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FEASIBILITY OF GREEN HYDROGEN PRODUCTION AND STORAGE IN THE STATE OF TAMIL NADU

SRIPATHI ANIRUDH, KAJOL, SANDHYA SUNDARARAGAVAN

WHY GREEN HYDROGEN?

Decarbonisation of Energy intensive Sectors

Climate and Energy Targets

Global Competition

RESEARCH SCOPE

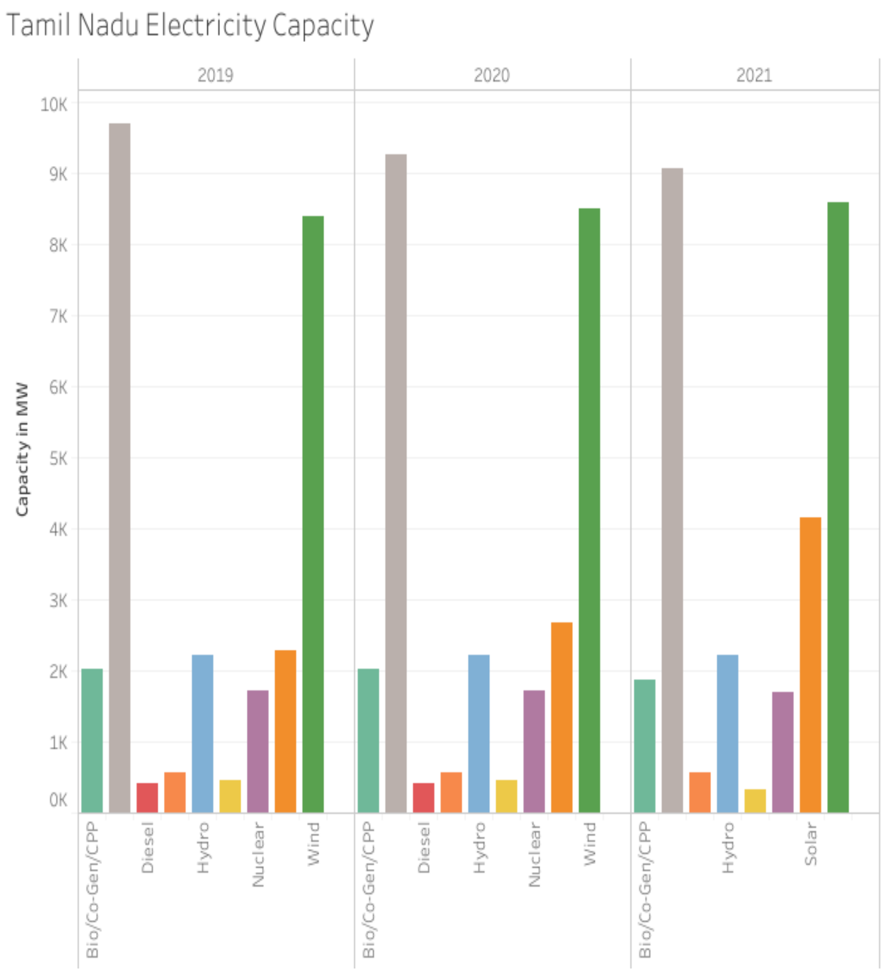
- Estimate the hydrogen production/storage potential, assessing techno-economical feasibility of green hydrogen production and storage integrating with wind power initiatives (Repowering / Offshore).

- Research looked at:
  - the current wind energy installation and curtailment scenario of TN wind power sector and upcoming wind power initiatives and scenario analysis (2030 / 40s)
  - scope of producing hydrogen from wind power and
  - using hydrogen as a storage medium based on factors such as capacity, cost of technologies

TAMIL NADU RENEWABLE ENERGY PORTFOLIO

Grid Connected Renewable Energy Capacity Installed in Tamil Nadu (as on 1st April'22)

Generation mode	Installed Capacity (MW)
Wind	9835.4
Solar	5303.5
Bio-power	1019.1
Small Hydro	123.1
Total	16281.1



