Remote Meter-Reading Project – Phase 1
Régie File R-3770-2011

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Presentation to the Régie de l'énergie – May 2012

HQD-8, Document 1
(English translated version)

Original text is in French.

Hydro Québec Distribution

Outline

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1. Telecommunications performance
   - RF network topology
   - RF network latency
   - NAN bandwidth and utilisation rates
2. ICT performance
3. End-to-end solution performance
4. Connection/Disconnection
5. Meter installation performance
   - Meter accessibility
   - Pilot project installations
   - Installations in Villeray (Capgemini)
   - Rollout strategies (Capgemini)

1 Telecommunications performance

- **RF network topology**
- **RF network latency**
- **NAN bandwidth and utilization rates**

RF network topology (1/3)

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1 Preliminary designs required to submit bids

- Location details of all meters and entire distribution system (substations, poles and equipment) sent to bidders

Bids included

- Partial AMI topology for entire province
- Estimated **maximum quantity** of telecommunications equipment

2 Proof of concept

- Validation of performance and quantity of equipment required for Landis+Gyr AMI solution used by Oncor (3.4 million meters)

- Performance and reasonableness of quantity confirmed

3 Final designs before signing contract

- Final design for pilot areas
- Filing of network design for Area 1 and commitment on maximum quantity of telecommunications equipment for Québec

- Contract signed May 18, 2011
- First data collector up and running May 23, 2011

*Contractual agreement with Landis+Gyr on **maximum quantity** of telecommunications equipment required to cover all of Québec and **achieve established performance levels***

RF network topology (2/3)

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Efficiency of RF network design

- Pilot project areas chosen for diversity of meter density and topographic diversity
- Strict process and effective design, taking into account environmental conditions and Landis+Gyr solution
- Tools and methods based on industry best practices

Summary of work done

- ✓ Final quantity similar to estimate, despite inherent constraints of pilot projects (lack of contiguous area, installation standard, quality of location details in rural areas, etc.)
- ✓ Estimated quantity for pilot projects representative of quantity for entire province
- ✓ Reasonableness of provincial quantity confirmed by third party firm YRH and pilot project results

Changes in quantity of telecommunications equipment

Pilot project	Preliminary design (based on meter density)		Optimized network
Memphrémagog RCM	1 collector 129 routers	⬇	1 collector 119 routers
Boucherville	1 collector 5 routers	⬆	1 collector 12 routers
Villeray	2 collectors 14 routers	⬆	2 collectors 16 routers
Total	4 collectors 148 routers	⬇	4 collectors 147 routers

Quantity of equipment: ⬇ Decrease ⬆ Increase

Estimates of 14,950 routers and 560 data collectors for Québec are reasonable and constitute a contractual commitment

RF network topology (3/3)

