*भारतीय मानक*
***Indian Standard***

**IS 16336 (Part 2) : 2015**

# विद्युतीय सुविधाओं के संदर्भ में सूचना के आदान-प्रदान हेतु सामान्य सूचना माडल ( सिम )

भाग 2 एबीटी से बने नियंत्रित मार्किट एवं लोड शेडिंग एवं पुनः स्थापन कार्यप्रणाली हेतु सिम विस्तार

# Common Information Model (CIM) for Information Exchange in the Context of Electrical Utilities

Part 2 CIM Extensions for ABT Based Regulated Markets and Load Shedding and Restoration Mechanism

ICS 33.200



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Power System Control and Associated Communications Sectional Committee, LITD 10

## FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Power System Control and Associated Communications Sectional Committee had been approved by the Electronics and Information Technology Division Council.

Utilities are having a wide deployment of various software systems for real-time monitoring and optimized operations, also for achieving various business functions. There is a large number of information exchange scenario's and use cases that exists within inter utility environment as well as in intra utility environment. There are multiple software systems and components involved in these information exchange scenarios, and they are procured from different vendors at different point in time. Often these information exchanges demands very complex integration projects with high cost of execution, which either results in a case to case custom integration using ad-hoc methods or a no integration scenario creating information silos. With a case to case custom integration the number of integration adapters which are needed will increase drastically especially when additional integration requirement increases. Intention of this standard is to bring in a Common Information Model and a set of interface specification thus by enabling the vendors for providing standardized interfaces in various applications and application components which requires an exchange of real-time and non-real-time information.

International Standards published by IEC, namely IEC 61970, IEC 61968 and IEC 62325 for intra application and inter application integration of systems is considered as the base standard for adopting a Common Information Model and Common Interface Specifications. Common Information Model provides a standard semantic model for a model based information exchanges in the context of Electrical utilities. Common Interface Specifications provides a standard set of services which defines how information is exchanged using the context of the standard model.

The scope of this series of standards limits to the following:

a) Identifying various information exchange use cases which are very specific to the country.
b) Provide a guideline for implementation of systems based on international practices with respect to the identified use cases.
c) Providing a number of standard model exchange profiles for specific information exchange scenario's which demands model exchange between two utilities or utility and system operator or utility and market operator.
d) Provide extensions to the models specified in adopted IEC Standards to cater country specific requirements which are not covered in the associated International Standards.

This standard (c) of above para and Para (a) and (b) are covered in (Part 1) and aspect given in (d) is covered in IS 16336 (Part 3).

*Indian Standard*

# COMMON INFORMATION MODEL (CIM) FOR INFORMATION EXCHANGE IN THE CONTEXT OF ELECTRICAL UTILITIES

## PART 2 CIM EXTENSIONS FOR ABT BASED REGULATED MARKETS AND LOAD SHEDDING AND RESTORATION MECHANISM

### 1 SCOPE

This standard covers, the following extensions to the CIM model as referred in IS 16336 (Part 1) to cater to the specific requirements which are not covered in the associated international standards.

Providing a number of standard model exchange profiles for specific information exchange scenario's which demands model exchange between two utilities or utility and system operator or utility and market operator.

The country specific requirements include, the modelling of availability based tariff (ABT) mechanism which is used in scheduling and settlements of power in Indian markets.

### 2 INTRODUCTION

**2.1** The broad objective of CIM model extensions is to cover the entire business process of the system operators in India at all levels (national, regional, state, and distribution companies). However this section presents CIM model extensions for the Availability Based Tariff (ABT)/ Deviation Settlement Mechanism (DSM) (Note: ABT and DSM are used in this standard alternatively). The proposed extensions can be further enriched by expanding the scope to cover other operations in a phased manner. ABT comprises of three components:

a) capacity charge, towards reimbursement of the fixed cost of the plant, linked to the plant's declared capacity to supply MWs;
b) energy charge, to reimburse the fuel cost for scheduled generation; and
c) Unscheduled Interchange — a payment for deviations from schedule, at a rate dependent on system frequency.

The last component would be negative (indicating a payment by the generator for the deviation) in case the power plant is delivering less power than scheduled and positive in case the power plant is delivering more power than scheduled when frequency is low. For a distribution company, unscheduled interchange charges will be corresponding to its drawal *versus* schedule. If the unscheduled interchange of the generator or beneficiary is above notified volume limits, then additional unscheduled interchange charges will be levied on them. In addition to this, penalty (in geometric progression) will be levied for mis-declaration by generators.

**2.2** In short, the effects of ABT on the participants of power system are provided below.

a) *Load Dispatch Centre*
   1) Energy scheduling,
   2) Energy accounting, and
   3) Balancing and settlement.
b) *Generating Stations*
   1) Penalty for mis-declaration in geometric progression of 2 days fixed charges.
   2) Realization of capacity charges in prorata basis with respect to achieved availability being lesser than the notified target availability.
   3) Negative UI charges at notified UI rate corresponding to frequency when dispatch is less than the schedule.
   4) Positive UI charges at notified UI rate corresponding to frequency when dispatch is more than the schedule.
   5) Additional UI charges when deviation is more than volume limits.
   6) Gaming constraints at 105 percent in a block and 101 percent in a day and UI rate capping.
c) *Distribution Companies*
   1) Negative unscheduled Interchange for actual drawal more than drawal schedule.
   2) Positive unscheduled Interchange for actual drawal less than drawal schedule.
   3) Additional UI charges when deviation is more than volume limits.
   4) Gaming Constraint for under drawl at 3 percent in a block and 12 percent in a day.

**2.3** While implementing ABT, the perspective changes with respect to where it is implemented. Modeling of Availability Based Tariff mechanism at system operator or RTO periphery includes energy scheduling, energy accounting, balancing and settlement. Generating stations, distribution companies, and HT industries shall comply with ABT mechanism. Load Dispatch Centre shall schedule, monitor, control and energy account the ABT mechanism. Energy scheduling shall be based on merit order dispatch, power purchase agreements and entitlements. Energy Accounting and balancing and settlement is done based on entitlements, gaming constraints, power purchase agreements, contract demand and open access agreements. The key factors that need to be considered while modeling ABT are the extent of applicability of ABT on different type of utilities based on the nature of the product chosen. When energy product is chosen, all the three components of ABT namely capacity charges, energy charges and Unscheduled Interchange charges are applicable. When open access product or power exchange product is chosen only unscheduled interchange charges are applicable. Modeling of Availability Based Tariff mechanism at generation periphery includes capability declaration, merit order dispatch, capacity charges realization, achieving PLF target, and positive UI charges maximization. Modelling of Availability Based Tariff mechanism at distribution periphery includes requirement declaration based on load forecast, entitlement, and positive UI charges maximization.

## 3 ENERGY SCHEDULING IN ABT MECHANISM AND CIM

The above factors had been considered in modeling ABT in CIM and the model is presented from the perspective of SLDC.

### 3.1 Information Exchange while Scheduling

Load Dispatch Centre exchanges various types of scheduling information with stake holders. The message types are depicted in Fig 1.

To understand the message types, basically the activities involved in scheduling process needs to be understood. In ABT, generating stations declare their day a-head capability. Central sector generating stations declare their capability through RLDC. State sector generating stations declare their capability directly to SLDC. SLDC computes and sends entitlement of DISCOMs. The entitlement percent is defined as per power purchase agreements. DISCOMs send drawl requisition up to their entitlement to SLDC. The drawl requisition by DISCOM to SLDC consists of three components, namely PPA component, Open access component and Market component. Based on the load forecast, entitlement and the merit order (merit based on rate of energy) of generating companies, drawl requirement is computed. Based on requirement from DISCOMs and availability from generating stations, SLDC notifies surplus capability. On receipt of surplus availability, if the earlier requested drawl is less than the load forecast, additional requirement is calculated and updated to SLDC. Based on generation capabilities and drawl requisitions, SLDC prepares generation schedule and drawl schedule. The succeeding chapters present the method and the extension classes required to adopt CIM for representing ABT.

