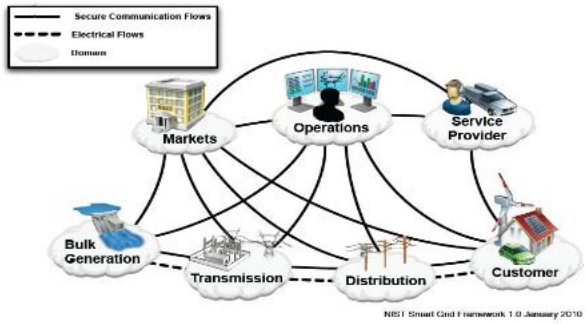
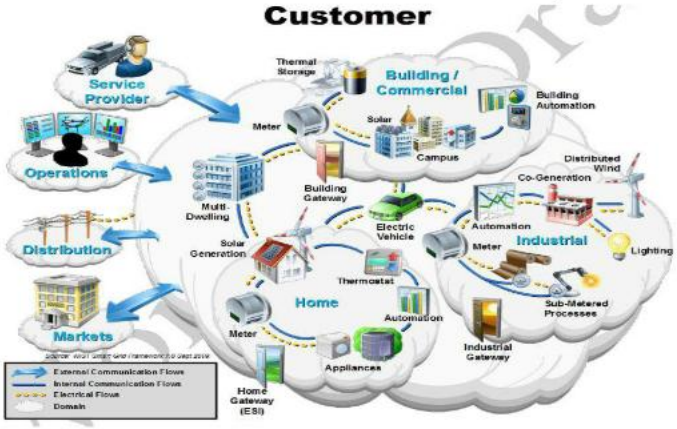
1 NIST 智能电网参考架构（概念）



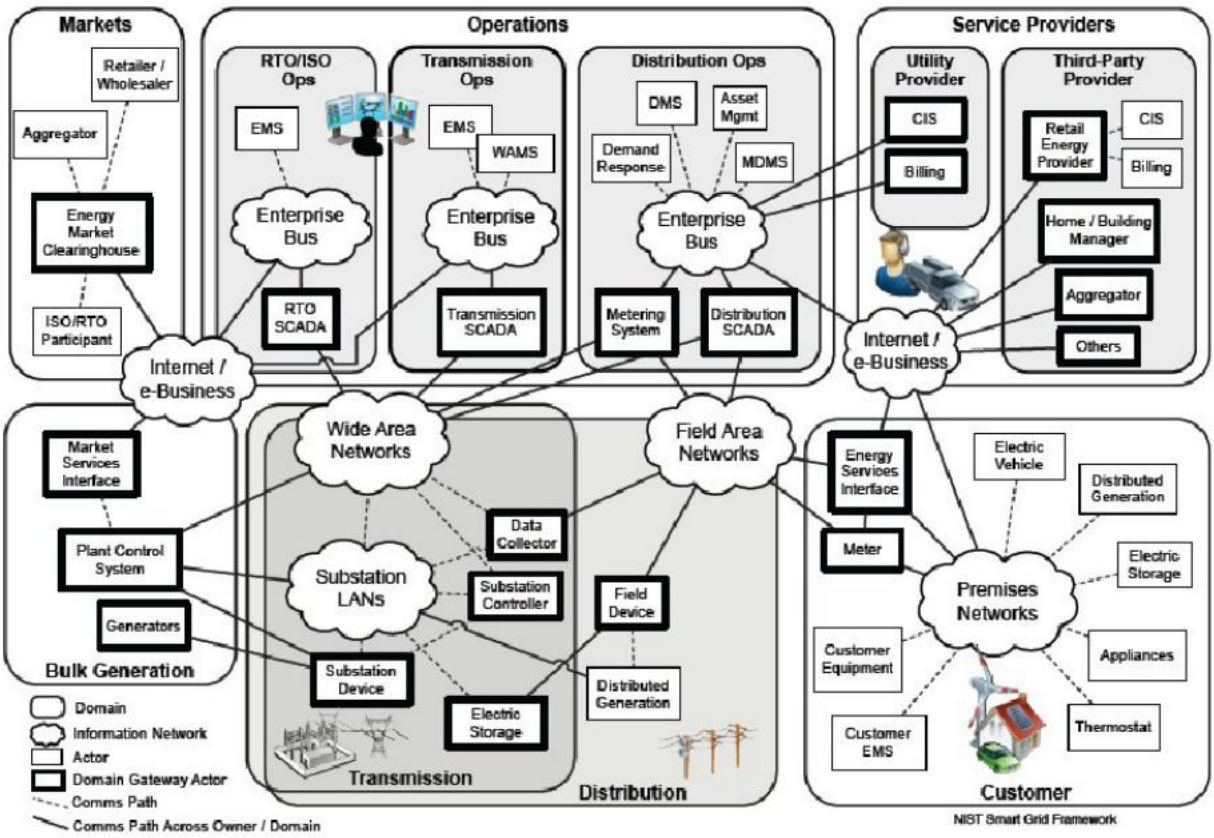


	Domain	Actors in the Domain
1	Customer	The end users of electricity. May also generate, store, and manage the use of energy. Traditionally, three customer types are discussed, each with its own domain: residential, commercial, and industrial.
2	Markets	The operators and participants in electricity markets.
3	Service Provider	The organizations providing services to electrical customers and utilities.
4	Operations	The managers of the movement of electricity.
5	Bulk Generation	The generators of electricity in bulk quantities. May also store energy for later distribution.
6	Transmission	The carriers of bulk electricity over long distances. May also store and generate electricity.
7	Distribution	The distributors of electricity to and from customers. May also store and generate electricity.

