What are the next steps - Requirements for H_2 sampling

Ward Storms – Toyota Motor Europe
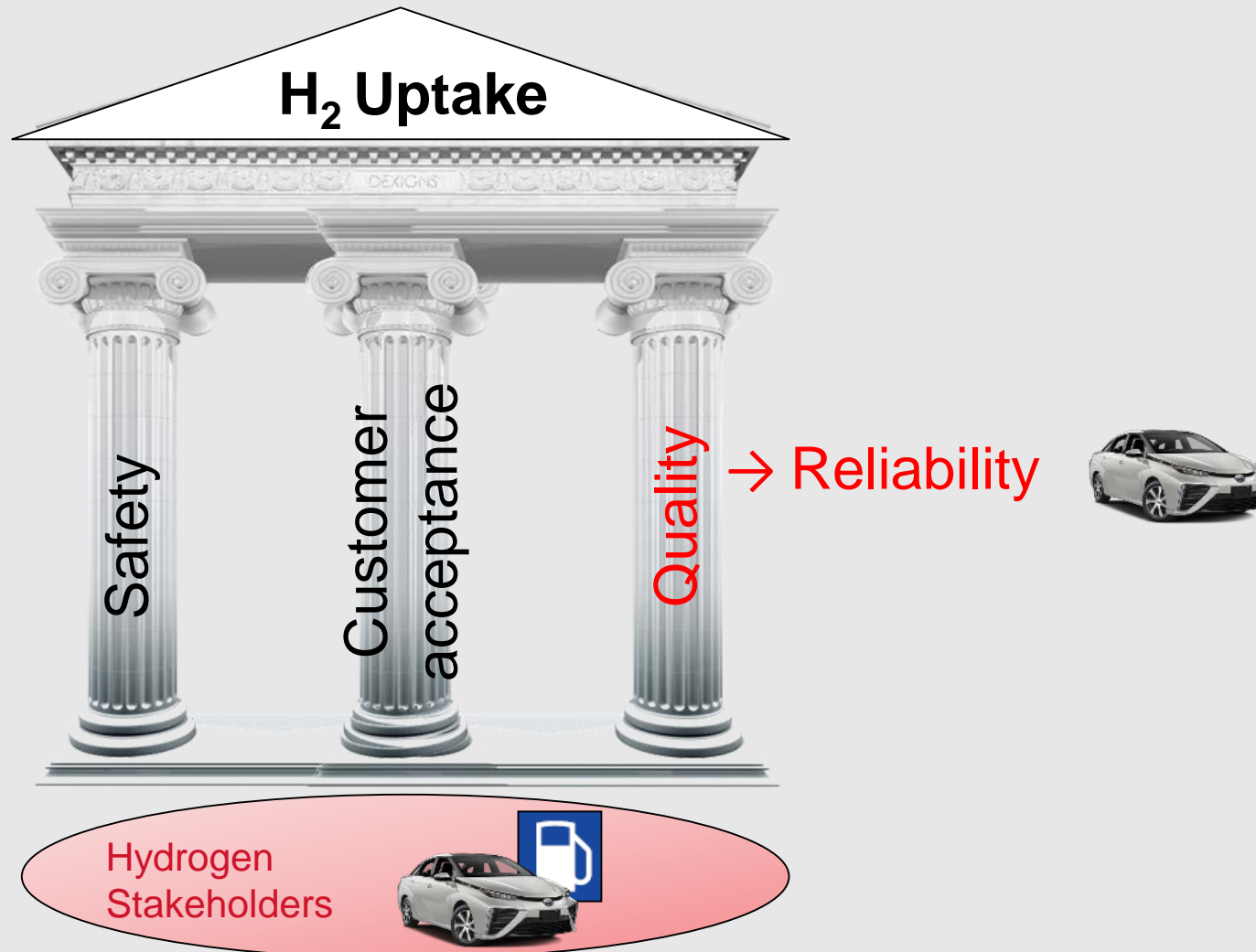
VSL, Delft
12th September 2019

