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				F	unctional Requir	ements (See [Definitions	Below)								Technolo	chnology Options for Each Network Tier - Top Three Choices (1 = first, 2 = second, 3 = third)											
C	urrent Communications Needs	Estimated Number of Communications Nodes to be Deployed for Each	Estimated Number of End Point Devices to be Deployed for Each	AC Independence (hours)	Bandwidth Throughput Estimated per Node (kbps)	(% of	Latency (msec)	Reliability (1 lov (%) 5 high	Microwave	Fiber	Other Private Network (i.e. BPL, PLC)	Commercial Wireline Network (wireline carriers)	Satellite (VSAT, satellite phones)	Licensed Wireless Microwave (pt to pt)	Fiber	Other Private Network (i.e. BPL, PLC)	Commercial Wireless Network (Cellular Carriers)	Commercial Wireline Network (wireline carriers)	(VSAT, satellite	Wireless V (i.e. pt to Mi	icensed Vireless icrowave ot to pt) Fib	Othe Privat Netwo (i.e. Bi er PLC)	e Wireless rk Network L, (Cellular			Unlicensed Wireless (Proprietary RF Mesh)	Unlicensed Wireless - Zigbee	Other Private Network - HomePlug
		Application (e.g. thousands of collectors)	Application (e.g. millions	;	Oua	intified Estima	atos				Tier 1 - Co	oro				Tior 2	Backhaul			Tior 2A - Acc	eess (to and noi	ets or collecte	rs/gatoways/tr	ke-out-points (if	nrocont))	Tier 3B (collectors to endpoints	Tior 4	1 - HAN
		thousands of confectors)	of fileters)		Qua	muneu Estima	ates				Her 1 - Ci	ле				Hel 2 -	DdCKIIdui			TIEL SA - ACC	.ess (to ena-poi	its or conecto	rs/gateways/ta	ke-out-points (ii	presentiji	enupoints	Her 4	- HAIN
	Remote Meter Reading (based on hourly reads)	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
ner	Advanced Metering Direct Load Control	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	Outage reporting & voltage sensing	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	Real time pricing	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
Custo	Distributed Generation Management	500 (Residential DG nodes)	500 (Residential DG nodes)	0	9.6	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	At the customer premises	150	TBD	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	At charging stations	150	TBD	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	Pricing Signals to Smart Appliances	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	in-Home Display of Customer Usage	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	Automated Feeder Switching	NA	525	24	56	95%	200	99.990% 5	2	1			3	2	1				3	2		3	1					
	Individual Feeder Switches	NA	475	24	56	95%	200	99.990% 5	2	1			3	2	1				3	2		3	1					
	Capacitor Bank Control	150	3,500	0	9.6	95%	2000	99.000% 3	2	1			3	2	1				3		2		1		3	1		
⊆	Fault Current Indicator	150	0	0	9.6	95%	2000	99.000% 3	2	1			3	2	1				3		2		1		3	1		
ributio	Transformer Monitoring (via smart meters)	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1		
Dist	Voltage and Current Monitoring (via smart meters)	150 100 (C&I DG nodes in	1,000,000 100 (C&I DG nodes in	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1		
	Renewable Energy/Distributed Generation Network Protection Monitoring	service)	service)	24	56	100%	200	99.990% 5	2	1			3	2	1				3	3	2		1					
	(via smart meters)	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1		
	Street Light Monitoring/Control	5	1,000	0	19.2	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1		
	AMI Network Management	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1		
	Remote Connect/Disconnect	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1		
ions	Meter Data Management	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1		
perat	Outage Management	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1		
ō	Distribution Asset Management	150	250,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1		
	Distribution Underground Network Management	NA	200	24	56	1%	200	99.990% 5	2	1		3		2	1			3			:	. 3		2				
	Demand Response	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1		3				2		1		3	1	1	2
_	Field Substations & Switching Stations	NA	1,100	24	600	100%	200	99.999% 5	2	1			3	2	1				3		2				3			
issio	Wide Area Situational Awareness (PMUs)	NA	5	24	600	100%	200	99.999% 5	2	1			3	2	1				3		2				3			
ansm	Line Protection and Control	NA	1,100	24	600	100%	200	99.999% 5	2	1			3	2	1				3		2 :				3			
F	Mobile Substation/Equipment	NA NA	25 500	24	56	100%	200	99.990% 5	2	1	2		3	2	1	2			3	3	2	2	1					
	System Protection/Teleprotection Billing	NA NA	300	24	9.6	100%	20	99.9999% 5	3	1	2			3	1	2					3	. 2						
vider	(via smart meters) Customer Information Management	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
ce Pr	(via smart meters) Consumer Web Portal	150	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
Servic	(via smart meters)	65 retailers	1,000,000	0	56	100%	2000	99.000% 5	2	1			3	2	1				3		2		1		3	1	1	2
	Emergency Response	NA	3,000	72	45	95%	500	99.990% 3	2	1		3		1	2			3		1			3		2			
=	Routine Dispatch	NA	3,000	72	45	95%	500	99.990% 3	2	1		3		1	2			3		1			3		2			
Othe	Work Management	NA	2,000	8	256	90%	5000	99.900% 3	2	1			3	2	1		3			2			1		3			
	Black Start Operations	NA	300	168	15	100%	2000	99.999% 3	3	2			1	3	2				1	2					1			
									1					1														