Typical Application Categories in the Customer Domain

Example Application Category	Description
Building or Home Automation	A system that is capable of controlling various functions within a building, such as lighting and temperature control.
Industrial Automation	A system that controls industrial processes such as manufacturing or warehousing. These systems have very different requirements compared to home and building systems.
Micro-generation	Includes all types of distributed generation including: solar, wind, and hydroelectric generators. Generation harnesses energy for electricity at a customer location. May be monitored, dispatched, or controlled via communications.

2 NIST 智能电网参考架构（描述）



NIST Smart Grid Framework

3 IEEE P2030 电力角度

1.

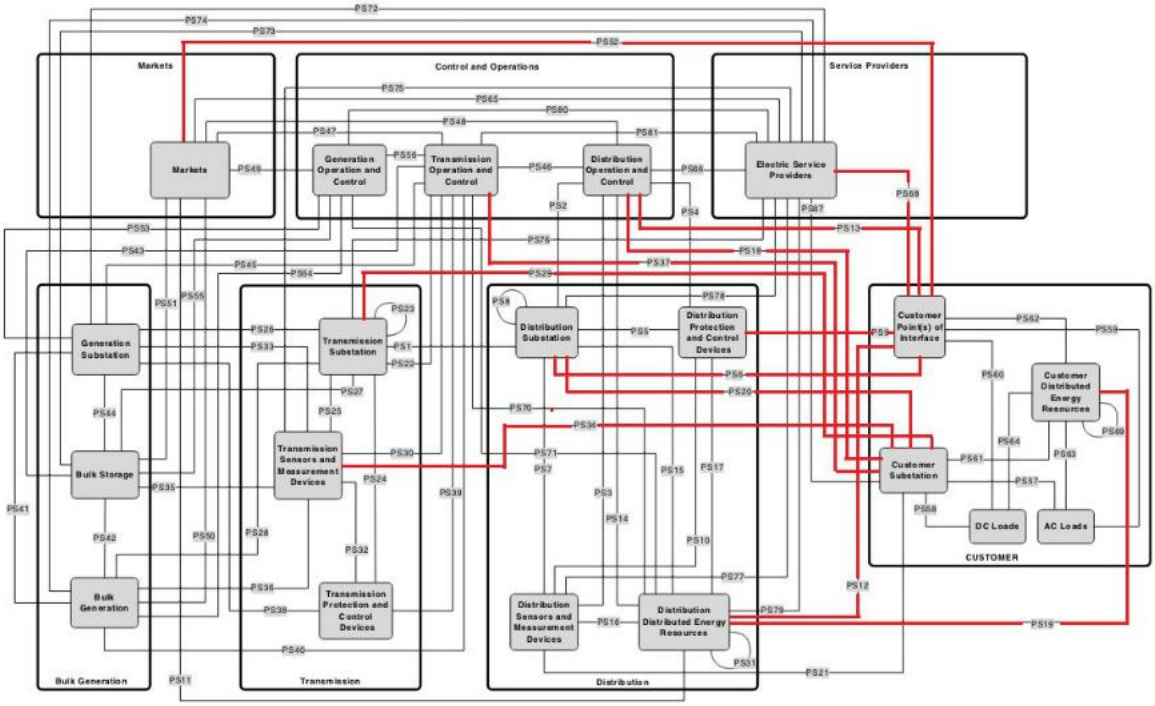


Figure P2030 PS-IAP

(1) 从电力系统角度看，用户侧领域分为**5**个实体：

customer point(s) of interface, customer substation, customer DER,DC loads, AC loads.

实体	描述	备注

交流负荷	使用交流电的用户侧负荷	
用户侧分布式电源	DER 包括需求响应、分布式发电、储能。	连接到输电网的用户发电和储能在大规模发电域考虑。用户侧DER可能包括电动汽车PHV。
用户端接口	用户侧设备与外部通信的公共点。	可以是物理接口盒、电表、EMS电能管理系统，发电控制器、负荷控制器、或者直接连接装置。一个用户可以不止一个接口点。
用户变电站	位于用户侧输电或者配电变电站，可以将电压转换为配电电压，再在用户侧进行配电，包括用于监测、控制、保护配电系统的基础设施。设施包括等变压器、母线、断路器、电容器组。	用户侧变电站可以是输电、配电电压等级的，取决于用户大小。
直流负荷	使用直流电的用户负荷	

(2)用户领域实体和智能电网其他领域实体之间的接口：

接口	实体 **1**	实体 **2**	备注
PS68	用户端接口	电力服务提供商	提供监测信息，控制用户发电、储能和负荷。包括用于监视和控制的接口。
PS52	用户端接口	市场	优化用户领域分布式发电、储能与负荷控制（如需求响应）。包括用于监视、控制和事件报告的接口。
PS13	用户端接口	配电运行与控制	通过配电运行与控制支持信息交换和用电设备控制。接口包括控制与监视接口。
PS6	用户端接口	配电变电站	协调保护并提供变电站所需的用户信息。接口包括保护、控制与监视接口。
PS9	用户端接口	配电保护与控制设备	为保护和控制设备提供用户信息、为用户装置提供保护和控制信息，接口包括保护、控制和监测接口。