Toyota's FCEV: Mirai

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Achieving hydrogen society

H$_2$ Uptake

Safety

Customer acceptance

Quality → Reliability

Hydrogen Stakeholders

The successful uptake of hydrogen technology is the responsibility of us all

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Reliability

Challenge:
clocking up 200,000 kilometres in just over 250 days

Driving style:
City traffic (Hamburg)
High speed driving (Germany)
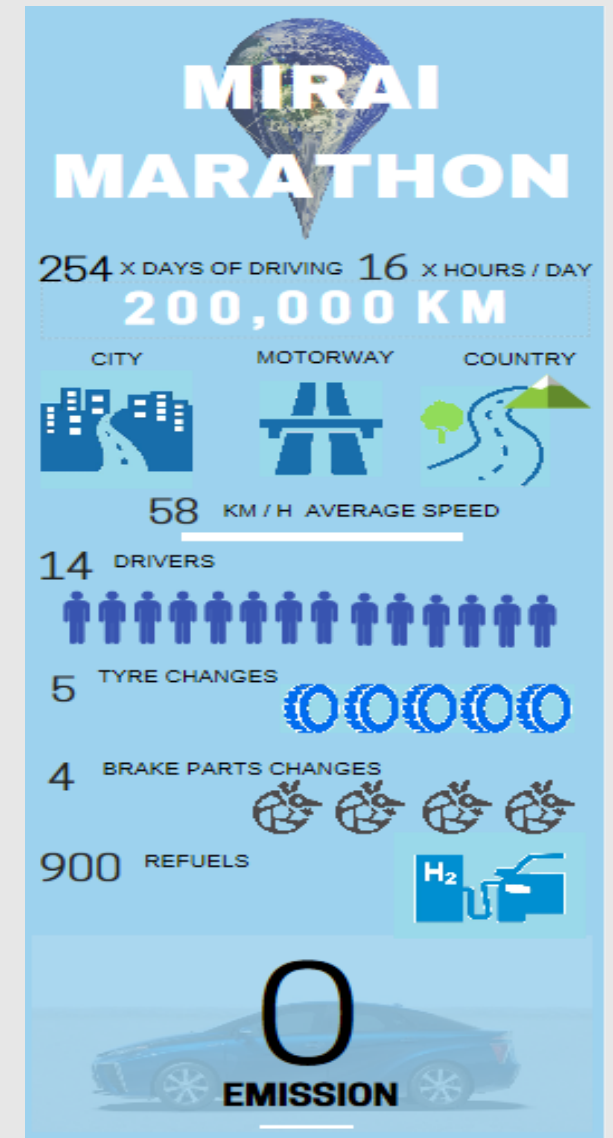Cold conditions down to -20°C (Norway)
Uphill-downhill in summer up to +37°C (Alps)

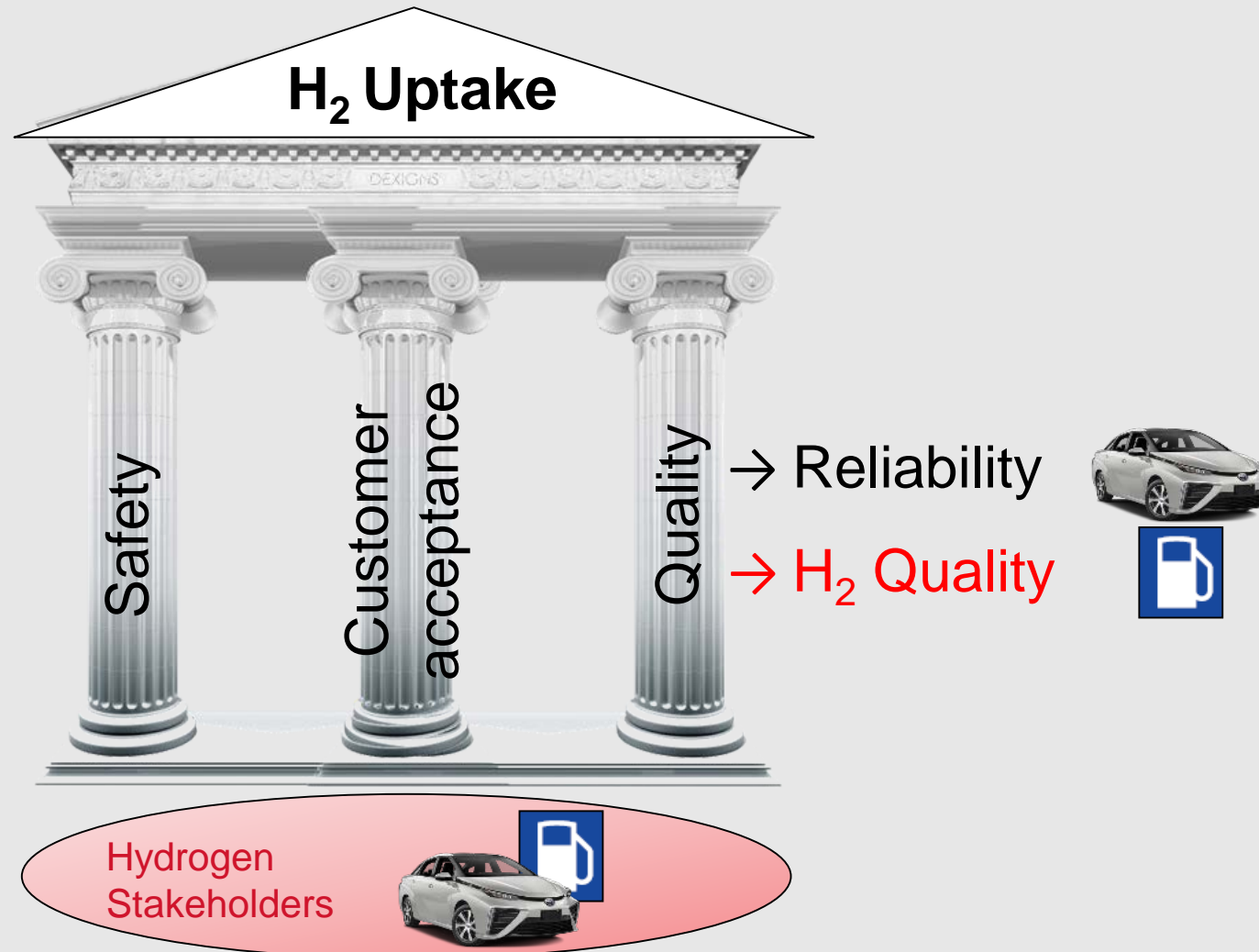*The Mirai operated with 100% reliability.*
Meaning for Europe:
Records like this brought by OEMs can build confidence and customer satisfaction.

