

DIGITAL AND ANALYTICS

Leveraging advanced process control and analytics in industrial automation

ABB's Advanced Process Control and Analytics Suite comprises tools, online and offline, to deploy advanced controllers and analytic models; this gives process and power industries monitoring, predictive analytics and closed-loop control abilities at the device, edge and cloud and ensures real-time operation efficiency gains.



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What if process and energy industries could optimize operations using emergent technologies like cloud, data analytics, visualization and advanced modeling algorithms as part of the Internet of Things revolution (IoT) to acquire leverage in Advanced Process Control (APC) and Analytics solutions? This evolution of knowledge acquisition, creation and transfer ability is power – power that translates not only to improvements in operational scheduling, but also to the ability to make predictions and estimations even in the absence of reliable measurement data.



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ABB leads the digital transformation of industry with over 70 million connected devices and 70,000 control systems world-wide and annual investments of \$1.5 billion in research and development, to provide customers in power and process industries with the most unified, cross-industry capability possible. It is this innovative spirit that has led ABB to invest increasingly in APC and analytics modeling abilities over the past 5 years to give customers powerful optimization and prediction tools.



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Title picture. Predictive power plant optimization solution based on ABB Ability APCA is employed onboard vessels to enhance fuel efficiency and reduce emissions.

Traditionally, APC relies on model predictive control and moving horizon estimation strategies that use either a linear or non-linear mathematical

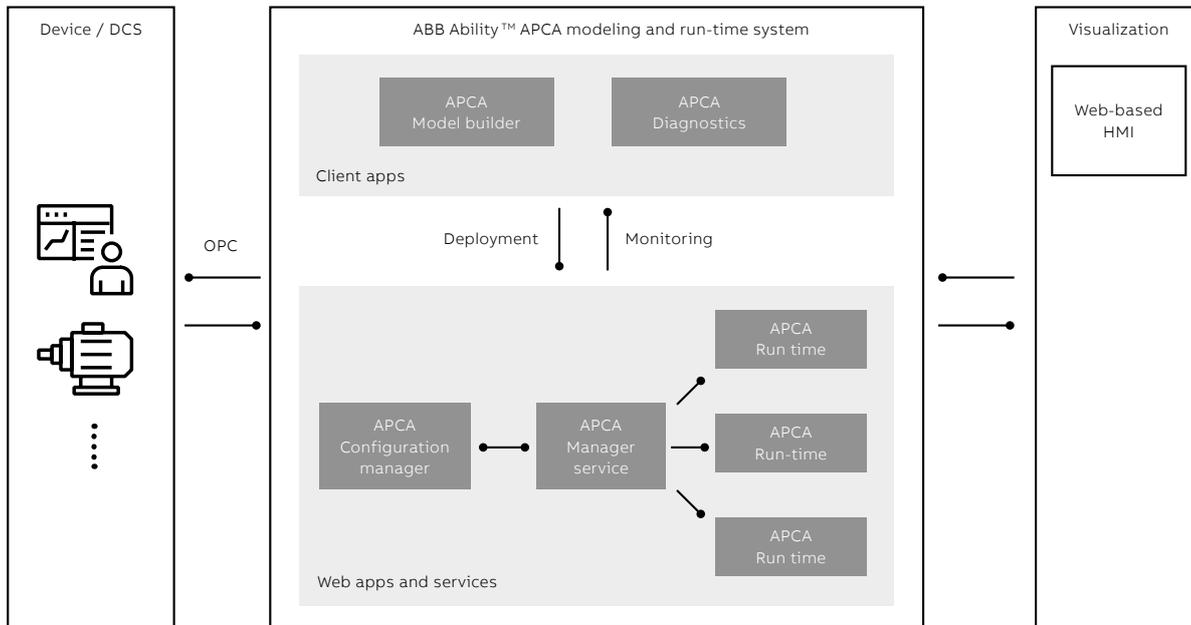
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model of the industrial plant and smart algorithms to estimate unmeasured states and control process variables. APC helps industries attain operational and financial targets by increasing throughput and reducing energy use.

Typically, process industries and energy companies integrate APC in distributed control systems (DCSs) such as ABB Ability™ 800xA and ABB Ability™ Symphony Plus, which allows industry users to benefit from distributed resource allocation, redundancy, and communication as well as the intrinsic cybersecurity infrastructure of these modern DCSs.

As APC technology continues to evolve with new components and features, ABB scientists and engineers are exploring the potential of artificial intelligence (AI) with the use of reinforcement learning neural networks as well as edge and cloud technologies for digital analytics and optimization for operational services in the process and power industries.





