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Wind Turbine-Mounted Base Stations for Coverage Enhancement in Rural Areas

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Abstract

- Despite global connectivity being a main requirement for future generations of wireless networks driven by the United Nation's Sustainable Development Goals, the low expected profit discourages telecom providers' investments in rural areas;
- Affordable and sustainable solutions for enhancing cellular infrastructures in these regions are indispensable for reducing the digital divide between high- and low-income zones;
- Wind turbine-mounted base stations (WT-mounted BSs) might be the best alternative to cell towers, satellites, or aerial base stations (ABSs). Indeed, installing base station (BS) equipment on tall wind generators would allow the transceivers to easily achieve line-of-sight (LoS) conditions within large areas, without payload constraints;
- This work evaluates the feasibility and the effectiveness of WT-mounted BSs and stimulates their implementation.

Introduction

- Generally speaking, rural areas are under-connected compared to nearby towns.
  For example, in 2019 the percentage of African urban households with Internet access was 4.5 times larger than rural ones [1];
- The digital divide between urban and remote areas is much more evident in the least developed countries (LDCs) rather in the most developed ones.

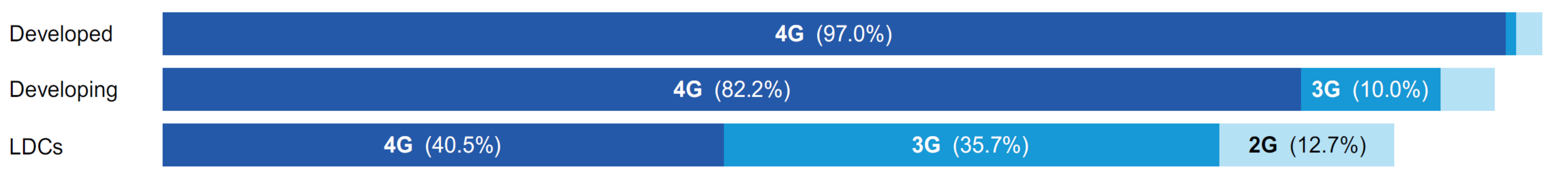

Fig.1: Population coverage by type of network in 2020 [1].

Current Solutions

- Diesel generators produce a large amount of CO_2 and are not sustainable for powering BSs, apart from their problem of high operational costs;
- Cell towers are often considered an eyesore and perceived as dangerous. Promising projects such as Facebook Connectivity's 'SuperCell' [2] might indeed suffer limitations because of their high visual impact;
- Wind turbine (WT) aerostats projects providing energy and connectivity, such as 'BAT' by Altaeros [3], have been suspended years ago since not economically competitive;
- Using ABSs implies privacy issues and risks in case of harsh weather, and both their autonomy and their payload capability can be important limitations;

Proposed Designs

- If enough space is available, the BS equipment is mounted inside the WT's nacelle in order to be concealed, easily accessible, and protected from harsh weather;
- If the nacelle is full and the WT's roof is easily accessible, the BS equipment can be mounted on top of it, to maximize the LoS probability;
- If the nacelle is full and the roof of the WT is not easily accessible, the BS equipment can be placed along the tower itself, but the coverage radius would be smaller compared to the previous options.

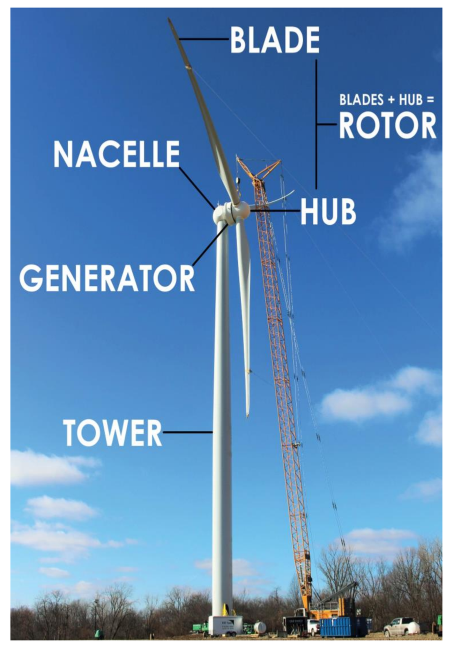

Fig. 2: WT components [4].

