energy system **122**, a multiclient system **124**, a CHP system **126**, a surface system **128**, a subsurface system **130**, a flare and vent system **132**, a CCUS system **134**, a drilling system **136**, and a supplemental system **138**. As mentioned above, each of the engineering workflow systems **78** may coordinate operations with the sustainability platform system **72** to perform the methodology **76** and generate action plans **90**. However, by using different modules or systems to analyze different aspects of engineering, the present embodiments described herein enable the sustainability platform system **72** to preserve computing resources for coordination and integration operations (e.g., collection and transmission of data, organizing plans, coordinating feasibility of different plans for enterprise) between the input data sources **74** and the engineering workflow systems **78** without analyzing different engineering solutions for sustainability improvements. It should be noted that each of the engineering workflow systems **78** may be complex systems that operate on their own respective platforms (e.g., processing systems, storage components, network connections) to perform various types of data analysis, operations, simulations, and the like. In addition, the output data provided by these engineering workflow systems **78** or used by the same may be stored for use by various entities in workflow databases **140** or other suitable storage component.

By way of example, the new energy system **122** may track, monitor, simulate, and design solutions for various industries to achieve more sustainable energy goals. The new energy system **122** may receive invoice data for energy costs associated with the enterprise (e.g., corporate data source **110**), real-time energy usage from IoT devices (e.g., real-time sources **108**), and other relevant data regarding the energy consumption data for various aspects of the enterprise. The energy consumption data may include utility provider information that indicates the source of the energy (e.g., coal, renewable), a rate schedule for the provided utilities, and the like. The new energy system **122** may also include databases or storage components that include models that represent other enterprise or facility operations, simulated models generated by artificial intelligence (e.g., neural networks, pattern analysis), machine learning algorithms, or the like. The models or lookup tables may provide information related to the amount of energy provided to different enterprises, the type of energy provided to these enterprises, the costs associated with commissioning these energy sources, and the like. For instance, the new energy system **122** may model the ability of wind farms and solar panel fields to provide energy for one or more facets of a particular enterprise. Alternative sources may also include renewable energy options such as solar power, wind power, hydroelectric power, hydrogen, geothermal energy, biomass, and other suitable alternative energy sources. The model may also include cost projections for commissioning these energy sources, as well as projections over the life of the enterprise. These models may be employed by the sustainability platform system **72** to determine action plans to apply to its respective input data related to the respective enterprise and identify action plans **90** that may assist in improving energy sustainability parameters for the enterprise. In addition to providing alternative energy sources, the new energy system **122** may also provided recommendations with regard to storing energy in batteries, storing hydrogen for later use, storing geothermal energy for use, and the like.

The combined heat and power (CHP) system **126** may perform analysis to determine methods for reusing emissions such as carbon dioxide to increase efficiency. For instance, heat can be recaptured during a portion of a process and the heat can be applied to a heat exchanger to produce energy or perform some other function using the heat recaptured from performing another process within the enterprise. As such, the CHP system **126** may request image data and infrastructure or design data for facilities of the enterprise from the sustainability platform system **72** to identify process components that may produce heat or power that may be recaptured and recycled for other functions within the enterprise. In any case, the CHP system **126** may help the sustainability platform system **72** determine action plans **90** that improve energy efficiency and reduce facility carbon emissions.

The multiclient system **124** may include data analysis systems from other sources. Indeed, these sources may provide information related to the operations of the enterprise that may be gleaned from the input data received by the sustainability platform system **72** but may not be determined by the sustainability platform system **72**.

The surface system **128** may include computing systems and databases of information that details operational data regarding various types of equipment that may be installed on the surface of the hydrocarbon production system **10**. As such, the surface system **128** may continuously update its data sources to track updated versions of components, identify replacement parts and products for components, track efficiency improvements of components, monitor recalls or issues with installed components, and the like. The surface system **128**, for example, may receive real-time data via the sustainability platform system **72** and determine that certain pieces of equipment are operating inefficiently, are reaching an end of life, has a more energy efficient counterpart available, or the like. The sustainability platform system **72** may coordinate with the surface system **128** to identify replacements, new components to add to the enterprise, and the like to improve the sustainability parameters of the enterprise operations.

In the same manner, the subsurface system **130** may include computing systems and databases of information regarding equipment that may be part of subsurface operations in the hydrocarbon production system **10**. As such, the subsurface system **130** may provide recommendations with regard to improved data acquisition processes, techniques, equipment, and the like that may enable the enterprise to improve sustainability parameters. By way of example, the subsurface system **130** may determine improved seismic data acquisition techniques that consume less energy as compared to previous techniques using existing equipment in the enterprise.

The flare and vent system **132** may provide recommendations with regard to flaring and venting excess emissions. In some embodiments, the excess emissions may be captured using carbon capture technology. As such, the flare and vent system **132** may coordinate with the carbon capture (CCUS) system **134** to determine carbon capture technology for storing captured carbon. The CCUS system **134** may provide data regarding costs, installation profile, and operations for carbon technology and recommendations with regard to injecting the captured carbon into appropriate locations. In some embodiments, captured carbon may not be useful for a particular enterprise but may be useful for other enterprises. As such, the CCUS system **134** may identify the industries or organizations that may use the captured carbon in an efficient manner.

The drilling system **136** may provide recommendations with regard to drilling operations for creating boreholes, wells, and the like. The drilling operations may include equipment information, slurry makeup, drilling fluids, water conservation operations, and the like. Further, the supplemental system **138** may include recommendations for other industries, suppliers, distributors, or consumers associated with the enterprise. For instance, the supplemental system **138** may include gasoline distribution facilities with gas pumps **54** that provide gasoline to consumers. The supplemental system **138** may provide information with regard to improving sustainability parameters for operations that occur between the enterprise associated with the sustainability platform system **72** and the organization operating the gasoline distribution facilities.

In addition to the engineering workflow systems **78**, strategy level planning systems **142** may interact with the sustainability platform system **72** to perform strategic planning operations for determining sustainability action plans **90**, performing screening analysis, determining economic aspects of the action plans **90**, determining optimization functions for the action plans **90**, and the like. That is, the strategy level planning systems **142** may evaluate an organization's sustainability operations at various hierarchical levels to perform some strategic planning for certain operations, such as performing decarbonization operations. By way of example, the strategy level planning systems **142** may include screening systems **144**, economic systems **146**, optimization systems **148**, and other systems that may analyze the feasibility and viability of implementing certain sustainability action plans **90**.

With this in mind, the strategy level planning systems **142** may perform materiality assessment to provide the enterprise with an opportunity to analyze risks and opportunities associated with implementing the action plans **90**, and to make any adjustments necessary to improve its business strategy. The assessment helps the organization understand where it is creating or reducing value for society and represents a comprehensive business case to senior executives about why and how to report ESG (environmental, social, governance) data and manage ESG performance. The information obtained and tracked on the platform may essentially help companies in this decision-making process towards their decarbonization strategy. With clear visibility across all 3 scopes (e.g., environmental, social, governance), materiality assessment would be facilitated. In this way, the strategy level planning system **142** may enable the sustainability platform system **72** to review action plans **90** with respect to government variable, risk management variable, target metrics, and the like.

In some embodiments, the strategy level planning systems **142** may perform evaluation operations based on organizational boundaries and operational boundaries. Organizational boundaries may determine operations that are operated and owned or controlled by the enterprise and thus are included in inventory analysis. The organizational boundaries may account for emissions according to an equity share in the enterprise associated with the respective operations (e.g., equity share approach) or with respect to the aspects of the enterprise that the enterprise may control (e.g., control approach). By way of example, the control approach may include financial control or operational control.

Operational boundaries determine which operations and sources generate emissions, associate sources for inventory, and explanations with regard to how the sources are classified. In some cases, the operational boundaries may attribute emissions as direct emissions and indirect emissions. With this in mind, certain organizations evaluate sustainability by tracking their emissions effectively as direct emission and indirect emissions. This tracking may help the sustainability platform system **72** understand hotspots for the enterprise and subsequently develop carbon footprint reduction plans and subsequent business strategy/future investment. In this way, the sustainability platform system **72** may help companies across a wide range of solutions in the hard-to-abate industries starting from measuring emissions to verifying and reporting. Subsequently, the sustainability platform system **72** may help them in their decarbonization pathway through the engineering capabilities accessible via the platform as described herein.

In some embodiments, the screening system **144** may perform some technical analysis with respect to overall or high-level system perspectives to determine a relative effectiveness of implementing or conducting sustainability improvement operations on the enterprise. The screening system **144** may then use the high-level analysis to coordinate with other engineering workflow systems **78** to determine suitable action plans **90** that may be beneficial for the enterprise.

In the same manner, the economic system **146** may provide economic or financial data related to the operational costs of the enterprise, economic considerations for improving sustainability parameters for the enterprise, and the like. In this way, the economic system **146** may provide some insight into economic cost benefits for implementing certain action plans **90**. In addition, the economic system **146** may coordinate with engineering workflow systems **78** to assess costs for performing certain tasks and/or for determining the economic feasibility of certain action plans **90**.

The optimization system **148** may determine or analyze optimization parameters for performing certain action plans **90**. For instance, the optimization system **148** may determine optimization parameters for reducing cost per carbon in decarbonization plans. In any case, the strategy level planning systems **142** may assist the sustainability platform system **72** to perform economic analysis to perform operations such as selecting action plans **90**, engaging engineering workflow systems **78**, selecting input data sources **74**, and the like when determining or implementing action plans **90** or performing other suitable operations.

By coordinating the various components described in FIG. **2** and throughout the application, the sustainability platform system **72** may provide a seamless integration and understanding with ESG scoring and reporting tools, which are designed to assess and measure the sustainability and societal impact of companies and investments. As such, the sustainability platform system **72** may help organizations evaluate their performance in key ESG areas and provide transparent reporting to stakeholders.

Further, it should be noted that although the embodiments described herein are detailed with respect to existing enterprise operations, in some embodiments, the sustainability platform system **72** may be used in earlier phases of business development such as field development planning. That is, field development planning may include facility and infrastructure planning operations for building new facilities in various industries. The sustainability platform system **72** and the methods described herein may be incorporated into the field planning operations to account for sustainability parameters in the field development plans.

It should be noted that the sustainability platform system **72** illustrated and described above with respect to FIG. **2** corresponds to one embodiment in which the sustainability platform system **72** may be implemented. However, the sustainability platform system **72** may also be implemented in accordance with other structures. For instance, the engineering workflow systems **78** may be part of the sustainability platform system **72** as a layer for performing analysis operations. The sustainability platform system **72** may also include other layers of operations such as digital foundation services, data infrastructure, and the like. Moreover, while certain aspects of FIG. **2** are shown as individual elements for data flow purposes, there may or may not be a physical, logical, and/or computational distinction therebetween. For example, in some embodiments, the sustainability platform system **72** may be considered as distinct from or to include the at least a portion of the engineering workflow systems **78**, at least a portion of the sustainability database **94**, at least a portion of the workflow database **140**, and/or at least a portion of the input data sources **74**.