Condition

Excellent
H$_2$ Quality

ISO 14687-2
EN 17124

MIRAI MARATHON

254 X DAYS OF DRIVING 16 X HOURS / DAY
200,000 KM
CITY   MOTORWAY   COUNTRY

58 KM / H AVERAGE SPEED

14 DRIVERS

5 TYRE CHANGES

4 BRAKE PARTS CHANGES

900 REFUELS

0 EMISSION

Toyota is committed to continuously improve our cars. However,
Hydrogen with high quality is required to avoid breakdowns and to achieve customer's trust

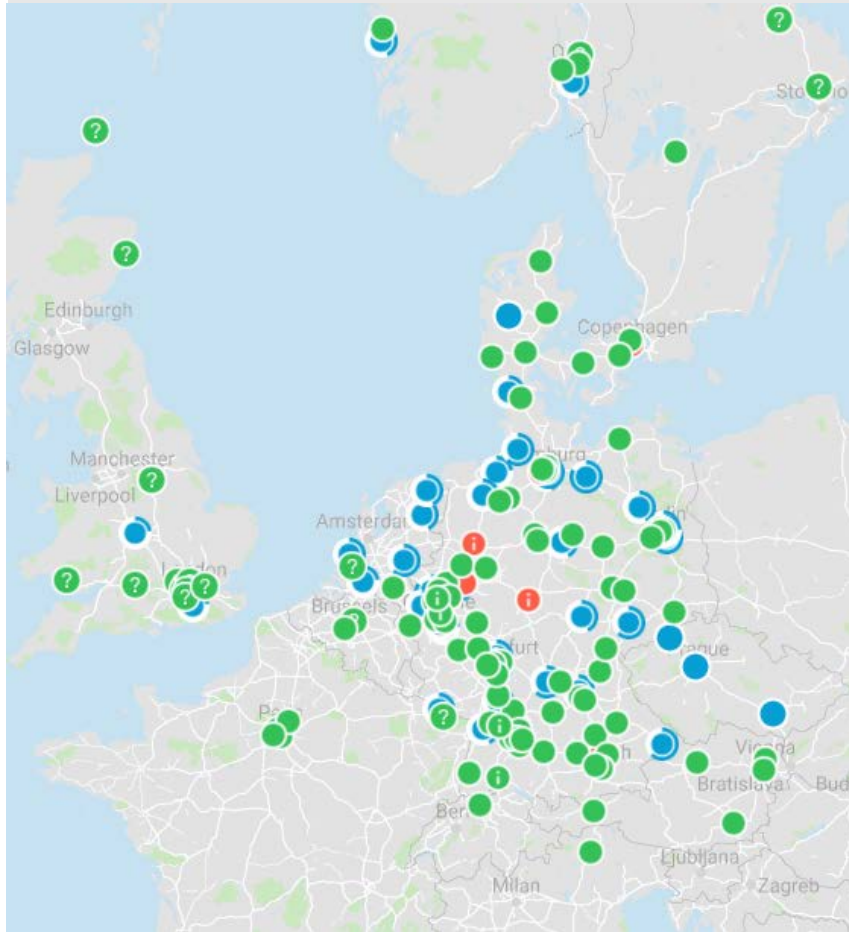**TOYOTA**

Achieving hydrogen society

H$_2$ Uptake

Safety

Customer acceptance

Quality

→ Reliability

→ H$_2$ Quality

Hydrogen Stakeholders

The successful uptake of hydrogen technology is the responsibility of us all

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Hydrogen Refuelling Infrastructure