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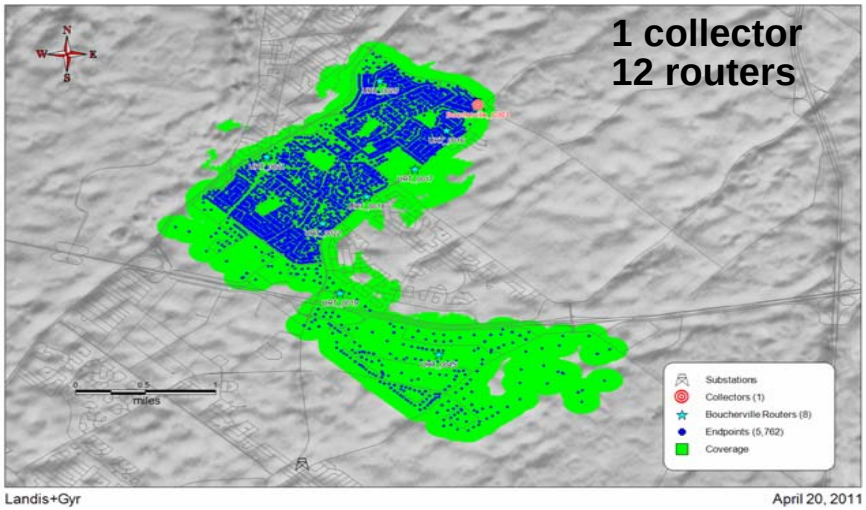
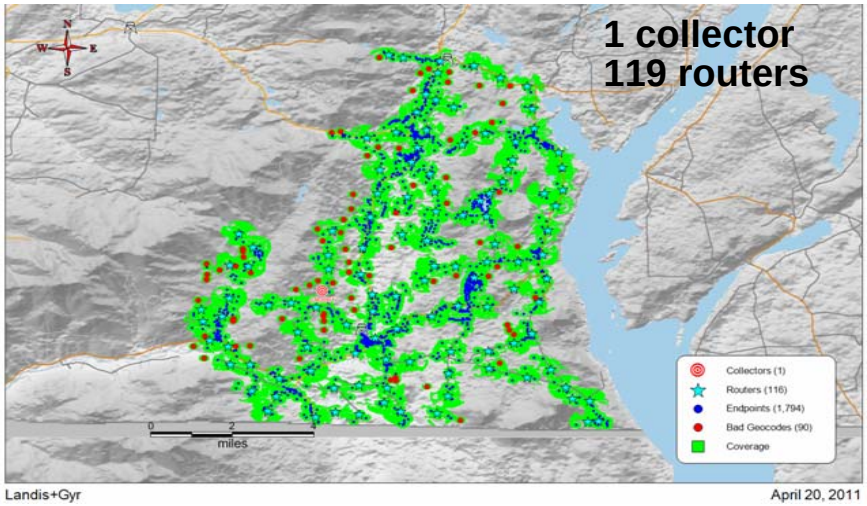
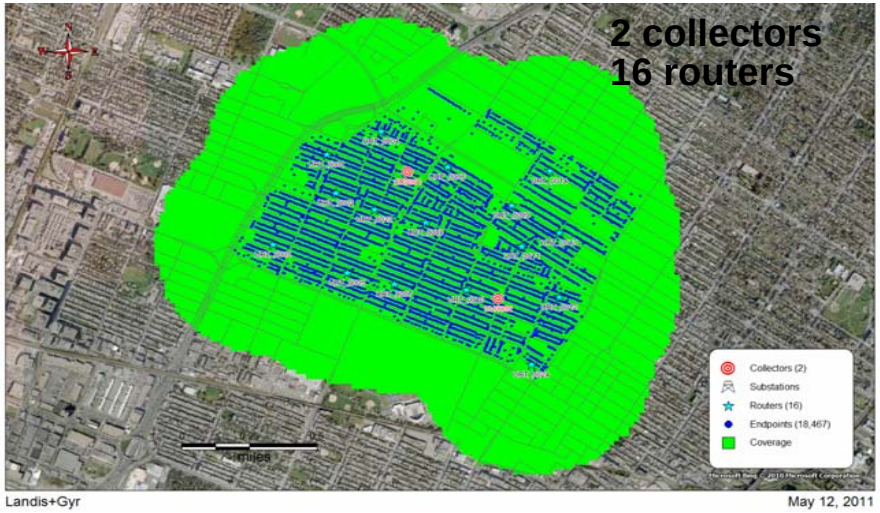
AMI – Boucherville pilot project



AMI – Memphrémagog RCM pilot project



AMI – Villeray pilot project



AMI system performance

- Coverage: 100% of meters
- Daily log-reading rate: 99.4%
- Availability: 100%
- Latency (specified delay)
- Resiliency (level of service maintained in various situations)

1 Telecommunications performance

- **RF network topology**
- **RF network latency**
- **NAN bandwidth and utilization rates**

RF network latency (1/2)