To perform the operations described herein, the sustainability platform system **72** may include a number of components to assist in processing, analyzing, collecting, and communicating data in accordance with the presently disclosed embodiments. With this in mind, FIG. **3** illustrates example components of the sustainability platform system **72**. As shown in FIG. **3**, the sustainability platform system **72** may include a communication component **152**, a processor **154**, a memory **156**, a storage component **158**, input/

output (I/O) ports **60**, a display **162**, and the like. The communication component **152** may be a wireless or wired communication component that may facilitate communication between different monitoring systems, gateway communication devices, various control systems, and the like. The processor **154** may be any type of computer processor or microprocessor capable of executing computer-executable code. The memory **156** and the storage component **158** may be any suitable articles of manufacture that can serve as media to store processor-executable code, data, or the like. These articles of manufacture may represent non-transitory computer-readable media (i.e., any suitable form of memory or storage) that may store the processor-executable code used by the processor **154** to perform the presently disclosed techniques. The memory **156** and the storage component **158** may also be used to store data received via the I/O ports **160**, data analyzed by the processor **154**, or the like.

The I/O ports **160** may be interfaces that couple to various types of I/O modules such as sensors, programmable logic controllers (PLC), and other types of equipment. For example, the I/O ports **160** may serve as an interface to pressure sensors, flow sensors, temperature sensors, and the like. As such, the planning system **150** may receive data associated with a well via the I/O ports **160**. The I/O ports **160** may also serve as an interface to enable the planning system **150** to connect and communicate with surface instrumentation, servers, and the like.

The display **162** may include any type of electronic display such as a liquid crystal display, a light-emitting-diode display, and the like. As such, data acquired via the I/O ports and/or data analyzed by the processor **154** may be presented on the display **162**, such that the planning system **150** may present designs for hydrocarbon sites (e.g., of a hydrocarbon production system **10**) for view. In certain embodiments, the display **162** may be a touch screen display or any other type of display capable of receiving inputs from an operator. Although the sustainability platform system **72** is described as including the components presented in FIG. **3**, the sustainability platform system **72** should not be limited to including the components listed in FIG. **3**. Indeed, the sustainability platform system **72** may include additional or fewer components than described above.

With the foregoing in mind, FIG. **4** illustrates a method **170** for generating a sustainability report for enterprise operations in accordance with embodiments presented herein. Although the following description of the method **170** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources and engineering workflow systems may perform the method **170** in any suitable order.

Referring now to FIG. **4**, at block **172**, the sustainability platform system **72** may receive enterprise facility data and enterprise production data. The enterprise facility data may include information regarding the structures owned, leased, or used by the enterprise. As such, the facility data may include information related to the building **56**, such as the type of light bulbs employed it the building, the type of heating and air conditioning systems employed at the building **56**, the business hours of the building **56**, and the like. In some embodiments, the facility data may be provided via the corporate data sources **110**.

The enterprise facility data may also include invoice or financial information related to the costs or resource consumption of the buildings **56**. For instance, the facility data may include energy costs, type of energy used, water consumption data, waste costs, and the like as gleaned from invoices provided to the enterprise. In addition, the enterprise facility data may include real time data from IoT devices **44** that may monitor resource consumption data such as watt-hours, water flow, waste weight, and the like.

In some embodiments, the enterprise facility data may include operational schedules for employees such as days that the employee works in the office, days that the employees work from home, addresses of employees, types of transportation utilized by employees, and the like. In this way, the employee travel to the buildings may be accounted for in the sustainability parameters.

The enterprise production data may include information regarding processes and systems employed for manufacturing, processing, and producing products for the enterprise. In the hydrocarbon production system **10** example above, the enterprise production data may include information related to the equipment in each facility used to extract, transport, store, process, and distribute hydrocarbons. As such, the information may also include operational information with regard to the manner in which the equipment is operated or used, the arrangement of the equipment, the emissions of the equipment, and the like.

In some embodiments, the equipment may provide data in real time using IoT devices **44** or directly communicating with the sustainability platform system **72**. The real time data may include temperature data, energy consumption data, water consumption data, waste production data, run time, operational schedules (e.g., times equipment is operating), and the like. In addition, the enterprise production data may include cost or invoice data for raw materials, energy, waste disposal, and the like.

It should be noted that the description of the enterprise facility data and the enterprise production data may include other data types not listed above. However, in general, the enterprise production data may provide data related to the sustainability parameters associated with performing core manufacturing or production processes. On the other hand, the enterprise facility data may correspond to data related to support services for performing business and engineering tasks associated with planning, preparing, and distributing products produced by the production operations of the enterprise.

At block **174**, the sustainability platform system **72** may receive financial data for raw materials used for enterprise operations. The enterprise operations may include maintaining business and production operations related to the enterprise facility data and the enterprise production data. The raw materials may include energy consumption, water usage, waste services, and other sustainability parameters. The financial data may provide information regarding invoices, rates for energy consumption, and the like. In some embodiments, the financial data may also include costs related to sustainability equipment, such as carbon capture technology, used to improve sustainability parameters.

At block **176**, the sustainability platform system **72** may receive greenhouse gas (GHG) emission data for the enterprise operations. The GHG emission data may be provided by or determined based on real time data acquired by real-time sources **108**, the image acquisition sources **102**, corporate data sources **110**, manual sources **112**, and the like. In some embodiments, the marketplace sources **104** and the third-party sources **106** may provide information related to the GHG emission data. That is, these sources may model or generate expected GHG emission data for the enterprise operations based on simulations, monitored data, or the like.

At block **178**, the sustainability platform system **72** may receive IoT data for the enterprise operations from any suitable IoT device **44**. As such, the IoT data may represent real time data regarding current operational and consumption parameters for devices within a structure of the enterprise, equipment used within the enterprise, and the like. The IoT data may provide insight into equipment and facility devices that may be adjusted to improve sustainability parameters for the enterprise. Moreover, the IoT data may provide feedback data with regard to how implemented action plans **90** are affecting the sustainability parameters for the enterprise.

At block **180**, the sustainability platform system **72** may identify a suitable reporting format to generate a sustainability report associated with the enterprise operations. The sustainability reporting format may be associated with a geographical location of the equipment, facilities, and operations of the enterprise. As such, the enterprise data may provide indications with regard to the regions or countries in which various aspects of the enterprise operations are undertaken. Based on these locations, the sustainability platform system **72** may query the sustainability database **94** or other suitable storage component to determine the reporting format used for the respective regions. That is, some regions or governmental agencies request reports regarding the sustainability parameters of the enterprise over the course of time. The reporting formats may include types of sustainability parameters to report, units in which the sustainability parameters are to be reported, a time period in which the sustainability parameters are to be reported, hierarchical levels in which to organize the sustainability parameters, an organizational structure to organize aggregated data, and the like. In addition, the sustainability platform system **72** may retrieve previously provided or produced reports **92** to determine the suitable reporting format. That is, the previously produced reports **92** may be scan and scraped to determine the sustainability parameters that are to be reported, along with other details with regard to the manner in which to report the sustainability parameters.

At block **182**, the sustainability platform system **72** may aggregate or organize the data received at blocks **172**, **174**, **176**, and **178** into appropriate data values in accordance with the reporting format determined at block **180**. In some embodiments, the sustainability platform system **72** may also organize data with respect to different hierarchical levels of operations such as a facility level, a region level, a city level, a country level, and other geographically based levels. In addition, the sustainability platform system **72** may aggregate the data based on operations for facility operations and production operations. Further, the sustainability platform system **72** may aggregate or group the collected data into a variety of types of subsets of data, such that each subset of data may be packaged and sent to any of the engineering workflow systems **78** for analysis. Indeed, the engineering workflow systems **78** may request a particular type of data in a particular format or grouping, and the sustainability platform system **72** may subsequently package the relevant data accordingly and transmit it to the requesting engineering workflow system **78** for analysis. Moreover, the user input received via the manual source **112** may provide reporting format request in which the sustainability platform system **72** may organize the collected data. In some embodiments, the sustainability platform system **72** may organize the aggregated data according to an organizational structure that may distribute datasets in particular organizational levels or hierarchies to allow the enterprise to evaluate the respective aggregated datasets in various manners.

As such, the sustainability platform system **72** may aggregate or organize the collected data, such as the enterprise facility data and the enterprise production data, into various hierarchical levels to perform appropriate analysis within the respective hierarchies. The hierarchical levels may relate to physical levels, logical levels, or a hybrid of both depending on an associated organizational structure specified for the enterprise. That is, the collected data may be organized at a work unit level within a facility, a facility level to cover the operations within the facility, a city level to cover the operations performed by facilities in a city, and so on.

Based on the aggregated data, at block **184**, the sustainability platform system **72** generated the sustainability report for the enterprise data based on the aggregated data and the suitable reporting format. In some embodiments, the sustainability report may be a dynamic, interactive report that may include visualizations that may be selected by user input and may cause the respective computing device to provide additional information related to the selection. In this way, the sustainability report may provide layers of information related to the sustainability parameters of the enterprise that correspond to different modular views of the enterprise.

At block **186**, the sustainability platform system **72** may send the sustainability report (e.g., report **92**) to a suitable computing device. That is, the sustainability platform system **72** may send the sustainability report to a user's device associated with a user that requested the sustainability report. Additionally, the sustainability platform system **72** may send the sustainability report to a computing device, website, or database associated with an agency or organization that provided information regarding the reporting format.

After receiving sustainability report, the respective computing device may cause an application to open or be executed regardless as to whether the computing device is in a sleep or low power mode. That is, the reception of the sustainability report may cause the computing device to perform some other action to cause a notification related to the sustainability report being received to be generated. The notification may include a visual notification, an audible notification, a haptic notification, or the like.

By enabling the sustainability platform system **72** to aggregate and group the collected data into various formats and structures, the sustainability platform system **72** may be able to use more modular processes to determine methods for improving different types of sustainability parameters at various hierarchical levels. Indeed, the aggregated data may be provided in parallel to different engineering workflow systems **78** in parallel, such that different systems may analyze the respective datasets to determine action plans **90** more efficiently. Further, the sustainability platform system **72** may compare distinct solutions and recommendations provided by different engineering workflow systems **78** with respect to the respective sustainability parameter being addressed.

It should also be noted that by starting with the broad scope of information in the method **170**, the sustainability platform system **72** may enable a user or machine learning algorithm gain insight into broad or larger scale sustainability parameters differences to help determine where improvements may be found. That is, if a certain region of the enterprise operations produces more desirable sustainability parameters as compared to another, the sustainability platform system **72** may then provide drilled down information related to the equipment or facility data to identify the operational differences that account for the improved sustainability parameters.

After generating the sustainability report, the sustainability platform system **72** may determine action plans **90** for improving one or more types of sustainability parameters. FIG. **5** illustrates a method **190** for generating a sustainability action plans for enterprise operations in accordance with embodiments presented herein. Although the following description of the method **190** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources and engineering workflow systems may perform the method **190** in any suitable order.