Case Study

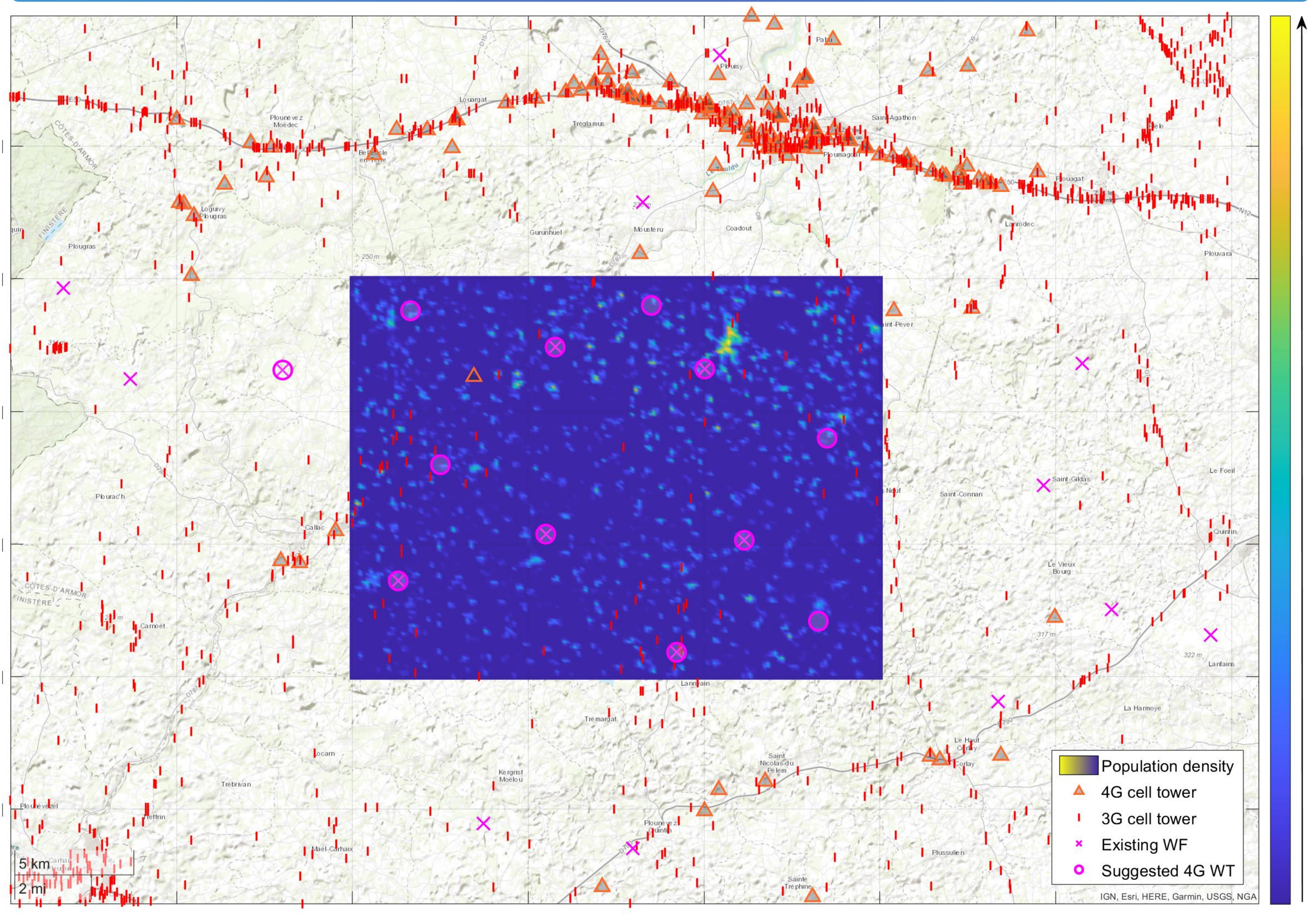

Fig. 2: System setup for the case study in western France. The population density map identifies the area of interest, which covers approximately 330 km^2.