### 3.2 Energy Scheduling Sub-processes

**3.2.1** *Capability Computation by Generating Stations*

Day ahead capability is calculated based on unit constraints, equipment constraints, fuel constraints, and

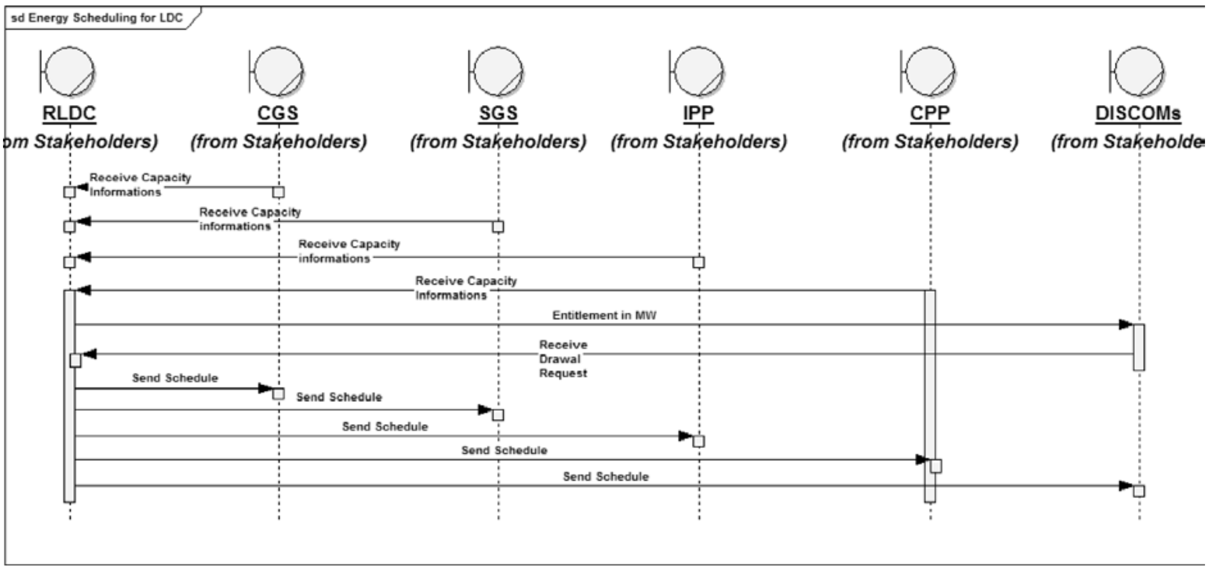


FIG. 1 INFORMATION EXCHANGE WHILE SCHEDULING

maintenance constraints. These constraints reduce the availability of the generating plant. The model of capability declaration information is depicted in Fig. 2.

**3.2.2** *Capability Declaration by Generating Stations*

Capability is declared by generating stations at the interface point. The declared capability is sent to the SLDC as information. The model of capability declaration information is depicted in Fig. 3.

**3.2.3** *Entitlement of Distribution Companies*

Based on the allocation percentage, load dispatch centre computes the entitlement of each DISCOM at its interface point with the transmission system after subtracting the transmission losses. The present CIM version does not have class for representing the entitlement percentage. Hence Common Information Model is extended to have a class named "EnergyScheduling:Allocation" with attributes:AllocationFromUtility, AllocationToUtility, AllocationType, ApplicableFromDateTime, ApplicableTodateTime, EntitlementPercentage, and EntitlementPriority. The representation of entitlement shall be through association with class "EnergyScheduling:EnergyTransaction" and its generalized class "Common:Document" attribute "Subject".

**3.2.4** *Requirement Declaration by Distribution Companies*

Distribution companies send requirement to load dispatch centre based on their entitlement and load forecasting. Corresponding CIM representation given in Fig. 4.

**3.2.5** *Energy Scheduling by Load Dispatch Centre*

The Generating Stations declare their capacity at their interface point with the transmission system. The Distribution companies submit their requirement at the interface point with the transmission system. Based on the entitlement percentage, transmission loss profile and merit order stack, load dispatch centre prepares the dispatch schedule and drawal schedule. In Fig. 5, the classes involved in modelling the ABT energy