PS12	用户端接口	配网 **DER**	直接为用户提供综合用户信息和配电系统DER控制。提供平衡本地发电和负荷的方法。接口包括控制和监测接口。
PS20	用户变电站	配电变电站	协调配电变电站和用户变电站。接口包括保护和监测接口。
PS29	用户变电站	输电变电站	协调输电变电站和用户变电站。包括保护系统，特殊保护系统，电话。接口包括保护、控制、监视。
PS34	用户变电站	输电传感与测量设备	为用户变电站提供信息，包括动态线路容量信息，输电线路维护信息等。接口包括监视接口。
PS18	用户变电站	配电运行与控制	通过用户电站为配电运行和控制提供监视与控制。包括控制、监视和SCADA接口。
PS37	用户变电站	输电运行与控制	通过用户电站为输电运行提供监视与控制。包括控制、监视和SCADA、报告和电话接口。
PS67	用户变电站	电力服务提供商	提供监测信息和用户侧发电、储能、负荷控制。接口包括控制和监测接口。
PS19	用户**DER**	配网 **DER**	协调配电DER和用户DER。接口包括监视与控制接口。

(3)内部实体之间的接口

接口	实体 **1**	实体 **2**	备注
PS57	用户变电站	AC 负荷	设备内部监视和AC负荷控制。接口包括保护、控制和监视。
PS58	用户变电站	DC 负荷	设备内部监视和DC负荷控制。接口包括保护、控制和监视。
PS61	用户变电站	用户DER	信息交换和变电站DER控制。接口包括保护、控制和监视。
PS59	用户变端接口	AC Loads	外部实体和用户的信息交换和AC负荷控制。 接口包括保护、控制和监视。

PS60	用户变端接口	DC Loads	外部实体和用户的信息交换和DC负荷控制。接口包括保护、控制和监视。
PS62	用户变端接口	用户 DER	外部实体和用户的信息交换和用户DER控制。接口包括保护、控制和监视。
PS69	用户DER	用户 DER	用户DER之间的接口，包括保护、控制、监视、报告和SCADA.

4 IEEE P2030 通信角度

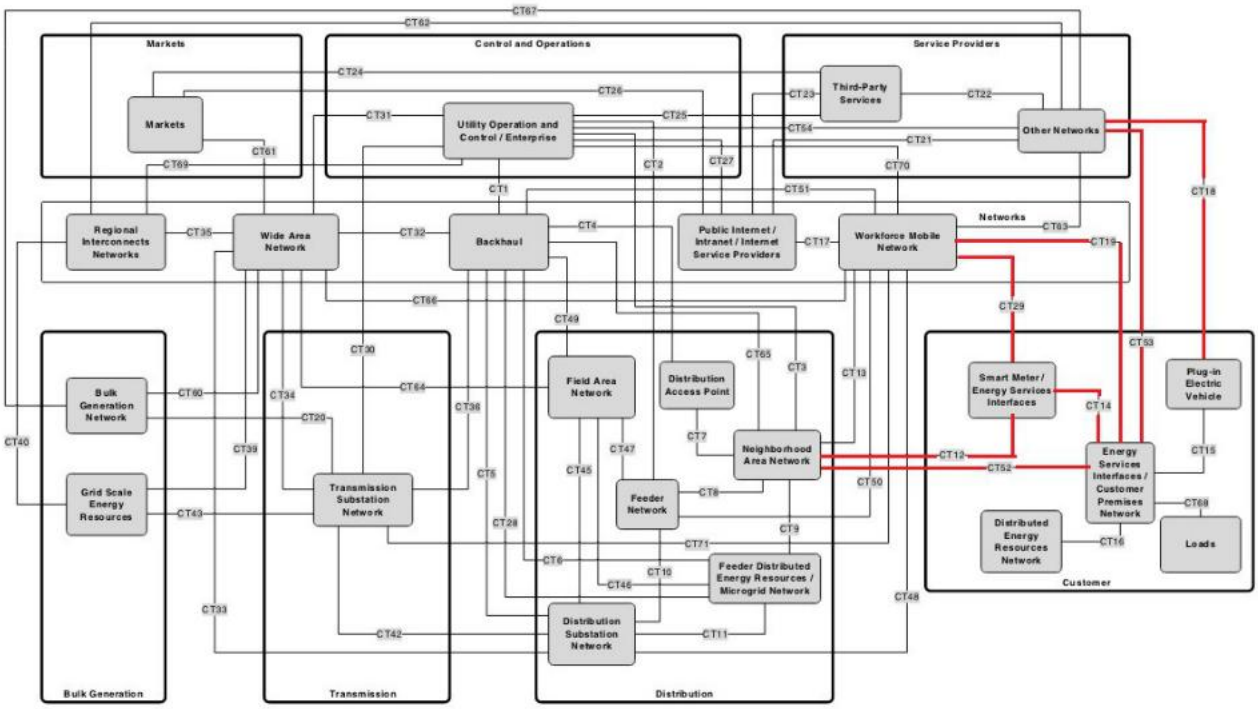


Figure 2. P2030 CT-IAP

(1)从通信角度看，用户侧领域**(customer domain)**分为**5**个实体：Smart Meter/Energy Services Interfaces，Energy Services Interfaces/Customer Premises Network，Distributed Energy Resources Network，Plug-in Electric Vehicle，Loads

