Gas Management for the Smart Grid

PN21: Panel Session on Gas Insulated Transmission Line (GIL) and Mixed Technology Switchgear (MTS)

April 23, 2008

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Agenda

Political Landscape

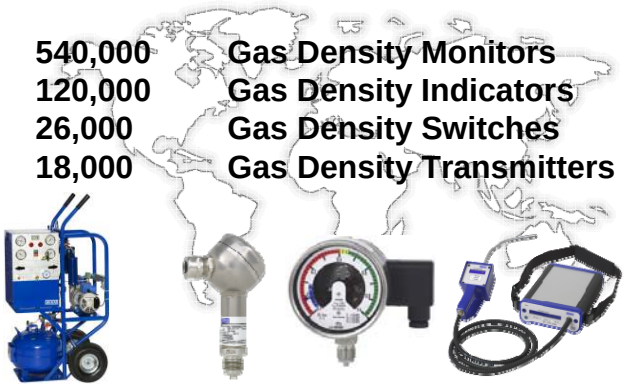
Reactive Gas Monitoring vs. Proactive Emission Detection

Gas Management

- **Online Monitoring**
- **MCA – Principle (Computer Aided Signal Analysis)**
- **Gas Management Case Study**

Who we are !

We are the people who have equipped more than 700,000 gas tanks with:



540,000 Gas Density Monitors
120,000 Gas Density Indicators
26,000 Gas Density Switches
18,000 Gas Density Transmitters

Filling, recovering, and purification

Announce the leak

Locate the Leak

Make the operation safe

Political Landscape

SF_6 is widely used in the T&D industry, because it is an excellent dielectric and has very good electrical arc switching characteristics.

It is chemically inert, non-toxic and non-flammable, making it most suitable for circuit breaker applications.

But, it is a greenhouse gas, GWP UNFCCC Guidelines *23,900* [1] compared to CO_2

⇨ SF_6 Inventories (manufacturing, use-phase, end of life, IPCC Guideline Vol.3, IPUU)

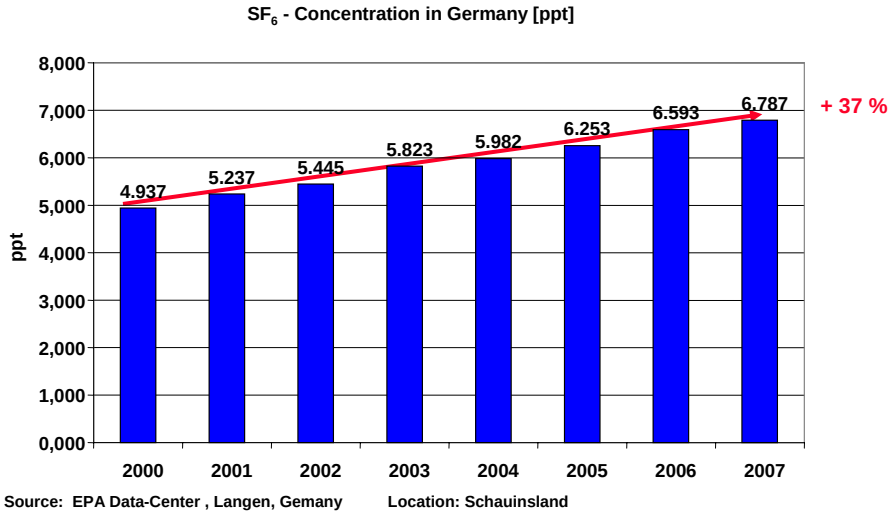
⇨ Voluntary Commitments (0.5 %/ year of the mass for High Voltage Switchgear)

⇨ Experts say: Typically 0.1 … 0.3 % / Year

1) F-Gas Regulation 842/2006 EU GWP = 22200, May 2006

IPCC: Intergovernmental Panel on Climate Change
IPUU: Industrial Processes and Product Use
UN FCCC: United Nations Framework Convention on Climate Change

SF_6 Concentration in Germany



Political Landscape – Requiring Condition-Based Monitoring

January 4, 2008

US Government to require mandatory Greenhouse Gas reporting

The US government signed into law the Consolidated Appropriations Amendment on January 4, 2008. This bill provides funding for and gives the Environmental Protection Agency (EPA) broad statutory authority for mandatory reporting of Greenhouse Gas emissions (which includes SF_6 gas). The EPA expects to issue a proposed rule by September 2008.