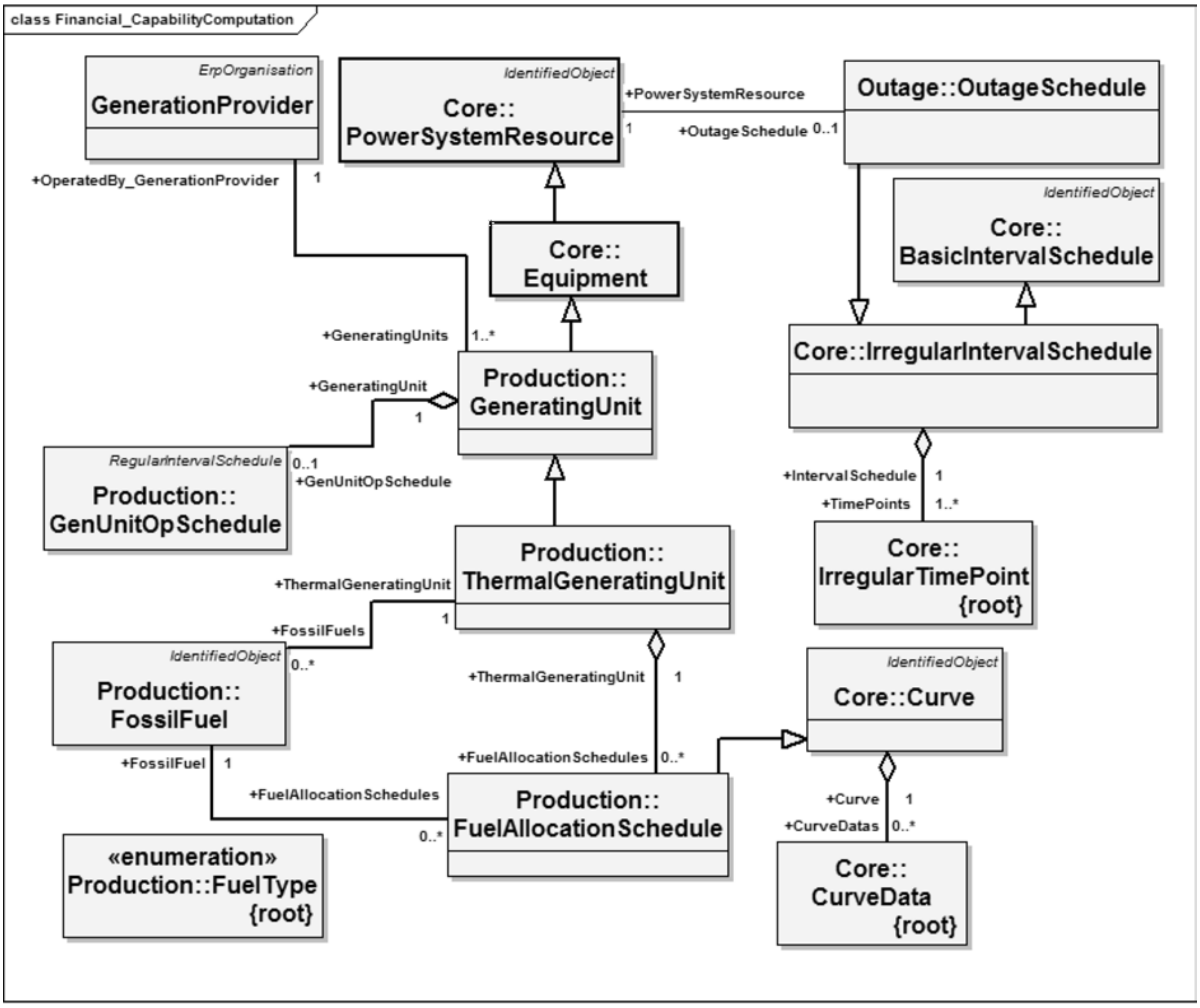


FIG. 2 CAPABILITY COMPUTATION BY GENERATING STATIONS

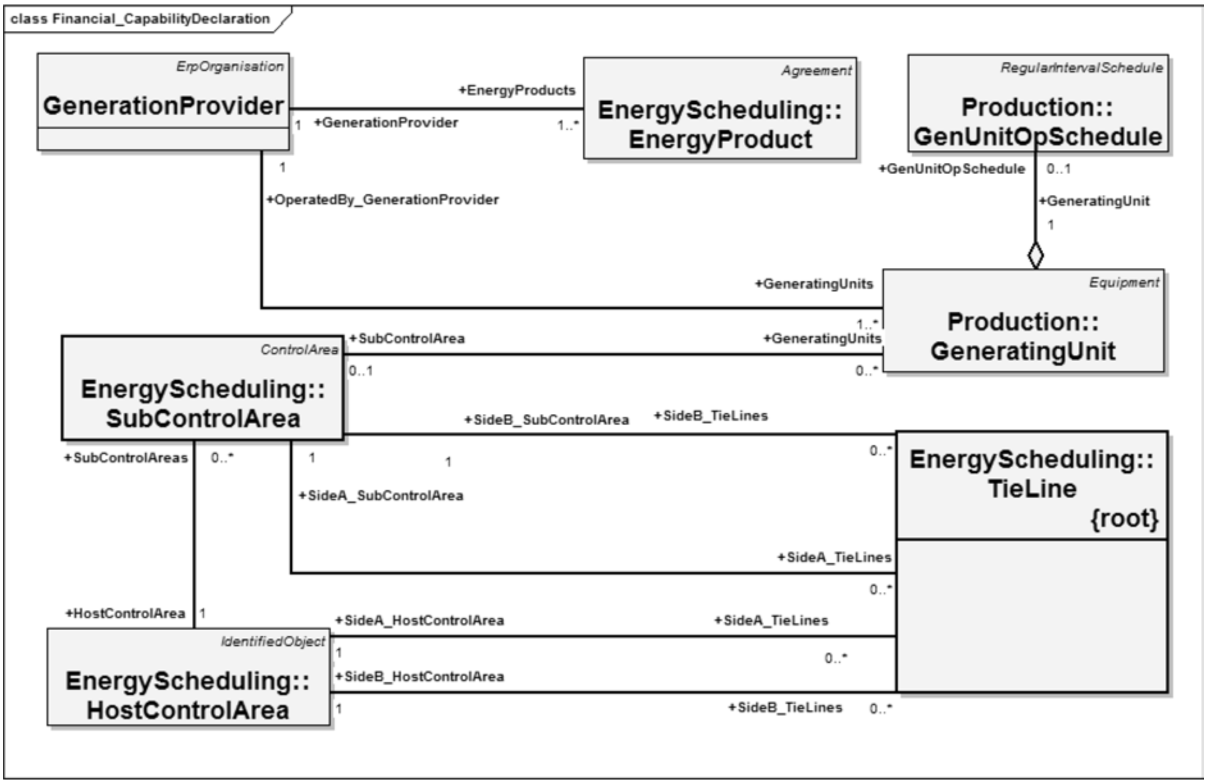


FIG. 3 CAPABILITY DECLARATION BY GENERATING STATIONS

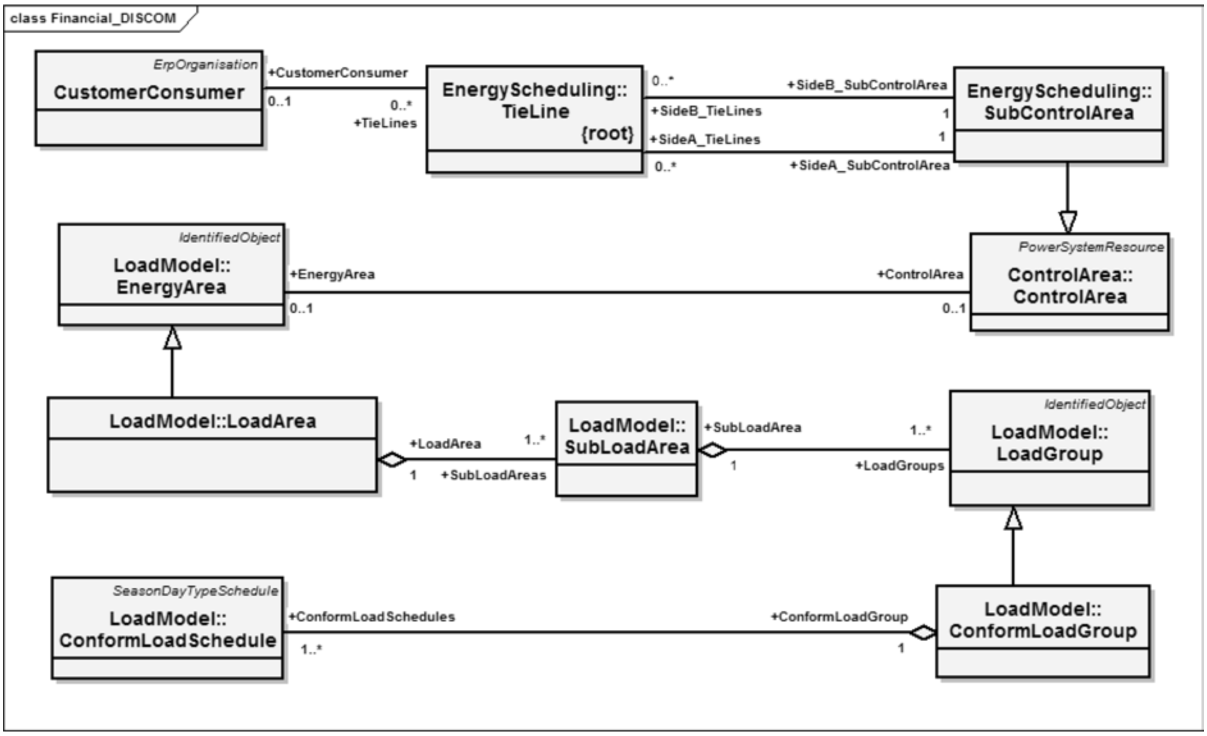


FIG. 4 REQUIREMENT BY DISCOM

scheduling mechanism in CIM are depicted. The classes depict a logical representation; the intricacies of the associations involved are not shown in this figure. They are represented in Fig. 2, Fig. 3 and Fig. 4. During suspension of ABT period, Load Dispatch Centre notifies it. CIM doesn't have class to represent this. Hence CIM has to be extended with a class "EnergyScheduling:NonABTPeriod".

**3.2.6** *Summary*

For modelling Energy Scheduling component of ABT mechanism in CIM, following extensions classes are required.

a) EnergyScheduling:Allocation
b) EnergyScheduling:MeritOrderList
c) EnergyScheduling:NonABTPeriod

The details of above classes are explained in Tables 1, 2, and 3.

**Table 1 Description of Extension Class 1: EnergyScheduling:Allocation**

(*Clause* 3.2.6)

*Use: To represent entitlement/ allocation as per power purchase agreement*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Attribute 1 | allocationFromUtility | String |
| ii) | Attribute 2 | allocationToUtility | String |
| iii) | Attribute 3 | allocationType | String |
| iv) | Attribute 4 | applicableFromBlock | int |
| v) | Attribute 5 | applicableToBlock | int |
| vi) | Attribute 6 | entitlementPercent | Percent |
| vii) | Association 1 | Common:Document | Generalization |
| viii) | Association 2 | Common:DateTimeInterval | Association |