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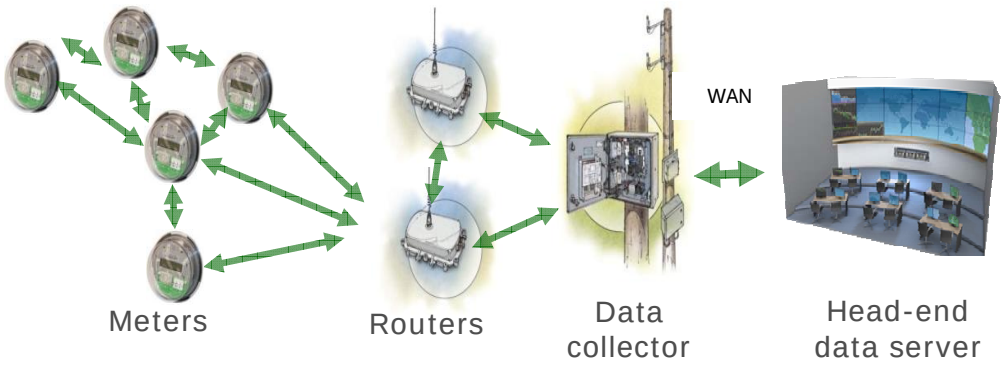
RF mesh network latency

- Latency is the ability to carry a communication from its source to its destination within a specified time period
- A data packet hops a variable number of times from one network component to another along a route

Mesh network latency is, by definition, unpredictable because the network dynamically establishes routes for each data packet



Network forms dynamically, adjusts and recovers automatically whenever there's an outage

Can prioritize individual messages

Number of hops for all routes in pilot project areas (4 data collectors)

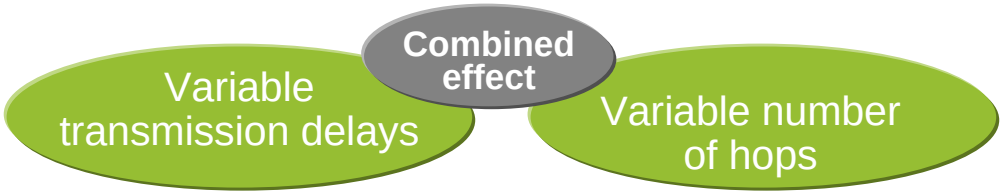
Hops	Boucherville	Mansonville	Villeray (2 collectors)
1	418	328	1,279
2	1,786	932	6,053
3	2,142	325	3,611
4	936	108	1,038
5	309	44	305
6	109	18	66
7	29	7	13
8	5	–	4
9	–	–	1

RF network latency (2/2)

The transmission delay for a single hop depends on several factors:

- Source occupancy rate
- Destination occupancy rate
- Physical media (RF band) contingency policy
- FHSS synchronization, etc.

Transmission delay between 0.5 and 7 seconds, but could theoretically be higher



Network latency can vary from 0.5 second to over 60 seconds

Command results

These results take into account delays associated with

- Application servers
- WAN connections
- Processing of command by meter
- Sending command and receiving response (network round-trip latency)

Priority data packets are processed first by all network components, ensuring lower latency than for other data packets

Connection/Disconnection – Priority command
(in seconds)

Zone	Latency			Commands
	Min.	Avg	Max.	
Toutes les zones	0:00:09	0:00:49	0:01:16	17

On-demand profile reading – Nonpriority command
(in seconds)

Zone	Latency			Commands
	Min.	Avg	Max.	
Boucherville	0:00:03	0:00:56	0:18:43	257
Mansonville	0:00:01	0:04:04	0:16:48	3069
Villeray mono pôle fournisseur TELCO	0:00:11	0:00:57	0:10:39	19
Villeray Toit d'édifice	0:00:04	0:02:07	0:12:25	229

1 Telecommunications performance

- **RF network topology**
- **RF network latency**
- **Bandwidth**

Bandwidth

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- Data collector is the bottleneck in RF mesh network because all communications go through it
- Useful bandwidth of AMI RF network is measured in terms of bandwidth available to data collectors, based on four parameters:

1. Number of radios per data collector – 4
2. Radio RF transmission rate – 115 kb/s
3. Useful transmission period of FHSS media access control – 4/7 of time
4. Maximum throughput of media shared using slotted ALOHA protocol – 36% (very conservative maximum)