http://h2.live/en

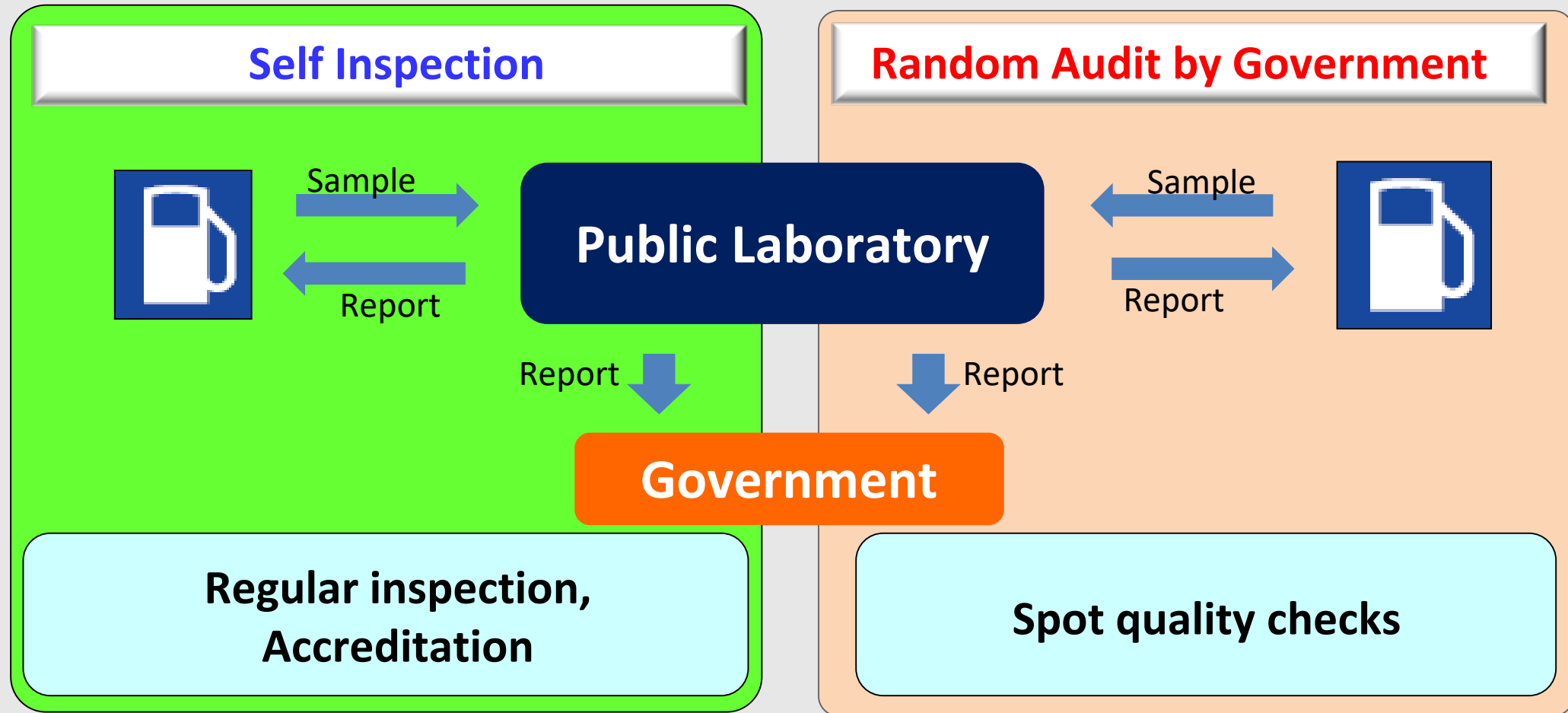| 700 bar station			2019 ACTUAL
Germany	🇩🇪		70
UK	🇬🇧		10
Denmark	🇩🇰		10
Norway	🇳🇴		4
Sweden	🇸🇪		3
Netherlands	🇳🇱		2
Belgium	🇧🇪		2
France	🇫🇷		4
Italy	🇮🇹		1
Iceland	🇮🇸		3
Austria	🇦🇹		5
Switzerland	🇨🇭		1
Latvia	🇱🇻		0
TOTAL			**115**