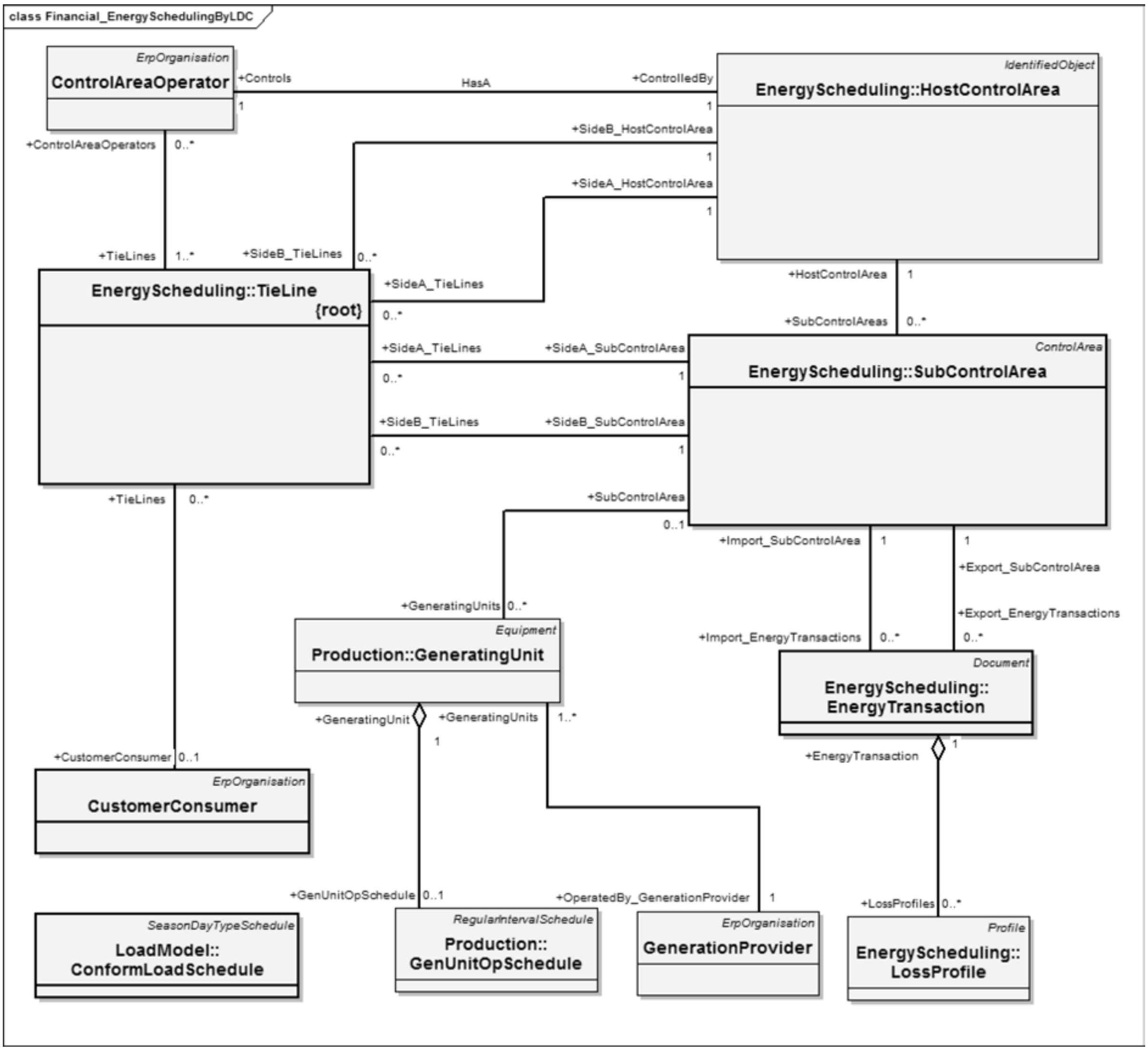


FIG. 5 ENERGY SCHEDULING BY LDC

**Table 2 Description of Extension Class 2: Energy Scheduling: Merit Order List**

(*Clause* 3.2.6)

*Use: To represent merit order list of generating stations based on their rate of energy charge using which load dispatch centres prepare schedules*

| Sl No. | Attribute | Description | Type |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Attribute 1 | meritOrder | int |
| ii) | Attribute 3 | utilityID | String |
| iii) | Association 1 | Common:DateTimeInterval | Association |

## 4 ENERGY ACCOUNTING AND CHARGES IN ABT MECHANISM AND CIM

### 4.1 Information Exchange in Energy Accounting and Charges Process

SLDC exchanges energy accounting and charges information with stake holders as depicted in Fig. 6.

Load Dispatch Centre exchanges/publishes information in two broad heads — State Energy Account and Charges and deviation account. Representation of this information in CIM is presented here.

**Table 3 Description of Extension Class 3: EnergyScheduling: NonABTPeriod**

(*Clause* 3.2.6)

*Use: To represent non ABT period or suspension of UI*

| Sl No. | Attribute | Description | Type |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Attribute 1 | fromBlockNumber | int |
| ii) | Attribute 2 | fromDateTime | AbsoluteDateTime |
| iii) | Attribute 3 | noticeIssueDate | AbsoluteDateTime |
| iv) | Attribute 4 | noticeNumber | int |
| v) | Attribute 5 | reason | String |
| vi) | Attribute 6 | toBlockNumber | int |
| vii) | Attribute 7 | toDateTime | AbsoluteDateTime |
| viii) | Association 1 | Common:Document | Generalization |

### 4.2 ABT Meter Data and CIM

The ABT meter data collection is the primary activity

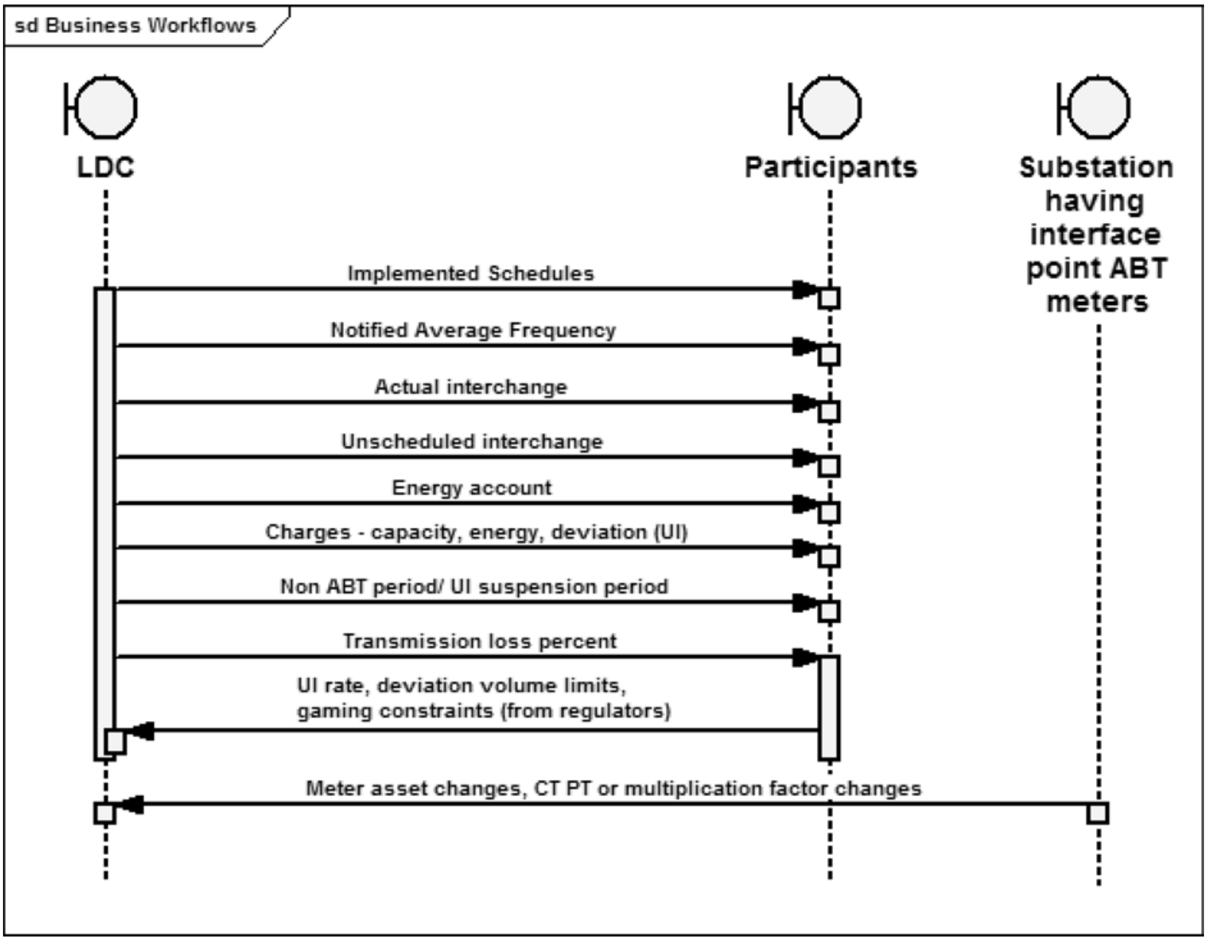


FIG. 6 INFORMATION EXCHANGE FOR ENERGY ACCOUNT AND CHARGES

for preparing an energy account. To prepare Energy account under ABT mechanism, the basic requirement is 15 min block wise (ABT) Load survey data. ABT meter data is acquired both offline and online mode. The present classes in CIM under packages “MEAS” and “METERING” are used for modeling ABT meter data. In ABT meter data acquisition, the multiplication factor is applied at control center rather than at substation. The quality of data is validated and CIM class used for the purpose is “Metering:Quality”. Hence, for ABT meter data modelling in CIM, the existing classes are sufficient and extensions are not required. ABT meter data representation in CIM is presented in Fig. 7.

