Summary report on renewable energy resource data in Ontario: Focus on wind, solar, and biomass resources.

Abstract

Theoretical resources are typically presented as a map that indicates the measured or modeled energy potential across a geographic area (e.g., wind speed; solar irradiance; biomass productivity). This is assessed using some combination of in situ data collection and geophysical modeling. This report assesses the availability and quality of such data in Ontario.

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1.0 Introduction

This report assesses the availability and quality of resource data and resource maps for primary land-based renewable energy resources in New Brunswick: wind, solar, and biomass. These maps do not serve as an assessment of any project site, but rather outline areas with relatively high or relatively low energy potential based on the nature of the resource alone. In other words, these maps are a starting point, but by themselves insufficient, as a basis upon which to assess actual, realizable renewable energy development prospects in an area. The maps and data considered within this report have been created at provincial, national, or international scales, and are therefore suitable for use in renewable energy assessment across Ontario.

2.0 Wind Energy Resource Maps

Wind energy maps are typically created by joining atmospheric circulation models with local topographic data to create a model of wind speed, power, and direction at varying heights above Earth's surface. In most cases, geophysical models are used to spatially interpolate measured data collected at weather stations. Typically, this work is undertaken by government agencies, often working with consulting firms, although more detailed and localized data are produced by and for wind energy developers. Wind maps can be created at a regional level (mesoscale) with a spatial resolution ranging from 1.5 to 2 km, or at a local level (microscale) with a typical spatial resolution ranging from 100 - 200 m. For the purposes of informing municipal planning, working with microscale data is ideal. For the purpose of communications and planning, resource data are classified according to the International Electrotechnical Commission (IEC), per table 1 below.

Table 1: IEC Standardized Classification System for Wind Resources. For more information about the IEC wind classification system visit: https://www.lmwindpower.com/en/stories-and-press/stories/learn-about-wind/what-is-a-wind-class

	Class 1 (High)	**Class 2 (Medium)**	**Class 3 (Low)**	**Class 4 Very Low)**
Reference Wind Speed	50 m/s	42.5 m/s	37.5 m/s	30 m/s
Annual Average Wind Speed	**10 m/s**	**8.5 m/s**	**7.5 m/s**	**6 m/s**
50-year Return Gust	70 m/s	59.5 m/s	52.5 m/s	42 m/s
1-year Return Gust	52.5 m/s	44.6 m/s	39.4 m/s	31.5 m/s

2.1 Preferred Data Source: Wind Energy Block Map

Table 2. Summary of the Wind Energy Block 1 KM

Name of Dataset	Wind Energy Block 100 m
Creation Date	April, 2005
Map Distributor	Ontario Ministry of Natural Resources and Forestry
File Format	ESRI Grid
Resolution	100 metre grid
Mapped categories (thematic description)	Wind speed (m s^{-1}) and wind power (W m^{-3}) for elevations of 10, 30, 50, 80, and 100 metres above ground level
Supplemental information	Statistics for the hourly, monthly, and annual variation in wind speed and power at elevations of 30 and 80 metres above ground level, as well as a rose diagram of typical wind direction
Map Creation & Data Sources	Maps were created using the WindMap model, which used atmospheric statistics from the Wind Energy Simulation Toolkit (WEST) and accounts for local terrain and surface roughness. The WEST dataset is based upon data collected from weather stations between 1958-2000 as part of the NCAR/NCEP reanalysis
Ease of use and Accessibility	Must be purchased from Service Ontario for $84. Data comes in a set of DVDs for the entire province, and is ready for use in ArcMap

2.2 Why not the Canadian Wind Energy Atlas data?

Similar to the Canadian Atlas of Wind Energy (CAWE), the Wind Energy Block Map (WEBM) is based upon atmospheric data from the National Center for Atmospheric Research (NCAR) and National Center for Environmental Prediction (NCEP) known as the NCAR/NCEP reanalysis. The difference between CAWE and WEBM is in how the data were processed, as well as what additional data were considered. The CAWE models wind speed and power at a meso-scale level using the Mesoscale Compressible Community (MC2) model. The WEBM was developed using the Wind Energy Simulation Toolkit (WEST), which also incorporates the MC2 model *in addition to* the Ms-Micro model, which considers how atmospheric circulation is altered by the local topography as it interacts with complex surfaces. Additional benefits of the WEBM over the CAWE include its finer spatial resolution and supplementary statistics.

