aPriori Regional Data Libraries

This document describes Regional Data Libraries, provides references to data sources, and explains the methodologies used in compiling that data.

Introduction

aPriori Regional Data Libraries include region-specific economic data for 87 regions of the world that is updated four times per year, with new additional regions in Mexico, India, and Saudi Arabia. aPriori Regional Data Libraries can be leveraged in customer digital factories by inheriting the relevant data, ensuring that updates are easily integrated into customer digital factories. The manufacturing data is a representation of typical manufacturing practices and costs in that region to support the generation of benchmark cost estimates.

Typical applications of benchmark estimates include:

- Fact-based supplier negotiation
- Benchmarking supplier quotes
- Assessing the cost impact of sourcing components or tooling to various or new regions
- Developing early budgetary estimates and tracking to targets
- Estimating ECOs and design alternatives

The following chart shows the currently supported regions in aPriori Regional Data Libraries:

EMEA			APAC		AMERICAS	
Eastern Europe	Italy	Russia	China	Australia	Brazil	Chile
Western Europe	Netherlands	• City of Moscow	• Beijing	India	Mexico	Canada
Austria	Norway	• Tyumen	• Chengdu	• Maharashtra	• Mexico City	• Atlantic (PE-NB-NL-NS)
Belgium	Poland	• Saint Petersburg	• Chongqing	• Delhi	• North	• West (BC-MB-SK)
Czech Republic	Portugal	• Moscow region	• Dalian	• West Bengal	• South-west	• Ontario
Denmark	Romania	• Sverdlovsk	• Guangzhou	• Karnataka	United States	• Quebec
Finland	Slovakia	• Leningrad	• Hangzhou	Indonesia	• Northeast (MA-NY-NJ-CT)	• Alberta
France	South Africa	• Kaluga	• Qingdao	Japan	• Northeast-Rural (ME-NH-RI-VT)	
Germany	Spain	• Udmurtia	• Shanghai	Malaysia	• Mid-Atlantic (DE-MD-PA-VA)	
Hungary	Sweden	• Altaiskii Krai	• Suzhou	Philippines	• North Central (IL-MI-MN-OH-WI)	
Ireland	Switzerland	• Republic of Dagestan	• Tianjin	Saudi Arabia	• Central (AR-IA-KS-MT-NE-ND-OK-SD)	
Israel	Türkiye		• Wuhan	Singapore	• Southeast (AL-FL-GA-IN-KY-LA-MO-MS-NC-SC-TN-WV)	
	United Kingdom			South Korea	• Mountain (AZ-CO-ID-NV-NM-UT-WY)	
				Taiwan	• Pacific (WA-OR-HI-AK)	
				Thailand	• Texas	
				Vietnam	• California	

Each data library is built in US Dollars (USD). All data that is gathered in foreign currencies is converted to USD based on the exchange rate at the time when the data is generated.

Sustainability Insight

With 2023 R1 updates, aPriori Regional Data Libraries have expanded their capabilities to provide sustainability insights. aPriori has partnered with Ecoinvent, a not-for-profit association based in Zurich, Switzerland, to provide high-quality data for sustainability assessments worldwide. Leveraging ecoinvent's Life Cycle Inventory (LCI) database as a foundation, aPriori's Digital Factories calculate material carbon emissions factors and electricity carbon emissions factors for each part based on custom-selected manufacturing processes and routine logic. Gain an unparalleled understanding of carbon emissions associated with the production process through manufacturing simulation and identify the most significant carbon contributors early in the design process.

Each dataset in the Ecoinvent Database includes Life Cycle Impact Assessment (LCIA) scores for several impact assessment methods, such as "IPCC 2021", and corresponding impact categories like "climate change" and "GWP - Global Warming Potential". Each activity in the Ecoinvent Database is attributed to a geographic location and reported using internationally accepted abbreviations as part of the dataset's name.

	MATERIAL CARBON EMISSIONS FACTORS	ELECTRICITY CARBON EMISSIONS FACTORS
Purpose	• Calculate the material CO_2e contribution for a part	• Calculate the process CO_2e contribution for a part
Process	• The carbon impact of the extraction and processing required to create the raw material used to manufacture the part • The carbon impact of additional processing steps to create the stock form required	• The energy usage from processes using electricity • The carbon impact of the electricity generated from the grid mix for a given country
Units	• kg CO_2e / kg of material	• kg CO_2e / kWh of electricity used
Location Mapping	• Europe • Rest of World	• Locations based on countries in aPriori's Regional Libraries

Regional Data

Much of the data included in aPriori Regional Data Libraries is maintained specifically for each geographic region but some data is maintained continentally or globally.