Useful bandwidth of Gridstream RF mesh network solution is

95 kb/s

Utilization rates based on minimum, average and maximum number of meters per data collector, depending on planned topology

	Minimum	Average	Maximum
Meters per collector	2,750	8,971	19,220
Utilization rate (%of useful bandwidth)	**2.1%**	**6.7%**	**14.4%**

- Calculation of utilization rate takes into account data packet size and overhead associated with transmission protocols
- **Figures are conservative** because Gridstream solution communications protocol throughput is higher than that of slotted ALOHA protocol

2 ICT performance

ICT performance
“Best of Breed” and interoperability (1/2)

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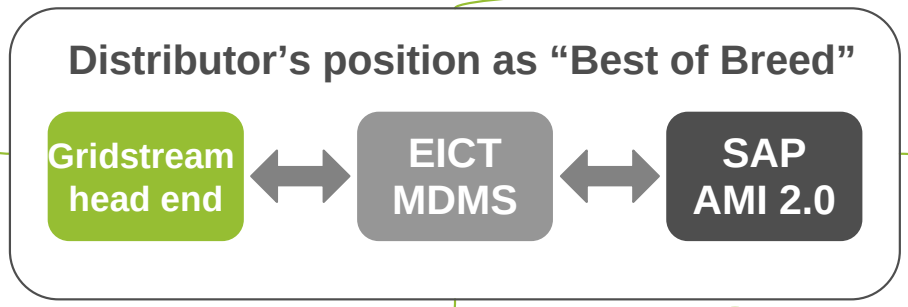
1

Open systems architecture with multiple interfaces

2

Many power utilities use

- SAP interfaced with various MDMSs
- EICT MDMS interfaced with various head ends and AMI systems
- Gridstream head end interfaced with various MDMSs



3

- Suppliers have demonstrated ability to set up interfaces between identical or similar systems
- Common goal of meeting recognized standards (IEC 61968) reduces risks

4

HQ SAP expertise centre

- Team of 100 people
- Implementation of several interfaces on SAP platform in recent years

ITC performance
Integration and interoperability (2/2)

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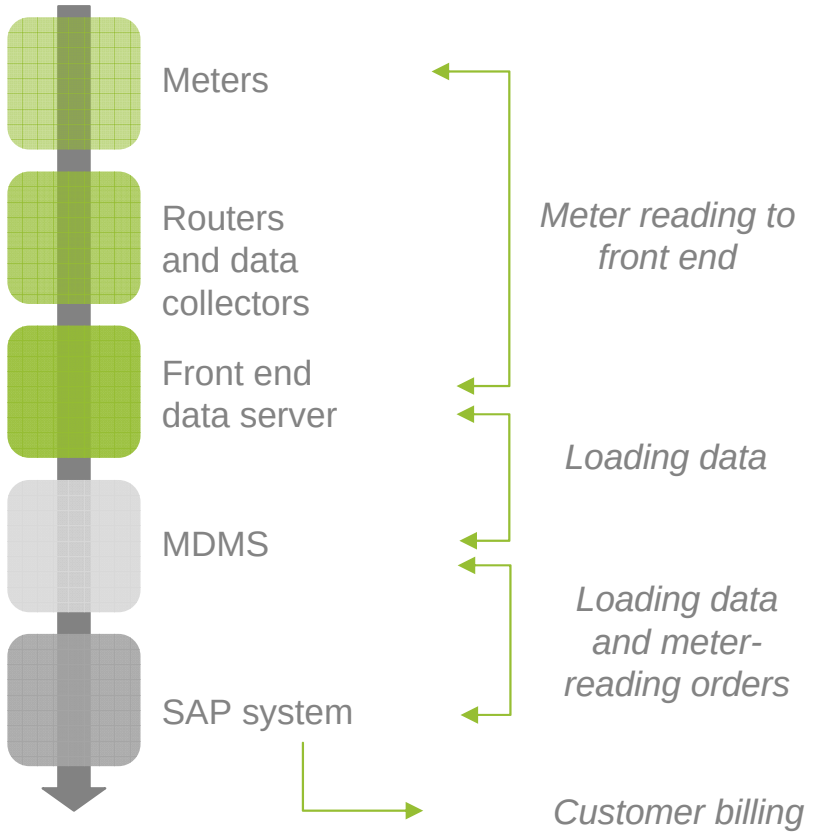
End-to-end integration testing