Advanced Metering - ~56 kbps per collector (.0044 kbps per meter) with 12000 meters per collector (dense urban) dropping to 100's per collector (rural) and little initial HAN communications traffic

Distributed Generation Management - Oncor has ~500 residential customers with renewable energy sources (wind and solar) and is growing by ~250/year which will be managed by advanced meters with internal discon

PEV Integration - Potential data traffic is included in Advanced Metering traffic estimates and delivered by HAN (i.e. Zigbee or HomePlug)

Pricing Signals to Smart Appliances - Potential data traffic is included in Advanced Metering traffic estimates and delivered by HAN (i.e. Zigbee or HomePlug)

In-home Displays of Customer Usage - Potential data traffic is included in Advanced Metering traffic estimates and delivered by HAN (i.e. Zigbee or HomePlug)

Distribution:
Automated Feeder Switching - Oncor has ~525 fully automated switches organized into "teams" with distributed intelligence for automated outage restoration, growing by ~75 per year.

Individual Feeder Switches - Oncor has ~475 remotely controlled switches (by D-SCADA), growing by ~50 per year.

Capacitor Bank Controls - Oncor has ~3500 remotely controlled capacitor banks via one-way paging communications currently, but is planning to migrate to using the Advanced Metering communications infrastructure to enable full two-way communications over the next five years to all capacitors located within the advanced metering communications area, potential traffic is included in Advanced Metering traffic estimates above

Fault Current Indicators - Oncor is planning to use the Advanced Metering system communications infrastructure to deliver the fault current sensor values to the appropriate head-end application, potential traffic is inclu n Advanced Metering traffic estimates above

Fransformer Monitoring - Oncor is planning to use the Advanced Metering system to sense end-point voltage values and report outages via the "last gasp" functionality of the meters to monitor transformers. Oncor will us infrastructure to deliver these values to the appropriate head-end application, potential traffic is included in Advanced Metering traffic estimates above

Distribution (continued):

Voltage & Current Monitoring - Oncor is planning to use the Advanced Metering system to sense end-point voltage values and use the advanced metering communications infrastructure to deliver these values to the appropriate head-end application, potential traffic

s included in Advanced Metering traffic estimates above

newable Energy/Distributed Generation - Oncor has ~100 C&i customers with conventional fuels (diesel, natural gas, landfill/sewage gas) or renewable energy sources (wind, solar) and is growing by ~5/year which will be managed by direct

munications to local SCADA-like RTUs and external disconnect switches.

Network Protection Monitoring - Oncor is planning to use the Advanced Metering system to sense end-point voltage values and report outages via the "last gasp" functionality of the meters to monitor network protec Oncor will use

the advanced metering communications infrastructure to deliver these values to the appropriate head-end application, potential traffic is included in Advanced Metering traffic estimates above.

Street light Monitoring/Control - Street light monitoring uses similar architecture to Advanced Metering with individual gateways acting as take-out-points for communications to/from up to 5000 lights each, lights to gatev

Operations:

AMI Network Management - Potential data traffic is included in Advanced Metering traffic estimates above

Remote Connect/Disconnect - Potential data traffic is included in Advanced Metering traffic estimates above

Meter Data Management - Potential data traffic is included in Advanced Metering traffic estimates above

Outage Management - Potential data traffic is included in Advanced Metering traffic estimates above and based upon "last gasp" reporting from smart meters to collectors (with battery backup)

Distribution Asset Management - Monitoring of distribution equipment (inc. transformers, fault indicators, etc.) potential data traffic is included in Advanced Metering traffic estimates above and based upon reporting by exception when conditions exist outside "normal" parameters

Distribution Underground Network Management - Monitoring and control of equipment located in underground vaults and manholes in downtown distribution network grids

Demand Response - Potential data traffic is included in Advanced Metering traffic estimates and delivered by HAN (i.e. Zigbee or Homeplug) to customers' controllable devices

Field Substations & Switching Stations - Broadband service required to field stations to support multiple VLANS (T-SCADA, D-SCADA, AMIS, enterprise, and other communications) whereby data from various event recorde and equipment condition monitoring devices output data streams will be carried to head-end systems with the appropriate priority of service (OoS)

