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Technological, Regulatory and Economical Challenges in the Hydrogen Value Chain

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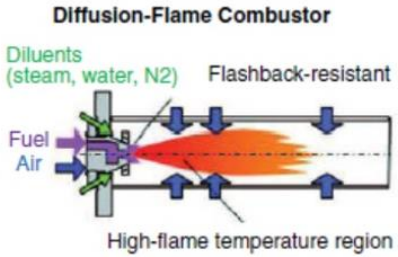
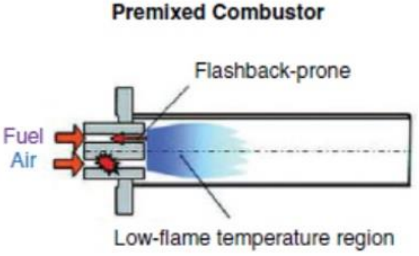
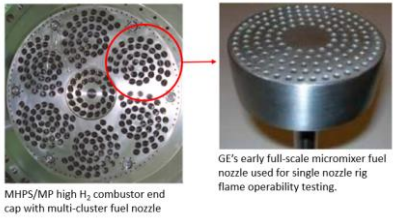
Hydrogen – Difficult Fuel

- Not an energy “resource” – energy “carrier”
- Must be “manufactured” (~50 to 60 kWh/kg)
- Safety challenges
  - Low luminosity
  - Difficult to seal
  - High flammability
- Combustion challenges
  - High flame speed
  - High NOx production (overblown)
- Can be burned in diffusion type combustors (old technology)
- But requires diluent injection (steam/water or N_2)
- Dry Low NOx (DLN) “premixed” combustor development underway
  - Multicluster/Micromixer Fuel Nozzle
  - Axial Fuel Staging (AFS)

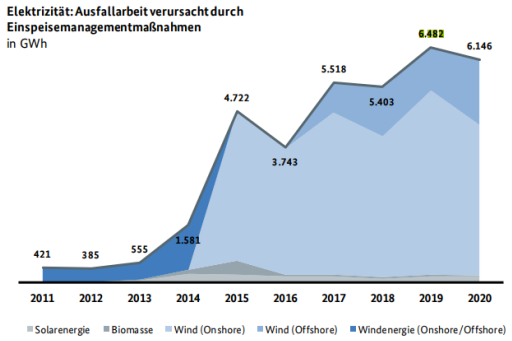






- Standard DLN combustor H_2 limit ~5%(v)
- Major OEMs offer 30%(v) capability
- Also third-party technology developers
- Next evolution ~60%(v)
- 100%(v) by 2030 (claimed) – definitely by 2050
- On a case by case basis

Burning H_2 Is Not the Issue...



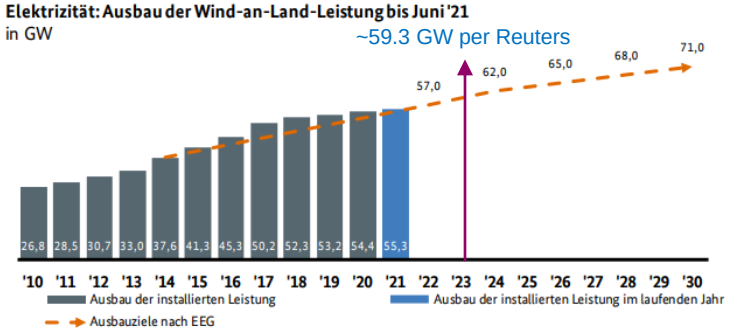


Abbildung 20: Ausbauziele Wind an Land

	Gesamt 31. Dezember 2019	Gesamt 31. Dezember 2020
	in MW	in MW
Wasserkraft	1.613,2	1.624,5
Gase[1]	413,9	376,5
Biomasse	8.336,8	8.748,4
Geothermie	47,1	47,1
Wind an Land	53.187,1	54.413,8
Wind auf See	7.555,3	7.774,2
Solar	48.913,6	53.720,7
Gesamt	120.067,0	126.705,2

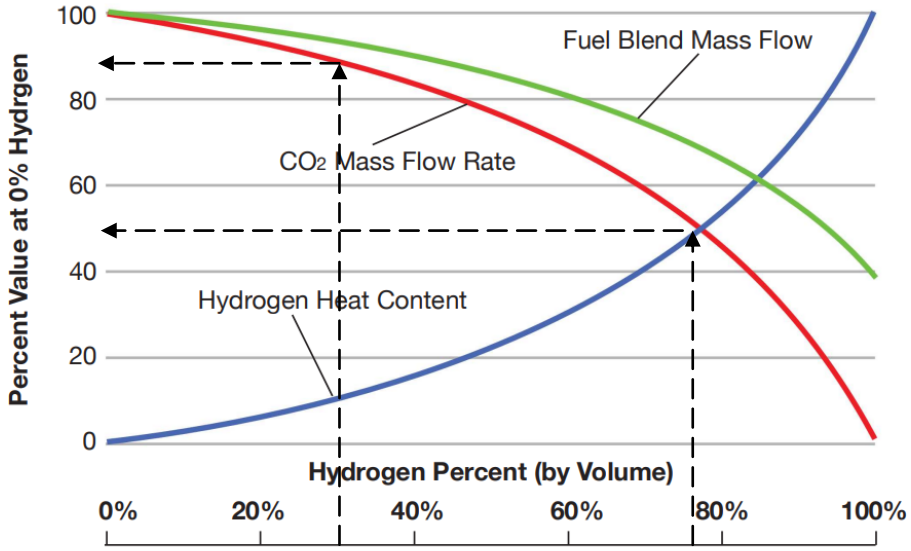
[1] Deponie-, Klär- und Grubengas

	Gesamt 31. Dezember 2019	Gesamt 31. Dezember 2020
	in GWh	in GWh
Wasserkraft	5.548	5.048
Gase[1]	1.063	1.089
Biomasse	40.152	40.948
Geothermie	187	197
Wind an Land	99.166	102.741
Wind auf See	24.379	26.903
Solar	41.383	45.030
Gesamt	211.879	221.956

[1] Deponie-, Klär- und Grubengas

- Germany (2020) total installed wind capacity 62.2 GW
- Total curtailment 6,146 GWh
- Total generation 129,640 GWh
- Curtailment rate ~4.5%
- 6,146 GWh / 8,760 h ~ 700 MW
- 700 MW / 1,250 MW = 0.56 x 8,760 ~ 4,900
- Entire wind curtailment in Germany can sustain only one 300 MW GT for about 5,000 h/yr

Impact on CO_2 Emissions



- 30%(v) is current DLN capability – small impact on CO_2 emissions
- ~75%(v) is requisite for 50% reduction in CO_2 emissions

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Renewables

Green hydrogen failings spoil 'wow effect' of renewables for IEA chief

Kelvin Ross • Jan 11, 2024

IEA executive director Fatih Birol

IEA report delivers reality check on green hydrogen but hails historic global growth in renewables

Green hydrogen will play a disappointingly small role in global decarbonisation between now and 2030, according to International Energy Agency executive director Fatih Birol.

Despite a plethora of projects and "huge excitement" around green hydrogen, Birol said IEA research had found a significant gap between the hype and the reality.

Speaking at a press conference for the launch of the IEA's Renewables market report, Birol said: "Of all the projects today in the pipeline, only 7% will see the light of day and come online before 2030."

He said this was "disappointing news", because green hydrogen "can and should play a very important role to address our climate challenge and diversify the energy mix".

Birol said the hydrogen bubble had burst because of a slow pace of projects reaching an investment decision, combined with a limited appetite from off-takers and higher production costs.