Referring now to FIG. **5**, at block **192**, the sustainability platform system **72** may receive the sustainability report for the enterprise. The sustainability report may be generated as described above with respect to FIG. **4** or may be provided as a data file with the relevant information organized in ERP reports, spreadsheets, publications, or the like. It should be noted that the data included in the sustainability report may include economic data that may be provided by the strategy level planning systems **142** as described above. As such, the sustainability report may include economic information related to cost functions for various sustainability variables and other parameters related to implementing action plans **90**, evaluating input data sources **74** or engineering workflow systems **78**, or the like. As such, an economic analysis may be initiated before the action plans **90** are determined to consider forecasted business activities, technology costs, and other prioritized areas.

At block **194**, the sustainability platform system **72** may generate one or more sustainability models for the enterprise based on the received sustainability report. In some embodiments, the sustainability model may be formulated by or contained within a machine learning model that detects patterns, trends, correlations, and other similarities between different datasets. As such, the sustainability model may provide sustainability parameter changes over time for different types of sustainability parameters with respect to different variables. For instance, an aspect of the sustainability model may include tracking operational parameters of facility operations and production operations with respect to GHG emissions. The sustainability platform system **72** may generate a sustainability model for the enterprise with respect to each different type of sustainability parameter or a combined sustainability model including multiple sustainability parameters. In some embodiments, the sustainability platform system **72** may generate a particular sustainability model based on a request from one or more of the engineering workflow systems **78**, based on user input, or the like.

The sustainability model may be a data model that defines structures, relationships, and constraints of the sustainability parameters with respect to the facilities, hierarchies, operations, or other components of the enterprise. Moreover, the initial sustainability model may include one or more currently implemented action plans (e.g., methods of operation of the enterprise). By way of example, the data model may be a conceptual data model, a logical data model, a physical data model, or the like. As should be appreciated, an organizational unit of an enterprise (e.g., delineated by region, business line, corporate entity, organizational or operational boundaries, facility, etc.) may be characterized by a single sustainability model. However, multiple action plans may be implemented, at one or more levels within a single organizational unit. Moreover, the organizational unit may be reevaluated to include different portions of the enterprise with corresponding action plans for the components thereof maintained at the desired component level. As more data is collected over time, the data model may be updated to include time references and may be used to generate a machine learning model for the sustainability parameters. Although in some embodiments the sustainability platform system **72** may not generate the sustainability model to perform the method **190**, the generated sustainability model may enable the sustainability platform system **72** to perform various analysis and processing operations in a more computationally efficient manner as compared to using the sustainability report.

At block **196**, the sustainability platform system **72** may receive sustainability target data. The sustainability target data may include GHG emission limits, water usage limits, waste production limits, and other measurable sustainability parameter limits or ranges. In some embodiments, the sustainability target data may be determined by querying governmental regulations provided by the corporate data sources **110**, accessible online, or the like. In addition, a user may define the sustainability target data via manual input. Further, the sustainability target data may include generic provisions to continually identify improvements in sustainability parameters. Moreover, the sustainability platform system **72** may determine sustainability target data based on achievements or goals detected in other enterprises similar to the respective enterprise.

At block **198**, the sustainability platform system **72** may determine whether the sustainability parameters for the enterprise as indicated in the sustainability report or generated sustainability model are acceptable in view of the sustainability target data. If the sustainability parameters are acceptable, the sustainability platform system **72** may return to block **192** and continue monitoring for updated sustainability reports.

If, however, the sustainability parameters are not acceptable, the sustainability platform system **72** may proceed to block **200** and identify an engineering workflow system **78** to address the unacceptable sustainability parameters. That is, as mentioned above, each of the engineering workflow systems **78** may provide action plans or recommendations to address particular sustainability parameters, particular aspects or operations of the enterprise, or the like. As such, the sustainability platform system **72** may determine whether one of the engineering workflow systems **78** is suited to address the unacceptable sustainability parameters. In some embodiments, each of the engineering workflow systems **78** may identify sustainability parameters that are associated with its respective analysis. The sustainability platform system **72** may then identify the one or more engineering workflow systems **78** that may be suitable to improve respective sustainability parameters. In some embodiments, the sustainability platform system **72** may broadcast the request for improved sustainability parameters to each of the engineering workflow systems **78**, which may then determine whether the respective analysis performed by the respective system may provide any support to achieve the sustainability target data. It should be noted that the broadcast may also be provided to the strategy level planning systems **142** to assess economic analysis context for action plans **90**, solutions provided by the engineering workflow systems **78**, or other related tasks that may be implemented for improving sustainability parameters.

After identifying suitable engineering workflow systems, the sustainability platform system **72** may, at block **202**, send the sustainability model and the sustainability target data to the identified engineering workflow system(s) **78**. In some embodiments, the sustainability platform system **72** may send portions of the sustainability model, as opposed to the entire sustainability model, to accommodate the analysis operations performed by the respective engineering workflow system **78**. In this way, the sustainability platform system **72** may reduce the amount of data that is transmitted across a network to improve network latency. Further, the engineering workflow system **78** that receives the modified sustainability model may efficiently process the received data without analyzing or reviewing data that may be irrelevant to its operations. Further, it should be noted that the sustainability platform system **72** may send multiple sustainability models or portions thereof to multiple engineering workflow systems **78** in parallel. As such, the various engineering workflow system **78** may perform their respective analysis operations in parallel, thereby improving the efficiency in which the sustainability platform system **72** may receive recommendations.

After receiving the sustainability model (or equivalent datasets), the respective engineering workflow system **78** may compare the data present in the sustainability model to other datasets that it tracked, stored, or modeled. The respective engineering workflow system **78** may then identify solutions or action plans that other enterprises have implemented or determine unique solutions for the enterprise based on its core functions. For example, the engineering workflow system **78** may receive information related to the operational schedule of the facility operations and production operations, model modifications to these operations over time, and determine suitable operational modifications that may assist the enterprise in achieving respective sustainability target data.

By way of example, the action plans provided by the engineering workflow systems **78** may provide operational recommendations to reduce GHG emissions for the facility operations, the production operations, or both. That is, the action plan may include recommendations with regard to operating field devices in the production operations differently to reduce carbon emissions. Further, a recommendation may include providing a carbon capture device at a facility to reduce carbon emissions and provide a location or entity to receive the captured carbon for reinjection operations. In addition, the recommendations may include reducing the amount of emissions flared when it is determined that some emissions can be directed to the capture technology to achieve the sustainability goals.

In some embodiments, the action plans may include recommendations that may provide an initial improvement in sustainability parameters, such as recommendations to change lights in facilities to light emitting diode technology, which consumes less energy compared to other light sources. However, after making this change, the effect on sustainability parameters to achieve net zero goals are limited because the gain is achieved immediately. As such, the action plans may project different operations and technologies to use over time to continue to enable the enterprise to achieve improved sustainability parameters.

At block **204**, the sustainability platform system **72** may receive the recommendations or generated action plans from the respective engineering workflow systems **78**. In some embodiments, the recommendations or action plans may include operational changes (e.g., equipment operation schedule change to operate at certain times when renewable sources of energy are available) for devices in the facility operations, the production operations, or both. In addition, the recommendations or action plans may include equipment changes that may involve replacing equipment with more efficient equipment, adding equipment that may not be previously present (e.g., carbon capture), identifying business partners to purchase carbon credits or exchange services, and the like.

At block **206**, the sustainability platform system **72** may send commands to devices within the enterprise to implement the action plan **90**. As such, IoT devices **44** may adjust respective operations of other devices to implement the recommended actions provided in the action plan **90**. In some embodiments, the action plans provided by the various engineering workflow systems **78** may be evaluated by the sustainability platform system **72** to determine whether each of them can be implemented with one another. Further, the action plans may be evaluated with respect to budgetary constraints and other constraints. The sustainability platform system **72** may select a combination of the provided action plans to use to generate commands based on the combination that suits the interests and constraints of the enterprise. These decisions may be made based on an optimization algorithm perform by the sustainability platform system **72**, user input received by the sustainability platform system **72**, or the like.

In some embodiments, the action plans **90** may be stored in the sustainability database **94** for analysis or retrieval at another time. In this way, the sustainability platform system **72** may evaluate action plans **90** prior to sending the sustainability model to engineering workflow systems **78** to identify recommendations more efficiently if the respective action plans **90** are applicable.

To help further illustrate, FIG. **6** is an example flow diagram of a sustainability platform system **72** receiving information, such as via one or more input data sources **74** or modules to determine output controls and/or instructions of one or more action plans **90** to optimize for different sustainability variables. In some embodiments, the input data sources **74** may be grouped by data type or source. For example, a sustainability management module may provide information regarding baseline sustainability parameters (e.g., carbon footprint, waste levels, water usage), a carbon capture module may provide information regarding current mitigation of sustainability parameters, and a capital planning module may provide input on the financial constraints and viability of certain actions and/or compliance parameters. Additionally, the sustainability platform system **72** may identify suitable engineering workflow systems **78** based on the expected outputs provided by those respective systems to generate the action plan(s) **90**. For example, the sustainability platform system **72** may utilize different engineering workflow systems **78** to provide instructions or control signals for heat and power operations (e.g., via a combined heat power module), for flaring control (e.g., via a flaring module), for methane control (e.g., via a methane module), and/or for other operations of the enterprise. Although FIG. **6** focuses on carbon-oriented workflows and variables, it should be understood that in other embodiments the sustainability platform system **72** may coordinate activities with modules that focus on water, waste, energy, and other suitable sustainability parameters.

Furthermore, the sustainability platform system **72** may receive sustainability parameter data such as water data and emission data in different scopes or hierarchical levels. For example, scope 1, scope 2, and scope 3 emission data (e.g., as defined by the EPA) may be obtained and considered when evaluating the enterprise sustainability model. In some embodiments, the sustainability platform system **72** may coordinate with the engineering workflow systems **78** such as a methane management system, a flaring management system, a combined heat and power optimization system, a carbon capture system (CCS), and/or an agriculture system. Based on the result provided by the engineering workflow systems **78**, the sustainability platform system **72** may evaluate the provided action plans **90** with different planning modules or systems to perform different respective analysis operations, such as via the planning block **86** (e.g., planning module). For instance, the sustainability platform system **72** may determine decarbonization pathways, decarbonization financial planning, and product carbon footprints based on the received action plans, measurement data, or both. The decarbonization pathways may indicate one or more operational or business changes (e.g., work from home policies) to improve carbon emissions across the enterprise. The decarbonization financial planning (e.g., via the strategy level planning systems **142**) may account for the costs associated with implementing the various action plans. The product carbon footprint may provide an indication of the expected carbon footprint associated with producing the product. As mentioned above, the product carbon footprint may capture a total amount of carbon emissions associated with the production of various products to the end of the lifecycle of the product. In this way, the decarbonization pathways that may be part of the action plans **90** may provide multiple scenarios of carbon emission reduction plans to meet emission goals for the enterprise while continuing to support business activities.