MNRE Website

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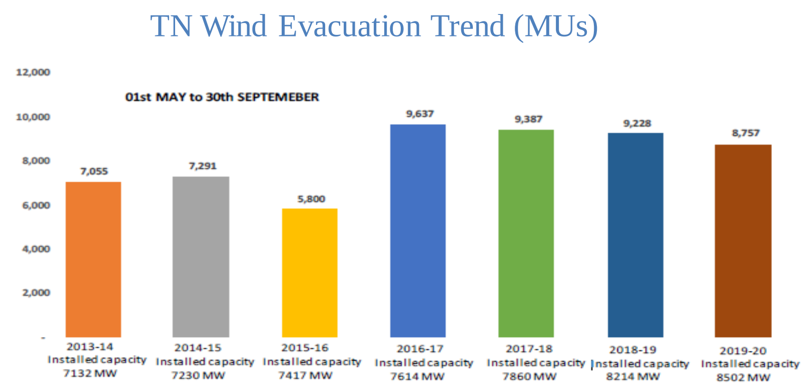
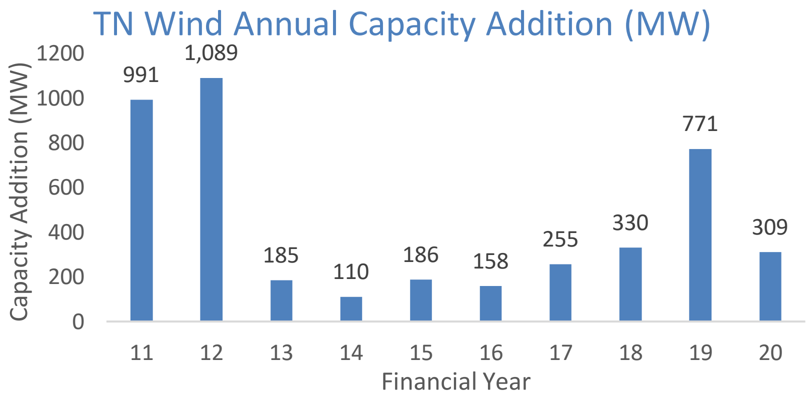
TAMIL NADU WIND SCENARIO

Wind Energy in Tamil Nadu	Current Installed (GW)	Forecasted Potential (GW)*
Onshore Wind	9.5	33
Offshore wind	0	35
Total	9.5	68**



TN Wind Evacuation Stats (1st May – 30th September)



- Decreasing TN wind power evacuation trend since FY 17, from **9637** MU to **8750** MU in FY 20 despite considerable capacity increase from 7.6 GW to 8.5 GW
- Average wind power backdown hours increased from 1.87 hrs (FY 18) to 3.52 hrs / day (FY 19)
- Backdown instances increased by over 100 % during peak season (May – Sep) in FY 19 compared to FY 18

