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Low-temperature water electrolysis (LTWE) harmonisation activities framed within JRC-FCH2JU FWC

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European Commission, Joint Research Centre (JRC), NL-1755 LE Petten

EU Workshop - Electrolysis: features, capabilities and projections, 23 May 2019, Huesca, Spain

LTWE harmonisation efforts – why and how

Under the JRC-FCH2JU Framework Contract, JRC

- Contributes to formulation and implementation of the FCH2JU strategy and activities in the areas of RCS, public safety, technology monitoring and assessment.
- Provides added value to programme objectives by complementing activities of funded projects.
- JRC deliverables are part of the FCH2JU AWP's

LTWE harmonisation efforts – status pre-2019 RP


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JRC TECHNICAL REPORTS

EU harmonised terminology for low-temperature water electrolysis for energy-storage applications

Tsotridis G., Pilenga A.

2018

Joint Research Centre

EUR 29300 EN

- **EU harmonised terminology for low-temperature water electrolysis for energy-storage applications** – published

Also input to the work of WG1 "Terms and Definitions" of CEN/CLC/JTC6 "Hydrogen in energy systems"

cen CENELEC

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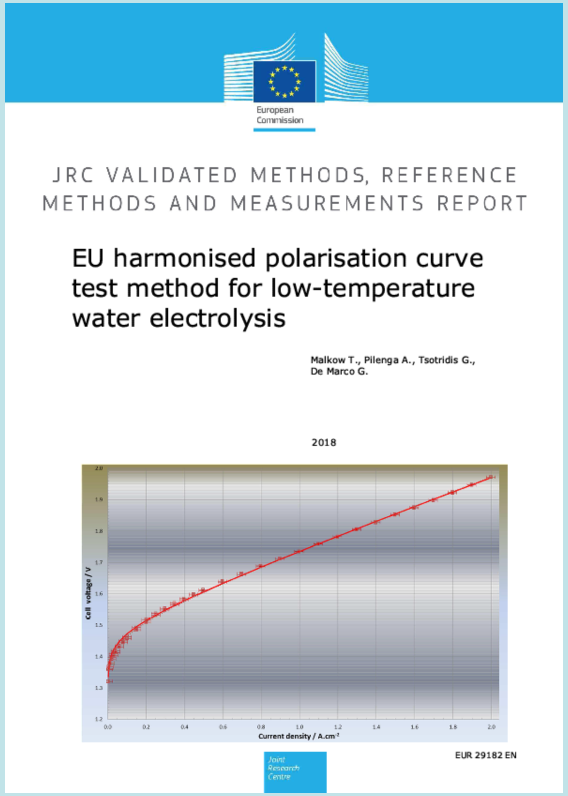
LTWE harmonisation efforts – JRC deliverables: Three testing procedures - published


European Commission

JRC VALIDATED METHODS, REFERENCE METHODS AND MEASUREMENTS REPORT

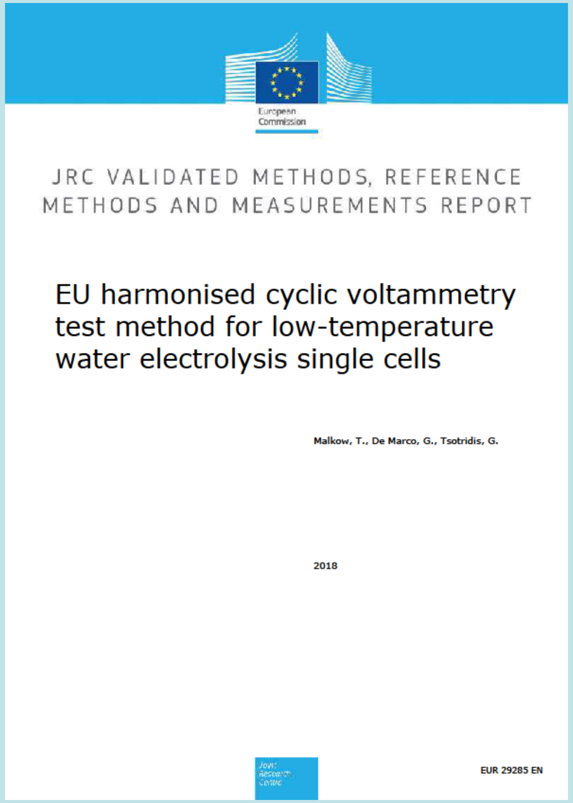
EU harmonised polarisation curve test method for low-temperature water electrolysis

Malkow T., Pilenga A., Tsotridis G., De Marco G.