实体	描述	注明
智能电表/能源服务接口	智能电表/能源服务接口执行各种智能量测任务,. 智能电表是AMI的主要部分. ESI （可选择安装在智能电表中相当于领域网 NAN 和用户侧网络CPN之间的通信网关，包括家庭楼宇电子系统HBES，负荷，电动汽车,用户侧DER网络.	The NAN, CPN, HBES, and DER networks may each be associated with different physical transmission mediums, and consequently, in order to maximize interoperability, standards involving communication with the smart meter should not be restrictive to a particular transmission medium (e.g., only RF or only power line). Standards allow a variety of physical transmission mediums (e.g., twisted pair, power line, and RF) and, in general, any standardized protocol and interface.
能源服务接口/用户驻地网络	能源服务接口 (ESI)是一类特殊设备,是网络中心,也可以是逻辑服务网关,用户驻地网(CPN)包括HAN, BAN, IAN.	It permits applications such as remote load control, monitoring and control of DER, in home display of customer usage, reading of non-energy meters, and integration with building management systems. It also provides auditing/logging functions that record transactions to and from home area networking devices.
DER网络	用户侧发电和储能系统可以使用有线或者无线网络，通过能源服务接口ESI或者电表sub-meters 连接到HAN, BAN, IAN.	Customer'energy resources can be used to balance the utility's electricity load. Energy can be supplied by customers back to the grid. It is expected that customers will have a balanced portfolio of energy generated locally (in their premises) and supplied by the utility, with an energy supply ratio that can be dynamically changed
Plug-in Electric Vehicle	电动汽车既可以是负荷，也可以是电源/储能，电能反馈电网提供平衡	PEVs are considered a load when the vehicle is stationary and energy is drawn from the grid to charge their batteries. Proper dimensioning of the utilities distribution networks with PEV adoption forecast is important to avoid unexpected peaks of energy consumption when charging PEVs. The mobile/roaming case is also considered when PEVs need to access charging, billing, and positioning information.
负荷	通过各种不同技术的本地网络通信，这些网络具有信息交换功能，也支持负荷管理。	Loads can be appliances, pump controls, HVACs, PEVs, etc. Loads can be located in industrial facilities, commercial facilities, or homes.

(2)用户领域实体和智能电网其他领域实体之间的接口：

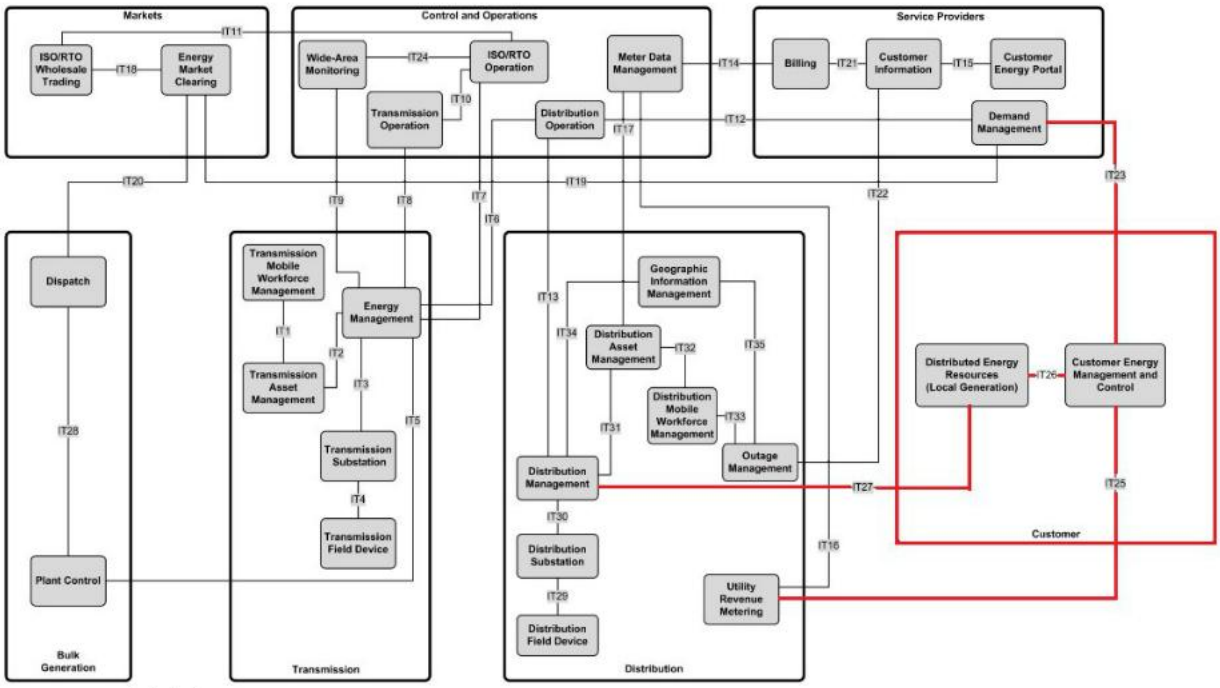
Interface	实体 1	实体 2	备注
CT12	智能电表/能源服务接口	领域网NAN	Connects the smart meters through wireline or wireless NAN. Smart meters could be residential (including building/business) or industrial-grade.
CT29	智能电表/能源服务接口	移动作业网络	Workforce mobile networks can access smart meters and the ESI to retrieve ESI logging data to be able to perform maintenance and repair work.
CT19	能源服务接口/用户驻地网络	移动作业网络	Workforce mobile networks can access the ESI via the HAN, IAN, or BAN to retrieve ESI logging data to be able to perform maintenance and repair work.
CT52	能源服务接口/用户驻地网络	领域网NAN	This provides connectivity between the ESI (which may be a stand-alone device or could be integrated into the smart meter itself) and WANs (e.g., GSM, EDGE,UMTS, GPRS, LTE, WiMAX, WCDMA, CDMA, microwave, satellite, etc.) in order to enable wide-area connectivity into the customer premises network (typically the ESI/EMS is the entry point) from a variety of other end-points (e.g., the utility distribution control/operations center, mobile PEV, and many others). This link could be associated with the following applications: AMI/NAN, DA, workforce automation, outage management, PEV (mobile charging, billing, localization, etc.), DER management/control, and various other applications.
CT53	能源服务接口/用户驻地网络	其他网络	This provides connectivity between the ESI (which may be a stand-alone device or could be integrated into the smart meter itself) and WANs (e.g., GSM, EDGE,UMTS, GPRS, LTE, WiMAX, WCDMA, CDMA,microwave, satellite, etc.) in order to enable wide-area connectivity into the customer premises network(typically the ESI/EMS is the entry point) from a variety of other end-points (e.g., the utility distribution control/operations center, mobile PEV, and many others). This link could be associated with the following applications: AMI/NAN, DA, workforce automation, outage management, PEV (mobile charging, billing, localization, etc.), DER management/control, and various other applications.
CT18	电动汽车	其他网络	This connectivity is used as a direct communications path to the EV and can be used when the vehicle is stationary, mobile, and/or roaming. This can replace and/or supplant CT15 as another means to reach the head-end software This connectivity can provide complete communications to the EV to support functions such as charging, billing, uploading rate/tariffs, load shedding and storage, and positioning using on-board energy information systems. For those EVs