01

Currently, the ABB Ability™ Platform is the digital-enabling technology that allows the implementation of APC solutions.

ABB Ability Advanced Process Control and Analytics Suite

The ABB Ability platform is ABB’s integrated industrial internet platform launched in 2017 and currently providing over 180 solutions across

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A recent innovation in digital solutions is the ABB Ability™ Advanced Process Control and Analytics (APCA) Suite, which offers analytics & optimization (A&O) services.

industries. It is the technology platform used to build and connect ABB Ability solutions, such as Ability™ Marine Advisory System OCTOPUS software for marine operations management and optimization [1].

It comprises several digital-enabling technologies that can reside at the device, edge and cloud levels. This unifying technology operates ABB’s own technology and industrial software while leveraging Microsoft’s enterprise-grade Azure cloud infrastructure, cybersecurity and services to meet customer needs.

A recent innovation in digital solutions is the ABB Ability™ Advanced Process Control & Analytics (APCA) Suite, which offers analytics & optimization (A&O) services for monitoring, predictive analytics and closed-loop control [2].

— 01 ABB Ability APCA architecture showing the deployment and monitoring of advanced controllers and analytics work-flow.

— 02 APCA examples of configuration manager displays.

02a APCA Configuration manager main page listing all deployed controllers in an installation.

02b APCA Configuration manager gantt chart view displaying the execution times and schedule of deployed controllers.

The ABB Ability APCA Suite comprises a set of tools that make the deployment of advanced controllers and analytic models a fully streamlined process→1: APCA Model builder (offline), APCA Diagnostics (offline), APCA Configuration manager (online), APCA Run-time engine (online) and APCA Manager web service (online). ABB Ability

— **ABB’s elegant solution for the pulp and paper industry is OPT800, a solution powered by Ability APCA to improve the efficiency of paper mills.**

APCA communicates its deployed advanced controllers and analytic models with the ABB Ability Edge and can operate at the edge in a Distributed Control System (eg, for control), or at the ABB Ability™ Cloud (eg, for optimization).

Developing and analyzing advanced controllers offline

The advantage of developing advanced controllers and analytics offline in APCA Model builder is that the client’s applications data can be readily leveraged by carrying out modeling and controller design tasks and analysis before deploying the solutions. Users can import large data sets and perform advanced data processing tasks like resampling, interpolation, and filtering in addition to open and closed-loop simulations. These capabilities deliver true operational advantages.

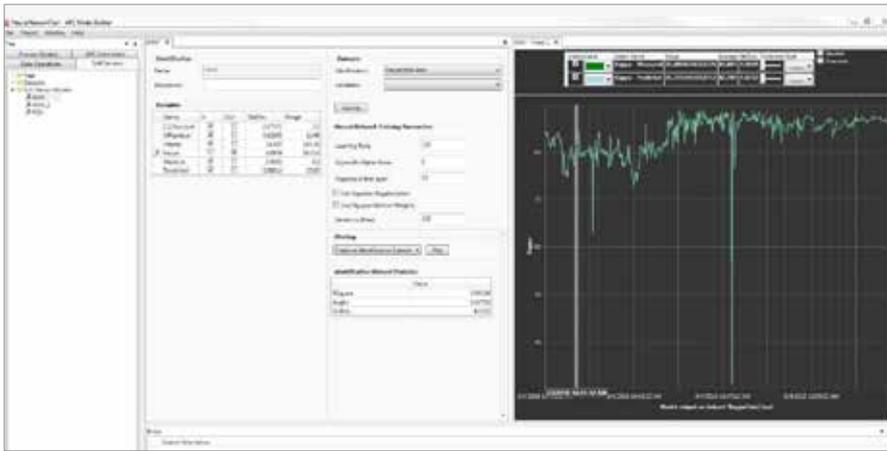
Security is one of the greatest challenges for industries reliant on data analytics and control and APCA Model builder provides a solution. Ability APCA issues certificates to authorized users to control the authenticity and integrity of the analytic models and advanced controllers developed in APCA Model builder. Thus, only models and controllers with valid certificates originating from authorized users will be digitally signed in APCA Model builder and can then be exported to the APCA Configuration manager. By removing the human decision-making component, security is refined and improved.