**4.3 Energy Account**

The energy account is prepared based on Capability Declaration, Schedule Interchange, Actual Interchange, and Entitlement. For modelling the energy account in CIM, the extended classes are “EnergyScheduling:Allocation” and “EnergyScheduling:NonABTPeriod”.

Applying tariff rates on the energy account will result in charges. The Availability Based Tariff structure and charges are modelled in CIM as provided in following section.

**4.4 ABT Charges and Balancing and Settlement**

ABT mechanism has four part charge mechanism. They are capacity charges and its realization, energy charges, unscheduled interchange charges and reactive energy charges. Modeling ABT charges, and balancing and settlement in CIM is not possible with the available CIM classes due to the unique requirements of Availability Based Tariff Mechanism. Hence CIM requires extension. The extensions are placed as a sub package in “FINANCIAL” package referred in Fig. 9. It is the logical choice since the balancing and settlement of energy account and charges are among the business entities represented in “FINANCIAL” package.

CIM does not address the requirements of ABT tariff structure. It needs extension for modelling ABT energy accounting and balancing and settlement mechanism. The ABT sub package is presented in Fig. 10. The required extension classes are presented in following sections.

**4.5 Description of Extension Classes for Modelling ABT Structure**

The details of extension classes required for modeling ABT structure are provided from Table 4 to Table 8.