			employing onboard smart chargers, complete EV charging control and vehicle information can be accessed. This connectivity is typically described as telematics and is widely utilized by several vehicle equipment manufacturers OEMs. The connection is established typically by wireless connectivity to the telematics provider head-end system wherein specific applications can provide connectivity to utilities and/or supplier head-end system The wireless service provider could use 3G/GSM, 4G/LTE/WiMAX, or satellite transponder technology inside the vehicle as the means to communicate.

(3)用户领域实体之间的接口：

接口	实体 **1**	实体 **2**	备注
CT14	智能电表/能源服务接口	能源服务接口/用户驻地网络	In general, the ESI is the gateway between the smart meter and the end-use devices and loads. By definition, the physical communication links between the ESI and the loads are part of the CPN (see CT68, CT15, CT16). In many cases, the ESI is physically located within the smart meter (i.e., the meter and ESI are one in the same). However, this may not always be the case. CT14 describes the properties of the link in this latter case.
CT15	能源服务接口/用户驻地网络	电动汽车	This provides connectivity between the ESI (which may be a stand-alone device or could be integrated into the smart meter itself) and the electric vehicle service equipment (EVSE) and/or electric vehicle (EV) in order to support functions such as charging, billing, load shedding and storage, and positioning information. It is assumed that the EVSE (also known as the charging station) is a part of the CPN, and likely connected to the EMS or similar system on the customer premises. Here (CT15), we only consider the case where the EV is physically located at a premise with an EVSE and is capable of communication with the ESI. Note that the ESI/CPN may communicate with the vehicle not only when it is located on the customer premises (e.g., parked or plugged into an onsite charging station) but also when the vehicle is mobile (e.g., to support services like mobile charging, billing, diagnostics, and positioning information). There are other links/paths in

			the reference architecture that deal with the case of communicating with the vehicle while it is mobile (e.g., CT53–CT18).
CT16	能源服务接口/用户驻地网络	DER网络	This provides connectivity between the ESI (which may be a stand-alone device or could be integrated into the smart meter itself) and the distributed energy resource network via the CPN to the DER in order to support functions such as charging, billing, load shedding, generation, and storage Here (CT1), we only consider the case where the is capable of communication with the ESI.
CT68	能源服务接口/用户驻地网络	负荷	This provides connectivity between the ESI (which could be physically located on the smart meter itself) and the various loads (possibly thousands) within the customer premises in order to support functions such as energy management, lighting control, solar protection, HVAC control, security/access control, control of audio/video services. The physical links associated with CT68 are generally considered a part of the HAN/BAN/IAN. Also, note that some of the key customer premises systems and controls such as HBES, BACS (building automation and control system), and EMS could physically reside in the ESI, or in a separate device connected directly to the ESI via CT68.