MDMS integration *Axis 1*	Integration into HQ IT system supporting meter reading and billing processes – Completed (Time It Right, Oct. 2010; MV-90, Feb. 2011)
Front end data server integration *Axis 2*	Integration of Command Centre with MDMS and SAP systems – Completed (Dec. 2011)
IT solution supporting rollout *Axis 3*	Partial automation and integrated testing in progress to complete commissioning – Late June 2012
SAP migration of axes 2 and 3 *Axis 5*	Upgrading SAP platform (AMI 2.0) > Standardization of exchanges between SAP and MDMS in progress – Fall 2012

End-to-end interoperability testing



3 End-to-end solution performance

End-to-end solution performance (1/2)

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Data integrity – *Confirmed*

- Use of front end server data for billing purposes validated through parallel testing of head end and SAP (comparison with manual meter reading)

Coverage rate – *100%*

- Handling of all installed meters was analyzed
- After network optimization, 100% of meters have adequate coverage

Regular meter-reading rate for billing purposes – *99.9%*

- Pilot project customers have been billed through AMI since January 2012
- Meter-reading rate of 99.9% for regular reading used for bimonthly billing

Ability to upgrade and monitor meter inventory – *Confirmed*

- Constant monitoring for advanced security and management of firmware releases by hardware type

Event and alert handling – *Confirmed*

- Ability of front end data server to flag events and alerts, which are monitored and treated directly at front end
- Transmission currently manual, will be automated in 2012

End-to-end solution performance (2/2)

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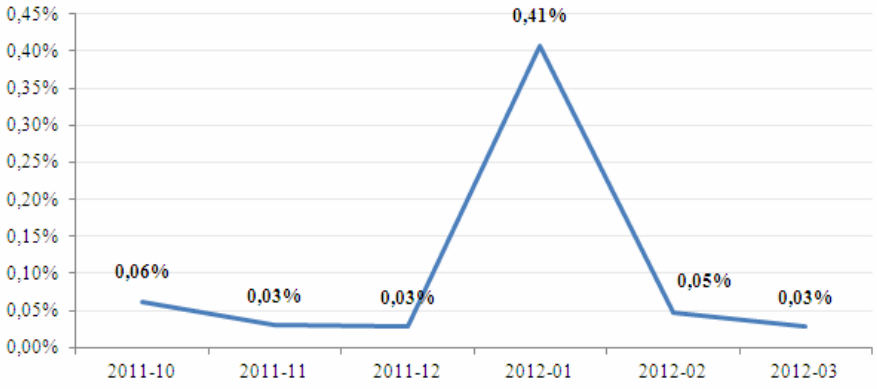
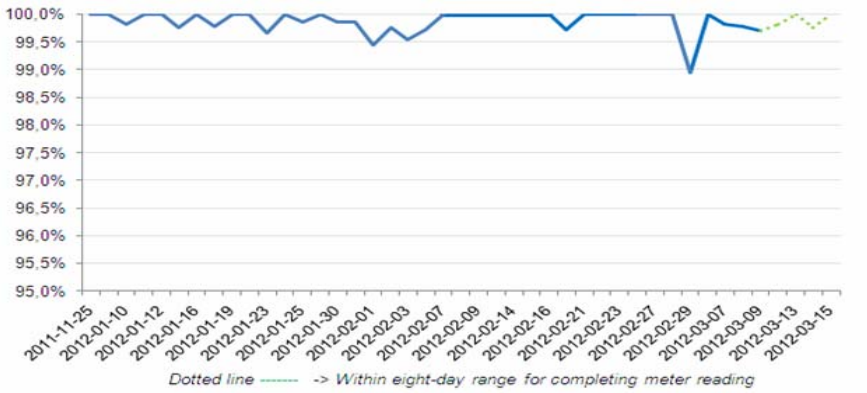
Changes in number of orphan meters (percentage of population)