Keeping the foregoing in mind, FIG. **7** illustrates a method **220** which the sustainability platform system **72** may simulate sustainability action plans **90** over a period of time for analysis, in accordance with embodiments herein. Although the following description of the method **220** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources and engineering workflow systems may perform the method **220** in any suitable order. As such, it should be noted that the embodiments described below may be performed via the planning block **86** or via a respective engineering workflow system **78**.

Referring now to FIG. **7**, at blocks **222** and **224**, the sustainability platform system **72** may receive the sustainability model and the sustainability target data as described above with reference to FIG. **5**. At block **226**, the sustainability platform system **72** may receive sustainability variable data associated with the sustainability target data. That is, the sustainability variable data may refer to one or more sustainability parameters that make up part of the sustainability target data or a variable in which the sustainability platform system **72** is requested to optimize. In some embodiments, the sustainability target data may include energy, emissions, water, and waste objectives. As an example, a user may select to optimize for the emissions portion of the sustainability target data, and the emissions may be the sustainability variable data received at block **226**.

In some embodiments, the sustainability platform system **72** may receive multiple sustainability variable datasets for optimization and may identify multiple engineering workflow systems **78** to coordinate with to determine action plans **90**. By evaluating each sustainability variable data in isolation, the sustainability platform system **72** may identify solutions in parallel and present action plans **90** that optimize for different sustainability variables to provide a user more context to make a selection of the generated action plans **90**.

At block **228**, the sustainability platform system **72** may generate an enterprise sustainability variable model based on the sustainability variable data and the sustainability model received at block **222**. That is, the sustainability platform system **72** may isolate a portion of the sustainability model that captures correlations and patterns related to the sustainability variable. In this way, the enterprise sustainability variable model may include a subset of data to allow the respective analysis component to efficiently process the respective subset of data, as opposed to filtering through datasets that may not be relevant for its analysis.

At block **230**, the sustainability platform system **72** may query the sustainability database **94** to determine whether other sustainability variable models stored in the sustainability database **94** have matching patterns. That is, the sustainability platform system **72** may compare the sustainability variable datasets across multiple sustainability variable models and identify any matching sustainability variable datasets. The matching datasets may correspond to a period of time or correspond to an improvement in the sustainability variable datasets, such as from previously determined sustainability models and action plans **90**. The sustainability platform system **72** may identify similarities in the emission sources, the scale of emission reductions desired, the location and environment of the enterprise or portion thereof between the present sustainability variable data and that of other sustainability variable models. As such, if the sustainability platform system **72** identifies matching datasets, the matching sustainability variable model may provide insights into action plans **90** that may be implemented by the respective enterprise to improve the sustainability variable parameters. Such insights may further increase the efficiency of the sustainability platform system **72**, reducing computational complexity and/or reducing computation time. Additionally, in some embodiments, the sustainability database **94** may be structured (e.g., tabulated, tagged, or otherwise delineated) according to potential similarities for more efficient queries. For example, the sustainability models (e.g., sustainability variable models) of the sustainability database **94** may include metadata associated with emission sources, emission scale, organizational scale, geographical location, and/or environment.

Returning to block **230**, querying a database of existing sustainability models may be performed based on one or more parameters within the sustainability database **94**. For example, querying may be based on similarities in emission sources to address one or more specific issues with of the current sustainability model. Moreover, in some embodiments, queries may include minimum success criterion that were achieved by the matching sustainability model (e.g., matching sustainability variable model). For example, emission reduction for a particular sustainability model must have met or exceeded an emission reduction target in order for the sustainability model to be matched with the current sustainability model.

Additionally or alternatively, the query may also examine the scale of the emission reduction in addition to matching emission sources. For example, sustainability models at different granularities within an enterprise (e.g., operations within a region versus operations at a particular facility) may be selected and optimized according to the emission sources they address and the scale of the emission reduction they provide. Indeed, an action plan **90** for a set of multiple facilities in a region producing a relatively large amount of emissions may have a higher correlation to another set of multiple facilities having the same order of magnitude of emissions than a single facility or set of multiple facilities having a relatively small amount of emissions (e.g., by one or more orders of magnitude). However, if no match at the same organizational unit size is found, in some embodiments, the query may return one or more action plans for smaller organizational unit sustainability models that match other query parameters. Such action plans may be aggregated to form an action plan for the generated sustainability variable model.

Additionally or alternatively, regional location and environmental (e.g., offshore versus onshore) parameters can also be incorporated into the query. For example, sustainability models within the sustainability database **94** may be correlated to a location where technology availability, costs, and regulations have impacted the simulation (e.g., optimization) of an action plan **90** and sustainability model. Correlating such parameters during querying may enable the suitability of sustainability models within the sustainability database **94** to be based on real world constraints, in addition to the anticipated emissions impact of the actions within the sustainability model.

With this in mind, at block **232**, the sustainability platform system **72** may determine whether matching patterns or datasets have been identified. The matching datasets may correspond to certain measurement values within some threshold (e.g., +/−5%, +/−10%, +/−20%, +/−50%), desired trends in the sustainability variable data (e.g., decrease in GHG emissions over time), or any other characteristic that may provide insight into improving a respective sustainability variable parameter.

If the sustainability platform system **72** identifies a matching pattern or desired effect, the sustainability platform system **72** may proceed to block **234** and determine a suitable sustainability action plan **90** based on the matching sustainability variable model. The matching sustainability variable model may be associated with an enterprise of the same industry type, a different industry type, a same regional location, a different location, or the like. The sustainability platform system **72** may retrieve the matching sustainability variable model and determine the action plans **90** implemented by the respective enterprise to achieve the results illustrated in the matching variable model. In some embodiments, the matching sustainability variable model may include a list of operational commands, operational schedules, types of equipment used, and other information that may be associated with the sustainability variable parameter.

Based on the sustainability action plans associated with the matching sustainability variable model, the sustainability platform system **72** may, at block **236**, simulate implementing the sustainability action plan over a period of time (e.g., months, years, decades) for the enterprise of the generated enterprise sustainability variable model. That is, the sustainability platform system **72** may simulate (e.g., via machine learning algorithms) the effects of the determined action plan(s) **90** in the context of the sustainability variable data to predict the effects of implementing the sustainability action plans **90** over a course of time for the enterprise. The simulation may perform an optimization of the sustainability variable data in the context of the input data (e.g., from the input data sources **74**) to generate a simulated sustainability variable model or full sustainability model for the enterprise. For example, cost data accurate for the location and scale of deployment in the original sustainability variable model (as opposed to that of the matched sustainability variable model) may be utilized in the simulation to determine emission reduction estimates for the newly simulated sustainability model. Indeed, the simulations may include capital expenditure data related to the costs for implementing the action plan **90** over time, the sustainability variable parameter effects over time, and the like. In this way, users may realize the benefits of implementing the action plan **90** over the life of the facility operations, the production operations, or both.

At block **238**, the sustainability platform system **72** may determine whether the simulated sustainability variable data achieves the sustainability target goals indicated in the sustainability target data. If the sustainability target goals are achieved, the sustainability platform system **72** may proceed to block **240** and send the sustainability action plan **90** to the computing device associated with the enterprise for implementation or evaluation in accordance with embodiments described above. However, if the simulated sustainability variables do not achieve the sustainability target goals, or if there were no matching sustainability variable models, the sustainability platform system **72** may proceed to block **242**. As should be appreciated, and as discussed further below with regard to FIG. **9**, the sustainability platform system **72** may verify that the respective action plan **90** indeed causes the enterprise to achieve sustainability goals defined by the sustainability target data. For example, a specific action plan **90** may provide acceptable sustainability parameters at a particular facility, but still fail to be acceptable for the enterprise as a whole, when extrapolated and aggregated with the rest of the enterprise data. As such determining whether the simulated sustainability variables are acceptable may also include evaluating the simulated action plan **90** along with enterprise data representative of the enterprise as a whole to determine whether the corresponding sustainability parameters are acceptable or achieve the goals set by the sustainability target data.

At block **242** and block **244**, the sustainability platform system **72** may send the sustainability variable model or the simulated sustainability variable model to an appropriate engineering workflow system **78** or to multiple engineering workflow system **78** and receive a sustainability action plan **90** from the engineering workflow system(s) **78**. That is, one or more of the engineering workflow systems **78** may affect the same sustainability variable parameter. As such, the engineering workflow systems **78** may analyze the received sustainability variable model and perform similar operations described in blocks **202** and **204** of the method **190** to determine operational changes or equipment changes to improve the respective sustainability variable data.

The engineering workflow system(s) **78** may provide a finer grain analysis of potential changes (e.g., optimization) to the sustainability variable parameter than the query that matches patterns at the organizational unit level. For example, an engineering workflow system **78** may utilize a facility level planner (e.g., Facility Planner on Delfi, Symmetry process software platform, Flaresim, FDPlan, and/or Drillplan on Delfi, available via Schlumberger Limited or other facility level planners) to optimize physical placement of, sizing of, number of, and/or operational characteristics of wells **22**, separators **42**, storage tanks **43**, pipelines **38**, flares, engines, motors, energy sources (e.g., solar panels, wind turbines, etc.) and/or other components of a facility. Moreover, an engineering workflow system **78** may utilize a facility level planner to optimize individual components of a single facility or multiple facilities (e.g., in parallel) of the sustainability variable model. Once the sustainability platform system **72** may receive the generated action plans **90** from the engineering workflow systems **78** and proceed to block **236** to simulate the effects of implementing the sustainability action plans **90** over the course of time for the enterprise and continue the method **220**.

If the simulated action plan **90** of block **236** is determined to have acceptable sustainability variables (e.g., at block **238**), the action plan **90** may be sent to the enterprise system, as in block **240**. As should be appreciated, when implemented, the new action plan **90** changes the sustainability model to an updated sustainability model. In some embodiments, the old sustainability model may be noted in the sustainability database **94** as being superseded, such as to reduce weightings therefore or insight therefrom for potential matching when querying for future matches, such as in block **230**. For example, future querying may ignore sustainability models designated as superseded. Moreover, the updated sustainability model may be added to the sustainability database **94** for such future queries.

As discussed above, the sustainability platform system **72** may utilize information from one or more input data sources **74** to build a sustainability report **92**, generate a sustainability model (e.g., at block **194** of method **190**, at block **228** of method **220**, etc.), and develop an action plan **90**. For example, to generate and/or implement an action plan **90**, data from certain data sources (e.g., input data sources **74**) may be useful for determining and/or performing the operations of the action plans **90** and/or for gauging the viability or effectiveness of an action plan **90**. However, in some scenarios, some information such as sustainability parameters associated with structures (e.g., building utilities), tools (e.g., fuel consumption, electricity consumption, etc.), and other operations of the enterprise may be unavailable or outdated. As such, the sustainability platform system **72** may estimate the missing data from the data available and/or simulate the missing data based on a current, previous, or matched sustainability model.