5 IEEE P2030 信息角度

Figure 3. P2030 IT-IAP

(1)信息实体包括 **DER**（**local generation**）和 **customer energy management and control**

Entity 实体	Description 描述	Comments 备注
用户侧能源管理和控制		典型包括家庭能源管理系统（HEMS），商业能源管理系统BEMS），工业能源管理系统(IEMS). 能源管理系统的功能可以是分布式的(比如在智能电表和HEMS之间),或者有其他服务提供商提供。.
分布式电源（本地发电）	DERs at the customer site	包括发电和储能，可调度或者不可调度（May or may not be dispatchable）

(2)用户领域实体和智能电网其他领域实体之间的接口：

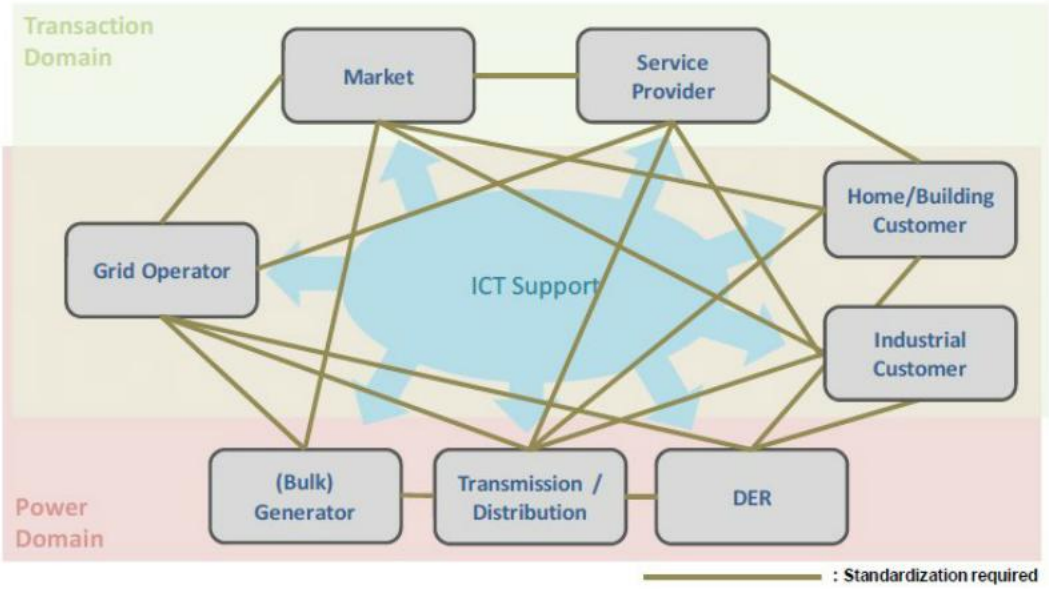
Interface	Entity 1	Entity 2	Comments
IT23	用户侧能源管理和控制	需求响应管理	需求响应信号、价格信号、具体的负荷用电量等。
IT25	用户侧能源管理和控制	公用事业计费和计量	将用电数据汇总到EMS。
IT27	DER (本地发电)	配网管理	电力系统监测用户侧分布式发电的能力（用量，可用等），可能采用无功控制。

(3)用户领域实体之间的接口：

接口	实体 **1**	实体 **2**	备注
IT26	DER (本地发电)	用户侧能源管理和控制	EMS.对DER进行监测、状态分析和控制

6 欧洲 **CEN/CENELEC/ETSI JWG**

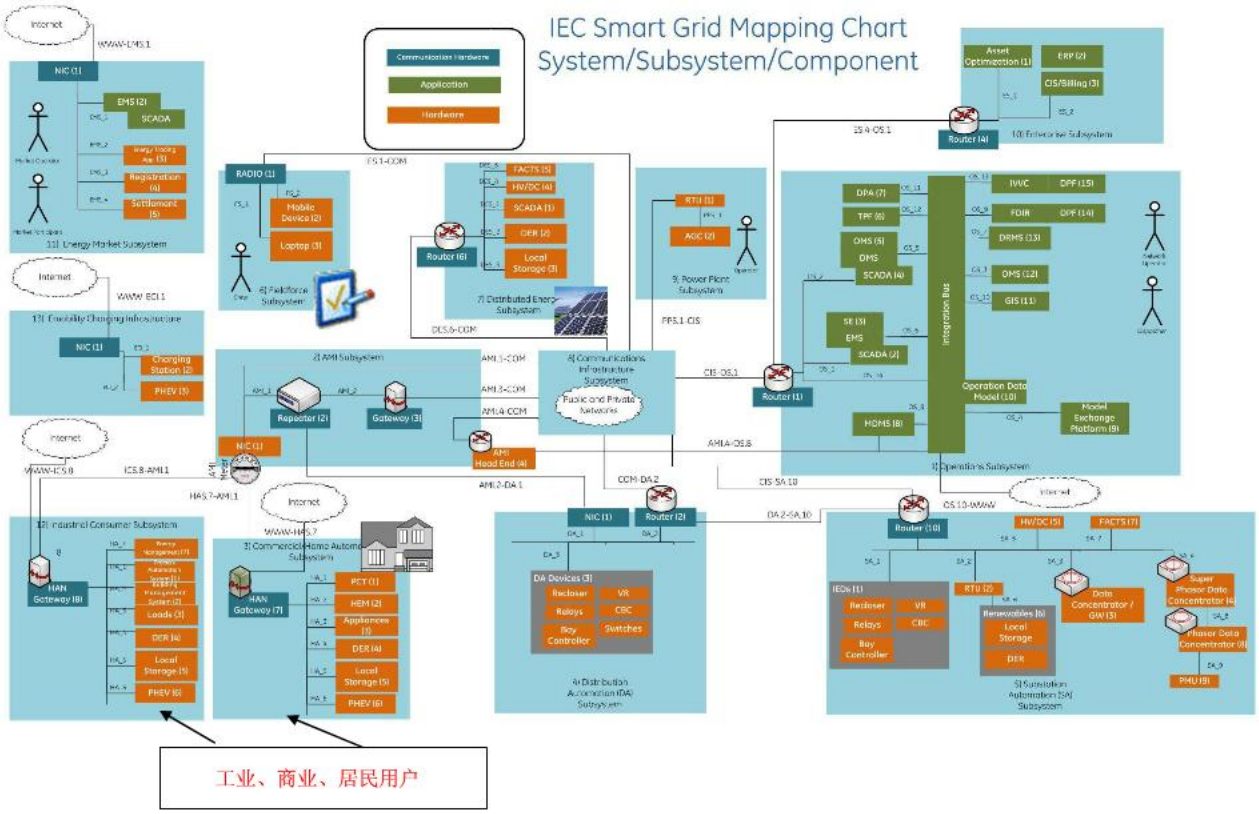
欧洲在美国 NIST 参考架构基础上，把输电和配电合并，把用户分开 **industrial customer** 和 **home/building customer** 2 个部分分别描述。