REGION LEVELS	DATA IN APRIORI REGIONAL DATA LIBRARIES
Data maintained specifically for each geographic region (87 regions)	Labor rates
	Direct and indirect Overhead rates
	Toolshop rates
	Material overhead and SG&A rates
Data maintained continentally - Asia - Europe - Rest of the World (North and South America, Africa, and Australia)	Material Pricing Data
Data maintained globally and does not vary for each region	Material physical properties and stock sizes
	Machines & machine properties

Machines

Each region has the same machine list with the same operating parameters (e.g. power, table size, etc.). We assume that the machines are running at the same speed and feed in each region.

Labor

aPriori's labor rates represent a fully-burdened labor rate that includes direct wages, directly paid benefits, and social overheads. For each process in each region, labor rates are determined using the following equation:

Fully Burdened Labor Rate = Direct Wage *Direct Benefits Factor* Social Insurance Factor

1. **Direct Wage** is determined for each process based on the **region**, **skill level**, and **industry**. A direct wage is the pay to the employee for manufacturing time worked — basic wages, piece rate, and bonus paid each pay period
- **region** is the global location of the Regional Data Library
- **skill level** is assigned for each process based on the typical skill required for a machine operator to run the process in a non-automated manufacturing environment
- **industry** is assigned by process group

INDUSTRY	PROCESS GROUPS	
Metal	• Assembly • Bar & Tube Fab • Composites • Forging • Heat Treatment • Machining • Other Secondary Processes	• Part Assembly • PCB • Powder Metal • Rapid Prototyping • Sheet Metal • Stock Machining • Surface Treatment
Plastic	• Assembly Plastic Molding • Composites • PCB • Plastic Molding	• Powder Metal • Roto & Blow Molding • Sheet Plastic
Casting	• Casting	
Electronics	• PCB Fabrication • PCB Assembly	• Wire Harness

- In addition to the world average industry, each Regional Data Library contains a set of wage grades (1-9) for six different industries:
  - » Aerospace
  - » Automotive
  - » Electronic
  - » Heavy Industrial Machinery
  - » Medical Device
  - » Oil and Gas
- The primary source for **Direct Wage** data is Kerkhoff Consulting Group. Additional regional data sources are used for verification and corroboration of the data, including the BLS, Eurostats, national labor statistics bureaus, and customer feedback.

2. **Direct Benefits Factor** is a region specific factor used to account for direct pay to employees for irregular activities — irregular bonuses, payments to employees' savings funds, payments in kind, allowances for commuting, vacation, and holidays.
   - Various sources are used to derive the Direct Benefits Factor, including a combination of information from the BLS, Eurostats, national statistical offices, and customer feedback.

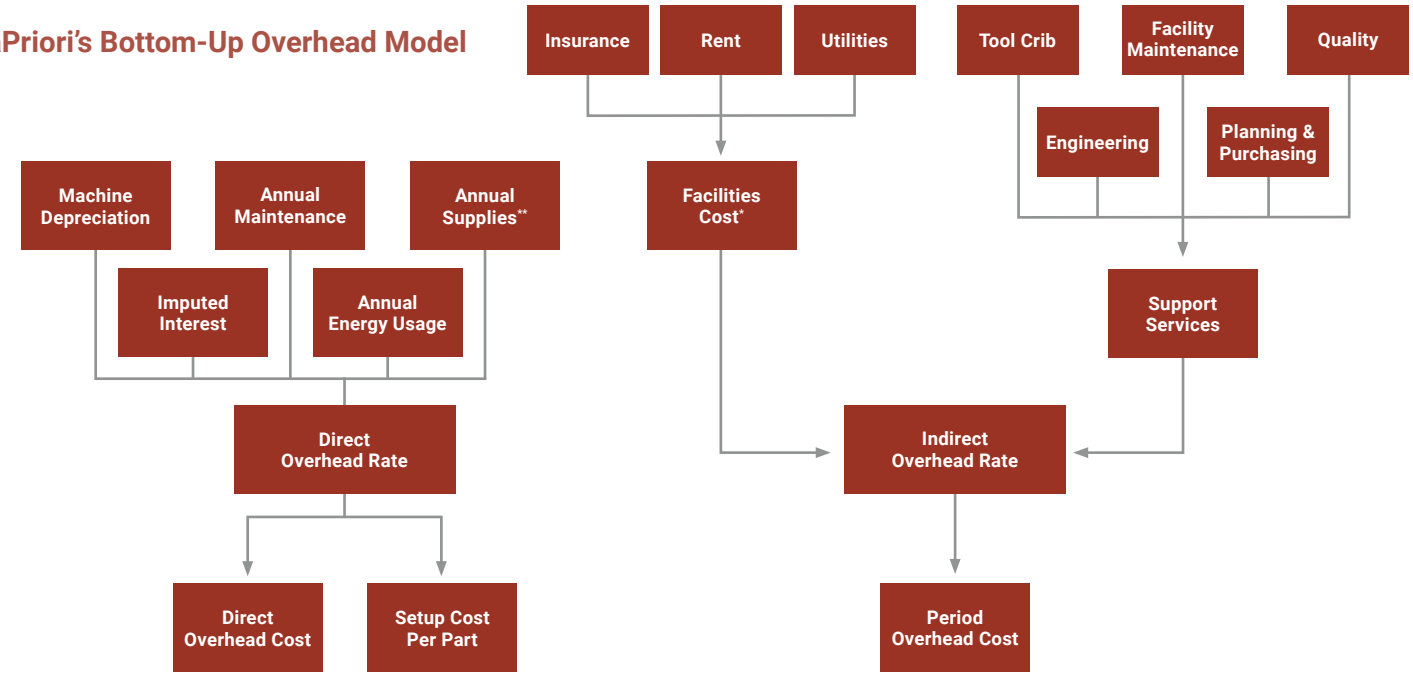
3. **Social Insurance Factor** is a region specific factor used to account for the social insurance expenses and labor related taxes such as unemployment insurance, health insurance, retirement and disability pensions, life & accident insurance, severance pay, taxes on payrolls, and other social insurance expenditures.
   - The primary source for Social Insurance Factor is Kerkhoff. Additional regional data sources are used for verification and corroboration of the data, including the BLS, Eurostats, national labor statistics bureaus, and customer feedback.