Daily reading rate – Frequency (monthly average)

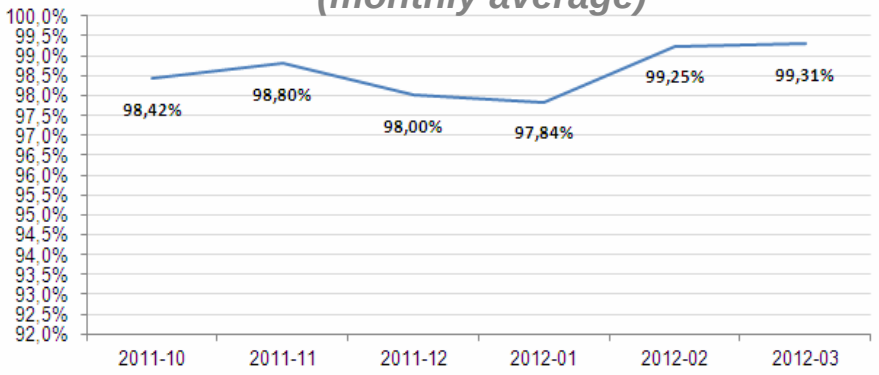
NB Jan. 2012: Technical testing followed by return to normal.

Regular meter-reading for billing purposes



AMI reading	Tolerance	Manual reading
99,9%	-5 +8 days	91,0%

Daily reading rate – Frequency (monthly average)



4 Connect/Disconnect

Connection/Disconnection

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Connect/Disconnect function built into residential meters and works on installation. Testing was done and results are conclusive.

1 Proof of concept

- **Proof of concept done on visit to Oncor, which uses this functionality with Landis+Gyr AMI. 9,000 connects/disconnects every day, with 98% success on first try**

2 Tests in controlled environment

- **Tests performed by Distributor in controlled environment** (lab)

3 Function tested in pilot projects

- **Function tested with customers in pilot project areas. Round trip (front end → meter → front end) between 30 and 60 sec.**

Functionality requires information systems to be integrated

and review of internal business processes and practices

Delivery of Disconnect function scheduled for late 2012 and Connect for late 2013

5

Meter installation performance

- **Meter accessibility**
- **Pilot project installations**
- **Installations in Villeray (Capgemini)**
- **Rollout strategies (Capgemini)**

Accessibility of indoor meters (single-phase without transformation)