1. IWPA – Curtailment of Wind Energy Generators (2019)
2. IDAM – Repowering of Old Wind Turbines in India (2018)

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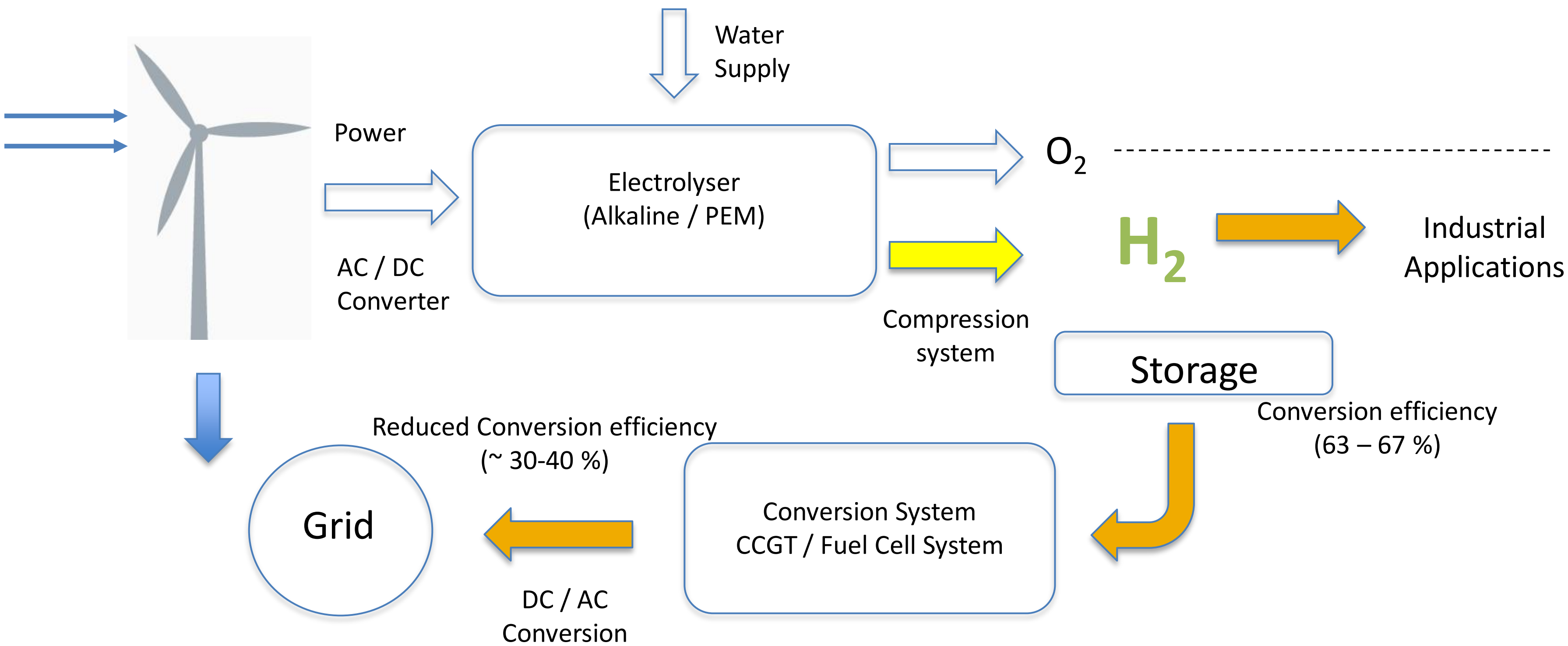
GREEN HYDROGEN CURRENT SCENARIO

- Commercial hydrogen production technique using Natural gas (Steam methane reforming – Grey H2).
- Electrolysis is the most discussed and near commercially viable option (Green H2).
- Biomass is a renewable source of energy and is considered a large and easy source for hydrogen production in India.
- Tamil Nadu has around 7 large fertiliser plants and 6 large Petro-chemical refineries. Around ~2.6 lakh tonnes of hydrogen was utilised from 2 major industrial sectors during 2016-18.

Refinery Product Estimation: https://www.ppac.gov.in/
Fertilizer production: https://fert.nic.in/sites/default/files/2019-09/Fertilizers-Scenario-2018.pdf

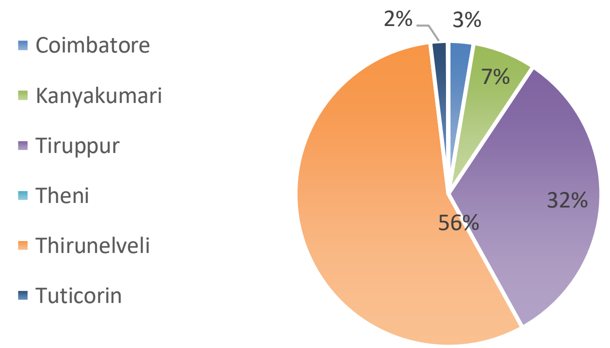
HYDROGEN PRODUCTION + STORAGE SYSTEM



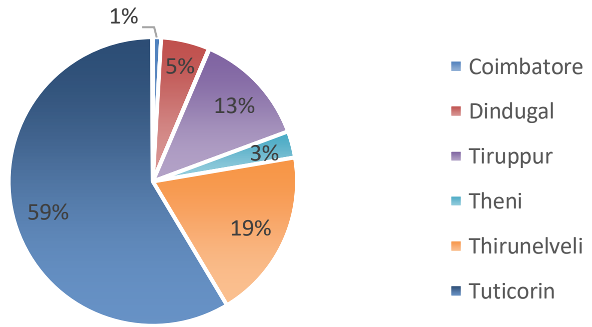
ANALYSIS 1: ANNUAL WIND POWER GENERATION IN TN