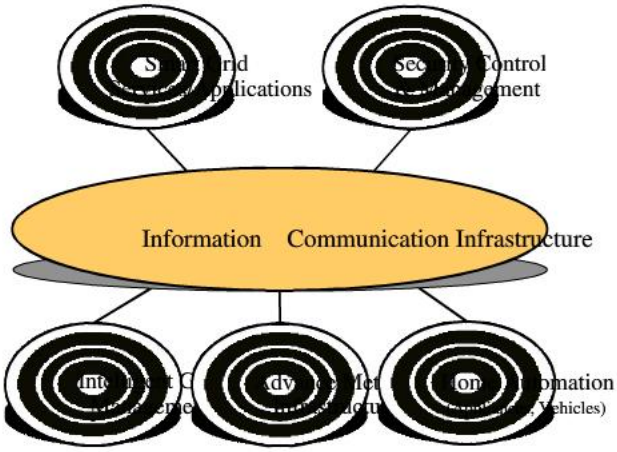
An EU conceptual model

7 IEC SG3 mapping chart

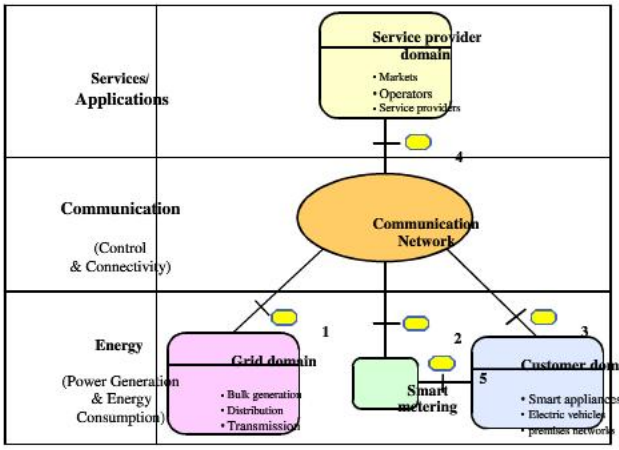
IEC SG3 mapping chart 把智能电网分为 13 个子系统。



智能电网标准化的关键领域



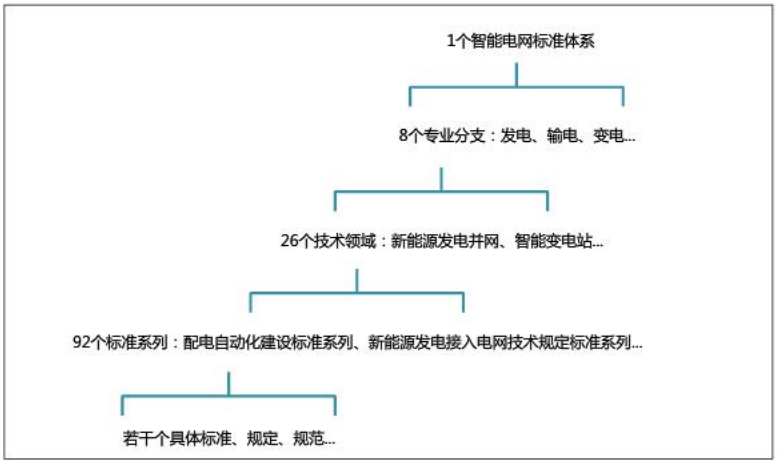
需要标准化的五个接口（**5 domains+5 reference points**）