2018

Joint Research Centre

EUR 29182 EN


European Commission

JRC VALIDATED METHODS, REFERENCE METHODS AND MEASUREMENTS REPORT

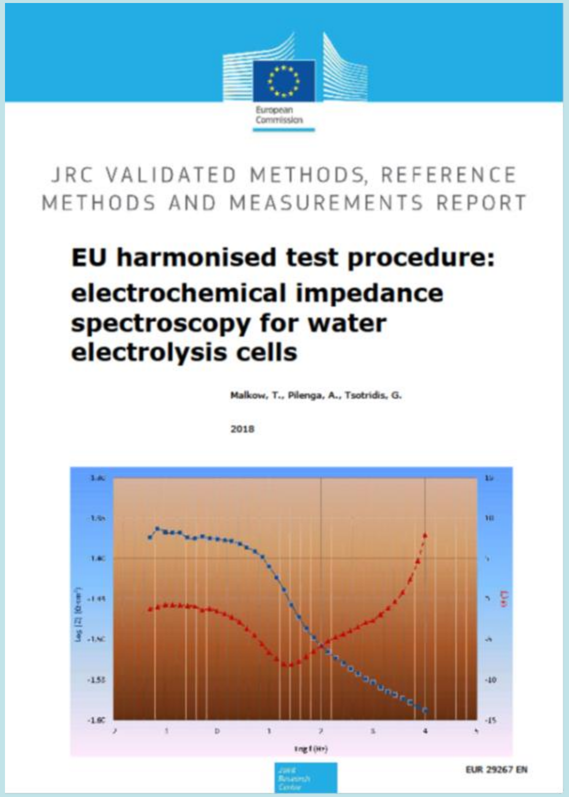
EU harmonised cyclic voltammetry test method for low-temperature water electrolysis single cells

Malkow, T., De Marco, G., Tsotridis, G.

2018

Joint Research Centre

EUR 29285 EN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JRC VALIDATED METHODS, REFERENCE METHODS AND MEASUREMENTS REPORT

EU harmonised test procedure: electrochemical impedance spectroscopy for water electrolysis cells

Malkow, T., Pilenga, A., Tsotridis, G.

2018

Joint Research Centre

EUR 29267 EN

Also input to the work of WG13 (now WG16) "Energy storage systems using fuel cell modules in reverse mode" of IEC/TC105 "Fuel Cell Technologies"

Available online at https://publications.europa.eu

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LTWE harmonisation - Testing protocols for PEMWE, AWE & AEMWE technologies - in progress

EU HARMONISED TEST PROTOCOLS FOR LOW TEMPERATURE WATER ELECTROLYSIS FOR ENERGY STORAGE APPLICATIONS

It completes the set of LTWE harmonisation documents.

Current status:

- over 100 pages document and still evolving
- Contribution from projects (i.e. QualyGrids)
- **not too late** to provide comments & suggestions
- in particular, input on AWE is welcome