Wide Area Situational Awareness (PMUs) - Units co-located with a limited number of field stations at key physical/electrical locations on the grid and data is transported with other station data streams within the appropriate VLAN

Line Protection and Control - Equipment is co-located with field stations and data is transported with other station data streams within the appropriate VLAN

Mobile Substation / Equipment - Communications to mobile equipment limited to SCADA activities to monitor and control equipment

System Protection / Teleprotection - Tel

Billing - Billing information will be gathered by the Advanced Metering system and potential data traffic is included in Advanced Metering traffic estimates above

Customer Information Management - Customer information will be gathered and managed by the Advanced Metering system and potential data traffic is included in Advanced Metering traffic estimates above nsumer Web Portal - All consumer information for the Web Portal will be gathered and managed by the Advanced Metering system and potential data traffic is included in Advanced Metering traffic estimates above, r that about 65 retail electric service providers sell energy to all 1.0 million advanced metered premises in the Oncor service area

Emergency Response - Mobile voice communications with VoIP codex of 15 kbps per channel, inclusive of control communications, with three channels in PTT mode per basestation, mobile data limited to 9.6 kbps maxi (110 basestations in service area, 3000 voice end users)

Routine Dispatch - Mobile voice communications with VoIP codex of 15 kbps per channel, inclusive of control communications, with three channels in PTT mode per basestation, mobile data limited to 9.6 kbps maximum (110 basestations in service area, 3000 voice end users)

Work Management - Mobile Workforce Management communications from head-end management system to ~2000 vehicle mounted PCs primarily composed of work ticket information (56 kbps) but map and file update require higher bandwidth (256 kbps)

Black Start Operations - Mobile and point-to point voice communications with VoIP codex of 15 kbps per channel, inclusive of control communications, with only one channel operating in PTT mode, no mobile data provid (10 fixed and command center sites in service area, 300 black start voice end users)

AC Independence Bandwidth

After the loss of electric service what applications need backup power to provide restoration and for how long (measured in minimum hours)? Estimated or tested data rates are required to support this application during normal and emergency conditions (in kilobits per second (kbps) at the node or collection point

Coverage Geographic areas that these networks are required to operate (estimated percentage of service territory)

How quickly does field data need to be updated (measured in milliseconds (ms) from endpoint-to-endpoint (i.e. not roundtrip))?

How many service interruptions are tolerated and how well must this network provide accurate data (as a percentage of overall traffic (e.g. 99.999%)? How secure must the network be from cyber and physical attacks (one a scale of 1-5 with 1 being low and 5 being high)?

nications network is the primary path to the utility data center and data processing infrastructure. The core may also be the transport for enterprise applications and will typically be architected in a self-healing ring topology or point-to-point with backup circuit redundancy. The core may have points-of-presence in substations and other company facilities.

The backhaul tier will aggregate the field area network including collectors, RF access points, data concentrators, etc. from the field access tier of the network and provide a delivery transport bridge to the core backbone tier.

Tier 3A - Access (to end-points or collectors/gateways/take-out-points (if present))

At this tier end-point devices or collectors/gateways/take-out-points will gain access to the network. It is commonly referred to as the last mile communication or Field Area Network and will be relatively low bandwidth for hand off to the Backhaul Tier.

Tier 3B – Access (to endpoints when a collector/gateway/take-out-point is present to aggregate end-points

At this tier end-point devices will gain access to the collector/gateway/take-out-point. It is commonly based upon some form of proprietary communications on unlicensed spectrum or powerline carrier technologies

Tier 4 - Home Area Network (HAN)

In home devices will typically communicate with the Access tier through various technologies. The HAN has not yet converged on a standard but is likely to consist of technologies like Zigbee or HomePlug which may connect directly with communication Tier 3A or Tier 3B.

Private licensed wireless radio networks operating under Part 90 of the FCC rules (LMRS two-way radio/pt to multi-pt services) vate licensed wireless microwave networks operating under Part 101 of the FCC rules (microwave point-to-point network Unlicensed Wireless ivate unlicensed wireless radio networks operating under Part 15 of the FCC rules (802.11x wireless LAN (e.g. WiFi) / 802.15x PANs (e.g. Zigbee) vate fiber networks owned or controlled by a utility rivate networks that are neither fiber nor wireless, such as powerline carrier Other Private Network mmercial networks that operate using licensed radio under Part 22 of the FCC rules (e.g. Verizon, AT&T, Sprint, etc. carrier networks)

mmercial networks that use any wireline technology, including fiber, DSL, coax or traditional twisted pair copper circuits tellite includes all types of fixed and mobile satellite services, including Very Small Aperture Terminals (VSATs) and satellite phones

Commercial Wireless Network Commercial Wireline Network