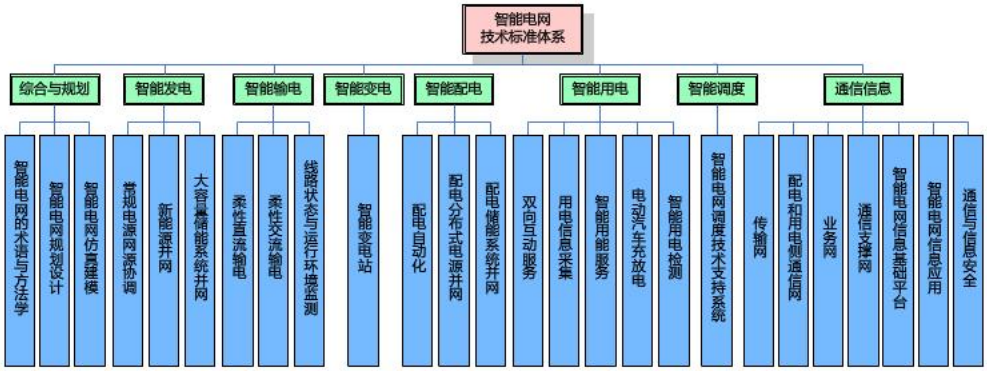
- **RP 1**—Interface between grid Domain and the Service Providers domains
- **RP 2**—For metering information exchange
- **RP 3**—Interface between operators/service providers and customers
- **RP 4**--services and applications to all actors
- **RP 5**—optional（可选）, between Smart metering and Customer domain

9 国家电网公司

1 个体系、8 个专业分支、26 个技术领域、92 个标准系列、若干具体标准。



标准体系的第一层是专业分支：包括综合与规划、智能发电、智能输电、智能变电、智能配电、智能用电、智能调度、通信信息等 8 个专业分支；标准体系的第二层是技术领域：划分的原则是关注智能电网各环节的主要发展方向以及我国智能电网研究与建设工作的重点，共包括 26 个技术领域；标准体系的第三层是标准系列：第三层中各标准系列构建的内在逻辑关系为“基础与综合”、“工程建设”（含设计、改造、验收、测试）、“运行与检修”、“设备与材料”，共包括 92 个标准系列；准体系的第四层是具体标准。



与智能电网用户接口 PC118 标准范围比较相关的主要有智能用电、及智能配电及通信信息专业。在智能电网技术标准体系中，智能用电专业分支重点关注五个关键技术领域：双向互动服务、用电信息采集、智能用能服务、电动汽车充放电和智能用电检测；智能配电专业分支重点关注三个关键技术领域：配电自动化、配电分布式电源并网和配电储能系统并网；通信信息专业重点关注七个关键技术领域：通信传输网、配电和用电侧通信网、业务网、通信支撑网、智能电网信息基础平台、智能电网信息应用、通信与信息安全。

10 总结分析

（1）NIST 智能电网架构和 P2030 之间的映射问题（摘自 July 12, 2011，IEEE P2030 – SGAC Conceptual Architectural Harmonization Working Party，John Ruiz）

Mapping between P2030 and the Conceptual Architecture is difficult because they are slightly different viewpoints on the architecture. P2030 is more of a"solution", not a conceptual architecture. P2030 focused more on the operation, not the actor and the use case.

- P2030 has developed a centralized solution (implementation), where Operations controls Transmission, Distribution, and AMI.
- P2030 Architecture is sometimes based upon physical location instead of logical domain.

There are some areas that are not covered in P2030 that are identified in the SGAC Conceptual Architecture.

- Weather related data is not mentioned in P2030.
- System Simulation is not identified in P2030.

Mapping between P2030 and the Conceptual Architecture identified areas that need review.

- P2030 explicitly talked about Meter Data Management in the Operations domain. Conceptual architecture does not explicitly identify Meter Data Management.
- The conceptual architecture seems to be missing services on Bulk Storage. There were several references to bulk energy storage in P2030.
- P2030 uses the term Geographic Information Management, conceptual architecture uses Topology. We assume them to be the same thing, but we may need to enhance it to Topology and Geographic Information in the conceptual model.
- P2030 identifies Customer Domain DER, the SGAC conceptual architecture does not address Customer DER.
- P2030 identifies Spares Management as a service, the SGAC conceptual architecture does not explicitly address this.
- Recommend moving the SGAC Conceptual Architecture business services for Communications to the Cross Cutting section. There are a few redundant services in the list.

（2）IEC SG3 Mapping chat 对用户进行了划分，包括工业用户和居民/商业用户。每类用户对外的连接包括 AMI 网络和英特网。对应两种接口。

（3）用户侧所有标准关注的对象（或者实体）基本是一致的。

（4）基于各种不同视角的智能电网总体架构分析，电网与用户的连接架构（或者智能电网用户接口架构）可在一定程度上达到统一。

（5）国家电网公司的标准体系分为 8 个专业：综合与规划、智能发电、智能输电、智能变电、智能配电、智能用电、智能调度、通信信息。8 个专业主要是电网物理本身的技术领域，不涉及到市场和商业方面（如其他架构设计中考虑的市场、服务提供商等），这样做优势是不受各

个电力市场、商业模式的影响，更关注技术智能电网技术本身，具备更普遍适应性的潜力。

（6）国家电网公司的标准体系分自顶向下的分层；每个专业又分为多个技术领域，比较详细的划分有利于标准的快速制定。满足智能电网个环节快速部署需求；各环节并行发展，也为标准之间横向的融合创造了更多的机会。