FIG. **8** illustrates a flow chart of a method **248** for simulating missing data. Although the following description of the method **248** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources may perform the method **248** in any suitable order. At block **250**, the sustainability platform system **72** may receive a sustainability model of an enterprise and/or one or more currently implemented action plans **90** that detail operations or equipment of the enterprise. Additionally or alternatively, a request for additional information, such as via manual entry by a user, may be received to initiate the method **248**. Furthermore, at block **252**, the sustainability platform system **72** may identify the data sources for measuring the sustainability parameters for the respective action plans **90**. For example, identification of data sources may be linked to the specific actions (e.g., workflows) detailed in the current or proposed action plan **90**. Based on the different metadata associated with each action, an appropriate data source may be found. In other words, the sustainability platform system **72** may match metadata that is associated with actions of an action plan **90** with a sustainability model and assign that metadata to a type of data source. For example, actions involving vented methane reduction may utilize data sources pertaining to the frequency and duration of venting across a facility or pipeline network, the volume of gas released during each venting period, either as a total volume or as a rate per unit of time, and/or the pressure of the network components connected to the vent site (as additional technological improvements may need to be made in order to reduce high pressure events and reduce the frequency of venting), amongst others. Furthermore, actions involving switching fuel sources for artificial lifting operations may include sources pertaining to the amount of fuel consumed per operation, either as a total volume or volume per unit of time, the cost associated with fuel consumption per operation, the proportion of fuel source in the overall energy supply to the operation, and/or the efficiency of pumps and other equipment that consumes the fuel, amongst others. Action metadata to assist with data source identification may include the type of industry modeled, value chain segment and subsegment, geography, environment (e.g. onshore, offshore), process engineering workflow, business model or source of revenue and operating procedure or process.

Additionally, at block **254**, the sustainability platform system **72** may identify any missing data sources that may be useful to perform the respective action plans **90**. For example, the sustainability platform system **72** may compare the identified data sources (e.g., from block **252**) with the input data sources **74** available to the enterprise or the sustainability platform system **72**. In some embodiments, the missing data sources may be identified based on the enterprise data described above with reference to FIG. **4**. Such missing data sources may include equipment information, production scheduling information, or any operational data related to the facility operations, the production operations, or the like. In addition, the missing data sources may also include datasets that have been received or are accessible to the sustainability platform system **72** but do not appear to be accurate or are associated with confidence values that are lower than a threshold. Indeed, some datasets may be expected to be available but are not present for analysis by the sustainability platform system **72** may be designated as missing data sources. By identifying the missing data sources, the sustainability platform system **72** may enable the users to focus efforts on updating or adding data sources to allow the respective action plans **90** to be implemented and baseline sustainability parameters to be calculated.

To identify the missing data sources, in some embodiments, the sustainability platform system **72** may utilize a logic component or machine learning module to match expected data sources to action plan metadata. Additionally or alternatively, the sustainability platform system **72** may identify gaps where no data source is found for a corresponding action plan metadata and/or identify gaps where either interval or real time data is missing from an existing data source. Moreover, the sustainability platform system **72** may identify gaps where a dependency required for transformation or computation of the raw data from the data source is missing. For example, an emissions factor, which may be used for transforming raw cost data into CO_2 emissions for a component of the enterprise, may have been deleted or found to be missing and, therefore, a missing data source may be identified based thereon.

At block **256**, the sustainability platform system **72** may send the missing data sources to a computing system associated with a user of the enterprise. For example, the missing data sources may be provided as a notification to the computing system and cause the computing system to automatically present the notification via an alert or the like as described above. For example, missing data sources may be supplemented by information input by a user in response to an alert/notification of certain missing data (e.g., missing data sources).

For data not supplemented by a user, or if block **256** is skipped or ignored (e.g., after a period of time), the sustainability platform system **72** may, at block **258**, simulate the missing data from the identified missing data sources, such as based on the current sustainability model and/or other sustainability models. That is, the sustainability platform system 72 may query the sustainability database 94, engineering workflow systems 78, or other component for other sustainability models that correspond to the sustainability model of the enterprise. The other sustainability models may correspond to other enterprise systems of the same industry, other enterprise systems that perform similar enterprise operations, other enterprise systems located in different geographical areas, other enterprise systems that employ similar equipment, or any other suitable enterprise system that has similar operational functions or equipment. In addition, the simulated data may be determined based on model data provided by manufacturers for components that are employed by the enterprise operations. For example, fuel consumption for an engine may be simulated (e.g., estimated) based on a manufacture's estimated fuel consumption rather than by direct measurement of a fuel flow rate. Further, the simulated data may be virtualized or extrapolated based on back allocation calculations (e.g., virtual flow meter) and the like. For example, CO_2 emissions for an engine may be based on the known or estimated fuel consumption. Based on the other sustainability models and collected information, the sustainability platform system 72 may determine virtual data that corresponds to the missing data. That is, the sustainability platform system 72 may determine expected data for the missing data as a way to hypothesize as to the viability of an action plan 90. In some embodiments, the simulated data may be acquired via digital twin systems that represent operations of the enterprise, by applying machine learning algorithms to relevant datasets, using artificial intelligence systems to project datasets, or any other suitable methodology.

In some embodiments, the simulation method utilized for generating the missing data may depend on the data type and the availability of additional parameters need to simulation the missing data. For example, missing emissions data may be simulated based on a prior emission measurement over a given time period, and other activities or production volume may be assumed as constants or with defined changes that have linear or non-linear effects on the missing emissions data. Moreover, missing emission data may be estimated using corresponding emission factor for the technology or process. Additionally, missing cost data may be simulated based on prior cost data and/or from proxy data sources, such as published cost data from public sources (e.g., industry publications, peer reviewed publications etc.). Additionally or alternatively, cost data may be estimated from a known consumption volume and standard unit cost.

Additionally, physical data, such as data obtained by direct measurement, may be simulated using a supervised machine learning model. For example, a regression model may be utilized to predict the physical data point based on independent variables. The sustainability platform system 72 may utilize a training dataset of other sustainability models or known data to establish a regression correlation between the output data (e.g., simulated data) and those independent variables. The trained model may then predict the missing physical data from input independent variables obtained from the input data sources 74. For example, a volume of vented gas, if not directly measured, may be predicted by developing a regression model which correlates vented gas volume with pipeline pressure, pressure change, gas temperature, and/or other variables. As should be appreciated, while different simulation methods are exampled above for particular types of missing data, any suitable simulation method (e.g., a machine learning model, utilizing proxy data sources, etc.) may be utilized for the different types of missing data.

With the foregoing in mind, the input data sources 74 and simulated data may be utilized in generating a sustainability model and/or action plans 90. For example, the method 248 for simulating missing data may be performed with or as a part of determining a sustainability action plan based on a matching sustainability model (e.g., at block 234) and simulating an action plan 90 (e.g., at block 236), as in the method 220. Furthermore, in some embodiments, the sustainability platform system 72 may utilize simulated data to determine the effectiveness of a selected action plan 90 as it is implemented. For example, sustainability managers of enterprises may select a sustainability action plan 90 from a list of action plans 90 provided by the sustainability platform system 72 or input via the manual source 112, and the sustainability platform system 72 may identify data sources that may be useful for determining the effectiveness of the selected action plan 90. The missing data sources may be simulated or provided to the user for updating the data acquisition infrastructure of the enterprise to perform a more effective sustainability analysis. In some embodiments, the sustainability platform system 72 may simulate or virtualize the missing data to perform some validation analysis related to the selected action plan 90.

Additional details related to identifying and/or simulating missing data sources for determining the effectiveness of an action plan 90 are described below with reference to FIG. 9. FIG. 9 illustrates a flow chart of a method 260 for identifying missing data sources to validate effectiveness of action plans 90. For example, during execution of an action plan 90, data from the input data sources 74 may be gathered to check if the forecasted sustainability parameters of the simulated sustainability action plan 90 (e.g., as from block 236 of the method 220) match (e.g., within a threshold) the measured sustainability parameters. Moreover, missing data may be simulated to perform such an analysis on the effectiveness of the executed action plan 90. As should be appreciated, the missing data sources may correspond to data values that are expected to be present, but are not reflected in the data available for use, missing data values that would otherwise be obtained via instrumentation or equipment, or both. Although the following description of the method 260 is described as being performed by the sustainability platform system 72 and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources and engineering workflow systems may perform the method 260 in any suitable order.

Referring now to FIG. 9, at block 262, the sustainability platform system 72 may receive one or more action plans 90 that details one or more workflows or recommended changes to operations or equipment of the respective enterprise. In some embodiments, to implement the received action plans 90, data from certain data sources (e.g., input data sources 74) may be useful for performing the operations of an action plan 90 and/or for determining the effectiveness of the action plan 90, such as regarding reduction of emissions. As such, at block 264, the sustainability platform system 72 may identify the data sources for measuring the sustainability parameters for the respective action plans 90.

At block 266, the sustainability platform system 72 may compare the identified data sources with the input data sources 74 available to the enterprise or the sustainability platform system 72. In this way, the sustainability platform system 72 may identify any missing data sources that may be useful to perform or analyze an action plan 90. In some embodiments, the missing data sources may be identified based on the enterprise data described above with reference to FIG. 4 or as described in the method 248 of FIG. 8. The missing data sources may thus include equipment information, production scheduling information, or any operational data related to the facility operations, the production operations, or the like. Further, the missing data sources may refer to more granular (e.g., action plan specific) data or data related to different hierarchical levels of the enterprise that may assist the sustainability platform system **72** in performing the embodiments described herein. In addition, the missing data sources may also include datasets that have been received or are accessible to the sustainability platform system **72** but do not appear to be accurate or are associated with confidence values that is lower than a threshold. Indeed, some datasets may be expected to be available but are not present for analysis by the sustainability platform system **72** may be designated as missing data sources.

By identifying the missing data sources, the sustainability platform system **72** may enable the users to focus efforts on updating or adding data sources to allow the respective action plans **90** to be implemented and/or evaluated and baseline sustainability parameters to be calculated. Indeed, given the breadth of operations performed by an enterprise, collecting, aggregating, and/or analyzing all data available from every aspect of the enterprise may be overwhelming for a person and computationally difficult or inefficient for a computing system. Moreover, processing the available data of the enterprise may be computationally inefficient if certain action plans **90** do not use the respective datasets. However, by identifying what data sources are missing that are relevant to an action plan **90**, irrelevant data may be ignored, increasing the operational efficiency (e.g., computing efficiency, time efficiency, etc.) of the computing system (e.g., the sustainability platform system **72**). Indeed, it may be useful to update the enterprise or gain access to certain types of data that may allow the sustainability platform system **72** to efficiently determine recommendations for improving sustainability parameters.

With this in mind, at block **268**, the sustainability platform system **72** may send the missing data sources to a computing system associated with a user of the enterprise. The missing data sources may be provided as a notification to the computing system and may cause the computing system to automatically present the notification via an alert or the like, such as described above with regard to block **256** of method **248**.