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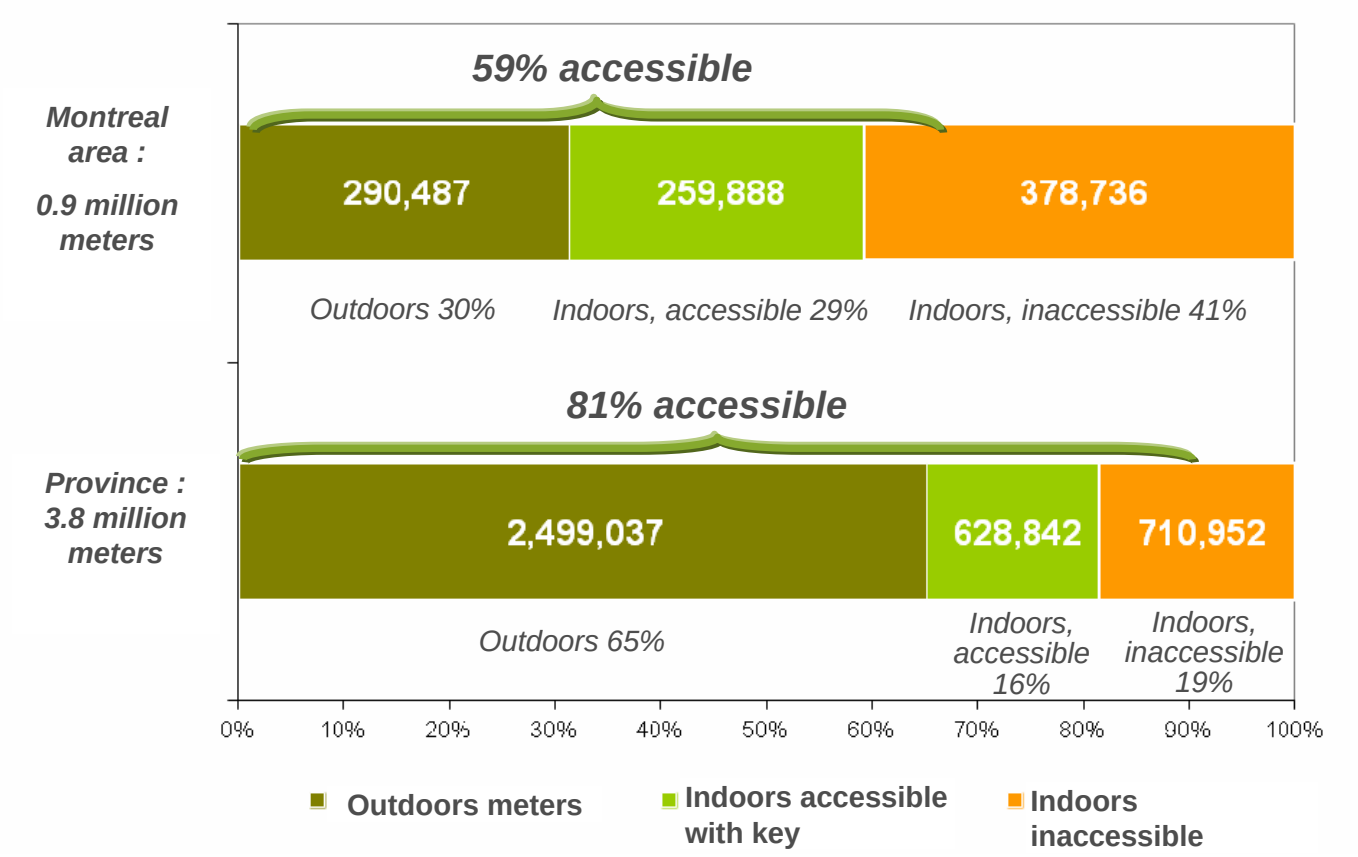

Indoor meter-reading rates on first pass *(first two months of 2012)*

- *84% province-wide*
- *80% for Montréal*

5 Meter installation performance

- **Meter accessibility**
- **Pilot project installations**
- **Installations in Villeray (Capgemini)**
- **Rollout strategies (Capgemini)**

Pilot project installations

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Breakdown of meters installed in pilot projects

(January 2012 data)

	WOs issued	Meters installed	*By HQD*	*By Capgemini*	Indoors
Boucherville	5,756	**5,735**	*5,735*	–	29.0%
Memphrémagog RCM	1,767	**1,762**	*1,762*	–	5.2%
Villeray	16,079*	**12,371**	*606*	*11,765*	81.9%
Total	**23,602**	**19,868**	***8,103***	***11,765***	

*In initial planning stage of the Villeray pilot project, 19,051 work orders were supposed to be issued. As at January 23, 2012, only 16,079 work orders had been issued in the field, 15,473 of them for Capgemini.

5 Meter installation performance

- **Meter accessibility**
- **Pilot project installations**
- **Installations in Villeray (Capgemini)**
- **Rollout strategies (Capgemini)**

Installations in Villeray (Capgemini) (1/2)

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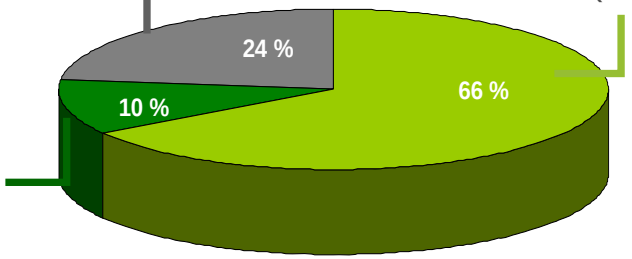
Work orders issued in field for Capgemini (15,473)

