Country Report
The Netherlands (NL)

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Wageningen UR - Food & Biobased Research
The Netherlands

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Country Report The Netherlands
Source: CBS, 2014

Energy production 2012

- Natural gas: 42%
- Crude oil & petroleum products: 38%
- Coal: 11%
- Renewables: 4%
- Electricity: 2%
- Waste: 2%
- Nuclear: 1%
- Electricity: 2%
- Renewables: 4%
- Coal: 11%
- Natural gas: 42%
- Crude oil & petroleum products: 38%
- Waste: 2%
- Nuclear: 1%
- Total energy production: 3,269 PJ

NL: 3269 PJ energy production --> gross final end-use of about 2200 PJ

Source: CBS, 2014
Share renewable energy to energy production 2000-2012

Country Report The Netherlands
Source: AgentschapNL, 2013
Renewable energy in NL
gross final end-use per sector

Country Report The Netherlands
Source: AgentschapNL, 2013
Renewable energy in NL gross final end-use vs. sources

2012: 97 PJ RE or about 4.5% of the gross national end-use

Bioenergy contributes for about 75% (71.3 PJ)

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Source: AgentschapNL, 2013
## Renewable energy in NL
gross final end-use from biomass

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>Domestic waste incineration (AVI's)</td>
<td>Power</td>
<td>7.7</td>
<td>+0.4</td>
<td>14.7</td>
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<td></td>
<td>Heat</td>
<td>6.6</td>
<td>-</td>
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<td>Direct/indirect cofiring coal-fired power plants</td>
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<td>-0.9</td>
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<tr>
<td></td>
<td>Heat</td>
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<td>-</td>
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<tr>
<td>Domestic wood stoves</td>
<td>Heat</td>
<td>12.7</td>
<td>+0.2</td>
<td>16.1</td>
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<tr>
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<td>Heat</td>
<td>2.9</td>
<td>+0.1</td>
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<td>Other combustion</td>
<td>Power</td>
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<td>+0.5</td>
<td>7.0</td>
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<tr>
<td></td>
<td>Heat</td>
<td>3.2</td>
<td>+0.3</td>
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<tr>
<td>Biogas</td>
<td>Power</td>
<td>3.9</td>
<td>+0.1</td>
<td>9.1</td>
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<tr>
<td></td>
<td>Heat</td>
<td>4.2</td>
<td>+0.2</td>
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<td>Biogas</td>
<td>0.7</td>
<td>-0.1</td>
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<td>Bio-gasoline</td>
<td>Transport</td>
<td>6.6</td>
<td>+0.4</td>
<td>14.8</td>
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<td>Bio-diesel</td>
<td>Transport</td>
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<td>+0.5</td>
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<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>71.3</strong></td>
<td><strong>+1.8</strong></td>
<td><strong>75</strong></td>
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</table>
Electricity from biomass in NL in 2012 (PJ*)

Total 25.7 PJ

7.7 waste incinerators
3.9 co-combustion
10.6 other combustion
3.5 biogas

PJ*: PJ gross final end-use – energy delivered to energy end-users (power, heat, transport)

Source: AgentschapNL, 2013
Heat from biomass in NL in 2012 (PJ*)

Total 31.3 PJ

- 5.0 PJ: waste incinerators
- 6.6 PJ: co-combustion
- 12.7 PJ: wood stoves home
- 2.9 PJ: wood stoves industry
- 0.9 PJ: other combustion
- 3.2 PJ: biogas

PJ*: PJ gross final end-use – energy delivered to energy end-users (power, heat, transport)

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Source: AgentschapNL, 2013
Transport fuels from biomass in the NL in 2011 (PJ*)

Real use, without double counting: about 14.3 PJ

21.3 PJ corresponds to 4.31% of fuel use road transport (goal 2011: 4.25%; goal 2012: 4.5%)

PJ*: PJ gross final end-use – energy delivered to energy end-users (power, heat, transport)

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Source: AgentschapNL, 2013
Bioenergy facilities in the NL

red bullets: combustion, 228 facilities, 937 MWe, 586 MWth

yellow bullets: domestic waste combustion, 12 facilities, 356 MWe, 1218 MWth

green bullets: gas from landfills, 41 locations, 15 MWe, 0 MWth, 1625 Nm³/hr green gas

blue bullets: wastewater treatment, 82 plants, 46 MWe, 8 MWth, 470 Nm³/hr green gas

purple bullets: manure co-digestion, 105 plants, 129 MWe, 18 MWth, 606 Nm³/hr green gas

grey bullets: food industry residues digestion, 13 installations, 18 MWe, 5312 Nm³/hr green gas

black bullets: GFT/ONF digestion, 11 installations, 11 MWe, 2 MWth, 3,892 Nm³/hr green gas