In some embodiments, the sustainability platform system **72** may, at block **270**, simulate the missing data based on other sustainability models. As should be appreciated, such simulation may be performed in the manner described above with regard to block **258**. That is, the sustainability platform system **72** may query the sustainability database **94**, engineering workflow systems **78**, or other component for other sustainability models that correspond to the sustainability model of the enterprise. The other sustainability models may correspond to other enterprise systems of the same industry, other enterprise systems that perform similar enterprise operations, other enterprise systems located in different geographical areas, other enterprise systems that employ similar equipment, or any other suitable enterprise system that has similar operational functions or equipment. In addition, the simulated data may be determined based on model data provided by manufacturers for components that are employed by the enterprise operations. Further, the simulated data may be virtualized or extrapolated based on back allocation calculations (e.g., virtual flow meter) and the like. Based on the other sustainability models and collected information, the sustainability platform system **72** may determine virtual data that correspond to the missing data. That is, the sustainability platform system **72** may determine expected data for the missing data as a way to hypothesize as to the viability of the action plan **90** received at block **262**. It should be noted that the simulated data may be acquired via digital twin systems that represent operations of the enterprise, by applying machine learning algorithms to relevant datasets, using artificial intelligence systems to project datasets, or any other suitable methodology.

After simulating the missing data, the sustainability platform system **72** may simulate or determine expected sustainability parameters for the enterprise based on the simulated data and the available data from the input data sources **74**. As such, at block **272**, the sustainability platform system **72** may determine whether the sustainability parameters are acceptable with reference to the sustainability target data described above. If the sustainability parameters are not acceptable, the sustainability platform system **72** may proceed to block **282** and select an alternative action plan **90**, such as at block **234** or **244** of the method **220**. For example, a user may be prompted to or the sustainability platform system **72** may automatically run a new optimization for an action plan to replace the unacceptable action plan **90**.

In some embodiments, one or more triggers may prompt the determination that the sustainability parameters are not acceptable. For example, a spike in emissions (e.g., CO_2 or other GHG) that was not forecast as a consequence of implementing the action plan **90** may trigger selection of an alternate action plan **90**. Moreover, other triggers may include thresholds, such as an emission or cost (e.g., capital expenditure, operating expenditure, or total expenditure) that exceeds the forecast trend by a percentage (e.g., 2%, 5%, 10%, 20%, or 30%) for a defined period of time (e.g. a number of weeks, months, or years, a fiscal quarter, etc.). Furthermore, if an action plan **90** created to address a specific emissions scope results in an increase of emissions of a different scope over a defined period of time, the action plan **90** may be deemed to not have acceptable sustainability parameters. The sustainability platform system **72** may recommend new workflows or actions to include in an alternate action plan optimization that would address the source of the trigger by using a logic component to match action items with specific emission sources, while accounting for constraints of emissions scope, geography, industry, and the like. Moreover, in some embodiments, the method **260** may be repeated for the alternate action plan **90** to evaluate the effectiveness thereof.

If, at block **272**, the sustainability parameters are acceptable, the sustainability platform system **72** may verify that the respective action plan **90** indeed causes the enterprise to achieve sustainability goals defined by the sustainability target data. For example, a specific action plan **90** may provide acceptable sustainability parameters at a particular facility, but still fail to be acceptable for the enterprise as a whole, when extrapolated and aggregated with the rest of the enterprise data. As such, at block **274**, the sustainability platform system **72** may receive updated enterprise data and proceed to block **276** to determine whether the corresponding sustainability parameters are acceptable or achieve the goals set by the sustainability target data. The enterprise data may include the simulated data and/or data representative of the enterprise as a whole. If the sustainability target data is not achieved, the sustainability platform system **72** may proceed to block **282** to recommend an alterative action plan **90**. If the sustainability target data is achieved, the sustainability platform system **72** may proceed to block **278** and store the validated action plan in the sustainability database **94** or other suitable storage.

By performing the method **260** described above, the sustainability platform system **72** may provide feedback for the enterprise to modify the action plans **90** and sustainability model of the enterprise to achieve improved sustainability parameters. Indeed, although the initially selected action plan **90** may not be best suited to achieve the sustainability target data, the sustainability platform system **72** may identify action plans **90** that may be better suited to achieve the targets in a more efficient manner by identifying the data sources that may assist in identifying a suitable action plan **90** more efficiently using fewer computing resources and less time. Moreover, the sustainability platform system **72** may identify solutions that avoid biases or misunderstandings with regard to improving sustainability parameters. That is, users may initially believe that sustainability parameters may be improved based on incorrect assumptions. By performing the method **260**, the appropriate data sources may be identified and tested to determine the most effective action plan **90** to achieve target sustainability goals.

Keeping the foregoing in mind and referring back to the data flow diagram **70** of FIG. **2**, the sustainability platform system **72** implement an automated optimization loop to continuously identify action plans **90** that enable the enterprise to continuously work to achieve improved sustainability parameters over time. Indeed, in some embodiments, the sustainability platform system **72** may continuously monitor the input data sources **74** to determine whether the enterprise is achieving the sustainability target data. After receiving the input data, the sustainability platform system **72** may generate the sustainability model as described above and receive updated input data. If the input data has changed more than some threshold amount (e.g., 2%, 5%, 10%, 20%, or 30%), the sustainability platform system **72** may regenerate the sustainability model using the updated data and identify other sustainability action plans **90** that may be better suited to enable the enterprise to achieve the sustainability parameters. It should be noted that although a number of embodiments described herein refer to determining whether a threshold is exceeded, it should be understood that the embodiments may also be performed in response to detected values falling below a threshold, falling outside of a threshold range, or any other suitable threshold comparison operations.

In addition to utilizing input data from the input data sources **74**, in some embodiments, the sustainability platform system **72** may generate action plans **90** and/or make selections between action plans **90** based on confidence data related thereto. In other words, threshold amounts of uncertainty (e.g., confidence levels, confidence values) regarding the estimated effectiveness of an action plan **90** to improve the sustainability parameters of an enterprise may be utilized to categorize and/or augment selection or generation of action plans **90**. For example, use of simulated data, such as estimated in the method **248**, when simulating an action plan **90** (e.g., at block **236**) or using simulated data for verifying an action plan **90** (e.g., at block **270**) may increase uncertainty in the simulation of the action plan **90** and, therefore, reduce the confidence level of the action plan **90** compared to utilizing measured data (e.g., from a real-time source **108**). Furthermore, different input data sources **74** may have different confidence levels or confidence values assigned thereto. Moreover, in some embodiments, manual sources **112** may have a set confidence level or be manually assigned. Additionally, in some embodiments, the simulation itself of the action plan **90** may be associated with an uncertainty. For instance, the sustainability platform system **72** may utilize deterministic, heuristic, and/or machine learning based algorithms, and uncertainty may be introduced or otherwise associated with computations based thereon. As an example, a Monte Carlo simulation of the action plan **90** may address such uncertainties, and the sustainability platform system **72** may provide values of the sustainability parameters for a particular confidence level (e.g., confidence interval).

With the foregoing in mind, FIG. **10** illustrates a flow chart of a method **290** for updating sustainability action plans **90** based on confidence data, according to one or more embodiments of this disclosure. Although the following description of the method **290** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources may perform the method **290** in any suitable order.

Referring to FIG. **10**, at block **292**, the sustainability platform system **72** may receive the sustainability model for the enterprise as discussed above. In addition, at block **294**, the sustainability platform system **72** may receive one or more sustainability action plans **90** for the enterprise as discussed above. At block **296**, the sustainability platform system **72** may determine confidence or uncertainty data related to each sustainability action plan **90** received at block **294**. That is, the sustainability platform system **72** may determine a confidence value (e.g., level, interval, or other uncertainty indication) associated with the effectiveness of the action plans **90**. In some embodiments, the confidence value may be generated based on the information available in the sustainability model and/or from the input data sources **74**. For example, if the sustainability model lacks information on certain portions of the enterprise operations, the confidence value for action plans **90** related to those portions of the sustainability model may be decreased.

Using the confidence values, the sustainability platform system **72** may, at block **298**, simulate the sustainability parameters for each action plan **90**. For example, in a similar manner as simulating missing data (e.g., as in the method **248** and method **260**) and/or during simulation of the action plan (e.g., block **234** of the method **220**), the sustainability parameters associated with the action plan **90** may be simulated (e.g., estimated) with an amount of uncertainty associated therewith. Additionally or alternatively, confidence data may be determined during the simulation of sustainability parameters, such as at block **298**. For example, the sustainability platform system **72** may utilize a Monte Carlo simulation, to establish means and standard deviations of sustainability parameters in accordance with a confidence interval.

As such, the sustainability platform system **72** may provide uncertainty data related to the effectiveness of each action plan **90** achieving certain simulated sustainability parameters at various times. At block **300**, the sustainability platform system **72** may provide (e.g., via a display) the simulated sustainability parameters along with each action plan **90** and the corresponding confidence or uncertainty values. For example, error bars or ranges may be provided with the estimated sustainability parameters. In this way, the sustainability platform system **72** or a user may evaluate whether to implement any action plan **90** while evaluating the confidence value associated with each action plan **90**.

In some embodiments, the sustainability platform system **72** may determine, at block **302**, whether the simulated sustainability parameters are acceptable. For example, the simulated sustainability parameters may be compared to sustainability target data to determine if an action plan **90** is estimated to be effective at improving the sustainability parameters of the enterprise. Furthermore, for a given confidence level or interval (e.g., 68%, 80%, 90%, 95%, 99%, 99.7%, etc.) if the uncertainty in the sustainability parameters extends outside a target range or beyond a target threshold, the sustainability parameters for that action plan **90** may be considered as unacceptable, such as when evaluating block **198** of the method **190**, block **238** of the method **220**, and/or blocks **272** and **276** of the method **260**. In some embodiments, if the sustainability platform system **72** determines that the simulated sustainability parameters are unacceptable, at block **304** the sustainability platform system **72** may determine one or more alternate sustainability action plans **90** and return to block **296** for determining confidence data for the alternate sustainability action plan(s).

At block **306**, the sustainability platform system **72** may determine a selection of one or more sustainability action plans **90**, such as based on the determination that the simulated sustainability parameters are acceptable and/or a user input. For example, the user input may be a selection of one or more particular action plans **90**, such as provided to the user at block **300**, or an approval of the action plan(s) determined to be acceptable at block **302**. Furthermore, at block **308**, the sustainability platform system **72** may send commands devices or implement the sustainability selected action plan(s) **90**, such as described above with reference to blocks **206** of the method **190** and/or block **240** of the method **220**.