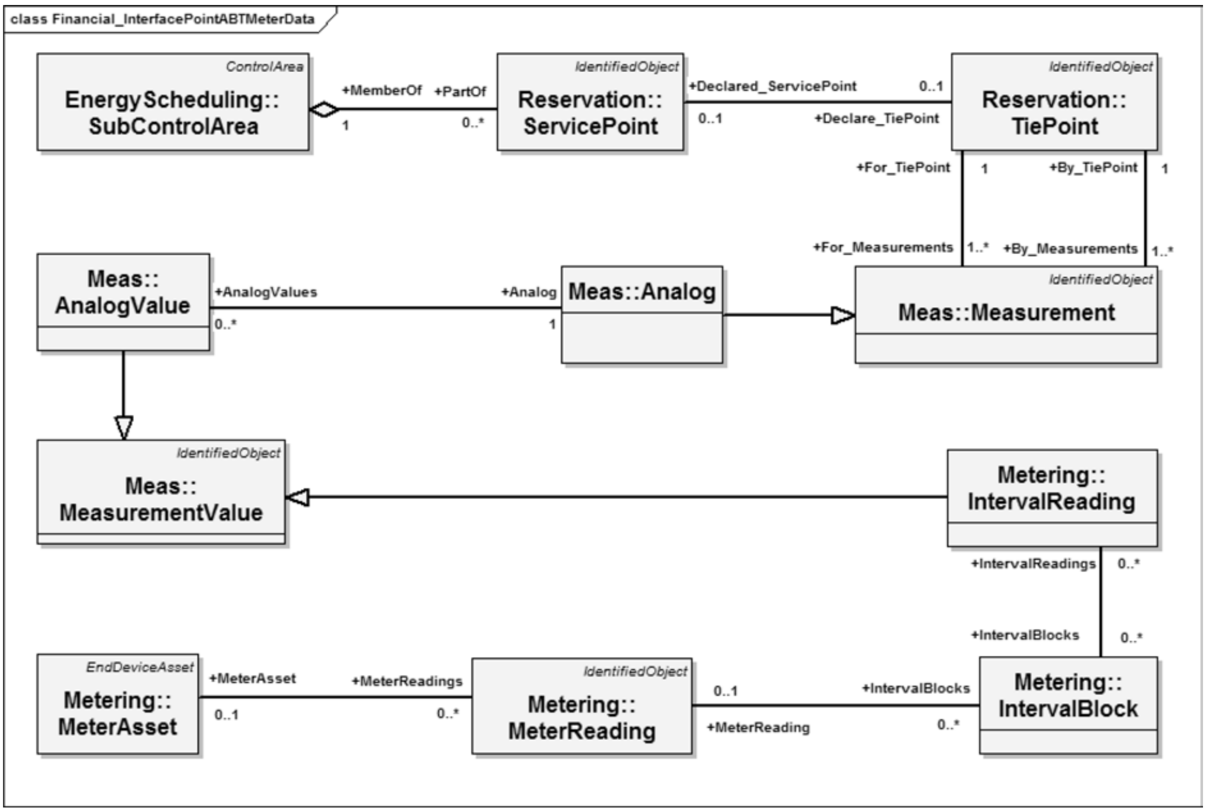


FIG. 7 ABT METER DATA REPRESENTATION IN CIM

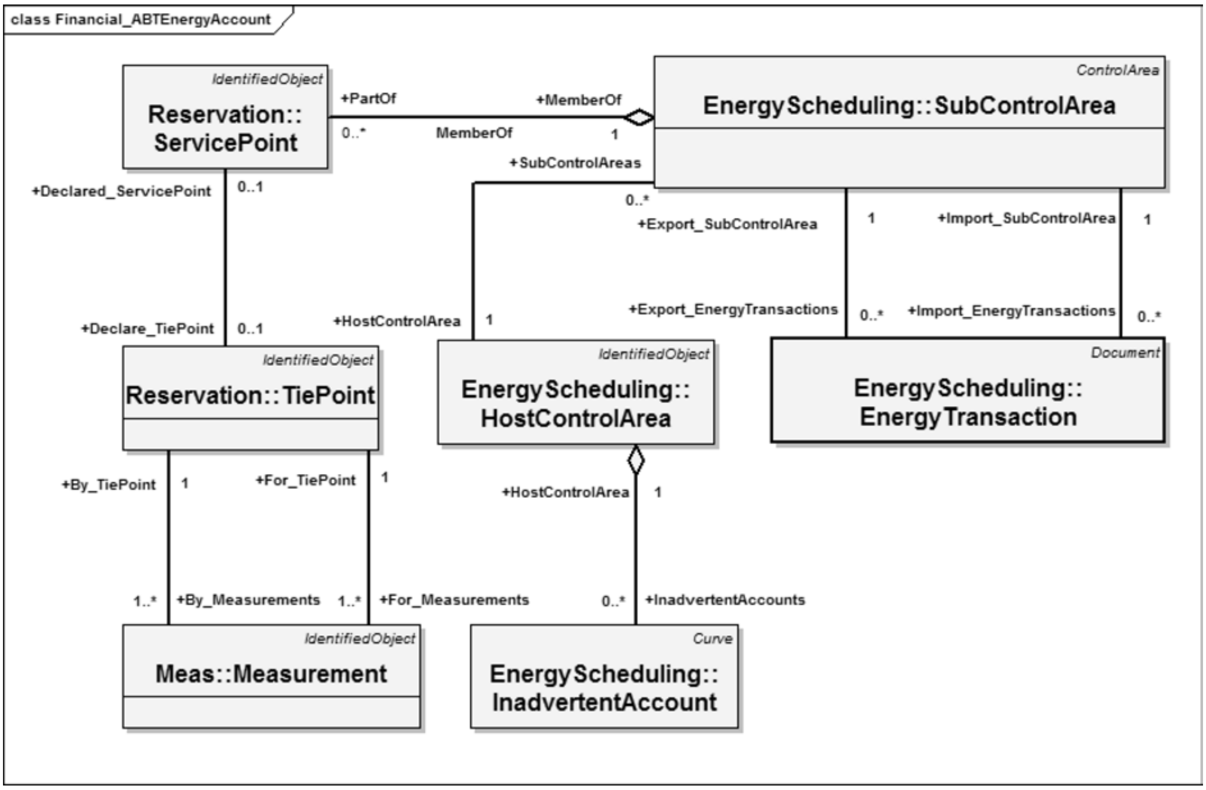


FIG. 8 ENERGY ACCOUNT

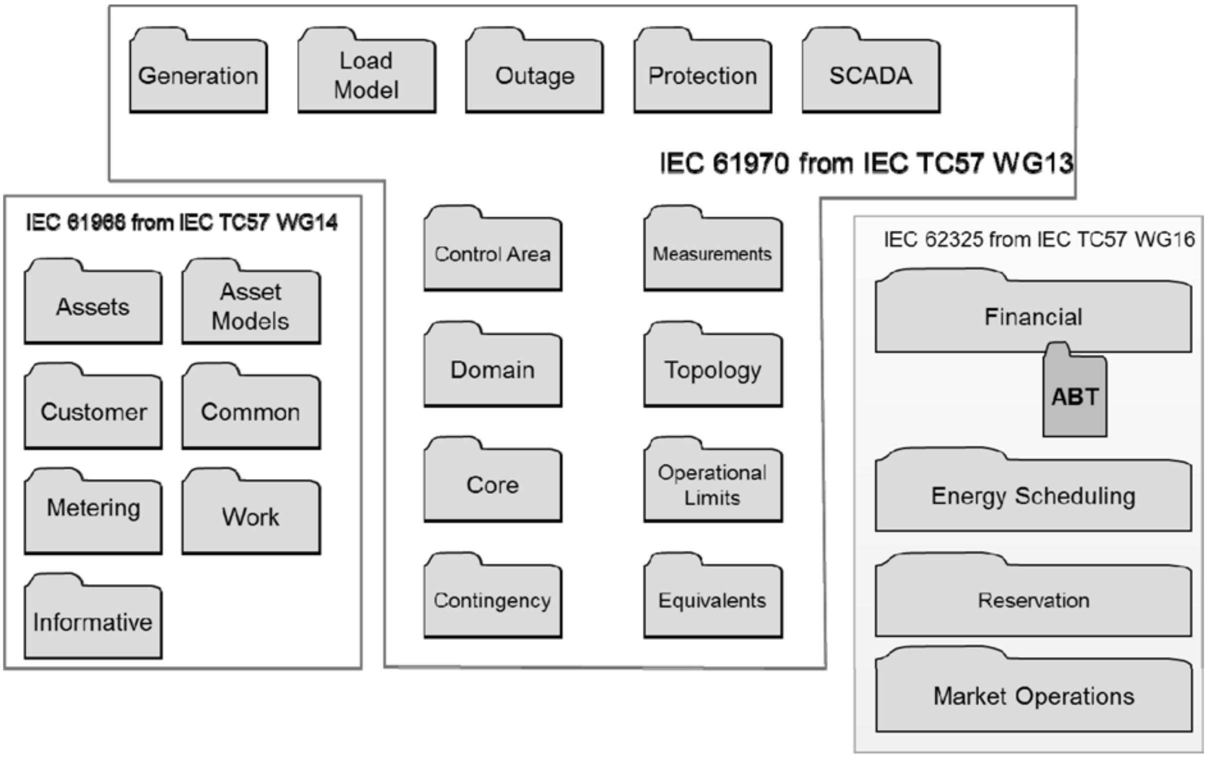


FIG. 9 ABT AS A SUB-PACKAGE TO FINANCIAL PACKAGE IN CIM

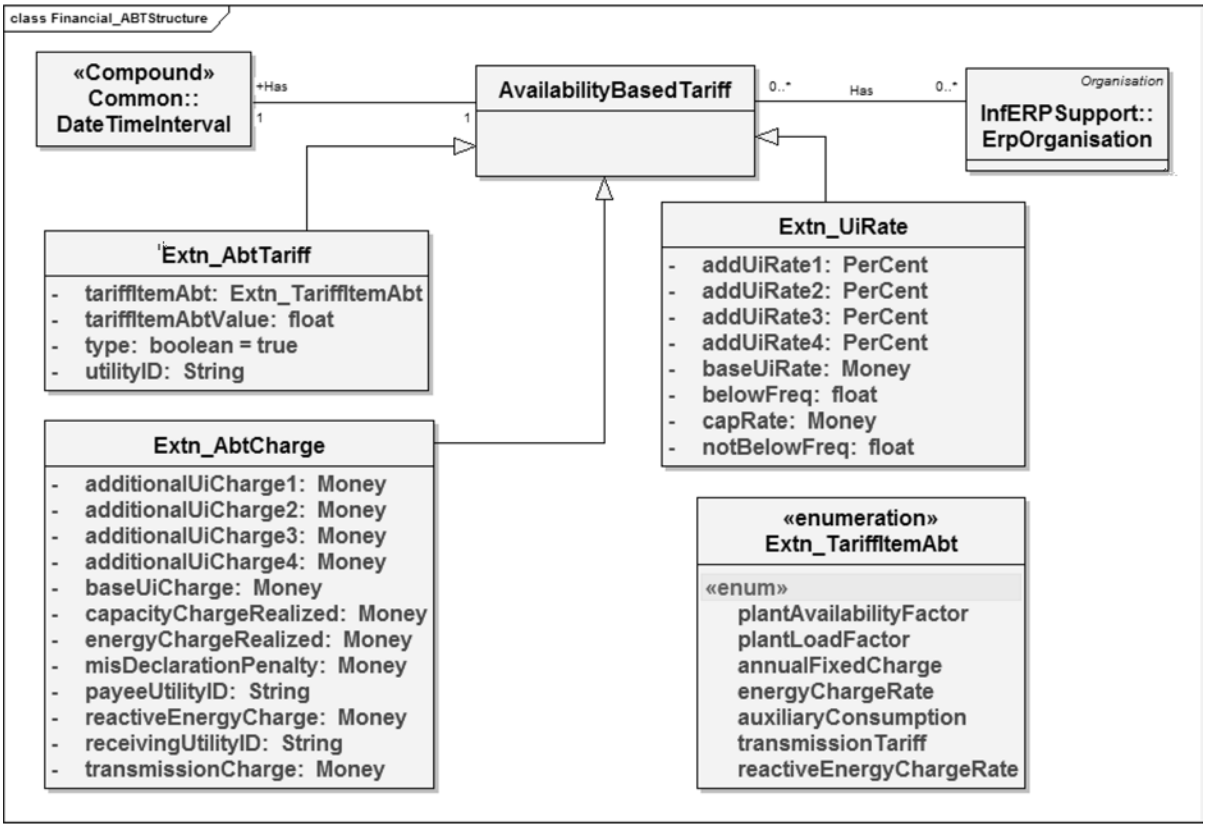


FIG. 10 ABT SUB-PACKAGE IN CIM

**Table 4 Description of Extension Class 4: Financial:AvailabilityBasedTariff**

(*Clause* 4.5)

*Use: To define Availability Based Tariff Structure*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Association 1 | InfERP:ErpOrganization | Generalization |
| ii) | Association 2 | Common:DateTimeInterval | Association |

**Table 5 Description of Extension Class 5: Financial: Extn_AbtTariff**

(*Clause* 4.5)

*Use: To define energy charge tariff notified by competent authority*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Attribute 1 | UtilityID | String |
| ii) | Attribute 2 | type | int |
| iii) | Attribute 3 | tariffItemAbt | Extn_TariffItemAbt |
| iv) | Attribute 4 | tariffItemAbtValue | float |
| v) | Association 1 | Financial:AvailabilityBasedTariff | Generalization |

**Table 6 Description of Extension enumeration Class 6: Financial: Extn_TariffItemAbt**

(*Clause* 4.5)