3.0 Solar Energy Resources

Factors that affect ground-level irradiance at a particular site include angle of solar incidence (primarily determined by longitude), albedo of surrounding features (reflectivity of irradiation), typical atmospheric conditions (absorption and reflectivity of incoming sunlight) and shading from surrounding features. Maps of solar irradiation are typically created using data from satellite imagery which capture information about atmospheric and topographic conditions, combined with in situ irradiance measurements taken at weather stations. Typically, irradiance maps are created at a coarse spatial resolution before considering shading, as variation in irradiance is minimal over short distances and varies meaningfully only over relatively large geographic areas. For this reason, when siting solar energy production facilities, the intensity of solar radiation is not as strongly considered as other variables such as the availability of land or the distance to the electrical grid. After an assessment of available data and maps or solar irradiation in Ontario, the preferred data source is the Physical Solar Model made available through the National Renewable Energy Laboratory (NREL) in the U.S.

3.1 The Physical Solar Model

Table 1. Summary of the Physical Solar Model

Name of Dataset	Physical Solar Model – National Solar Radiation Database
Creation Date	March, 2016
Model Distributor	National Renewable Energy Laboratory (NREL) - https://maps.nrel.gov/nsrdb-viewer/
File Format	ESRI Shapefile
Spatial Resolution	4 km
Map Categories (Thematic Description)	Modelled values for the inter-annual averaged ground horizontal irradiance (kWh m^{-2} day^{-1}) for much of North and South America. The model is within +/- 5% accuracy for annual averaged ground horizontal irradiance.
Map Creation and Data Sources	The REST2 model was used to calculate ground horizontal irradiance under clear sky conditions. For cloudy conditions, the FARMS model is used, which incorporates the PATMOS-x algorithms and measured values for aerosol optical depth and precipitable water vapor. Data from the Geostationary Operational Environmental Satellite between 1998-2014 is used within the models, as well as meteorological data from the NASA Modern Era-Retrospective Analysis datasets.
Ease of use and Accessibility	The Physical Solar Model can be viewed on the NSRDB Data Viewer, and can be downloaded in the ESRI Shapefile format from the National Renewable Energy Laboratory website.

3.2 Why use the Physical Solar Model (PSM)?

The map is easily accessible, created at an acceptable spatial resolution and is accurate to within +/- 5% annual average ground horizontal irradiance (GHI) when compared to measurements from weather stations across the United States. The PSM is also superbly documented, allowing users to assess and interpret uncertainty in the data. While it would be preferable to use a solar resource model developed specifically for use in Canada, the publicly available models are inferior to the PSM. For example, a Canadian version of the popular SUNY solar resource model developed by Dr. Richard Perez is available from Natural Resources Canada. Unfortunately, the SUNY model has a coarser grid cell size, uses a smaller temporal selection of GOES data, is not GIS-ready as the data are in CSV format, and has little to no documentation concerning its creation available to the public. Additional Canadian models are likewise flawed in similar ways, leaving the PSM as the strongest option.

4.0 Biomass Energy Resources

Biomass energy is broadly defined as organic matter that is used as a fuel source in the production of energy (heat, transport/motor power, electricity). The focus of this project is on cellulosic biomass potential (crop residues and forestry residues). The study is not considering the use of whole crops (i.e., we are not considering corn-to-ethanol and other 'first generation' sources of biomass for energy/fuel). Mapping theoretical biomass resources requires a combination of land-use maps and agricultural / forestry census statistics, as described below.

4.1 AAFC Map and Field Crop Statistics from OMAFRA

Table 2. AAFC Annual Crop Inventory Map

Name of the Dataset	Agriculture and Agri-Food Canada Annual Crop Inventory 2016
Map Distributor	Agriculture and Agri-Food Canada
File Format	GeoTIFF
Spatial Resolution	30 metre grid
Map Categories (Thematic Description)	The AAFC Annual Crop Inventory maps feature over 40 distinct class of agricultural activity, including field crops, horticultural crops, and pasture land. Since the first the first crop inventory was published in 2009, the thematic precision of the inventory has increased over the years, with more crops being included in each revision.
Map Creation and Data Sources	The map was created using a decision-tree based classification approach upon optical and infrared satellite imagery, and the map was validated using field measurements taken by insurance companies and provincial ministries. Satellite Imagery from the Landsat-8, Sentinel-2, Gaofen-1, and RADARSAT-2 satellites
Ease of use and Accessibility	The AAFC Annual Crop Inventory Map for 2016 is available for download from the Canada Open Data portal. Additional Crop Inventory Maps from 2011-2017 are also available for download.