- The considered rural area is located between the towns Guingamp and Carhaix-Plouguer, in the French region of Brittany;
- Average wind speed is 8 m/s [5] and some WTs are already present [6];
- This quite sparse populated area [7] is mostly covered by 3G cell towers [8];
- We evaluate equipping the existing WTs around the area of interest and also deploying new ones in order to improve the average data rate per user as well as the revenues of both telecom and power providers.

Simulation Results

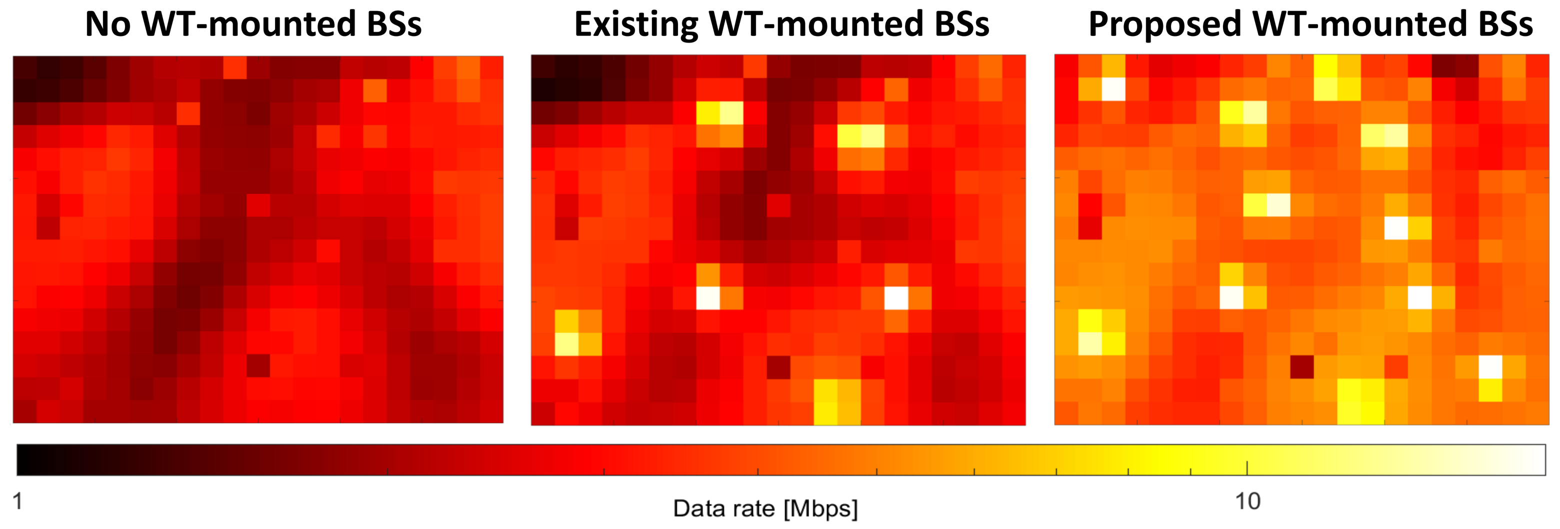

Fig. 3: Simulation results for the case study in western France.

- The bias for associating to a 4G BS instead of a 3G one has been optimized to a factor 29;
- The above figures clearly show an improvement in terms of average data rate inside the area of interest due to the deployment of WT-mounted BSs;
- In fact, the current average data rate per user is 3.08 Mbps, but it could improve to 4.12 Mbps if the existing WTs were equipped, and it would rise up to 4.96 Mbps by just adding five WT-mounted BSs.

Conclusions and Future Works

- By means of realistic case studies, this poster showed that deploying WT-mounted BSs can be an effective solution for improving the average data rate in rural environments;
- Therefore, it is believed that WTs should be further incentivized in underdeveloped countries and rural areas in general;
- An open problem to be considered consists in optimizing the number and the locations of the WTs hosting the BS equipment in a network that includes also ABSs and aerial users, for instance.
- This solution should be evaluated also for new promising technologies of wind energy harvesting, such as large bladeless wind oscillators.

References

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Background image available from https://pxhere.com/en/photo/1324513.

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