END 2019
200 public 700 bar HRS

>20 HRS suppliers are already active in EU

A vast network of H2 refueling stations combined with a robust **H$_2$ Quality assurance system** is required to protect our customers and the expansion of the H$_2$ society.
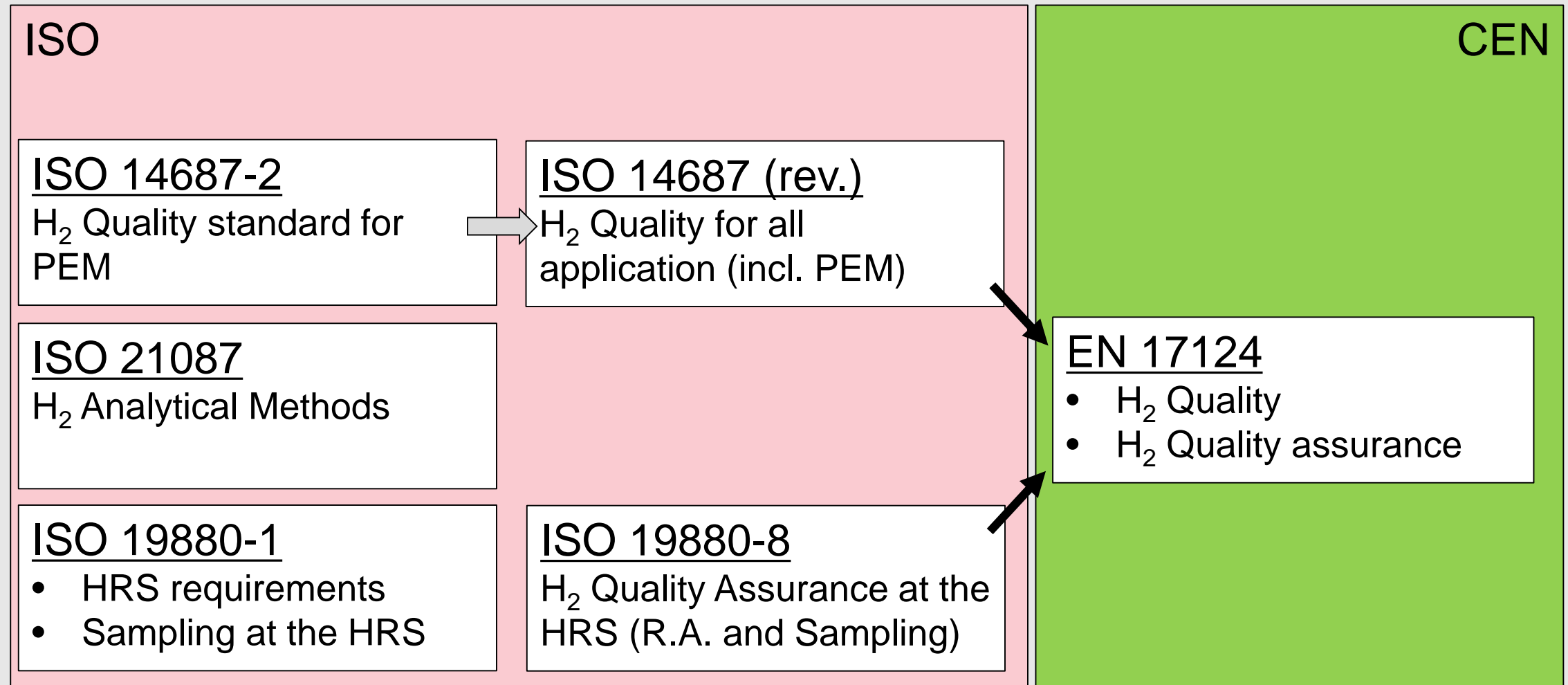
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TOYOTA's ideal Fuel Quality Management System

Self Inspection

Random Audit by Government

Sample → **Public Laboratory** ← Sample

← Report | Report →

Report ↓ | ↓ Report

Government

Regular inspection, Accreditation

Spot quality checks

A hydrogen quality management system similar to the gasoline system is desirable

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Framework of H_2 Quality related standards (ISO & CEN)

ISO

CEN

ISO 14687-2
H_2 Quality standard for PEM

→

ISO 14687 (rev.)
H_2 Quality for all application (incl. PEM)

ISO 21087
H_2 Analytical Methods

EN 17124
- H_2 Quality
- H_2 Quality assurance

ISO 19880-1
- HRS requirements
- Sampling at the HRS

ISO 19880-8
H_2 Quality Assurance at the HRS (R.A. and Sampling)

Framework of standards for H_2 quality assurance exist, but technical gaps remain to be present

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H2 sampling challenges: transport & stability

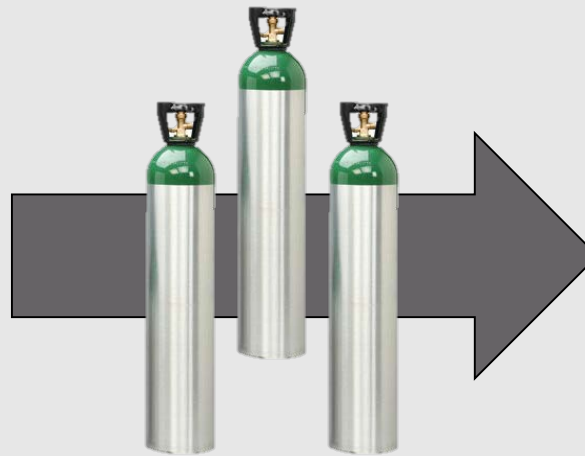Example: behavior of H_2S in a cylinder containing other ISO14687-2 impurities