Email to *Alberto.Pilenga@ec.europa.eu*

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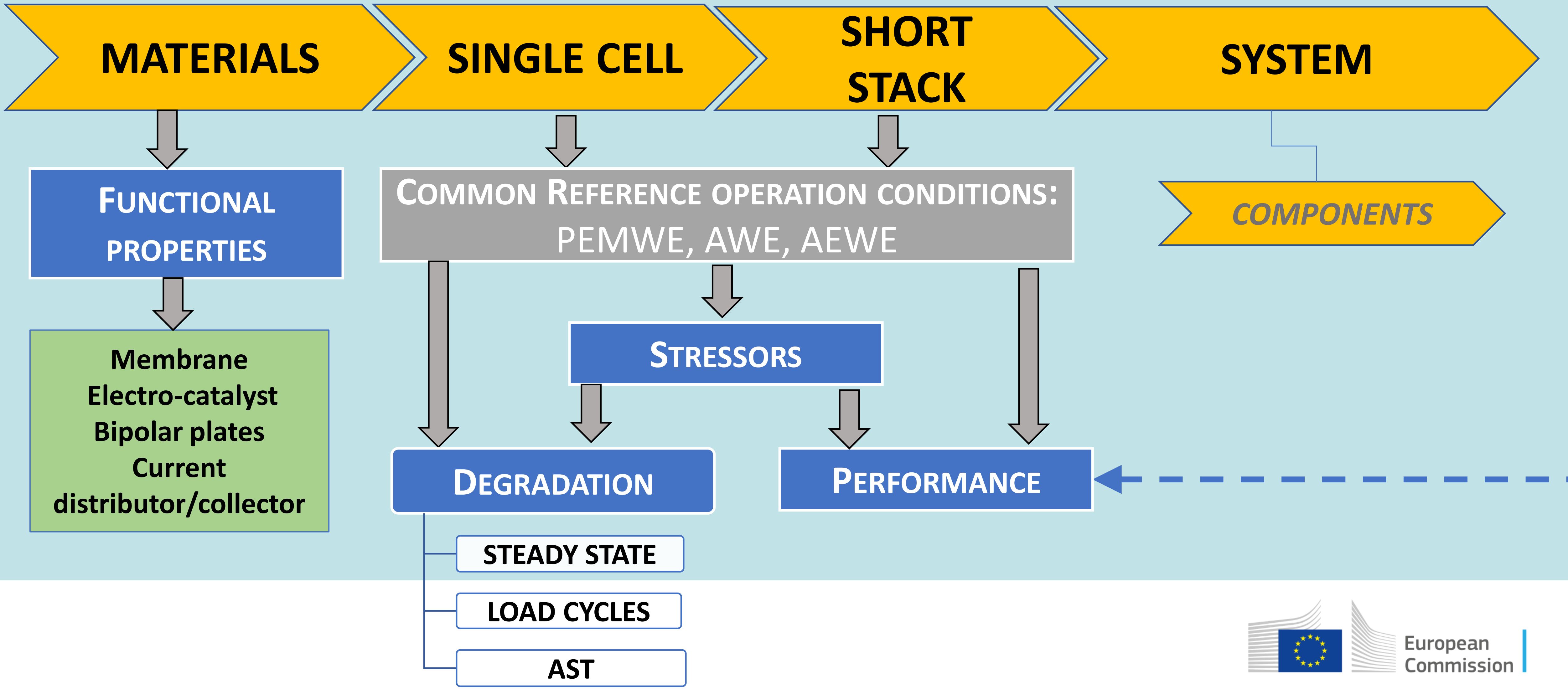
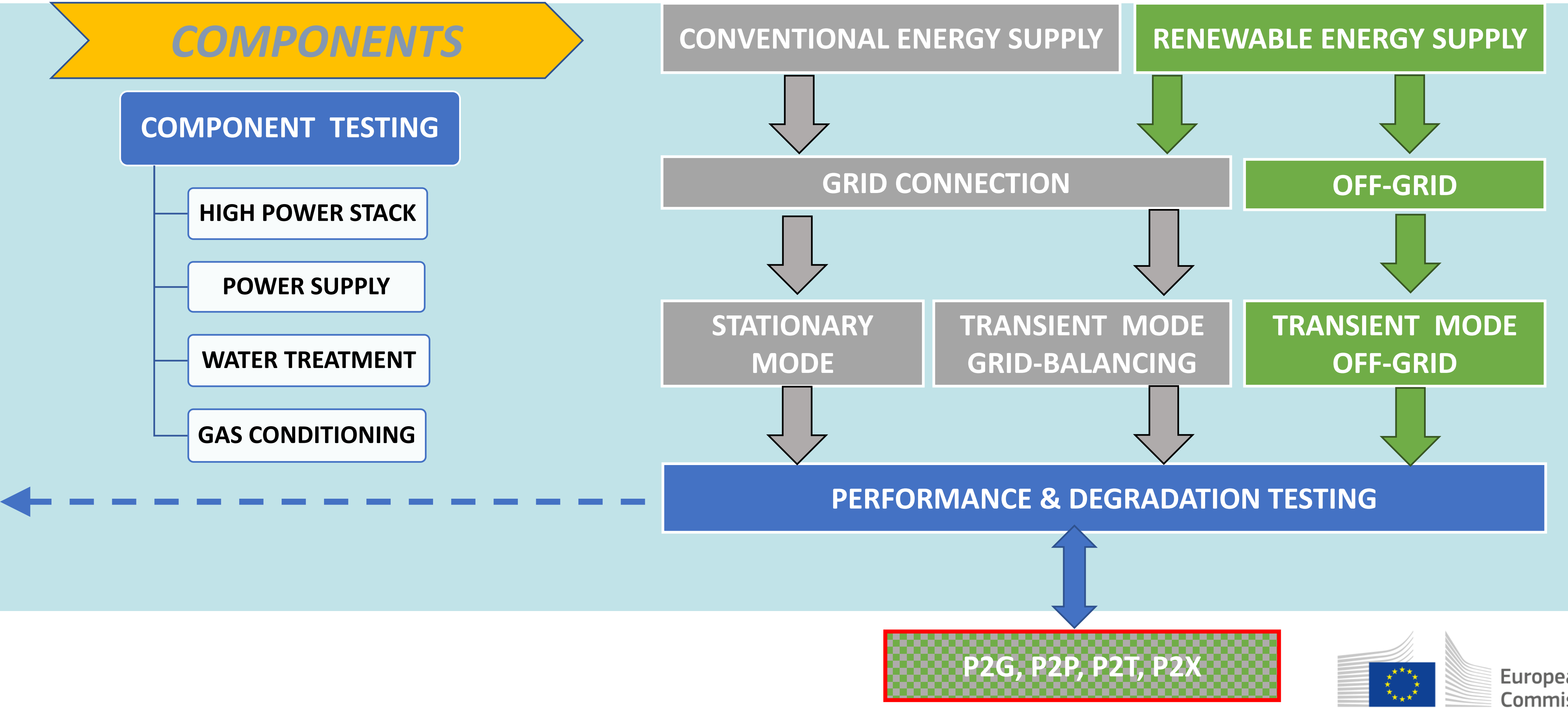
Scope of LTWE testing harmonisation