- Location: MERRA 2 satellite data, wind power generation for the selected location is obtained with a 1-hour timestep as output.
- Wind Generations: With certain assumptions, the total wind power simulated in TN. We estimated that by 2030 to reach 17.3 GW and 31.6 GW by 2030 (without wind repowering).
- Wind Spillage scenarios: 3 spillage scenarios were considered; Baseline (12%), pessimistic (18%) and optimistic (6%)

District-wise wind installation share of TN wind capacity



Installations before 2005



Installations between 2015-20

TN Wind Power Scenario 2030 and 2040

Scenario 2030

Type	Installed Capacity (GW)	Generated Units (MU)	CUF (%)
Repowering	10.78	18900	20.05
Onshore	5.09	10800	24.22
Offshore	3.70	13000	40.11
Total	**19.57**	**42740**	**24.90**

Scenario 2040

Type	Installed Capacity (GW)	Generated Units (MU)	CUF (%)
Repowering	15.7	31890	24.88
Onshore	10.10	23634	26.66
Offshore	13.3	45300	38.88
Total	**39.12**	**100830**	**29.42**

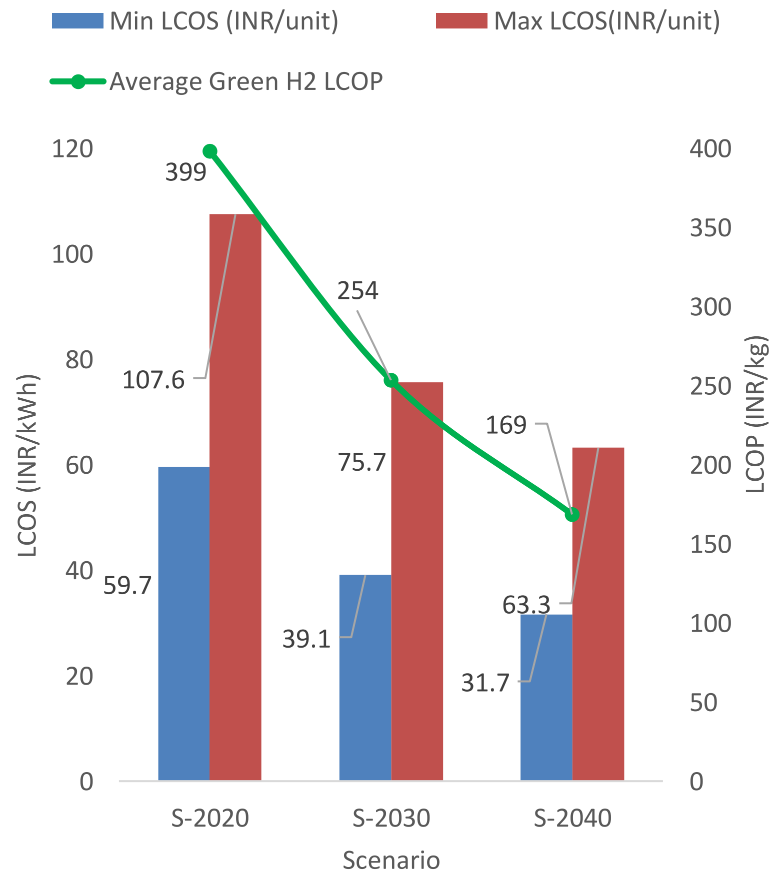
ANALYSIS 2: HYDROGEN PRODUCTION AND STORAGE POTENTIAL UTILISING EXCESS WIND POWER

Technology	Advantage	Disadvantage	Technology Maturity
Alkaline	• Mature technology • Lower capex • Reliable stack lifetime	• Can't handle dynamic load • Huge system size •	Mature
PEM	• Good dynamic load response • Small system size / kW	• High CAPEX • Complex system • High purity water requirement	Commercial
Solid Oxide	• High electrical efficiency • Low material cost	• Material degradation due to high temperature operation	Demo projects

- In the current state of technological readiness, electrolysis is the only commercial option for green hydrogen production. Current electrolyser efficiency is around 55-65 percent .
- Since our analysis focuses on using renewable power for electrolysis, PEM is a suitable option.
- For LCOS: Storage duration of 3 weeks is assumed with storage to discharge duration ratios of 1 and 3.