March 10, 2008

German Federal Office for Environmental Protection
Short-term forecast of 2007 greenhouse gas emissions.

The total output in Germany of all greenhouse gases for the year 2007 was reduced by approximately 24 million tons (-2.4%) in relation to 2006. The emissions of SF_6, however, rose by 6.9 per cent. Measured SF_6 emission concentrations in Germany are up 37% from 2000-2007 and show the continued need to reduce SF_6 emissions.

Gas Reporting in Germany

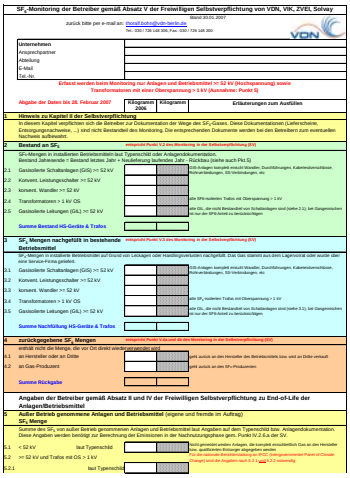
In accordance with the voluntary undertaking from summer 2005, manufacturers and operators of electrical equipment using SF6 continue to be committed to recording the quantities of SF_6 used.

The VDN collects this data from the network operators and makes it anonymously available to the Federal Office for Environmental Protection.

The attached survey sheet, which was explained at the VDN 'Infoday' on 19.10.2005 in Fulda, is based on the previous years' survey sheet, with some changes which have been necessitated by the new voluntary undertaking.

The sheet is subdivided into the subject areas:
- Gas used in plants (on site)
- Refilled gas
- Returned gas
- Permanently decommissioned plants

Survey sheet for SF6 quantities
Download: XLS file



SF_6-Monitoring der Betreiber gemäß Absatz V der Freiwilligen Selbstverpflichtung von VDN, VIK, ZVEI, Solvay

Stand 30.01.2007

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VDN

Unternehmen	
Ansprechpartner	
Abteilung	
E-Mail	
Tel.-Nr.	

Erfasst werden bahn Monitoring nur Anlagen und Betriebsmittel >= 52 kV (Hochspannung), sowie Transformatoren mit einer Oberspannung > 1 kV (Ausnahme: Punkt 5)

Abgabe der Daten bis 28. Februar 2007

	Kilogramm 2006	Kilogramm	Erläuterungen zum Ausfüllen

1 Hinweis zu Kapitel II der Selbstverpflichtung
In diesem Kapitel verpflichten sich die Betreiber zur Dokumentation der Wege des SF_6-Gases. Diese Dokumentationen (Lieferscheine, Entsorgungsnachweise, ...) sind nicht Bestandteil des Monitoring. Die entsprechenden Dokumente werden bei den Betreibern zum eventuellen Nachweis aufbewahrt.

2 Bestand an SF_6 entspricht Punkt V.2 des Monitoring in der Selbstverpflichtung (SV)

SF_6-Mengen in installierten Betriebsmitteln laut Typenschild oder Anlagendokumentation.
Bestand Jahresende = Bestand letztes Jahr + Neubefüllung laufendes Jahr - Rückbau (siehe auch Pkt.5)

2.1	Gasisolierte Schaltanlagen (GIS) >= 52 kV		SF6-Anlagen komplett einschl Wandler, Durchführungen, Kabelverschlüsse, Kühlverbindungen, Erdverbindungen, etc
2.2	Konvent. Leistungsschalter >= 52 kV		
2.3	konvent. Wandler >= 52 kV		
2.4	Transformatoren > 1 kV OS		alle SF6-isolierten Trafos mit Oberspannung > 1 kV
2.5	Gasisolierte Leitungen (GIL) >= 52 kV		alle GIL, die nicht Bestandteil von Schaltanlagen sind (siehe 2.1), bei Gasgemischen ist nur der SF6-Anteil zu berücksichtigen
	Summe Bestand HS-Geräte & Trafos		

3 SF_6 Mengen nachgefüllt in bestehende Betriebsmittel entspricht Punkt V.3 des Monitoring in der Selbstverpflichtung (SV)

SF_6-Mengen in installierte Betriebsmittel auf Grund von Leckagen oder Handlingsverlusten nachgefüllt. Das Gas stammt aus dem Lagervorrat oder wurde über eine Service-Firma geliefert.