Stability pattern & decay dependent to:
- Cylinder passivation
- Cylinder pre-treatment
- Mixture composition

For example, the stability of H_2S is greatly dependent on the cylinder type, passivation etc.
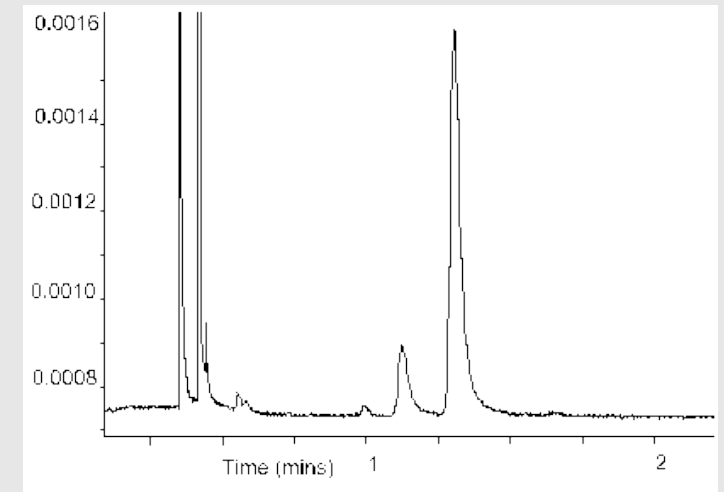
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Quality Assurance Chain

Sampling

Transport

Analysis

Management of the Quality Assurance chain is crucial to have analysis results which are representing the quality of the H_2 gas at the nozzle

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H2 sampling challenges

Hydrogen Refueling Station sampling

General
- New and unknown impurities
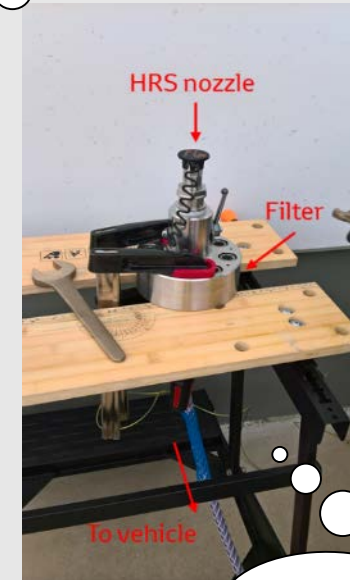- New sampling devices/techniques?

Gas sampling equipment
- Independence of operator
- Requirements for H_2 sink
- Purging

Gas sampling cylinder
- Pretreatment: Vacuum or ultra pure H_2?
- Proper cylinder passivation
- Volume

Particulate Sampling
- Representiveness
- Kind of particulates at HRS?

Representative, safe, easy & robust sampling is key for H2 quality assurance

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H2 sampling challenges: transport & stability

Transport: impurity stability

General
Understanding of interaction of impurities among themselves & with cylinder wall

Storage conditions
- Temperature
- Pressure
- Lead time for transport

Cylinder
- Cylinder materials
- Passivation of cylinders
- Pre-treatment of cylinders

Understanding and counter measuring impurity instability is key for representative sampling

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H2 sampling challenges: analysis

Analysis

General
- New impurity screening & method development
- Harmonization of existing methodologies

Gas Analysis
- Analysis Lead time / sequence ⇔ stability
- Cost

Accurate, fast and reasonable priced analysis is required

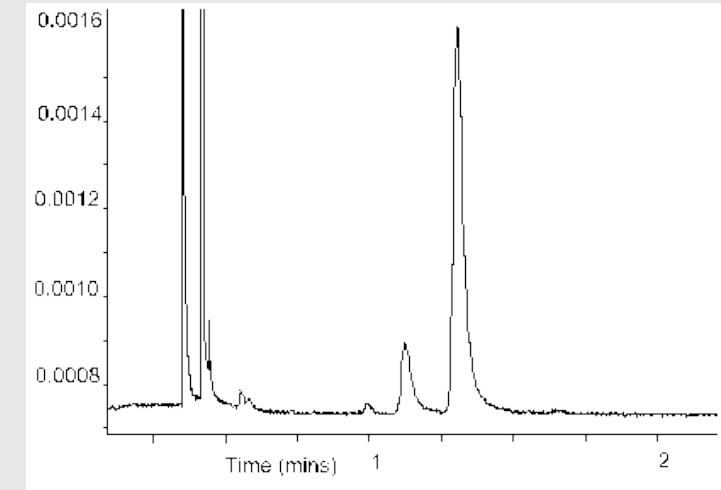**TOYOTA**

Conclusion

Sampling

Transport

Analysis

Key challenges

- Independence of HRS operator
- Alternative / no H_2 sink
- Purging requirements
- Cylinder preparation
- New impurities