Name	Controller	OPC Source	Status	Last Modified	Edit	Delete	Backup	Export	Home
Operator Control	OPFC_0	opics://localhost:8888/RobotController/1	Prepared	Jun 4, 2018 9:40:23 AM					
Operator Control with Analytic Model	OPFC_0_001	opics://localhost:8888/RobotController/1	Auto	Jun 11, 2018 3:50:50 PM					
LevelControl	LevelOPC	opics://localhost:8888/RobotController/1	Auto	Jun 11, 2018 3:50:50 PM					
HandoverControl	PowerPart_Linear_Stat_LinearOP	opics://localhost:8888/RobotController/1	Auto	Jun 11, 2018 3:50:50 PM					
HydPowerPart	PowerPart_Linear_Stat_LinearOP	opics://localhost:8888/RobotController/1	Auto	Jun 11, 2018 3:50:50 PM					
Preheating	OPFC_00001	opics://localhost:8888/RobotController/1	Prepared	Jun 4, 2018 9:40:27 AM					
HeatExchanger	HE_Controller	opics://localhost:8888/RobotController/1	Auto	Jun 11, 2018 3:50:51 PM					
APCControl	OPFC_00001	opics://localhost:8888/RobotController/1	Manual	Jun 11, 2018 3:50:50 PM					

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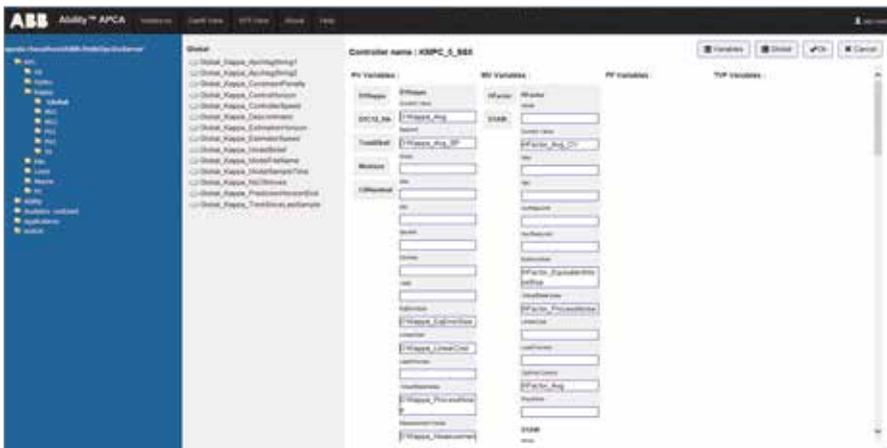
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03c

Furthermore, with APCA Diagnostics, users can analyze the performance of deployed controllers by visualizing the controller actions history from log files. Estimated values of the process variables and the quality of predictions can be compared with the data received from the plant, thus allowing control engineers to easily troubleshoot abnormal situations.

Deploying and monitoring advanced controllers and analytics online

Advanced controllers can be created, edited, imported, exported or deleted by users in a web-application known as an APC Configuration manager →2a, which also verifies the signature

once any controller file is imported; this process is similar to the model builder security process. Error messages are generated in cases of invalid files or missing signatures, thereby maintaining security.

A key feature of this online system is the ability to include industrial communication standards (eg, OPC) that allow users to connect to a plant, create or configure tags and map them to imported controller variables. Security is established with authentication and encryption techniques; usually the secure web socket communications (HTTPS), certificate-based security (SSL) and transport layer security (TLS) are used.

03 Examples of APCA displays.

03a APCA Model builder fitting an ANN model for the Kappa value in a digester.

03b APCA Configuration manager displaying the configuration properties of a loaded controller.

03c APCA Configuration manager displays the map of signal tags to controller variables and parameters.

An APCA Run-time engine instance is created by the APCA Configuration manager when controllers are loaded to the system. The run-time engine contains the optimization algorithms computing in the background. Every run-time engine instance created is monitored by the APCA manager service →2b. If a run-time engine fails, the manager restores the failure within the sampling period, thereby ensuring functionality under adverse conditions. Other run-time instances such as messages or an alarm event will also be either routed and, or displayed in the web application by the APC manager service. Accordingly, the APC manager service and the APC Run-time engine work in concert to safeguard the operation of controllers that have been deployed.

The use of ABB Ability SmartVentilation improves air quality and provides mines with energy savings from 30 to 50 percent annually.

Analytics

One problem control engineers often face is the need to infer data from missing measurements or infer backup data for unreliable measurements. In these cases, analytic models can be deduced from either first principles or process data and deployed in the APCA Run-time system.

Analytic models that can be used in the APCA Model builder are: graphical (first principles), linear regressions, nonlinear regression, principal component analysis (PCA), artificial neural networks (ANN) and support vector machines (SVM). Users can test various models and choose the one with either the best fit or performance statistic, thereby leveraging state-of-the-art advanced analytics.

Applications in industrial automation

ABB Ability APCA supports business units within ABB's industrial automation division with optimization and analytic technology to address consequential challenges in its industries.