3.1	Gasisolierte Schaltanlagen (GIS) >= 52 kV		SF6-Anlagen komplett einschl Wandler, Durchführungen, Kabelverschlüsse, Kühlverbindungen, Erdverbindungen, etc
3.2	Konvent. Leistungsschalter >= 52 kV		
3.3	konvent. Wandler >= 52 kV		
3.4	Transformatoren > 1 kV OS		alle SF_6-isolierten Trafos mit Oberspannung > 1 kV
3.5	Gasisolierte Leitungen (GIL) >= 52 kV		alle GIL, die nicht Bestandteil von Schaltanlagen sind (siehe 3.1), bei Gasgemischen ist nur der SF6-Anteil zu berücksichtigen
	Summe Nachfüllung HS-Geräte & Trafos		

4 zurückgegebene SF_6 Mengen entspricht Punkt V.4 und Ab des Monitoring in der Selbstverpflichtung (SV)
enthält nicht die Menge, die vor Ort direkt wieder verwendet wird

4.1	an Hersteller oder an Dritte		geht zurück an den Hersteller des Betriebsmittels bzw. wird an Dritte verkauft
4.2	an Gas-Producent		geht zurück an den SF_6-Produzenten
	Summe Rückgabe		

Angaben der Betreiber gemäß Absatz II und IV der Freiwilligen Selbstverpflichtung zu End-of-Life der Anlagen/Betriebsmittel

5 Außer Betrieb genommene Anlagen und Betriebsmittel (eigene und fremde im Auftrag)
SF_6 Menge

Summe der SF_6 von außer Betrieb genommenen Anlagen und Betriebsmittel laut Angaben auf dem Typenschild bzw. Anlagendokumentation. Diese Angaben werden benötigt zur Berechnung der Emissionen in der Nachsorgephase gem. Punkt IV.2.4.a der SV.

5.1	< 52 kV laut Typenschild		Nicht aufgeführte weiteren Anlagen, die komplett einschließlich Gas an den Hersteller bzw. qualifizierten Entsorger abgegeben werden
5.2	>= 52 kV und Trafos mit OS > 1 kV		Für die nationale Berichterstattung im IPCC (Intergovernmental Panel of Climate Change) sind die Angaben nach 5.2.1 und 5.2.2 notwendig
5.2.1	laut Typenschild		

Why is Condition-Based Monitoring Important ?

- US Energy Independence and Security Act of 2007 (Title XIII – Smart Grid)
  - Federal funding and support of "modernization" of US T&D infrastructure
  - Detect emerging problems and fix them before they seriously impact the quality of service

The Energy Independence and Security Act

Reactive Gas Monitoring Today

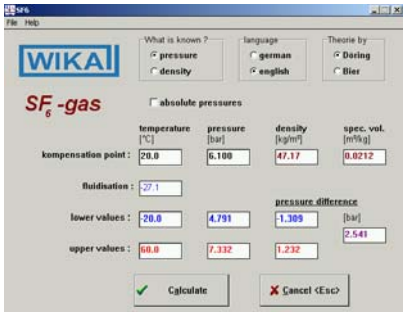
Limitations for Gas Management

Dial markings were never meant to give a reading with high resolution

It is just an annunciator !

Reactive Gas Monitoring Today – Manual Calculations

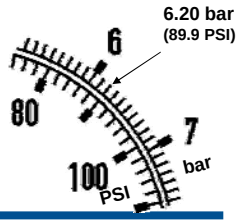
Initial Pressure Compensated	: 6.200 bar = 89.9 PSI
Actual Pressure Compensated	: 6.100 bar = 88.5 PSI
Initial Gas Mass 100 %	: 11.520 kg
Tank Volume	: 0.240 m³
Density @ 6.200 bar	**: 47.91 kg/m³ (g/L)**
Density @ 6.100 bar	**: 47.17 kg/m³ (g/L)**
Difference	**: 0.74 kg/m³**
Lost SF_6 Mass	**: 0.74 kg/m³ · 0.240 m³**
Lost SF_6 Mass	**: 0.178 kg**



After 3 Years, the conclusion is:

1.54 % in 3 Years is a loss of 0.51 % of the gas mass per year

⇨ Tank lost 59.3 gr. / yr. or 2.092 oz/yr.