Country Report The Netherlands
Source: www.b-i-o.nl, AgentschapNL, 2014
**Biomass use for non-energetic applications**

- **Agricultural sector**: NL 2nd largest exporter agricultural & food products (2 Mha agricultural land). Processing & upgrading (protein extraction) of agroresidues is increasingly improving.
- **Horticulture sector**: biobased focus on residues upgrading, production high-quality/complex extractives, production aquatic BM.
- **Chemical industry**: target consuming 50% less fossil resources within the next 25 years. NL biopolymers: 200 kt (2013) -> 650 kt (2020) = * 3 in coming 6 yrs.

**Current application biomass in Dutch BBE (13 Mt)**
- Wood processing & paper industry: 4 Mt
- Chemical industry: 3 MT
- Energy sector: 6 MT (power/heat)

Source: Protocol monitoring materiaalstromen BBE, FBR, DEC 2013
Dutch BBE (2011)

- 2.6 – 3.0 billion € added-value
  - Materials (wood & paper) sector: 2.4 billion €
  - chemical sector: 542 million €
  - biofuel sector: 100 million €
  - energy sector: 70 million €

- 29,300 – 33,400 fte

Source: Monitoring BBE NL, RVO, 2013
Biomass related (national) policy goals and instruments

Goals

- Renewable Energy Directive RED (EU)
  - 20% RE in EU in 2020 -> 14% in NL; incl. 10% biofuels in transport
  - >= 27% RE in EU in 2030; no specific goals for biofuels in transport (cost-effectiveness will require about 12% biofuels in transport) -> % in NL still to be specified

Instruments

- Top consortium for Knowledge and Innovation – BioBased Economy (TKI-BBE)
  - BBE = strong international position NL
  - support of biobased innovation across the entire biomass chain
  - network of about 100 stakeholders from industry, SMEs, GOs, NGOs, RTOs, universities
  - budget (2012): 42-51 M€ GOV + 150-180 M€ individual contributions

- Green Deals: sustainability appointments government – industry – NGOs

- SDE Subsidies: budget 2013 = 3 billion €

Source: Monitoring BBE NL, RVO, 2013
NL has a **strategy on BioBased Economy**.

Key aim is sustainable biomass valorisation ("value pyramid")

- prioritising on biomaterials/chemicals, and using residues for biofuels, electricity and heat

- concept of ‘co-production’ with biorefineries as key technology

The Dutch strategy aims to further develop NL’s strong knowledge position in **biotechnology, food-chemistry, agrofood, chemistry and logistics** (harbours) by realising a number of public-private joint ventures.
Bio(based) Economy Strategy Roadmap Biorefinery

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http://edepot.wur.nl/50725
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Bio(based) Economy Strategy Roadmap Biorefinery

NL focus:

• domestic crops
• aquatic biomass
• imported biomass
• residues

Moonshots: visions on sustainable, commercial biorefinery plants tailored to the Netherlands
Bio refineries in NL

- commercial (red)
- demo & pilot (blue)
Commercial biorefineries

- BioMCN (www.biomcn.eu)
- Cargill/Nedalco (www.cargill.com/company/businesses/nedalco/index.jsp)
- Empyro pyrolysis plant (www.empyroproject.eu)
- Greenmills (www.orgaworld.nl/en/greenmills.html)
- VION Ecoson (www.ecoson.nl)
• Upgrading of by-product glycerin (from biodiesel production) to biomethanol for transport
• Plant in Delfzijl opened officially on 25\textsuperscript{th} of June 2010
• Production capacity of 250 million litres
• Integrated biorefinery of Cargill starch industry together with Royal Nedalco bioethanol plant in Sas van Gent
• Cargill's wheat processing plant supplies Nedalco with raw materials for its alcohol production process
• 2nd generation plant 2.0 Ml/a bioethanol
• Construction of pyrolysis plant started in February 2014
• Modules
• Feedstock e.g. wood chips
• Production of 20 million litres of pyrolysis oil per year
• Pyrolysis oil used for bioenergy (ST) and chemicals (LT)

http://www.empyroproject.eu
Greenmills is a joint initiative of Rotie, Noba, Biodiesel Amsterdam and Orgaworld BV to integrate processes
Production of biodiesel 100 Mton = 113 Ml/year, bioethanol 5 Ml/year and biogas 25 m³/year