SYSTEM TESTING



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Formulary for efficiency: **current, energy, overall**

ENERGY EFFICIENCY — ε		
Single cell	**Note**	**Equation No**
$U^0_{rev} = \Delta G^0/(n\,F)$	1.229 V under SATP	[3]
$U_{rev}(T,1atm) = 1.5184 - 1.5421 \cdot 10^{-3} \cdot T + 9.523 \cdot 10^{-5} \cdot T \cdot Ln(T) + 9.84 \cdot 10^{-8} T^2$	U_{rev} in the 0-100 °C temperature range	[22]
$U^0_{tn} = \Delta H^0/(n\,F)$	1.481 V under SATP	[4]
$U_{tn}(T,1atm) = 1.485 - 1.49 \cdot 10^{-4} \cdot (T - T^0) - 9.84 \cdot 10^{-8} \cdot (T - T^0)^2$	U_{tn} in the 0-100 °C temperature range	[23]
$\varepsilon_{cell,case1} = \frac{U_{tn}}{U_{tn} + U_{cell} - U_{rev}}$	Case 1 Constant heat input-based definition	[9]
$\varepsilon_{cell,case1} = \frac{U_{tn}(T,p)}{U_{tn}(T,p) + U_{cell}(T,p) - U_{rev}(T,p)}$	Case 1 For any T,p conditions	[11]
$\varepsilon_{cell,case2} = \frac{U_{rev}}{U_{cell}}$	Case 2 Free energy-based definition	[12]
$\varepsilon_{cell,case2}(T,p) = \frac{U_{rev}(T,p)}{U_{cell}(T,p)}$	Case 2 For any T,p conditions	[14]
$\varepsilon_{cell,case3} = \frac{n \cdot F \cdot U_{tn}}{n \cdot F \cdot U_{tn}}$	Case 3 $\varepsilon = 1$ When $U_{rev} < U_{cell} \leq U_{tn}$	[15] [16]
$\varepsilon_{cell,case3} = \frac{U_{tn}}{U_{cell}}$	Case 3 Enthalpy-based definition when $U_{cell} > U_{tn}$	[17]