GREEN HYDROGEN PRODUCTION AND COST SCENARIO

Year		Spillage Scenario		
		Base case (12%)	Optimistic (6%)	Pessimistic (18%)
2020	Without Repowering	0.3-0.42	0.16-0.21	0.47-0.63
2030	Without Repowering	1.02-1.28	0.51-0.64	1.54-1.92
	With Repowering	0.89-1.12	0.44-0.56	1.34-1.67
2040	Without Repowering	2.48-2.97	1.24-1.48	3.72-4.46
	With Repowering	2.16-2.60	1.08-1.30	3.25-3.90



- Average LCOP is around INR 400 /kg hydrogen for the current timeline and is expected to reach 250 and 150 (INR/kg) by 2030 and 2040 respectively.
- LCOS is expected to be around INR 60-100 /unit gradually reducing to INR 30/unit by 2040.

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KEY FINDINGS

- Green hydrogen production potential from wind power is about 0.35 LMT at present, which accounts for 13 percent of the current hydrogen demand in TN. Green hydrogen potential of 1.1 LMT and 2.5 LMT is expected by 2030 and 2040 respectively.
- Hydrogen as seasonal storage will be able to tap 850-2500 MU by 2030 by utilizing excess wind power. By 2040, seasonal storage potential can reach over 2200-6500 MU, considering different spillage scenarios.
- If the spillage of wind power at the state level can be effectively utilized, we can achieve our GH2 target with ease and help in the revival of the wind sector.

By 2030: 3.2 x 2020, and
By 2040: 8.3 x 2020

CONCLUSION

- While RE wind generation tariff is expected to fall, landed cost of hydrogen (LCOH) production may vary when compared to the assessment provided in this paper.
- While the LCOH may be comparable for the onsite-hydrogen production, most of the hydrogen consumption will take place at refineries and ammonia production facilities. In that case, utilization of spilled RE power can be promoted.
- Clarity/Awareness of hydrogen system performance, water requirement for electrolysis and storage system is vital.
- LCOS of hydrogen storage with the compressed gas vessel is not cost competitive due to the huge storage requirement and low round trip efficiency of the system as compared to other seasonal systems such as pumped hydro, and compressed air storage. **The whole supply chain needed for the "hydrogen economy" needs to be more efficient and economically feasible.**
- Exploration of the storage mechanisms and hydrogen transportation through pipelines needs to be seriously considered for better utilization of the hydrogen storage system.
- Further, a seasonal storage-specific pilot should be explored to study the competitive side of hydrogen storage.

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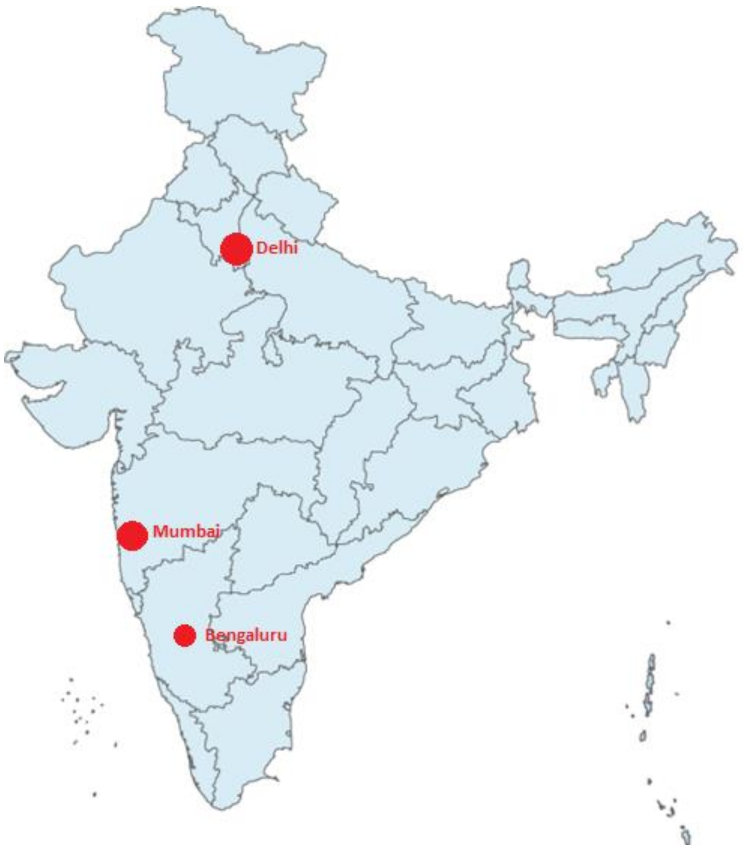