• Integrated production of biogas, CHP and biodiesel from animal waste
• Production capacity per year:
  - 9,000 MWh from biogas
  - 50,000 ton refined fat
  - 5,000 ton biodiesel
• Biophosphate plant opened officially on 6th October 2014
Biorefinery demo and pilot plants

- ACRRES (www.acrres.nl)
- AlgaePARC (www.AlgaePARC.com)
- Avantium YXY Technology (www.avantium.com)
- Bioprocess Pilot facility (www.bpf.eu)
- COSUN the unbeatable beet (www.cosun.com)
- Croda (www.crodaoleochemicals.com)
- Grassa!! (www.grassa.nl)
- Harvestagg (www.harvestagg.nl)
- Indugras (www.indugras.nl)
- Millvision/Greencell-ID (www.greencell-id.eu)
- Newfoss (www.newfoss.com)
- Purac (www.purac.com)
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ACRRES
Application Centre for Renewable RESources
(Wageningen UR, ENECO, Prov Flevoland, Lelystad)

- National applied research centre for RE & green raw materials
- Focus: biomass, solar and wind; applied R&D, demo & teaching
- Multi-purpose pilot-scale biorefinery facility
- Research and testing of new production methods, nutrient recycling and soil quality issues
- Digestable and fermentable feedstocks (residues and crops), waste water valorisation
- Outputs: biogas, proteins, microalgae and bioethanol

http://www.acrres.nl
• Microalgae production & refinery platform for the production of proteins, lipids, carbohydrates and pigments
• Located in Wageningen
• Develop technology and processes to fractionate microalgae biomass
• Systems analysis
• Sustainability assessment

http://www.AlgaePARC.com
- Chemical catalysis biorefinery
- Pilot plant in Geleen
- Feedstocks: cellulose, hemi-cellulose, starch, sucrose
- Outputs: furan based biofuels, monomers for polymers, fine and specialty chemicals, solid fuels

http://www.avantium.com
Bioprocess Pilot Facility (BPF)

- Open-access multipurpose facility
- State-of-the-art 5000 m² facility consisting of complex piloting equipment and supporting labs to investigate scale-up issues
- Modules/technologies: pre-treatment and hydrolysis, fermentation, downstream processing and food grade

http://www.bpf.eu
COSUN the unbeatable beet

- Beet to food, feed, chemicals, materials and energy
- Cosun processes about 75,000 ha beet (22-25 tonnes d.m. per ha/year) into sugars and animal feed
- Within this pilot project they valorise the whole beet plant, i.e.: the beet, the leafs and the carrots

http://www.cosun.com
• Residual plant oils to biobased polymers, coatings, chemicals and personal care products
• Green chemical intermediates for polymers by oleochemical biorefining

http://www.crodaoleochemicals.com
• Green biorefinery
• Small-scale, mobile
• High-value sustainable protein (feed) and fibre based products (board)
• From grasses and protein-rich agroresidues (beet leaves)
• Capacity pilot-plant: 1-5 tonnes fresh materials per hour

http://www.grassa.nl
- Cultivated grass to energy and turf
- Small-scale green biorefinery
- Mobile press has been developed to press grass on the harvesting location to obtain the required dry matter content
- Grass juice and press cake will both be valorised
• Grass from nature management to feed and chemicals
• Small scale green biorefinery
• Patented Super-Heated Steam (SHS) Technology tested for production of animal feed and chemicals

http://www.indugras.nl
• Nature and verge grass to fibres for paper and cardboard
• Refinery of protein-poor nature and verge grass into cellulosic fibres and value-added biobased products by mild fractionation
• Production of grass box Greencell-ID

http://www.greencell-id.eu
• Verge grass and grass from nature management to energy, fibres, nutrients and feed
• Small scale green refinery
• Patented mild extraction technology
• Residues paper industry to lactic acid and its derivates
• Residues (a.o. cellulose) produced by a paper factory are separated and fermented to lactic acid and its derivates
• Paper sludge as a source for bio-plastics
• Development of technologies that separate chalk from cellulose
• Purac fermentation process in which this (low quality) cellulose can be converted into lactic acid

http://www.purac.com
Major R&D projects

- BE-Basic (www.be-basic.org)
- Biobased Performance Materials (www.biobasedperformancematerials.nl)
- Biorizon Roadmap Aromatics (www.biorizon.eu)
- CatchBIO (www.catchbio.com)
- Mimosa project (www.essent.eu)
- Seaweed Biorefinery (seaweed.biorefinery.nl)
- BioSolar Cells
BE-Basic = Biotechnology based Ecologically BAlanced Sustainable Industrial Consortium
International public-private partnership
Develops industrial biobased solutions to build a sustainable society
Research is organized in ‘flagships’ that are addressing major scientific/socio-economic challenges like: carbon-based compounds, nitrogen-based specialties, bioconstruction materials, etc.

http://www.be-basic.org
BPM is working on new biopolymers (feedstock for bioplastics) and on applied research to improve the properties of bioplastics.