*Use: To various tariff rates notified by competent authority*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | enum 1 | plantAvailabilityFactor | PerCent |
| ii) | enum 2 | PlantLoadFactor | PerCent |
| iii) | enum 3 | AnnualFixedCharge | Money |
| iv) | enum 4 | EnergyChargeRate | MonetaryAmountPerActiveEnergyUnit |
| v) | enum 5 | AuxiliaryConsumption | Generalization |
| vi) | enum 6 | TransmissionTariff | MonetaryAmountPerMW |
| vii) | enum 7 | reactiveEnergyChargeRate | MonetaryAmountPerReactiveEnergyUnit |

## 5 LOAD SHEDDING AND RESTORATION

**5.1** Load shedding is the term used to describe the deliberate switching off of electrical supply to parts of the electricity network, and hence to the customers in those areas. Load shedding can be required when there is an imbalance between electricity demand (customer's usage) and electricity supply (the ability of the electricity network to generate and transport the

**Table 7 Description of Extension Class 7: Financial: Extn_UiRate**

(*Clause* 4.5)

*Use: To define unscheduled interchange rate notified by competent authority*

| Sl No. | Attribute | Description | Type |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Attribute 1 | notBelowFreq | float |
| ii) | Attribute 2 | belowFreq | float |
| iii) | Attribute 3 | baseUiRate | Money |
| iv) | Attribute 4 | capRate | Money |
| v) | Attribute 5 | addUiRate1 | PerCent |
| vi) | Attribute 6 | addUiRate2 | PerCent |
| vii) | Attribute 7 | addUiRate3 | PerCent |
| viii) | Attribute 8 | addUiRate4 | PerCent |
| ix) | Association 1 | Financial:AvailabilityBasedTariff | Generalization |

**Table 8 Description of Extension Class 8: Financial: Extn_AbtCharge**

(*Clause* 4.5)

*Use: To define reactive energy rate notified by competent authority*

| Sl No. | Attribute | Description | Type |
|---|---|---|---|
| (1) | (2) | (3) | (4) |
| i) | Attribute 1 | additionalUiCharge1 | Money |
| ii) | Attribute 2 | additionalUiCharge | Money |
| iii) | Attribute 3 | additionalUiCharge | Money |
| iv) | Attribute 5 | baseUiCharge | Money |
| v) | Attribute 6 | capacityChargeRealized | Money |
| vi) | Attribute 7 | energyChargeRealized | Money |
| vii) | Attribute 8 | misDeclarationPenalty | Money |
| viii) | Attribute 9 | payeeUtilityID | String |
| ix) | Attribute 10 | reactiveEnergyCharge | Money |
| x) | Attribute 11 | receivingUtilityID | String |
| xi) | Attribute 12 | transmissionCharge | Money |
| xii) | Attribute 4 | additionalUiCharge | Money |
| xiii) | Association 1 | Financial:AvailabilityBased Tariff | Generalization |

required amount of electricity to meet this demand). When there is a shortfall in the electricity supply, there can be a need to reduce demand very quickly to an acceptable level, or risk the entire electricity network becoming unstable and shutting down completely. This is known as a cascade event, and can end in a total or widespread network shutdown affecting very large areas of a country. Some examples include the blackouts in northeast America and Canada in 2003 and across Italy in the same year.

Load shed application is based on load forecast and energy drawl schedule received from a load dispatch centre. The requirements of load shed and restoration application as specified by Restructured Accelerated Power Distribution Reform Programme (R-APDRP) for India is provided in this section. The load shed application shall automate and optimize the process of selecting the best combination of switches to be opened and controlling in order to shed the desired amount of load under a DISCOM area.

Given a total amount of load to be shed, the load shed application shall recommend different possible combinations of switches to be opened, in order to meet the requirement. The dispatcher is presented with various combinations of switching operations, which shall result in a total amount of load shed, which closely resembles the specified total. The dispatcher can then choose any of the recommended actions and execute them. The recommendation is based on basic rules for load shedding and restoration. In case of failure of supervisory control for few breakers, the total desired load shed/restore will not be met. Under such conditions, the application shall inform the dispatcher the balance amount of load to be shed/restore. The load-shed application shall run again to complete the desired load shed/restore process. The result of any Load Shed operation shall be archived in Information storage and retrieval system.

**5.2 Basic Rules for Load Shedding and Restoration**

The load shall be shed or restored on the basis of following basic rules:

a) *By load priority* — The Load Shed Application (LSA) Software shall have a priority mechanism that shall allow the user to assign higher priorities for VIP or any other important load. The load assigned with the higher priorities shall be advised to be shed later and restore earlier than load with relatively lower priorities. Each load priority shall be user definable over the scale of at least 1-10.

b) *By 24 h load shed /restore history* — The loads of equal priorities shall be advised for restoration in such a way that loads shed first shall be advised to be restored first. The application shall ensure that tripping operations is done in a cyclic manner to avoid the same consumers being affected repeatedly, however, priority loads shall be affected least.

c) *By number of consumers affected* — The consumer with equal priority and similar past load shed history shall be considered by the application in such a way that minimum number of consumers are affected during the proposed load shed. The data for number of consumers connected to a feeder/device shall be taken from computerized billing system.

**5.3 Modes of Operation**

The load-shed application shall operate in four modes. Each mode of operation can be enabled or disabled by operator independently. The load can be shed and restore in possible combination that is manually shed and auto restore, or *vice-versa*, or both operations in the same modes. Different types of load shedding are as follows:

a) *Manual Load Shed* — In this mode, operator specifies a load to be shed in a project area. The software shall determine and propose all the possible combinations of switches to be operated for the requested load shed considering the basic rules for load shed and restoration. In case more than one options are possible, then the application shall identify all such options with the priority of consumers along with the number of consumers are likely to be affected for the particular load shed option. The dispatcher shall select and execute one of these options for affecting the load shed.

b) *Manual Load Restoration* — In this mode operator specifies the desired load to be restored. The software shall determine the switches to be operated for the requested load restore considering the basic rules for load shed and restoration. In case more than one option is possible, then the application shall identify all such options with the priority of consumers along with the number of consumers are likely to be restored for the particular load restore option if chosen by dispatcher. The dispatcher shall select and execute one of these options for effecting the load restoration. The Load Shed Application shall maintain a load restore timer, which shall automatically start after tripping of Circuit Breaker due to manual load shedding. An alarm shall be generated to remind the operator to restore the loads when this timer expires. For manual mode of operation the dispatcher shall enter the value of load restore timer.

c) *Auto Load Shed* — This shall have two modes namely frequency based load shed and time of day based load shed as described below.

   1) *Frequency based load shed* — The function shall execute the tripping of breakers based on the system frequency automatically considering the basic rules for load shed and restoration. The software shall automatically execute the switching operations as soon as system frequency reaches at LSS_str frequency threshold and it shall continue to do so unless system frequency crosses the LSS_stp frequency limit. The frequency limits shall be dispatcher assignable up to single decimal points. Once frequency crosses below LSS_stp limit, then load shed can only be started and again restoration can be started when frequency attains above the LSS_str. In the proposed software configuration, Limit LSS_str shall be lower than LSS_stp. A suitable protection to ensure that shall be in the range has to be provided in the user interface such as discard, forbidden, etc, if a user accidentally enters LSS_str higher or equal to LSS_stp or LSS are entered higher than LSR.

   2) *Time of day based load shed* — The function shall operate to shed load at the predefined time of the day and load to be shed. The software shall automatically execute the switching operations considering the basic rules for load shed and restoration.

d) *Auto Load Restoration* — This shall have two modes namely frequency based load restoration and time of day based load restoration as described below:

   1) *Frequency based restoration* — The function shall execute the closing of breakers based on the system frequency automatically considering the basic rules for load shed and restoration. The software shall automatically execute the switching operations as soon as system frequency attains LSR_str, and it shall continue to do so as long as system frequency is crosses above the mark LSR_stp. The frequency limits shall be dispatcher assignable up to single decimal points. Once frequency crosses below LSR_stp limit, then load shed can only be started again when frequency attains LSR_str. Limit LSR_str shall be lower than LSR_stp and suitable protection to ensure that shall be provided in user interface such as discard, forbidden etc if user accidentally enters LSR_stp higher or equal to LSR_stp or LSR limits lower than LSS. The sequence of frequency limits shall be permitted as LSR_str>LSR_stp>LSS_stp>LSS_str. Adequate protection as mentioned above shall be given if user tries to violate the same.