Improving mill efficiency in the pulp and paper industry

ABB Ability APCA helps process industries such as the pulp and paper industry to optimize operations even when measurements are not adequate or available. ABB's elegant solution for this industry is OPT800 – a solution powered by Ability APCA to improve efficiency. Developed ANN analytic models, based on measurements such as the H factor, alkalinity, moisture, and residual alkalinity are obtained at the digester's blow line and are used to predict the often unavailable Kappa value within digesters [3]. ANN prediction models that are identified, trained and validated in APCA Model builder are then used to design APC controllers →3a-c. The use of analytic models in conjunction with advanced controllers not only strengthens production and yield from 1 to 5 percent but also reduces Kappa value and residual alkali variation between 25 and 50 percent in digesters. Similar reductions in waste and improved variation of key performance indicators are achieved during other stages of the pulp and paper process [4].

Optimizing ventilation systems in underground mines

The newest ABB Ability APCA capability can identify complex multiple-input multiple-output (MIMO) systems using, for example, gain delay models. This technology has been crucial in the

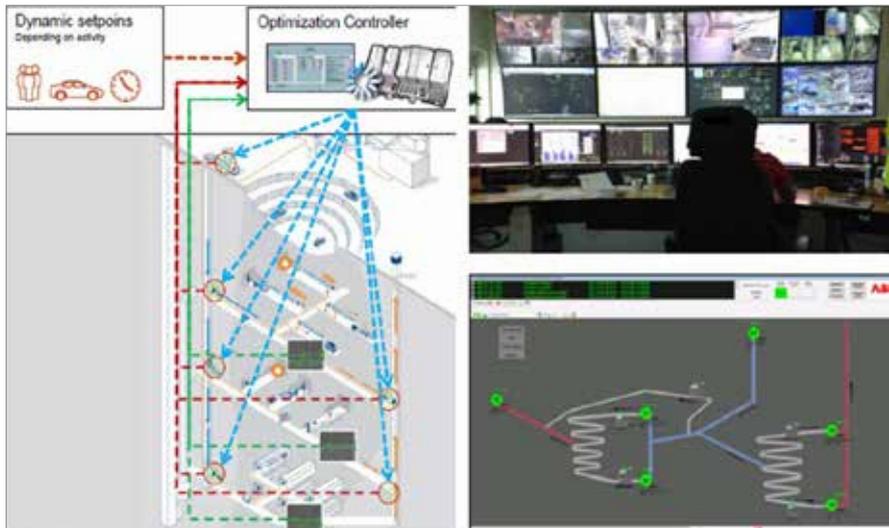
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By taking advantage of ABB's APCA technology, ship operators can reduce fuel costs and consumption by at least 4 percent, and lower emissions; this reduces the carbon footprint and overall cost of operation.

creation of the ABB Ability SmartVentilation solution, a modular system that can be integrated into ABB Ability 800xA and is designed to optimize the ventilation systems of underground mines →4.

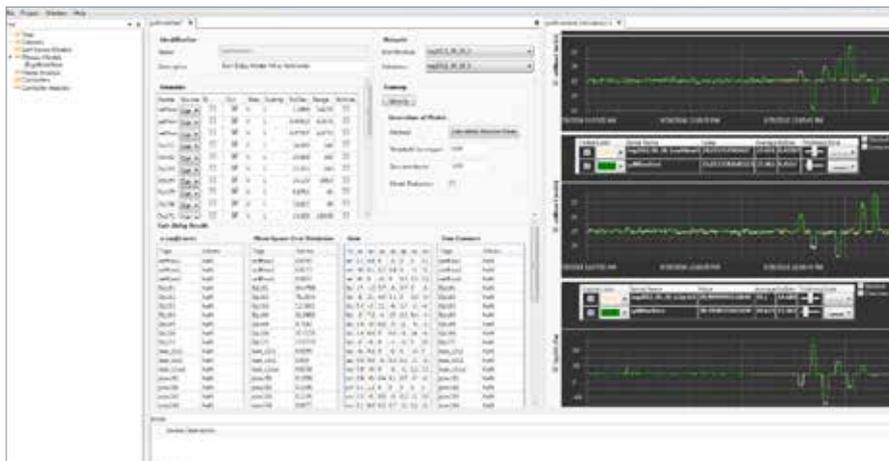
ABB Ability SmartVentilation maintains optimal airflow levels and provides rapid expulsion of blast gases while ensuring minimum power consumption [5]. While conventional operation of ventilation systems poses safety risks to employees and leads to higher than necessary expenditures for total energy consumption, the use of ABB Ability SmartVentilation improves air quality and provides mines with energy savings up to between 30 and 50 percent annually.