aPriori determines a **direct and indirect OH hourly rate** for each machine by region.

Overhead (OH)

aPriori determines a direct and indirect OH hourly rate for each machine by region, following the methodology below. **The following chart shows the sources of data that are used in the overhead model.**

aPriori's Bottom-Up Overhead Model



By default aPriori accounts for facilities cost in Indirect Overhead; a digital factory level switch is available to account for in facilities cost in Direct Overhead

***By default aPriori does not estimate annual supplies for a workcenter; customers can populate data in their digital factory*

	TYPE OF OVERHEAD	SOURCE
Direct Overhead	• Cost of Energy to power the machines » Machine Power » Electricity rates • Imputed Interest • Machine Depreciation (including the cost of installation) • Machine maintenance	• Machine Manufacturers and Resellers • Kerkhoff, Europe's Energy Portal, US Energy Information Administration, Aneel (the Brazil Electricity Regulatory Agency). • OECD • World Bank
Indirect Overhead	• Facility Costs » Building Depreciation » Property Taxes » Insurance » Utility Costs (not including energy to power the machines) • Support Services » Direct Wages, Benefits & Social Overhead » Allocation per machine	• NIA Global (Commercial Real Estate Services Provider) • Kerkhoff • US Energy Information Administration, • Europe's Energy Portal » Consultation with Manufacturing Accounting Experts • Kerkhoff, BLS, Eurostats, and other national labor statistics bureaus • Consultation with Manufacturing Accounting Experts

Direct Overhead

Each workcenter's Direct OH is comprised of machine depreciation + imputed interest + machine maintenance + energy to run the machine + annual supplies. We calculate an annual workcenter budget considering these factors and translate it into an hourly rate based on the annual earned machine hours for the workcenter.

Direct OH Rate = Workcenter Direct OH/Annual Earned Machine Hours

Annual Earned Machine Hours = Capacity (# of shifts * hours per shift * # of work days per week *number of working weeks per year) * Machine Utilization (% time machines are running)

The capacity varies by region, taking into account their standard work week (e.g., shifts per day, working days per week), typical holiday / vacation allotment, etc.

Machine Depreciation — Machine depreciation includes the cost to buy the machine and the cost to install the machine. We use straight line depreciation and assume a $0 salvage value. For most machines, we depreciate the machine over 10 years. Machine costs are obtained from a number of sources, most frequently the machine manufacturer or a reseller. In some cases we estimate the cost of the machine by considering the cost of similar machines.

Imputed Interest — Imputed interest is the interest on the capital used for the machine investment that is assumed, even though no physical interest is received. aPriori uses a standard formula published by the Fraunhofer Institute and RWTH Aachen University in Germany. **Annual Imputed Interest = (Total Machine Cost + Salvage Value) / 2) * Imputed Interest Rate.** Imputed interest rates are obtained from the World Bank and the Organization for Economic Co-operation and Development (OECD).