- Stability of impurities
- Storage conditions (T & P)
- Passivation / pre-treatment
- Lead time between sampling and analysis

- New method development
- Harmonization
- Accuracy &Cost
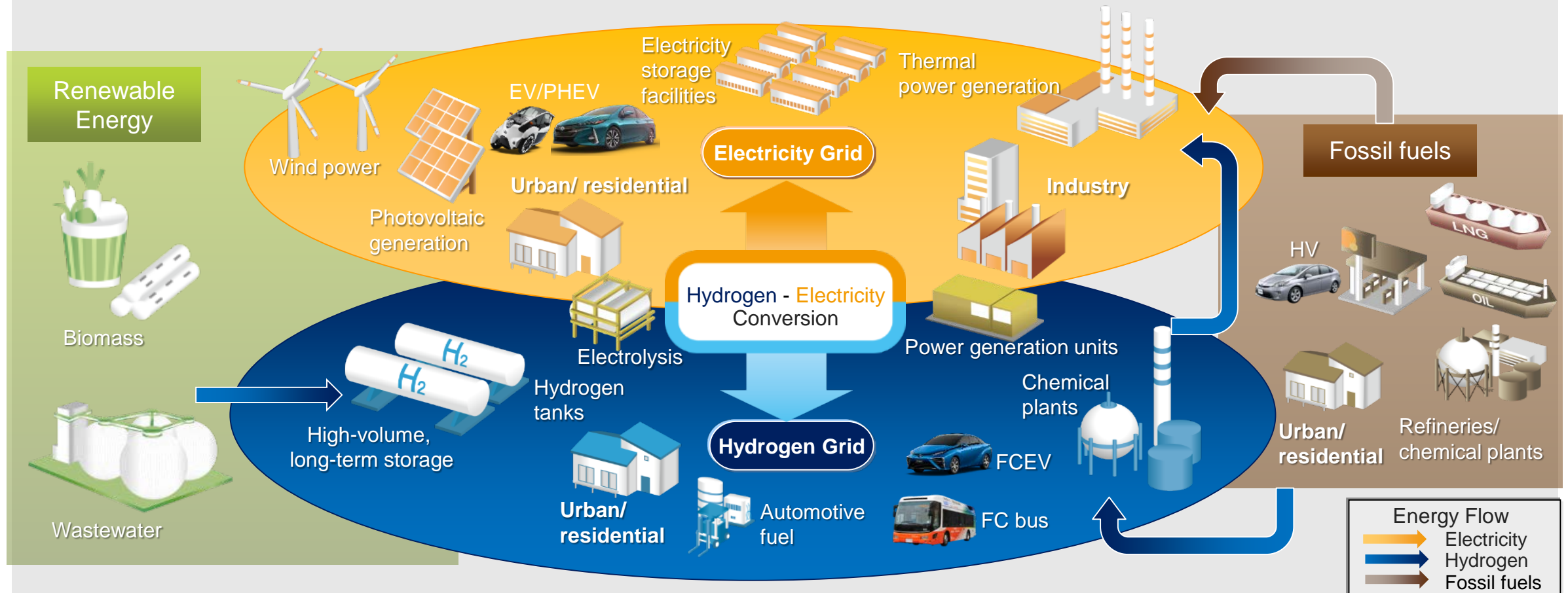- Lead time for analysis
- Required gas volume

Understanding and management of the Quality Assurance chain is crucial.
Toyota wants to continue collaboration with industry and institutes to remove the challenges ahead.

THANK YOU

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Open questions

- Any specific questions to the previous speakers
- Questions from the audience

Future Vision: HyGrid (Hybrid Hydrogen – Electricity Grid)

Source: HyGrid Study Group HP

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Framework of H$_2$ Quality related standards

ISO 14687-2

Impurity	Limit [µmol/mol]
Water	5
Total Hydrocarbons	2
Oxygen	5
Helium	300
Argon Nitrogen	100
Carbon Dioxide	2
Carbon Monoxide	0.2
Total Sulphur compounds	0.004
Formaldehyde	0.01
Formic Acid	0.2
Ammonia	0.1
Total Halogenated compounds	0.05
Maximum particulates concentration	1 mg/kg

Characteristics	
Hydrogen fuel index	99.97%
Total non-hydrogen gasses	300 µmol/mol