Optimizing fuel consumption in the marine industry

The ABB Ability™ Marine Advisory System OCTOPUS powered by ABB Ability APCA has been successful in the shipping power sector where fuel costs and consumption and power plant operation are primarily responsible for high costs and emissions.



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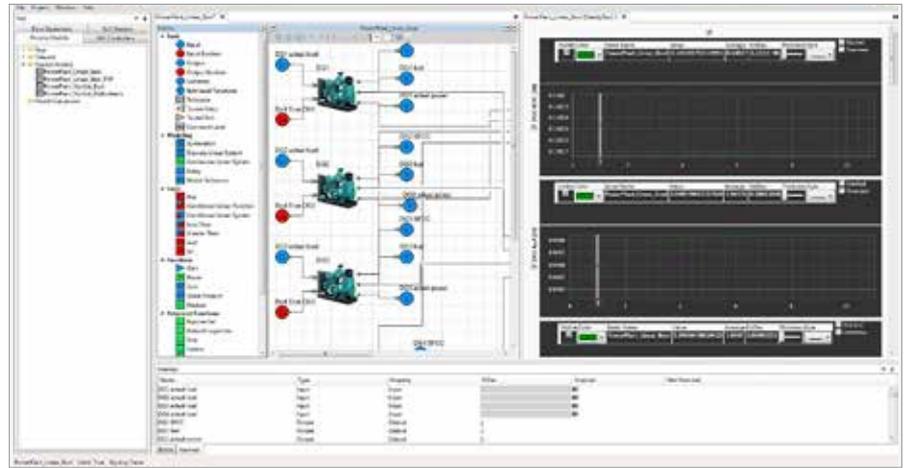


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04a The layout of a mine that employed a gain delay model identified by APCA Model builder to optimize the ventilation system.

04b APCA Model builder fitting a gain delay model for the ventilation system of a mine.

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05 A graphical model of a power plant inside a vessel developed in the APC Model builder showing open-loop simulation plots.



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References

[1] K. Tervo, J. Pietilä, L. Domínguez, M. Lundh, T. Ollika inen, "Closing the loop from office to propeller with ABB Ability™," *Generations*, 2017, pp. 136-139.

[2] L. Domínguez, S.M. Kumar, E. Gallesteý and S. Saynevirta, "A data-driven revolution," *INTECH*, 2017, pp. 12-17.

[3] A. Badwe and R. Saten, "Pulp mill optimization no longer pulp fiction," *ABB Review* 1/2016, pp. 53-59.

[4] ABB's OPT800 suite of advanced control solutions for pulp & paper <http://new.abb.com/pulp-paper/abb-in-pulp-and-paper/systems/control-systems/advanced-process-control>

[5] ABB's SmartVentilation: A real-time mine ventilation optimization solution https://library.e.abb.com/public/1d50e713bab926dc1257d9600368d69/ABB_Mining_Flyer_Smart-Ventilation_LR.pdf

[6] M. Lundh and W. Garcia-Gabin, "Estimation and Optimization of Vessel Fuel Consumption," *Technical Report ABB Corporate Research*, 2015.

The predictive power plant optimization solution uses the predicted power demand of a ship during its entire voyage as input data, which is then exploited to determine the optimal load for each generator.

This long-term optimization uses a model predictive controller that relies on a process model of the entire plant to predict the plant state in future time steps (prediction horizon) resulting in the optimal distributive load over the entire voyage to be determined →5. An optimal control sequence is then determined for a shorter time span (optimization horizon).

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The newly designed and updated ABB Ability Advanced Process Control and Analytics Suite revolutionizes data analysis and reduces modeling effort.

The fuel consumption of each generator is modeled as a non-linear function of the loads and online statuses; thereby relying on monitored specific fuel oil consumption curves and user-defined constraints. APC controllers then take into account the identified fuel efficiency model for each diesel generator to adjust the corresponding loads in real time.

By taking advantage of ABB's APCA technology, ship operators can reduce fuel costs and consumption by at least 4 percent [6], and lower emissions; this reduces the carbon footprint and overall cost of operation.

Revolutionizing data analysis

The IoT revolution has provided process industries like the pulp and paper industry and the energy dependent marine transport sector with the ability to deploy and monitor advanced controllers, analytics and optimization solutions at the edge and to and from an industrial cloud. The newly designed and updated ABB Ability Advanced Process Control and Analytics Suite revolutionizes data analysis and reduces modeling effort. The result is improved commissioning and online monitoring of advanced controllers. The new technology has the potential to take software-as-a-service, as a business model, to an entirely new level making strategic predictions easy and collaborative operations optimal. ●