Reactive Monitoring vs. Proactive Monitoring

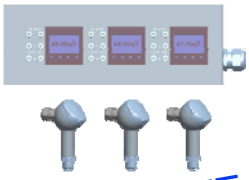
Gas Density Monitors …

- Ensure the safe operation of switchgear
- Control the filling of switchgear
- Show the current density situation

REACTIVE

Gas Management Systems …

- Measure low emission rates
- Acquire data into a database
- Analyze data
- Calculate trends in real-time
- ➢ RESULT: informed decision-making



PROACTIVE

Proactive Gas Monitoring Today - Online

Measure / Communicate / Analyze ⇨ MCA Principle

Process - Level

M

Permanent Measurement

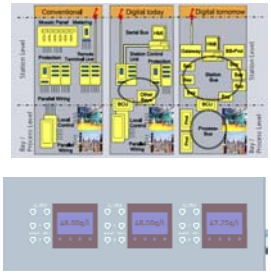
Field Device

Bay - Level

C

Communicate the Data

IEC 61850



Data Aquisition / Communication

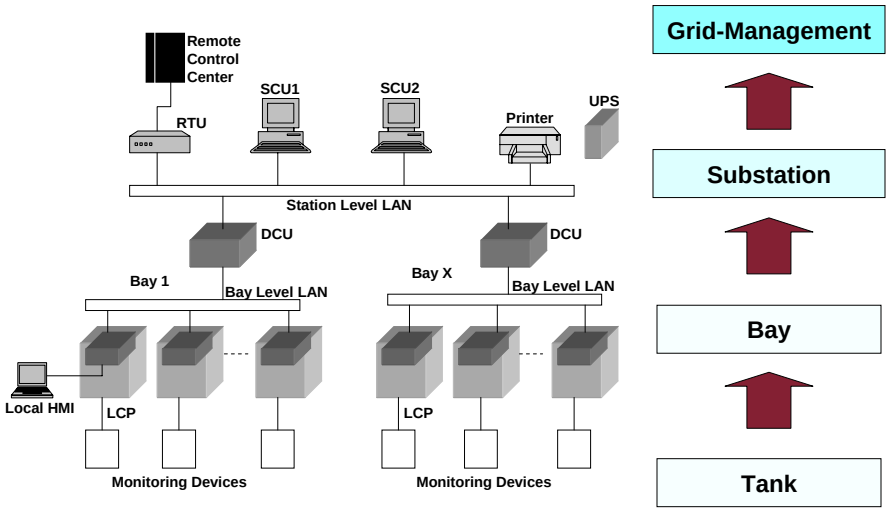
Network - Level

A

Database Datawarehouse

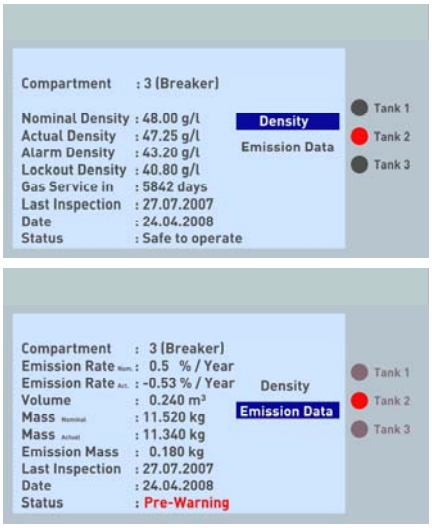
C omputer
A ided
S ignal
A nalysis

Gas Management System: Flow of Information

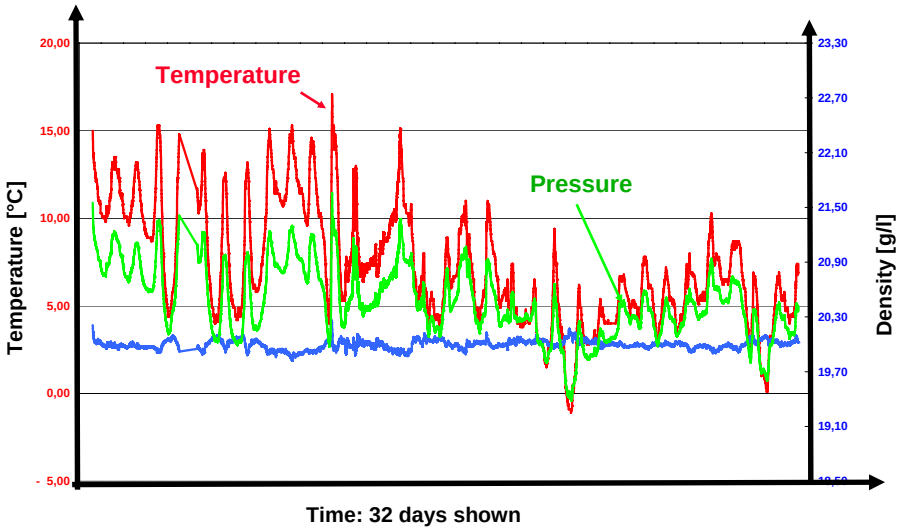


GMS Infrastructure: Customized Software

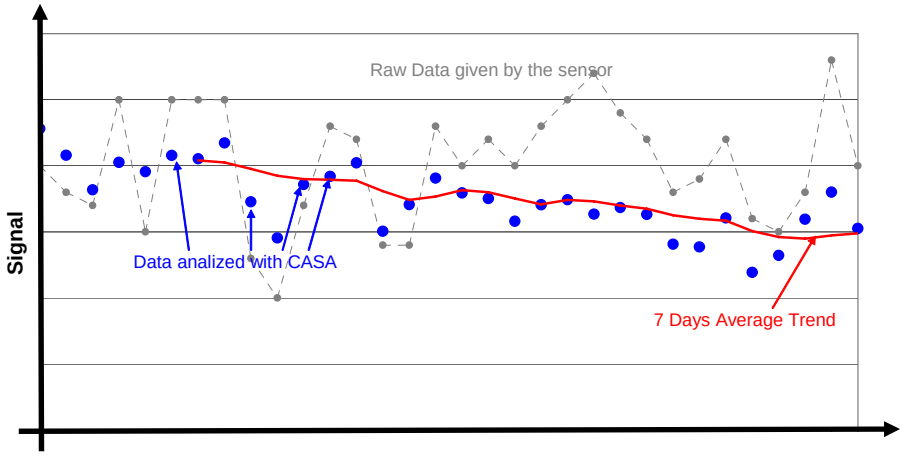
- Display the information needed to:
  - Investigate a leak
  - Prioritize maintenance on critical breakers
  - Calculate emissions for the grid



Raw Data of Measurement



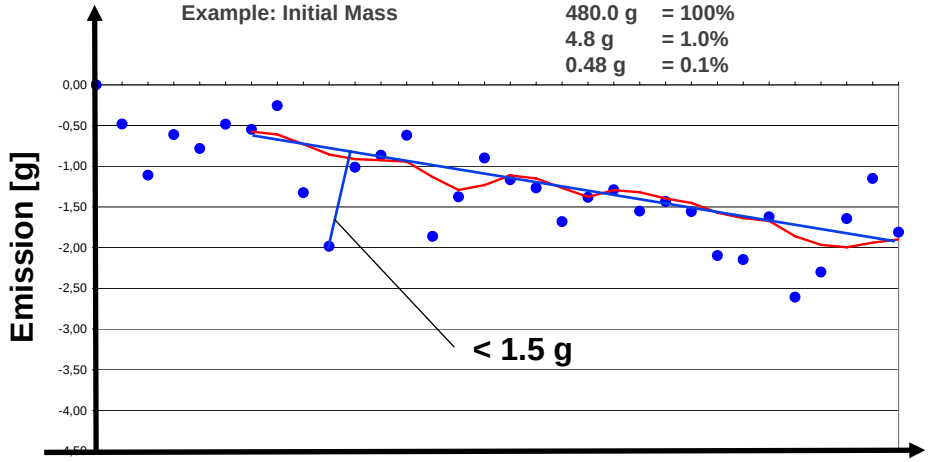
Computer Aided Signal Analysis



Emission [g] Calculated by CASA

Example: Initial Mass

480.0 g = 100%
4.8 g = 1.0%
0.48 g = 0.1%



What can we do with an innovative Concept ?