- Collaboration between large and small companies and from end-user to supplier of raw materials.
- Focus on materials from biobased building blocks.

http://www.biobasedperformancematerials.nl
• Profitable ways to biobased functionalized aromatics
• Shared research center with an initial focus on technology development for the production of functionalized biobased aromatics for performance materials, chemicals & coatings
• Cross-border initiative between TNO, VITO and the Green Chemistry Campus (Bergen op Zoom)

http://www.biorizon.eu
CatchBio = CATalysis for sustainable CHemicals from BIOmass

CatchBio aims to develop clean and efficient processes for biomass conversion into low-cost and sustainable biofuels, chemicals and pharmaceuticals.

Divided in four research clusters:
- energy
- bulk chemicals
- fine chemicals and pharmaceuticals
- socio-economic aspects

http://www.catchbio.com
Main challenges CatchBIO:
• fundamental studies on the stability of the catalysts
• drop-in greenification for limited number of current bulk chemicals and biofuels
• new routes to fine chemicals and pharmaceuticals
• intelligent combination of thermochemical, chemocatalytic and biocatalytic processes
• characterisation/analysis of raw materials and complex product mixtures

http://www.catchbio.com
• Biobased Economy Park Cuijk

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http://www.essent.eu
Multi-input, multi-output Biorefinery:
• protein extraction and valorisation
• cellulose/hemicellulose conversion to lactate
• lignin for energy
• feasible at smaller scale than current 2nd generation ethanol plants

Key innovations:
• lactate as intermediate for biobased products
• recycling of soluble streams from fermentation broth
• recovery of valuable components from bleed streams

3 year R&D trajectory including pilot & demonstration
• Large scale biorefinery of seaweeds for the production of CO₂ neutral chemicals, 3rd generation biofuels and bio-energy
• Aim to adapt the biorefinery concept to seaweed

[Diagram of seaweed biorefinery process]

http://seaweed.biorefinery.nl
Regional initiatives

- BioEconomy Innovation Cluster Eastern Netherlands BIC-ON (Gelderland, Overijssel) ([www.gelderland.nl](http://www.gelderland.nl))
- Biobased Delta (Brabant, Zeeland, Zuid Holland)
- Rotterdam Bio Port ([www.portofrotterdam.com/bioport](http://www.portofrotterdam.com/bioport))
- Port of Amsterdam
- Flevoland
- Biobased Limburg – Source B
- Biobased Economy North Netherlands (Drenthe, Groningen, Friesland)
- Dutch Biorefinery Cluster ([www.dutchbiorefinerycluster.nl](http://www.dutchbiorefinerycluster.nl))
- A new cluster initiative/ program with triple helix partners
- Facilitating the transition towards BBE

- Companies (circa 100), Governmental organisations (Provence of Gelderland and Provence of Overijssel) and research institutes join forces
- Size: 100 M€

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http://www.gelderland.nl
Focus: biobased building blocks, biobased aromatics, biobased performance materials and chemicals, functional plant components, aquatic biomass, coatings, white biotech for fuels and chemicals, bioport

**Focused Top Locations Biobased Delta**

- Vlissingen harbour
- Biobased Innovations Garden “Rusthoeve”
- Green Chemistry Campus
- + Nieuw Prinsenland
- + Moerdijk Harbour
- + Biopark Terneuzen
- + Bio Base Europe
- + ….

Stakeholders: Green Chemistry Campus, DOW, Cosun, Purac, sabic, Bio Base Europe, Avans, Prov. Zeeland/Brabant/Zuid-Holland, Port of Rotterdam, TUD, Leiden University, Plant One, RCI, BE-BASIC, DSM, Biotechpark Delft, Kenniscentrum Plantenstoffen, Growport, Greenport, BOM, REWIN, Impuls, Innovation Quarter, Rusthoeve, …

Source: Monitoring BBE NL, RVO, 2013; [www.biobaseddelta.nl](http://www.biobaseddelta.nl)
Rotterdam as gateway for Biobased Economy in Europe
Opportunities to optimise the value chain of biomass for pharma, food and biomaterials
Increase in volume and diversity of biomass
More than 45 chemical companies, 5 oil refineries and 14 biobased industrial companies

http://www.portofrotterdam.com/bioport
Focus: Use of organic residues for bioenergy, biofuels and biomaterials

Amsterdam has a unique logistical location within the world's largest international energy hub ARA (Amsterdam, Rotterdam, Antwerp), three connecting seaports serving the European hinterland. The port of Amsterdam is an excellent hub for energy, renewable energy and biobased economy.