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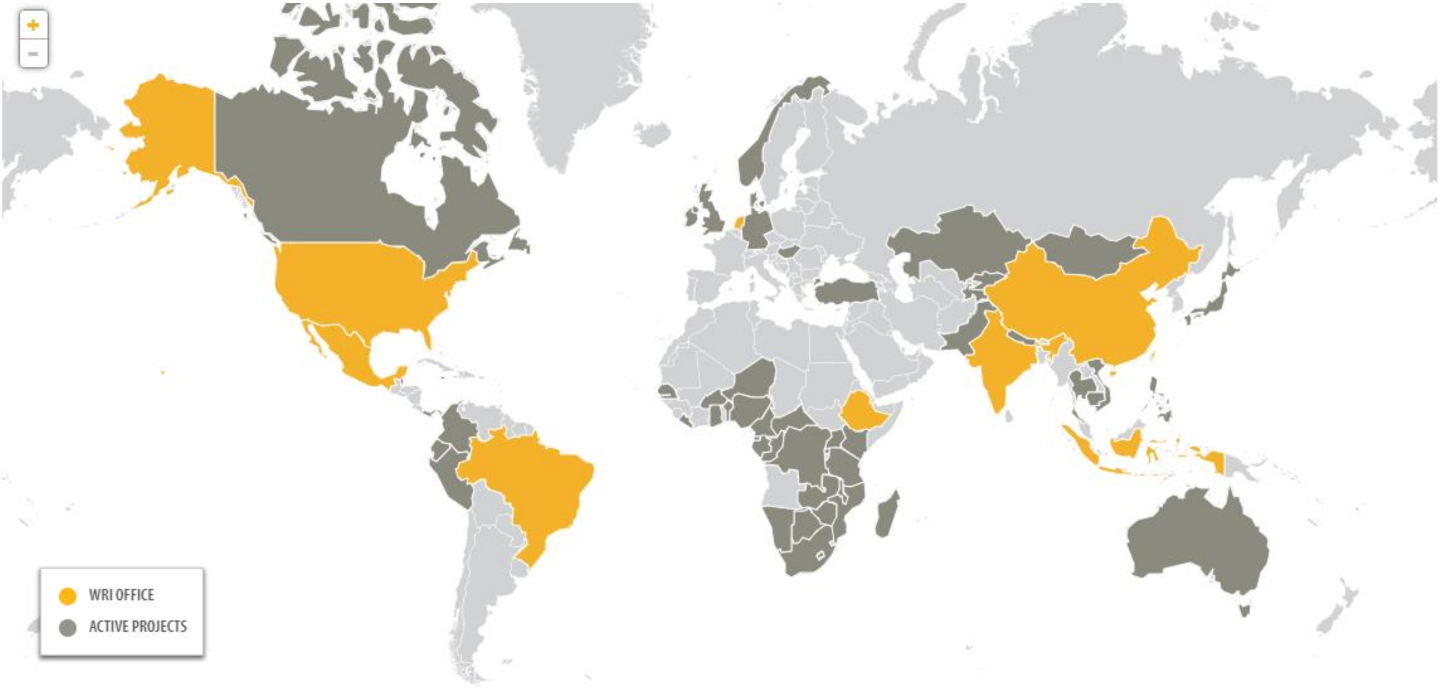

THANK YOU

SRIPATHI ANIRUDH, *SRIPATHI.ANIRUDH@WRI.ORG*

KAJOL, *KAJOL@WRI.ORG*

SANDHYA SUNDARARAGAVAN, *SANDHYA.RAGAVAN@WRI.ORG*