As discussed above, in some embodiments, the engineering workflow systems **78** may assist with the designing and monitoring of abatement solutions to generate an action plan **90** based on the sustainability model or report **92** associated therewith. In other words, the engineering workflow systems **78** may determine particular actions and/or solutions (e.g., equipment) for abating or reducing the negative sustainability parameters to improve the overall sustainability of the enterprise operations. In some embodiments, the engineering workflow system **78** may be related to a number of abatement technologies associated with reducing GHG emissions, water usage, waste accumulation, and the like. However, while the engineering workflow systems **78** may have multiple defined avenues for abatement stored in the workflow database **140**, over time, additional technologies may be added to the workflow database **140**. Moreover, as the workflow database **140** grows, it may take more and more computing resources to filter the abatement technologies for determining which abatement technologies and actions to implement for a particular enterprise.

By way of example, the engineering workflow systems **78** may include access to a database (e.g., workflow database **140** and/or sustainability database **94**) or catalog of abatement technologies, which may be scraped from a network (e.g., Internet), internal databases, manually input, or the like. For instance, technologies related to energy industries may be found in various web-provided catalogues. In some embodiments, machine learning models, such as a large language model, may search the internet based on sustainability and abatement prompts to identify abatement technologies that may be available. The abatement technologies may be focused on performing certain operations, such as avoiding routing flaring, performing flare maintenance, avoiding use of light oils to dilute extra heavy oils to transport them to deep conversion refineries, replacing leaky equipment, employing best operating practices, conducting routine leak detection and repair (LDAR), employing renewable energy to generate heat, steam, and electricity, capturing and sequestering carbon when producing and refining high carbon assets, using green hydrogen in hydroconversion refinery, employing high-efficiency pumps than run on renewable energy, monitoring and repairing for corrosion in legacy assets, and the like. For example, a flaring and venting engineering workflow system **78** may incorporate a reduction in routine flaring or increased flaring maintenance for increased flaring efficiency (e.g., increased burn effectiveness) into an action plan. In some embodiments, each engineering workflow system **78** may be associated with one or more abatement technologies. It should be noted that the engineering workflow systems **78** may correlate technology parameters with each of these abatement technologies for increased indexing efficiency. In other words, potential actions or abatement technologies available for incorporation into an action plan **90** by the engineering workflow systems **78** may be associated with their own set of technology parameters, such as emissions reduction maximal capacity, construction/decommissioning time, lifetime cost Capex/Opex, geographical applicability, and the like. Additionally, in some embodiments, the technology parameters may also include a sustainability scope (e.g., scope 1, scope 2, or scope 3 type emission) and/or one or more sustainability parameters identifying which sustainability parameters may be affected by the abatement technology.

With the foregoing in mind, FIG. **11** illustrates a flow chart of a method **320** for adding abatement technologies with corresponding technology parameters to a database, according to one or more embodiments of this disclosure. Although the following description of the method **320** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources may perform the method **320** in any suitable order.

At block **322**, one or more implementations of one or more abatement technologies may be identified, such as via scraping from catalogs, other databases, a network (e.g., Internet), or via manual entry. For example, a large language model machine learning algorithm (e.g., a retrieval augmented generation (RAG) model) of the sustainability platform system **72** or a third-party meta engine communicating therewith may search real-time data sources such as news articles, regulatory websites, supplier catalogs, etc. to extract workflows and abatement technologies (e.g., products, services, equipment, etc.). In some embodiments, the machine learning algorithm may be pre-programmed with relevant sustainability data sources from which to extract such abatement technologies, or targeted prompts may be generated to broaden the search, for example, to a portion or the entirety of the world wide web. Furthermore, the sustainability platform system **72** may perform the search periodically (e.g., daily, weekly, etc.), in response to a user request, or in response to a request to generate a new action plan **90**. As should be appreciated, while different abatement technologies may be identified, particular implementations may also be separately or categorically maintained within the database of the sustainability platform system **72**, such as based on scale or equipment type.

Additionally, at block **324**, the sustainability platform system **72** may assign one or more technology parameters to the abatement technologies and/or implementations thereof. For example, in some embodiments, a large language model algorithm or other machine learning or artificial intelligence system may develop associations between the abatement technologies and the technology parameters. Additionally, the sustainability parameters that are affected by an abatement technology, as well as to what extent and its abatement capacity may be associated with the abatement technology. Furthermore, how long the abatement technology would take to implement, how long it would last, its associated costs, and/or geographical applicability may define indexes within the database (e.g., workflow database **140** and/or sustainability database **94**) for computationally efficient selection of abatement technologies to implement for an action plan **90**. Moreover, the sustainability platform system **72** may correlate the abatement technologies with engineering workflow systems **78** based on descriptions of the engineering workflow systems **78** in conjunction with the sustainability model of the enterprise. As such, abatement technologies may be assigned technology parameters for efficient indexing and association with target data and aspects the sustainability model.

In some embodiments, at block **326**, the extractions of the abatement technologies and the technology parameters associated therewith may be provided, such as to a user (e.g., user computing system), for review of the identified abatement technologies. As should be appreciated, while deterministic and/or machine learning models may provide expedited information gathering, a user may provide oversight to verify viability, legality, and/or potential effectiveness of the identified abatement technologies. At block **328**, the sustainability platform system **72** may receive user feedback regarding the acceptability of the identified abatement technology implementations and/or the assigned technology parameters associated therewith. At block **330**, the abatement technology implementations with the corresponding technology parameters may be stored in the database (e.g., workflow database **140** and/or sustainability database **94**).

As discussed above, each abatement technology may be associated with one or more sustainability parameters. That is, the technology parameters for an abatement technology, or implementation thereof, may include which sustainability parameters may be affected by the abatement technology. The sustainability platform system **72** may identify engineering workflow systems **78** to query or access based on the association between the desired sustainability parameters (e.g., target sustainability data) and the respective abatement technologies. For example, if the sustainability parameters are not acceptable at block **198** or block **276**, the sustainability platform system **72** may query a lookup table or database for engineering workflow systems **78** and abatement technologies associated with the respective sustainability parameters. Furthermore, in some embodiments, after identifying the relevant abatement technologies, the engineering workflow systems **78** may identify potential implementations of the relevant abatement technologies for inclusion in an action plan **90**.

With the foregoing in mind, FIG. **12** illustrates a flow chart of a method for selecting abatement technology implementations for use in a sustainability action plan, according to one or more embodiments of this disclosure. Although the following description of the method **340** is described as being performed by the sustainability platform system **72** and in a particular order, it should be understood that any suitable computing system with access to the appropriate data sources may perform the method **340** in any suitable order.

At block **342**, the sustainability platform system **72** may receive a sustainability model for the enterprise, such as via generation at block **194** or as in block **222** or block **292**, and at block **344** the sustainability platform system **72** may receive sustainability target data, such as in block **196** or block **224**. The sustainability model may define the current state of operations, such as including processes, equipment, operational parameters, etc. of the enterprise, and the sustainability target data may include desired amounts of the sustainability parameters. As should be appreciated, the sustainability target data may also include cost data or other constraints so as to maintain practicality. At block **346**, the sustainability platform system **72** may identify one or more viable implementations of one or more abatement technologies based on the sustainability target data and the sustainability model. For example, the sustainability platform system **72** may identify technology parameters compatible with (e.g., coinciding with the goals, products, equipment, location, or other aspects of the enterprise) the sustainability model, and the database of abatement technologies may be filtered based on the identified technology parameters.

After identifying implementations of abatement technologies that could be utilized within the enterprise and that are within the constraints of the sustainability target data, at block **348** the sustainability platform system **72** may determine a selection of the abatement technology implementations based on an optimization of the sustainability parameters. For example, the sustainability platform system **72** may analyze individual abatement technologies and/or different combinations of abatement technologies to determine which set of abatement technology implementations optimize the sustainability parameters. Additionally or alternatively, the identified abatement technologies and/or technology parameters may be provided, at block **350**, such as to a user (e.g., user computing system). For example, the user may be provided with a listing of abatement technologies that are compatible with the sustainability model and meet the constraints of the sustainability target data. Additionally, in some embodiments, the sustainability platform system **72** may provide the user with one or more recommended abatement technologies, such as based on the optimization of block **348**. Furthermore, at block **352**, the sustainability platform system **72** may receive the user selection of abatement technology implementation(s). As such, at block **354**, the sustainability platform system **72** may generate a sustainability action plan **90** based on the selected (e.g., via the user at block **352** and/or the optimization at block **348**) abatement technology implementation(s).

As discussed herein, the sustainability platform system **72** may perform various analysis operations to determine action plans **90** using measure, report, and verify operational workflows. In addition, the sustainability platform system **72** may provide abatement planning and modeling workflows, as well as abatement operations. As such, the sustainability platform system **72** may provide for improved efficiency for aggregating and analyzing enterprise data to generate a sustainability model with action plans **90** for improving sustainability parameters.

Reference throughout this specification to "one embodiment," "an embodiment," "embodiments," "some embodiments," "certain embodiments," or similar language means that a particular feature, structure, or characteristic described in connection with the embodiment may be included in at least one embodiment of this disclosure. Thus, these phrases or similar language throughout this specification may, but do not necessarily, all refer to the same embodiment. Although this disclosure has been described with respect to specific details, it is not intended that such details should be regarded as limitations on the scope of this disclosure, except to the extent that they are included in the accompanying claims.

Additionally, the methods and processes described above may be performed by a processor. Moreover, the term "processor" should not be construed to limit the embodiments disclosed herein to any particular device type or system. The processor may include a computer system. The computer system may also include a computer processor (e.g., a microprocessor, microcontroller, digital signal processor, or general-purpose computer) for executing any of the methods and processes described above.

The computer system may further include a memory such as a semiconductor memory device (e.g., a RAM, ROM, PROM, EEPROM, or Flash-Programmable RAM), a magnetic memory device (e.g., a diskette or fixed disk), an optical memory device (e.g., a CD-ROM), a PC card (e.g., PCMCIA card), or other memory device.

Some of the methods and processes described above, can be implemented as computer program logic for use with the computer processor. The computer program logic may be embodied in various forms, including a source code form or a computer executable form. Source code may include a series of computer program instructions in a variety of programming languages (e.g., an object code, an assembly language, or a high-level language such as C, C++, or JAVA). Such computer instructions can be stored in a non-transitory computer readable medium (e.g., memory) and executed by the computer processor. The computer instructions may be distributed in any form as a removable storage medium with accompanying printed or electronic documentation (e.g., shrink wrapped software), preloaded with a computer system (e.g., on system ROM or fixed disk), or distributed from a server or electronic bulletin board over a communication system (e.g., the Internet or World Wide Web).

Alternatively or additionally, the processor may include discrete electronic components coupled to a printed circuit board, integrated circuitry (e.g., Application Specific Integrated Circuits (ASIC)), and/or programmable logic devices (e.g., a Field Programmable Gate Arrays (FPGA)). Any of the methods and processes described above can be implemented using such logic devices.

While the embodiments set forth in this disclosure may be susceptible to various modifications and alternative forms, specific embodiments have been shown by way of example in the drawings and have been described in detail herein. However, it should be understood that the disclosure is not intended to be limited to the particular forms disclosed. The disclosure is to cover all modifications, equivalents, and alternatives falling within the spirit and scope of the disclosure as defined by the following appended claims.