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Quality assurance chain: stability challenges
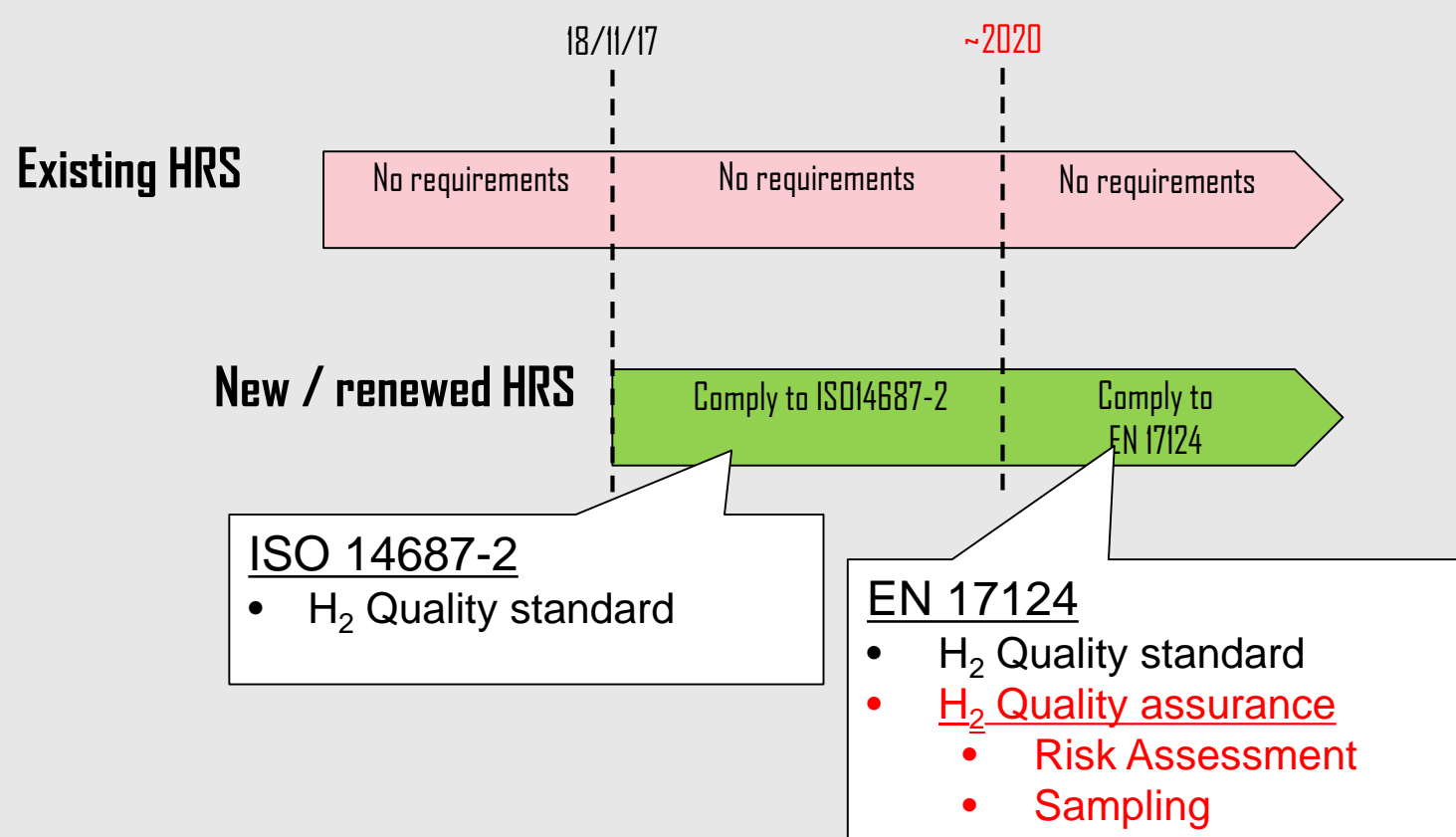
ISO 21087:2018 (draft) recommendations:

"Vessels with a <u>passivated internal surface are strongly recommended </u>to avoid impurity losses and contaminant crossover between samples."

"Sample vessel <u>purging requirements may vary</u> with sampling strategy and vessel type."

"Sample stability in vessel cannot be assumed, and <u>minimal time</u> between sampling and analysis <u>is strongly recommended.</u>"

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Current regulation of H₂ Quality in Europe

Directive 2014/94/EU – deployment of alternative fuels infrastructure

Timeline

18/11/17	All new or renewed HRS must meet H₂ quality standard 14687-2 : 2012
31/12/2017	EN 17124 on H₂ quality is developed
30/04/2018	Final vote on EN 17124
~ Pending EU COM	EU directive implements EN 17124 instead of ISO 14687-2
18/11/2019	All EU member states will have taken action to comply with 2014/94/EU
~ Pending EU COM +2Y	All new or renewed HRS must meet EN17124:2017 standard

18/11/17 — **~2020**

Existing HRS
No requirements | No requirements | No requirements

New / renewed HRS
Comply to ISO14687-2 | Comply to EN 17124

ISO 14687-2
• H₂ Quality standard

EN 17124
• H₂ Quality standard
• H₂ Quality assurance
  • Risk Assessment
  • Sampling

Hydrogen standards and quality requirements should be aligned globally

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