2) *Time of day based restoration* — The function shall operate to restore load at the predefined time of the day and load to be restored. The software shall automatically execute the switching operations considering the basic rules for load shed and restoration.

e) *Alarms/Events* — All load shed and restore operations executed shall be logged in the system as events. In case the supervisory control fails during the operation in predefined time, an alarm shall be generated with the possible reason for the failure.

**5.5 CIM Model for Load Shedding and Restoration Mechanism**

Based on the above information CIM model has been prepared and presented in Fig. 10. This model utilizes IEC 61968 and IEC 61970. The classes required representing switch; breakers, their failure event and status are available in present CIM. The classes required to represent Distribution Transformer is present in package "WiresExt" of IEC 61968. Representation of group of consumers connected to distribution transformer can be represented using the class "EnergyConsumer". The link between these two classes is shown in Fig. 10. To enable rotation based

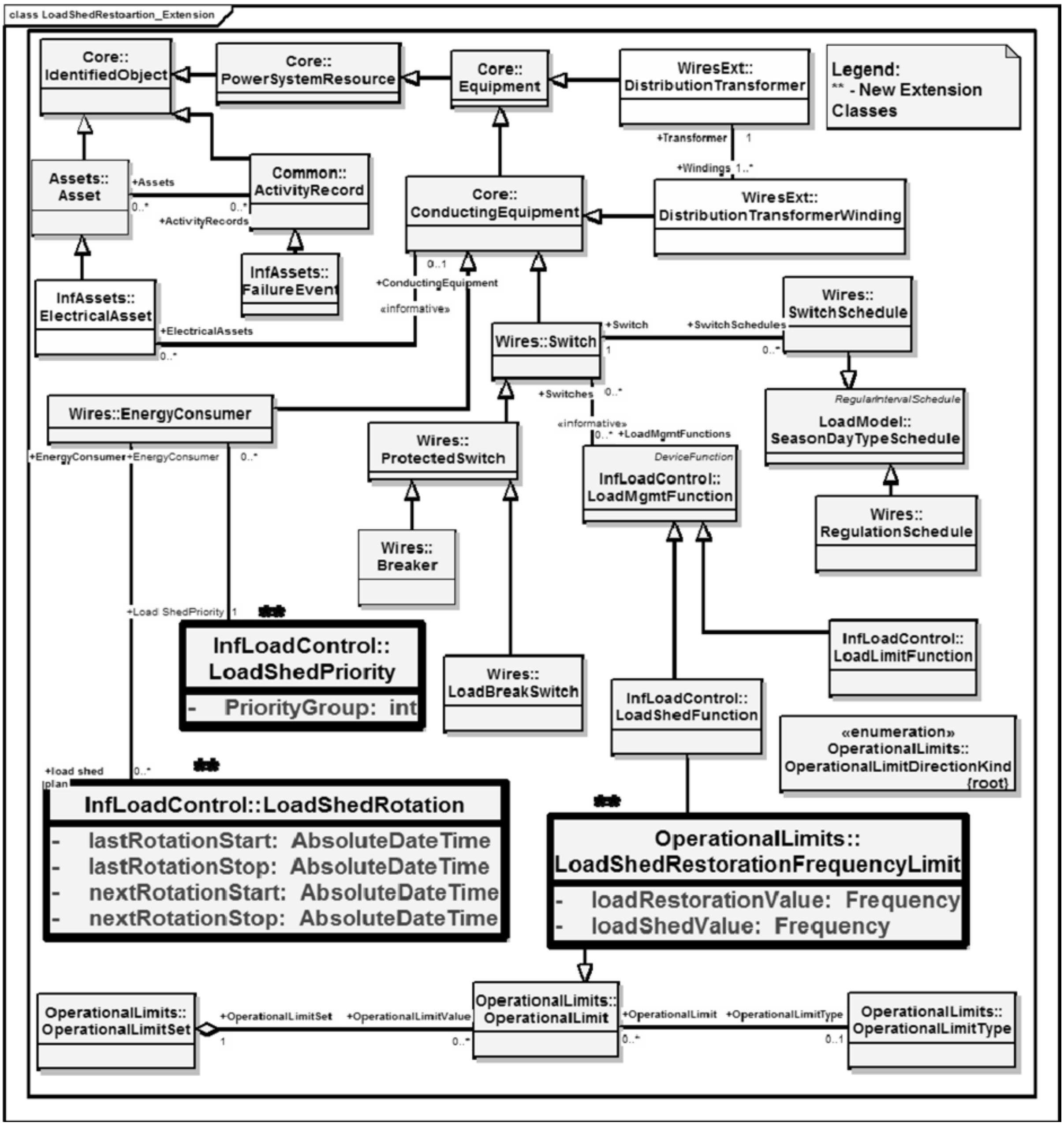


FIG. 11 LOAD SHEDDING AND RESTORATION IN CIM

load shedding principle, a new class "LoadShedRotation" has been extended. From present CIM class "Customer", priority principle can be applied using its attribute "Customer:vip". This representation is insufficient to comply with priority principle in which customers are grouped and priority given in scale of 1 to 10. Hence, in this paper, an extension class "LoadShedding-Priority" is presented. It has association with the class "EnergyConsumer" and hence "DistributionTransformer" which can be load shed through switches. The energy consumer class is eventually linked to the metering package through "EnergyConsumer — ServiceDeliveryPoint - MeterReading -MeterAsset", there by facilitating identification of consumers. The present representation of operational limits does not specify limits for load shed and restore frequency ranges. A new class "LoadShedRestorationFrequencyLimit" associated with existing class "OperationalLimits" is extended.

Figure 10 depicts the representation of classes (existing and extended) and their associations using which load shedding and restoration application can be implemented in India.

**5.6 Description of Extension Classes for Representing Load Shed and Restoration in CIM Description of Extension Class: LoadShedPriority**

Energy Consumers are grouped into priority groups in scale of 1 to 10. During load shedding, higher priority group shall be shed last. During load restoration, higher priority group shall be restored first. The description of the extension class is given in Table 9.

**Table 9 Description of Extension Class 9: LoadShedPriority**

(*Clause* 5.6)

*Use: To configure priority level of consumer*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Attribute 1 | PriorityGroup | int |
| ii) | Association 1 | EnergyConsumer | Association |

**5.7 Description of Extension Class: LoadShedRotation**

This class is used for storing history of rotational load shedding. It can be also be used to represent the rotational plan corresponding to Energy consumer. Along with time of day, this class can be used to initiate load shedding or restoration as the situation warrants. The description of this extension class is provided in Table 10.

**Table 10 Description of Extension Class 10: LoadShedRotation**

(*Clause* 5.7)

*Use: To configure history of rotation and also plan for rotational load shedding*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Attribute 1 | lastRotationStart | AbsoluteDate-Time |
| ii) | Attribute 2 | lastRotationStop | AbsoluteDate-Time |
| iii) | Attribute 3 | nextRotationStart | AbsoluteDate-Time |
| iv) | Attribute 4 | nextRotationStop | AbsoluteDate-Time |
| v) | Association 1 | EnergyConsumer | Association |

**5.8 Description of Extension Class: LoadShedRestorationFrequencyLimit**

This class is used for representing limits on frequency. It inherits from class OperationalLimits: OperationalLimit which has association with following classes:

a) OperationalLimit:OperationalLimitSet
b) OperationalLimit:OperationalLimitType
c) OperatoinalLimit.limitKind

High or low limit depends on the OperatoinalLimit.limitKind. The description of this extension class is given in Table 11.

**Table 11 Description of Extension Class 11: LoadShedRestorationFrequencyLimit**

(*Clause* 5.8)

*Use: To configure load shed and restoration frequency limits*

| Sl No. (1) | Attribute (2) | Description (3) | Type (4) |
|---|---|---|---|
| i) | Attribute 1 | loadShedFreq | AbsoluteDate-Time |
| ii) | Attribute 2 | loadRestorationFreq | AbsoluteDate-Time |
| iii) | Association 1 | LoadShedFunction | Association |
| iv) | Association 2 | OperationalLimit | Generalization |

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