Machine Maintenance — Estimated annual expense based on industry research. Varies from 1.25% - 10% of machine cost for different machine types; most commonly it is 3% - 6% of a machine's cost per year.

Energy to run the machine — (machine power * annual earned machine hours) * cost of energy.

Machine Power — Machine Power is frequently found on the manufacturer's spec sheet. In some cases we estimate the power by analyzing the energy usage of similar machines.

Cost of Energy — The regional electricity rate is sourced from the Kerkhoff Consulting Group, and the following bureaus are used as secondary sources: Europe's Energy Portal, US Energy Information Administration, Aneel, and others.

Annual Supplies — aPriori's Starting Point Cost Models contain a variable for annual supplies, though aPriori does not populate it in the Regional Data Libraries. The field is provided for ease of deployment to support companies that want to explicitly account for work center specific supplies in direct overhead.

Indirect Overhead

Indirect OH is comprised of a Facility Budget and a Support Services Budget.

Facility Budget — The Facility budget accounts for the annual costs associated with the factory, including insurance, and utility costs (excluding the costs to run the machines). We estimate the facility budget amount apportioned to the workcenter based on the work center's square footage. We use rental rates by region to estimate the cost of the facility.

Facility Budget = Annual Rent + Insurance + Utilities

Annual Rent = Square Footage of the Workcenter
*** (1 + Factor For Non Production Factory Space)**
*** Annual Cost Per Sq Ft**

Square Footage of the Workcenter = Machine Length
*** Machine Width * Allowance Factor**

Insurance = Annual Rent
*** (Fire Factor + Loss Factor + Liability Factor)**

Utilities = Annual Rent
*** (Electric Factor + Heat/Gas Factor + Water Factor)**

Note: Factors are represented as a % of annual rent.

Support Services Budget — Support staff is modeled as a fixed overhead. We estimate support services for the workcenter based on applying a fraction of each support services to the workcenter (for example a quality worker covers 20 workcenters, therefore 5% of their salary is applied to a workcenter's indirect overhead).

Support Services are the fully burdened salaries and expenses for the following groups.

- Engineering
- Maintenance
- Planning & Purchasing
- Quality
- Tool Crib

Materials

The Regional Data Libraries support commonly used material compositions appropriate to each manufacturing process group. Physical properties and material stock sizes are maintained on a global level and are based on common data sources. Material pricing data in North and South America, Africa, and Australia regions use the World Average data. For regions within Europe and Asia, separate material pricing data are provided to reflect a closer representation of the continental average price. Japan and South Korea are included in the Europe continental as the regional material pricing is closer to European regions.

Metal compositions are maintained using their US standard names and various international standards — DIN (German Institute for Standardization), EN (European Standard), JIS (Japanese Industrial Standards), and GB (Guobiao standards – China). Polymers are listed by US names and common European names. Material prices are updated four times per year.

The primary material price data source is the Kerkhoff Consulting Group and the aPriori cost modeling team maintains market adjustment factors to align the prices with competitive material rates offered by mills and large regional distributors. Other data sources used to validate the material rates are:

- Current and historical material pricing data from OEMs, Mills
- Public material commodity tracking sites, e.g. American Metal Market LLC, Plastics News Global Group
- Relevant financial market sites, e.g. London Metals Exchange
- Relevant financial indicators, e.g. Dow Jones U.S. Iron and Steel Index (DJUSST), U.S. Aluminum Index (DJUSAL), Bloomberg European Steel Index (BESTEEL: IND)
- Various supplemental industry sites and publications, e.g. Plastics Technology, Steel Business Briefing

These sources track commodity contracts traded on exchanges, gather material price data based on real transactions from a diverse group of providers, and offer trend analysis and market condition forecasts. aPriori adjusts specific commodity prices as needed and continually improves the material data through customer feedback and engagement.

Regional Data Library Updates

aPriori updates the Regional Data Libraries four times per year. Updates are available for the current and previous major aPriori product releases. **Updates may contain:**

- Materials rate updates
- New material compositions
- Labor rate updates
- Overhead rate updates
  - » Updates to overhead rate inputs (Electricity, Rent, Imputed Interest Rates, etc.)
- Tool shop rate and price updates
- New machines

Each update contains release notes summarizing updates, enhancements, and bug fixes. **Note that all data and assumptions in Regional Data Libraries can be edited. Options include:**

1. Editing in a customer digital factory by using aPriori's overlay digital factory capabilities to combine aPriori and customer data.
2. Editing in a specific cost estimate scenario during cost refinement.

WANT TO LEARN MORE?

CLICK HERE to schedule a demo of the aP Manufacturing Insights Platform, the comprehensive manufacturing process simulation technology.

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