With a Gas Management System you can…

- Measure low level leak rates
- Show clear emission levels of specific breakers
- Detect leaks early (⇨Forecasts, CBM, SAM concepts assisted)
- Prove commitment / emission rates (by utilities)
- Improve tank filling (tanks are most likely overfilled)
- Issue emission certificate for breakers (competitive advantage for best in class)
- Introduce Emission Trading (CDM – Projects etc…)
- Lay a foundation for nation-wide emission reporting (regulated like cap & trade)

Gas Management Case Study
Direct labor savings via GMS

Case Study Assumptions: Infrastructure

- **Typical Utility**
- **Approx. 1050 high-voltage substations**
- **Avg. of 16 SF_6 tanks per substation**

- **25-year time horizon**
- **Maintenance crew of 1 person**
- Labor costs $36/hr. *1)*
  (incl. 30% overhead)
- Inflation factored in via labor costs

1) US Bureau of Labor Statistics, 2006 hourly pay figure for Electrical and Electronics Repairers, Powerhouse, Substation, and Relay

Case Study Worksheet

Costs for Reactive Monitoring – Typical Utility

Service life (in years): 25 years
How many substations do you operate? 1050 substations
How many gas tanks / monitors do you control in one substation (rough figure)? 16 tanks
How often do you take readings from the monitors? Once per 2 months
How many individuals travel as a team to take readings? One
What does a team member cost per hour? $35.88 USD
How many minutes are needed to get to/from the substation (roundtrip)? 120 minutes
How much time is spent in the substation preparing the job? 30 minutes
How many minutes are spent reading each gas density monitor? 2 minutes
How much time is needed to prepare the follow-up paperwork per substation (documentation)? 60 minutes

Total Lifecycle Times
Driving time: 120 minutes
Organization: 30 minutes
Manual Readings: 32 minutes per substation
Documentation: 60 minutes

Total direct labor cost for reactive monitoring: **$34,094,970 USD**
Total direct labor cost for reactive monitoring / substation: $32,471 USD
Total direct labor cost for reactive monitoring / tank $2,029 USD

Other “hidden costs” of reactive monitoring

- Transportation costs to/from substations
- Unplanned power failures
- Maintenance outages at inopportune times
- Training for new employees due to forecast retirements
- Cost of replacing SF_6 gas
- -
- -
- -
- -

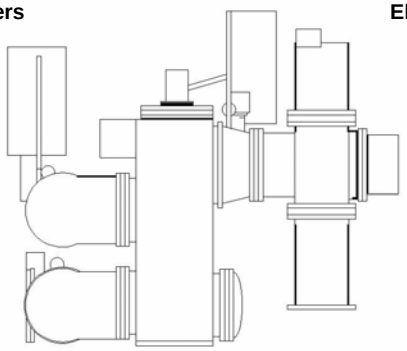
What´s next?

- **Gas Density – Temperature Transmitter Combo**
- **CASA Software Optimization**
- **Pilot Substations to prove the concept**
  - o **Europe** ✓
  - o **Asia** ✓
  - o **Americas** **TBD - Who wants to start ?**

What else could we do with an innovative Concept ?

Mechanical parameters

- SF_6-density
- Temperature
- Switch position
- Operating time
- Travel curve
- Spring position
- Charging energy
- Charging time

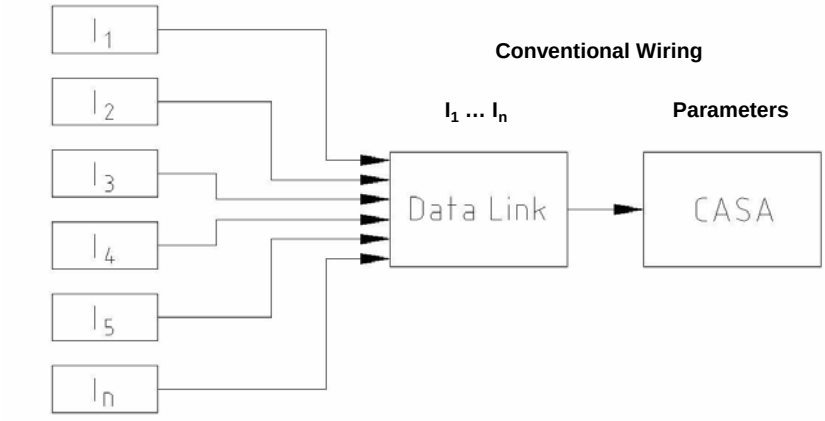


Sketch GIS

Electrical parameters

- Primary voltage
- Primary current
- Motor running time
- Motor current
- Motor voltage
- Auxiliary voltage
- Trip coil current
- Trip coil voltage

What else could we do with an innovative Concept ?



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