Work orders suspended pending further contact (3,708)

Work orders with installation done on first visit (10,169)

Work orders with installation requiring more than one contact (1,596)



- First visits were carried out for 15,473 work orders
- 66% of meters were installed on first visit
- Highly satisfactory outcome for Villeray, a very challenging area, with **86%** of meters indoors, as opposed to **37%** for areas 1 and 2 as a whole

In initial planning stage of the Villeray pilot project, 19,051 work orders were supposed to be issued. As at January 23, 2012, only 16,079 work orders had been issued in the field, 15,473 of them for Capgemini.

Meters installed by Capgemini

(January 2012 data)	Indoors and outdoors		Indoors		Outdoors	
On first visit	10,169	86%	7,921	83%	2,248	99%
On subsequent visit	1,596	14%	1,566	17%	30	1%
Total	**11,765** *100%*	**100%**	**9,487** *81%*	**100%**	**2,278** *19%*	**100%**

- 86% of meters installed on first visit
- For indoor meters, 83% installed on first visit

Installations in Villeray (Capgemini) Performance (2/2)

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Installation service Provider's performance

- Confirmation of provider's ability to install meters in challenging environment (86% indoors)
  - Overall average of 29 meters per installer (peak of almost 50)
  - Average of 38 meters per installer three weeks in a row
  - Pilot target was average of 33 meters per installer

5 Meter installation performance

- **Meter accessibility**
- **Pilot project installations**
- **Installations in Villeray (Capgemini)**
- **Rollout strategies (Capgemini)**

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Rollout strategies (Capgemini)

Contact sequence for meter installation[1]

1. Massive first pass through field, knocking at every door, with maximum installations (cherry picking)
2. Appointments made by phone: mornings, noon, evenings and weekends
3. After that, neighborhood sweep as final installation attempt

- Minimum of 94% of installations done by Capgemini in areas 1 and 2: 3.1 million meters
- Capgemini anticipates completing between 97% and 98% of installations: between 3.21 and 3.25 million.

Feedback on experience

- Strategies generally followed in massive rollouts
- Capgemini has used these rollout strategies on similar contracts, each with more than a million meters

- Contracts completed successfully, on time and within budget

1. "Contact" refers to visit by installer or telephone call to customer

Appendix – Capgemini's Villeray results projected for rollout in areas 1 and 2

Installations in Villeray + projected work orders for suspended work

Indoors (86%)

CONTACTS	1	3	4	5	6	7	8	9	10+
TOTAL: 13,195	7,921 60.03%	3,124 23.68%	1,013 7.68%	447 3.39%	313 2.37%	179 1.36%	121 0.92%	48 0.36%	29 0.22%
Suspended [1] (included)	–	*2,194*	*712*	*314*	*220*	*126*	*85*	*34*	*20*

94.8%

1. The 3,708 work orders suspended after first visit, when pilot projects ended in January 2012, have been pro-rated to completed installations that required more than one contact.

Outdoors (14%)

CONTACTS	1	3	4	5	6	7	8	9	10+
TOTAL: 2,278	2,248 98.68%	8 0.35%	7 0.31%	4 0.18%	7 0.31%	3 0.13%	–	–	1 0.04%

99.5%

Villeray: 15,473

Projection for massive rollout (areas 1 and 2) – Capgemini

Indoors: 1.2 million meters (37%)

CONTACTS	1	3	4	5	6	7	8	9	10+
TOTAL	737,000	290,000	94,000	42,000	29,000	17,000	11,000	4,000	3,000

Outdoors: 2.1 million meters (63%)

CONTACTS	1	3	4	5	6	7	8	9	10+
TOTAL	2,062,000	7,000	6,000	4,000	6,000	3,000	–	–	1,000

➔ **Projected that 97%–98% of installations will be done by Capgemini**

➔ **Approximately 74,000 returns to Distributor**