CURRENT EFFICIENCY — η_I		
Single cell	**Note**	**Equation No**
$\eta_I(T,P,I) = 1 - \frac{2 \cdot F}{I_{DC}} \cdot \left[\dot{n}_{H_2\_loss}(T,p,I) + 2\dot{n}_{O_2\_loss}(T,p,I)\right]$	General formula (academic viewpoint)	[38]
$\eta_I^{H_2} = \frac{2\,F\,\dot{n}_{H_2\,measured}}{I_{DC}}$	Hydrogen production efficiency (industry viewpoint)	[39]
$\eta_I^{O_2} = \frac{4\,F\,\dot{n}_{O_2\,measured}}{I_{DC}}$	Oxygen production efficiency (industry viewpoint)	[40]
Stack		
$\eta_{I\,stack}^{H2} = \frac{2 \cdot F \cdot \dot{n}_{H_2}}{I_{DC} \cdot N}$	Hydrogen production efficiency (industry viewpoint)	[41]
$\eta_{I\,stack}^{O2} = \frac{4 \cdot F \cdot \dot{n}_{O_2}}{I_{DC}\,N}$	Oxygen production efficiency (industry viewpoint)	[42]

OVERALL EFFICIENCY — η_ω		
Single cell	**Note**	**Equation No**
$\eta_\omega^{cell} = \varepsilon_{cell} \cdot \eta_I^{cell}$	Total efficiency (academic viewpoint)	[43]
$\eta^{HHV} = \frac{HHV \cdot}{P_{thermal} + P_{electrical}} \cdot \dot{n}_{H_2}$	Instantaneous cell efficiency (industry viewpoint)	[45]
$\eta^{HHV} = \frac{HHV \cdot \dot{n}_{H_2} \cdot \Delta t}{W_e + Q_{cell} + Q_{H2O}}$	Integral form of cell efficiency (stationary operating conditions)	[46]
Stack		
$\eta_\omega^{stack} = \varepsilon_{stack} \cdot \eta_I^{stack}$	Total efficiency (academic viewpoint)	[44]
Component		
$\eta^{HHV}_{component} = \frac{HHV}{P_{component\ extern}} \dot{n}_{H_2}$	Component efficiency	[47]
System		
$\eta^{HHV}_{system} = \frac{HHV}{P_{system\ extern}} \cdot \dot{n}_{H_2}$	System efficiency (industry viewpoint)	[48]
$\varepsilon_{system} = \frac{N \cdot U_{tn}(T,p)}{U_{stack}} \left(\frac{\eta_{AC/DC}}{1+\xi}\right)$	System efficiency excluding faradic efficiency (industry viewpoint)	[49]
$\varepsilon_{system} = \frac{N \cdot U_{tn}(T,p)}{U_{stack}} \cdot \frac{2 \cdot F \cdot \dot{n}_{H_2}}{I_{DC} \cdot N} \cdot \left(\frac{\eta_{AC/DC}}{1+\xi}\right)$	System efficiency including faradic efficiency (industry viewpoint)	[50]

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FUEL CELLS AND HYDROGEN JOINT UNDERTAKING

Any questions?

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Stay in touch!

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