4.2 Forest Resource Inventory

Ontario's Forest Resource Inventory (FRI) provides data on stand characteristics and harvest treatment – two critical variables in determining forest residues – for all lands licensed to the forestry inventory. This does not include areas in southern Ontario, which can be mapped using the AAFC map described above, or some other land-cover map. Forest lands in southern Ontario are almost harvested treated with selective cutting. FRI data can be found here: https://www.ontario.ca/page/forest-resources-inventory

4.3 Example Map of Theoretical Biomass Resources

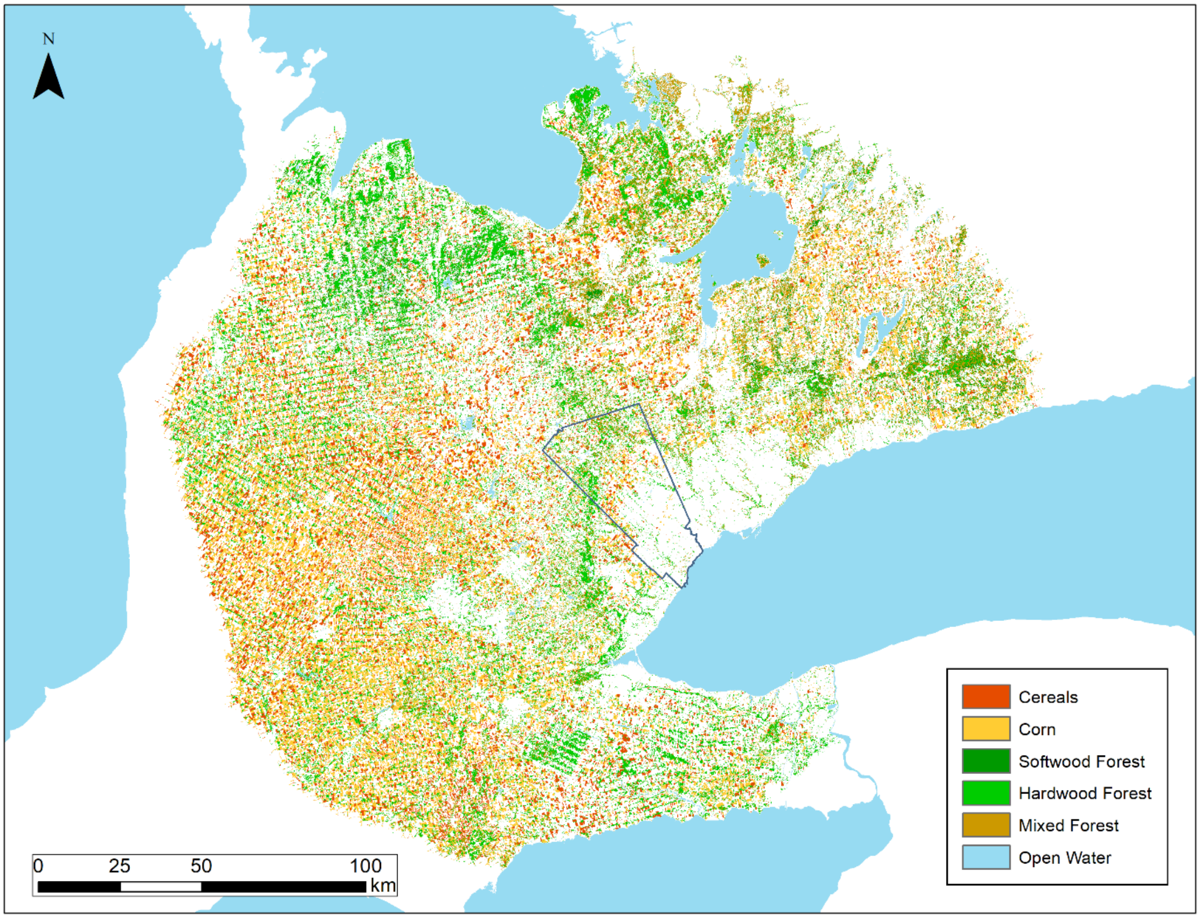

Figure 1: Map of theoretical biomass resources in Peel region. Since biomass can be transported, we have mapped biomass within a 150km radius of Peel Generally speaking, biomass can be transported approximately 150km before the economic and energetic costs exceed the benefits. As such, we consider any biomass resource within 150km of Peel as theoretically available to Peel. Here, we have re-classified the map to show only those land cover categories that are producing biomass types we are interested in – crop residues and forestry residues.