In 2012 Amsterdam handled 200,000 tons of biomass. This will grow up to 2 million tons in 2020.

By building inspiring partnerships with a mutual necessity for growth. In Amsterdam biomass meets market.

The port of Amsterdam is an ideal location for biomass. Due to existing dry bulk handling the port of Amsterdam has an abundance of expertise and experience in storage, transhipment and processing.
Flevoland

Focus: Bioenergy, cascading, BBE testing & demonstration

Stakeholders involved: Wageningen UR/ACRRES, Eneco, HarvestaGG, CAH Vilentum, Ringg, OMFL
Focus: Biobased performance materials and chemicals, biomedical materials, process technology and biobased building blocks, biobased horticulture applications and agrorefinery, nutraceuticals and cosmetics; Biobased Business Brainport (valorisation minerals from residues to food, feed and pharma)

Stakeholders involved: Greenport and Transitiehuis Venlo, Chemelot, DSM, Sabic, Lanxess, Avatium, paper and cardboard industry, Maastricht university, Prov. Limburg, ...; BOM, SRE, ...
Focus: valorisation organic residues, proteins and hydrocarbons to food and non-food, fibres and biopolymers, chemical building blocks, biofuels

Products include sugar beets, potatoes, milk (and all of its derivative products) and grains, which makes the Northern Netherlands exceptionally attractive to companies with activities based on the ingredients produced by agro-processors.

Strong paper and cardboard sector, which process a substantial amount of biomass.

Carbohydrate Competence Center (CCC), a consortium of knowledge institutions and businesses setting out to generate, develop and share knowledge in the carbohydrates area.

Stakeholders involved: Avebe, Friesland Campina, Cosun, Agrifirm, BioMCN, Grassa, DOC, PKI, API, Cumapol, Eemshaven, Wetsus, CCC, NOM, FrieslandCampina, Meesterbakkers, Steensma Food Ingredients, DOC Kaas, Koopmans Meelfabrieken, Groningen University, Hanzehogeschool Groningen, UMCG, Van Hall Larenstein (division of Wageningen University), Dairy Campus, Dutch Drying Institute, Wetsus, ...
NL Regional initiatives
Dutch Biorefinery Cluster

• Leading companies in agro-food sector and paper industry have joined forces for full and efficient utilization of biobased raw materials through open innovation
• Developing new high added-value products and technologies for the market of tomorrow
• Closing production chains in a sustainable way

http://www.dutchbiorefinerycluster.nl
Major national stakeholders
Industry

- AEB
- Avantium
- Albemarle Catalyst
- Beuker
- Biodiesel Amsterdam
- Biomass Technology Group
- BioMCM
- Bumega
- Cargill/ Royal Nedalco
- Clean Energy for Me
- Cosun
- Corbion Purac
- Croda
- DSM
- DS Smith Packaging
- Eska Graphic Board
- Feyecon
- Grassa
- Greenmills
- Harvestagg
- HyGear
- Hoogland Marrum
- Millvision
- NewFoss
- OrgaWorld
- Ports of R’dam/A’dam
- Rotie
- Solidpack
- Smurfit Kappa
- VION
- .....

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Major national stakeholders
Research & Development

- Delft University of Technology (DUT)
- Dutch Organisation for Scientific Research (NWO)
- Energy research Centre of the Netherlands (ECN)
- Netherlands Institute for Catalysis Research (NIOK)
- Netherlands Organisation for Applied Scientific Research (TNO)
- University of Nijmegen (UN)
- University of Groningen (RUG)
- University of Utrecht (UU)
- University of Twente (UT)
- Wageningen University and Research centre (WUR)
Major national stakeholders

Other

- Ministry of Economic Affairs
- Netherlands Enterprise Agency (RVO)
- Topsector Agro & Food
- Topsector Biobased Economy
- Topsector Chemistry
- Topsector Energy
- .....
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www.IEA-Bioenergy.Task42-Biorefineries.com