The techniques presented and claimed herein are referenced and applied to material objects and concrete examples of a practical nature that demonstrably improve the present technical field and, as such, are not abstract, intangible or purely theoretical. Further, if any claims appended to the end of this specification contain one or more elements designated as "means for [perform]ing [a function] . . . " or "step for [perform]ing [a function] . . . ", it is intended that such elements are to be interpreted under 35 U.S.C. 112(f). However, for any claims containing elements designated in any other manner, it is intended that such elements are not to be interpreted under 35 U.S.C. 112(f).

What is claimed is:

1. An enterprise system comprising:

one or more facility level devices of an enterprise, wherein the one or more facility level devices comprise sensors configured to measure operational parameters of the one or more facility level devices, wherein the measured operational parameters comprise current values of one or more sustainability parameters due to the one or more facility level devices; and

a sustainability platform system configured to:

obtain a sustainability model representative of a state of operations of the enterprise based on the measured operational parameters of the one or more facility level devices, wherein the state of operations of the enterprise comprises one or more respective operations of the one or more facility level devices performed with regard to extracting hydrocarbons from a reservoir;

receive sustainability target data associated with the enterprise, the sustainability target data comprising one or more threshold limits, one or more ranges, or both of the one or more sustainability parameters;

obtain one or more action plans based on the sustainability model and the sustainability target data, wherein the sustainability platform system is configured to obtain the one or more action plans by:

identifying one or more engineering workflow systems correlating with the sustainability model and associated with the one or more sustainability parameters of the sustainability target data; and

determining, via the identified one or more engineering workflow systems, the one or more action plans associated with improving at least one sustainability parameter of the one or more sustainability parameters based on the sustainability model;

simulate a performance of the one or more action plans over a period of time relative to the one or more sustainability parameters;

determine whether the simulated performance of the one or more action plans is effective to cause the one or more sustainability parameters to be within the one or more threshold limits, the one or more ranges, or both over the period of time; and

in response to determining that the simulated performance of the one or more action plans is effective, send one or more commands to the one or more facility level devices to cause the one or more facility level devices to adjust the one or more respective operations according to the one or more action plans to effect a change in the current values of the one or more sustainability parameters.

2. The enterprise system of claim **1**, wherein the sustainability platform system is configured to obtain the sustainability model by:

receiving enterprise data indicative of the state of operations of a portion of the enterprise associated with a geographical region, wherein the state of operations of the portion of the enterprise comprises sources of emissions, scales of emissions, or both; and

generating the sustainability model based on the enterprise data and the sustainability target data.

3. The enterprise system of claim **2**, wherein the sustainability platform system is configured to:

generate a sustainability report based on the enterprise data and the sustainability target data, wherein the enterprise data comprises the measured operational parameters; and

generate the sustainability model based on the sustainability report.

4. The enterprise system of claim **1**, wherein the one or more sustainability parameters comprise a carbon footprint of the one or more facility level devices, a water usage of the one or more facility level devices, a waste output of the one or more facility level devices, a greenhouse gas emission of the one or more facility level devices, or any combination thereof.

5. The enterprise system of claim 1, wherein simulating the performance of the one or more action plans comprises optimizing the one or more respective operations of the one or more facility level devices with respect to a reduction of the one or more sustainability parameters.

6. The enterprise system of claim 1, wherein the sustainability platform system is configured to obtain the one or more action plans by:

querying a sustainability database comprising a plurality of sustainability models with corresponding action plans;

identify a matching sustainability model of the plurality of sustainability models that corresponds to the sustainability model based on one or more query parameters; and

selecting one or more corresponding action plans of the matching sustainability model as the one or more action plans.

7. The enterprise system of claim 6, wherein the one or more query parameters comprise an amount of desired emission reduction, a geographical region, an environment of the enterprise, a type of emission to be reduced, a source of emissions, or any combination thereof.

8. A method comprising:

obtaining, via a computing system, a sustainability model representative of a state of operations of an enterprise based on measured operational parameters of one or more devices associated with the enterprise, wherein the measured operational parameters comprise current values of one or more sustainability parameters due to the one or more devices, wherein the state of operations of the enterprise comprises one or more respective operations of the one or more devices performed with regard to extracting hydrocarbons from a reservoir;

receiving, via the computing system, sustainability target data associated with the enterprise, the sustainability target data comprising one or more threshold limits, one or more ranges, or both of one or more sustainability parameters;

obtaining, via the computing system, one or more action plans based on the sustainability model, wherein obtaining the one or more action plans comprises:

querying a sustainability database comprising a plurality of sustainability models with corresponding action plans;

identify a matching sustainability model of the plurality of sustainability models that corresponds to the sustainability model based on one or more query parameters, wherein the one or more query parameters comprise an amount of desired emission reduction, a geographical region, an environment of the enterprise, a type of emission to be reduced, a source of emissions, or any combination thereof; and

selecting one or more corresponding action plans of the matching sustainability model as the one or more action plans;

simulating, via the computing system, a performance of the one or more action plans over a period of time relative to the one or more sustainability parameters;

determining, via the computing system, whether the simulated performance of the one or more action plans is effective to cause the one or more sustainability parameters to be within the one or more threshold limits, the one or more ranges, or both over the period of time; and

in response to determining that the simulated performance of the one or more action plans is effective, sending, via the computing system, one or more commands to the one or more devices associated with the enterprise to cause the one or more devices to adjust the one or more respective operations according to the one or more action plans to effect a change in the current values of the one or more sustainability parameters.

9. The method of claim 8, wherein obtaining the sustainability model comprises:

receiving enterprise data indicative of the state of operations, wherein the state of operations comprises the one or more query parameters; and

generating the sustainability model based on the enterprise data and the sustainability target data.

10. The method of claim 9, comprising:

generating a sustainability report based on the enterprise data and the sustainability target data; and

generating the sustainability model based on the sustainability report.

11. The method of claim 10, wherein obtaining the one or more action plans comprises:

identifying one or more engineering workflow systems correlating with the sustainability model and associated with the one or more sustainability parameters of the sustainability target data; and

determining, via the identified one or more engineering workflow systems, the one or more action plans associated with improving at least one sustainability parameter of the one or more sustainability parameters based on the sustainability report.

12. The method of claim 8, wherein the one or more sustainability parameters comprise a carbon footprint of the one or more devices, a water usage of the one or more devices, a waste output of the one or more devices, a greenhouse gas emission of the one or more devices, or any combination thereof.

13. The method of claim 8, wherein simulating the performance of the one or more action plans comprises optimizing the one or more respective operations of the one or more devices with respect to a reduction of the one or more sustainability parameters.

14. A non-transitory, machine-readable medium comprising instructions that, when executed by one or more processors, cause the one or more processors to perform operations comprising:

obtaining a sustainability model representative of a state of operations of an enterprise, based on measured operational parameters of one or more devices associated with the enterprise, wherein the measured operational parameters comprise current values of one or more sustainability parameters due to the one or more devices, wherein the state of operations of the enterprise comprises one or more respective operations of the one or more devices performed with regard to extracting hydrocarbons from a reservoir;

receiving sustainability target data associated with the enterprise, the sustainability target data comprising one or more threshold limits, one or more ranges, or both of one or more sustainability parameters;

obtaining one or more action plans based on the sustainability model, wherein obtaining the one or more action plans comprises:

querying a sustainability database comprising a plurality of sustainability models with corresponding action plans;

identify a matching sustainability model of the plurality of sustainability models that corresponds to the sustainability model based on one or more query parameters; and selecting one or more corresponding action plans of the matching sustainability model as the one or more action plans; or

identifying one or more engineering workflow systems correlating with the sustainability model and associated with the one or more sustainability parameters of the sustainability target data; and

determining, via the identified one or more engineering workflow systems, the one or more action plans associated with improving at least one sustainability parameter of the one or more sustainability parameters based on the sustainability model;

simulating a performance of the one or more action plans over a period of time relative to the one or more sustainability parameters;

determining whether the simulated performance of the one or more action plans is effective to cause the one or more sustainability parameters to be within the one or more threshold limits, the one or more ranges, or both over the period of time; and

in response to determining that the simulated performance of the one or more action plans is effective, sending one or more commands to the one or more devices associated with the enterprise to cause the one or more devices to adjust the one or more respective operations according to the one or more action plans to effect a change in the current values of the one or more sustainability parameters.

15. The non-transitory, machine-readable medium of claim **14**, wherein simulating the performance of the one or more action plans comprises optimizing the one or more respective operations of the one or more devices with respect to a reduction of the one or more sustainability parameters, wherein the one or more sustainability parameters comprise a carbon footprint of the one or more devices, a water usage of the one or more devices, a waste output of the one or more devices, a greenhouse gas emission of the one or more devices, or any combination thereof.

16. The non-transitory, machine-readable medium of claim **14**, wherein obtaining the one or more action plans comprises:

querying the sustainability database comprising the plurality of sustainability models with corresponding action plans;

identify the matching sustainability model of the plurality of sustainability models that corresponds to the sustainability model based on the one or more query parameters, wherein the one or more query parameters comprise an amount of desired emission reduction, a geographical region, an environment of the enterprise, a type of emission to be reduced, a source of emissions, or any combination thereof; and

selecting the one or more corresponding action plans of the matching sustainability model as the one or more action plans.

17. The non-transitory, machine-readable medium of claim **14**, wherein obtaining the sustainability model comprises:

receiving enterprise data indicative of the state of operations of a portion of the enterprise associated with a geographical region, wherein the state of operations of the portion of the enterprise comprises sources of emissions, scales of emissions, or both; and

generating the sustainability model based on the enterprise data and the sustainability target data.

18. The non-transitory, machine-readable medium of claim **14**, wherein obtaining the one or more action plans comprises:

identifying the one or more engineering workflow systems correlated with the sustainability model and associated with the one or more sustainability parameters of the sustainability target data; and

determining, via the identified one or more engineering workflow systems, the one or more action plans associated with improving the at least one sustainability parameter of the one or more sustainability parameters based on the sustainability model enterprise data.

19. The non-transitory, machine-readable medium of claim **17**, wherein the operations comprise:

generating a sustainability report based on the enterprise data and the sustainability target data; and

generating the sustainability model based on the sustainability report.

20. The non-transitory, machine-readable medium of claim **14**, wherein obtaining the one or more action plans comprises:

querying the sustainability database comprising the plurality of sustainability models with corresponding action plans; and

in response to identifying no matching sustainability model of the plurality of sustainability models that corresponds to the sustainability model based on the one or more query parameters:

identifying the one or more engineering workflow systems correlated with the sustainability model and associated with the one or more sustainability parameters of the sustainability target data; and

determining, via the identified one or more engineering workflow systems, the one or more action plans associated with improving the at least one sustainability parameter of the one or more sustainability parameters based on the sustainability model.

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